Shortage of qualifed science teachers in Norway

A System Dynamics approach

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To my Family and my best friends

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ABSTRACT

In the following research we present a work which addresses the problem of a shortage of qualified science teachers in secondary school education in Norway. The shortage of qualified science teachers in secondary schools has been addressed in recent years by the Norwegian media. The results of our work confirm the public concerns expressed and, through the model, we were able to find that the situation of shortage was present some time prior the media became interested in the issue. We have tested different policies in an attempt to solve the shortage, and none of them resulted in a complete solution. Our second policy "INCREASE WAGES" presented resulted in an improvement to the initial situation, but the cost of increased wages seemed to be economically unsustainable. The third policy "TRAINING/UPGRADING" also resulted in an improvement but the number of teachers required to fulfil the shortage will simply move the problem into another sector of the teaching workforce. The fourth policy "INCREASE WAGES and TEACHERS TRAINING" was the solution which improved the initial situation without creating negative effects on other parts of the system.
The final policy appears to be the direction in which the real system is heading, but recent decisions have not been strong enough to change the situation.

STRUCTURE OF THE REPORT

The research will be divided into different sections:

- A first introduction explains the purpose of the thesis and introduces the problem, the research questions, the dynamic hypothesis, the methodology and the policies which we intend on implementing in the model;
- The second chapter describes both the education system and Norway in general;
- The third chapter focuses on the structure of the educational system in Norway, introducing the three different levels: primary, secondary and tertiary;
- The fourth chapter describes the model structure and the main sectors;
- The fifth chapter introduces the statistical data used in the model;
- The sixth chapter reports the validation tests conducted on the structure to validate the results obtained by the model;

- The seventh chapter will show the behaviour of the structure that represents the problem and the results of the policies tested to prevent the problem;
- The final chapter outlines our conclusions and possible directions for future research.

1 PURPOSE OF THE PAPER

1.1 TOPICS AND GOALS

"Children are growing up in a society marked by science […].Teaching in science and technology, and teaching about interconnections in nature, is intended to help pupils to acquire the adequate knowledge, skills and attitudes they need to become active citizens and participate in sustainable development."[1]

What we present in this research is a System Dynamics approach that will test the concerns raised by different associations in Norway (Ministry of Education in Norway, Norwegian Directorate for Education and Training and the Norwegian Teachers Association) about the possible future crisis regarding the shortage of qualified science teachers in primary and secondary education.

Interest in the education sector has risen since I become a student here in Norway. This country has been considered one of the best in Europe in terms of health and education systems. For this reason it is always classified by the European Union as one of the best countries for living in[2]. I was surprised when my attention was captured by the "ringing alarms" and the concerns which have been expressed in the Norwegian media. As a student in System Dynamics I thought that the methodology could be applied to test the assumptions and see if media concerns were justified.

Over the last few decades many fields of research and different approaches has looked closely at the problem of shortages in teaching staff and different methods have pointed out the problem from different perspective.

Sociology of education, for example, sees the problem as a consequence of demographic trends combined with a low supply of teachers. On the other hand sociology of organization focuses more on the excess of demand due to a high turnover[3]. The present paper is trying to

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[1] Norwegian Directorate of Education and Training (2006). Core Curriculum for primary and secondary education in Norway.
http://www.udir.no/L97/L97_eng/index.html

[2] Norway is ranked as first country in the UN Human Developing Index (HDI). The HDI is a comparative measure of life expectancy, literacy, education, and standard of living for countries worldwide.
http://en.wikipedia.org/wiki/UN_Human_Development_Index
http://hdr.undp.org/hdr2006/statistics

[3] Ingersoll, R. M. (2001). "Teacher turnover and teacher shortage: An organization analysis." American Educational Research Journal **38**(3): 499 - 534.

look to the problem utilizing a problem oriented method using the knowledge already presented in other researches to evaluate better the possible causes of the future shortage of teacher in science in the Norwegian educational system.

1.2 PROBLEM STATEMENT

"*There is a general shortage of teachers possessing the required qualifications in natural science as well as in certain practical subjects […].*[4]"
"The shortage is particularly acute in subjects like mathematics, physic, chemistry and geography/geology."[5]
"[…] there is a growing tendency for an increasing number of students graduating in natural science not to enrol on postgraduate courses of education (PCE)."[6]
"If the recruitment of teachers with qualifications in such subjects does not increase, there is a risk that they will practically disappear from schools."[7]

During recent years in Norway there has been increased media attention on the education system. Recent projects, made with the participation of the Ministry of the Education and other educational institutions, have discovered a diminishing supply of qualified teachers in science and an increased average age of the teaching population.
With statistical data they concretize the concern of a future shortage of qualified science teachers. So far the real problem of shortage has not yet arrived, but the strong assumption sustained by empirical evidence suggests that will only be a matter of time before that moment will come.

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[4] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

[5] Næss, T. (2002). Realfagslærere i skolen. Rekruttering, beholding og avgang. NIFU skriftserie. NIFU. Oslo, NIFU - Norsk institutt for studier av forskning og utdanning. **:** 106 pages.

[6] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

[7] Næss, T. (2002). Realfagslærere i skolen. Rekruttering, beholding og avgang. NIFU skriftserie. NIFU. Oslo, NIFU - Norsk institutt for studier av forskning og utdanning. **:** 106 pages.

There is a shortage of qualified teachers in science.

This master thesis will focus on this problem.

1.3 HYPOTHESIS

The future shortage of qualified science teachers in education is going to be realised within the education system, due to the following reasons:

- there will be a lack of supply of qualified students in science subjects;
- the agreement reached in 2001, after the salaries bargaining, called "school package 2"[8], has influenced the retaining of teachers but not the recruitment;
- high turnover.

The policy which has been adopted to prevent attrition of science teachers is not preventing the future lack of qualified science teachers. It is influencing negatively the recruitment of new teachers, this due to the fact that they are also very attractive for well paid jobs in private and government sector.

A long-term policy has not been yet established for recruiting/up grading qualified science teachers. The conjunction which leads to a high number of available places due to retirement and leaving should be used positively to allow new qualified science teachers to re-new the school system and increase the quality.

When the "school package 2" was implemented it has reduced the chances for the new teachers to find a place to work or to get qualified. Consequentially these two events have increased the average age of the teaching population. This also creates a "greying work force", which soon will retire, resulting in a decrease in the number of qualified teachers.

[8] In 2001 the government and the teachers' unions negotiate for the renewal of the teachers' salaries, the agreement they reached was called "school package 2" in which the number of hours of work per teachers were increase due to an increase of salaries per hour of work per teachers. Norges Offentelige Utredninger (2003). Om grunnlaget for inntektsoppgjørene 2003. NOU - Norges offentelige utredninger. Oslo.

In addition the required knowledge for science teachers in primary education has been lowered. New teachers are allowed to teach scientific subjects even without having background knowledge of the subject.

This decision has been taken to a primary level since in the compulsory education mathematics as science skills are not highly required into pupils education, and also because there were a need of re-filling the available positions that the teachers left after leaving the education for better jobs.

1.4 CAUSAL LOOP DIAGRAM

The Causal Loop Diagram (CLD) is one of the main tools used in System Dynamics to clarify the dynamic hypothesis to represent the feedback structure in the system. The CLD will be illustrated and commented, loop by loop, as follow.

Here in Figure 1 we represent the simple dynamic core of the system a loop generated by the retirement of the teachers.

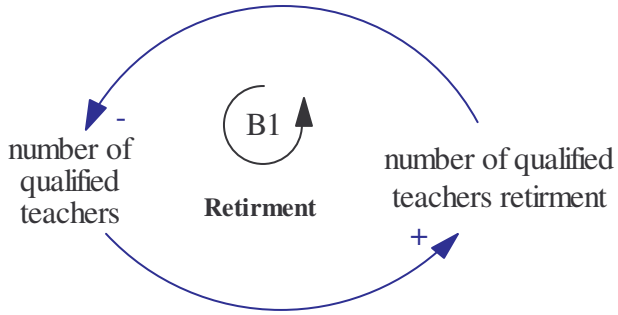

Figure 1: Balancing Loop B1, retirement of qualified teachers

The first Balancing loop (B1 – "Retirement") is representing the natural cause why quality teachers decrease in number. More qualified teachers there are, more retirements of qualified teachers there are going to be and less qualified teacher there will be as a consequence.

The second Balancing loop (B2 – "Qualified recruitment") shown in figure 2 represent the first dynamic hypothesis.

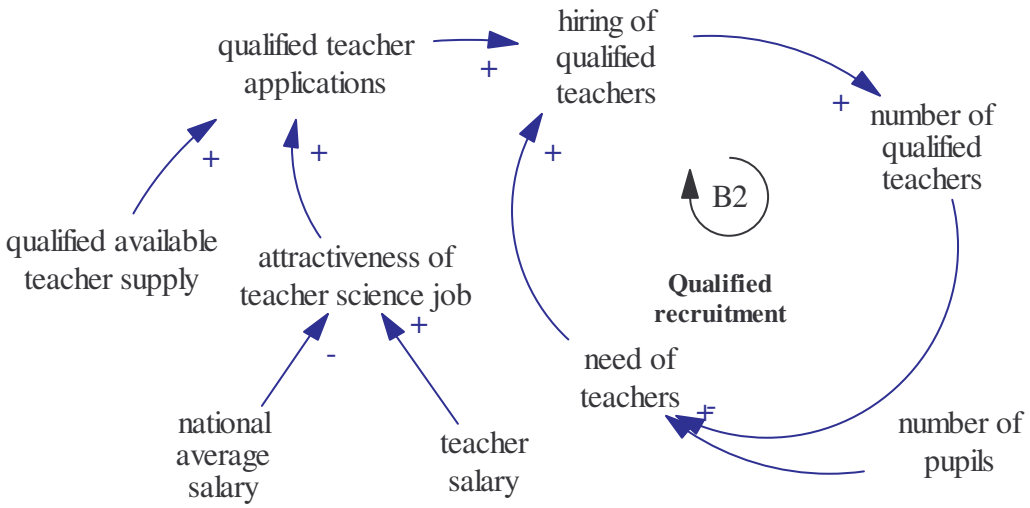

Figure 2: Balancing Loop B2, recruitment of qualified teachers

If the number of qualified teachers decreases, due to the number of pupils, the need of teachers will increase therefore there will be an attempt to hire more qualified teachers. The hiring of qualified teachers year by year is limited by the qualified teacher applications. The qualified teacher applications are limited by the attractiveness of teacher science job and the qualified available teacher supply. The attractiveness of teacher science job is estimated as a ratio between teacher salary and the national average salary in Norway.

In Figure 3 is represented the Reinforcing Loop (R1 – "Turnover") the decrease of qualified teachers leads to a higher rate of teachers qualified living their positions. The turnover, also referred as "attrition of teachers", will lead to a shortage of workforce qualified. To prevent this "attrition" the main solution was the increase of salaries for the teachers which increase the attractiveness of teacher science job and consequentially decrease the turnover.

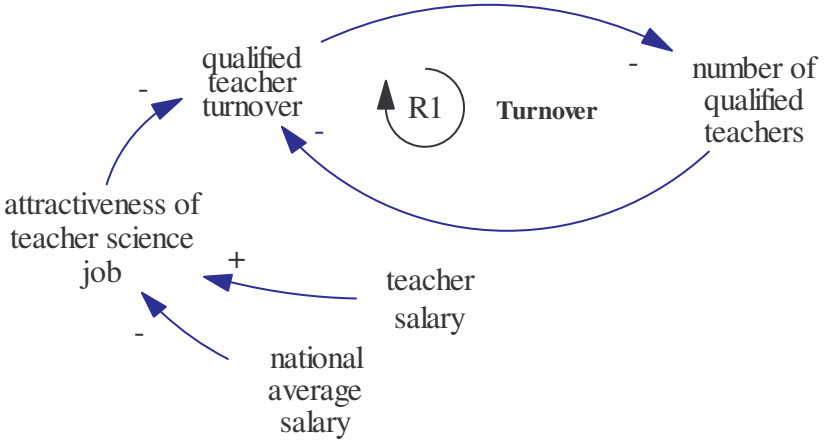

Figure 3: Reinforcing Loop R1, turnover effect on qualified teachers

Turnover is a general cause which can be provoked by different factors, what is important in our research is to highlight the solution that has been taken, the increase of the salaries to the attractiveness and decrease as a consequence the turnover.

Salaries policy and salary bargaining are, in our hypothesis, one of the cause that originated the problem. In Figure 4 we present the complete CLD showing and explaining why we believe salaries are responsible for the shortage of qualified teachers and for the lack of qualified teacher applications.

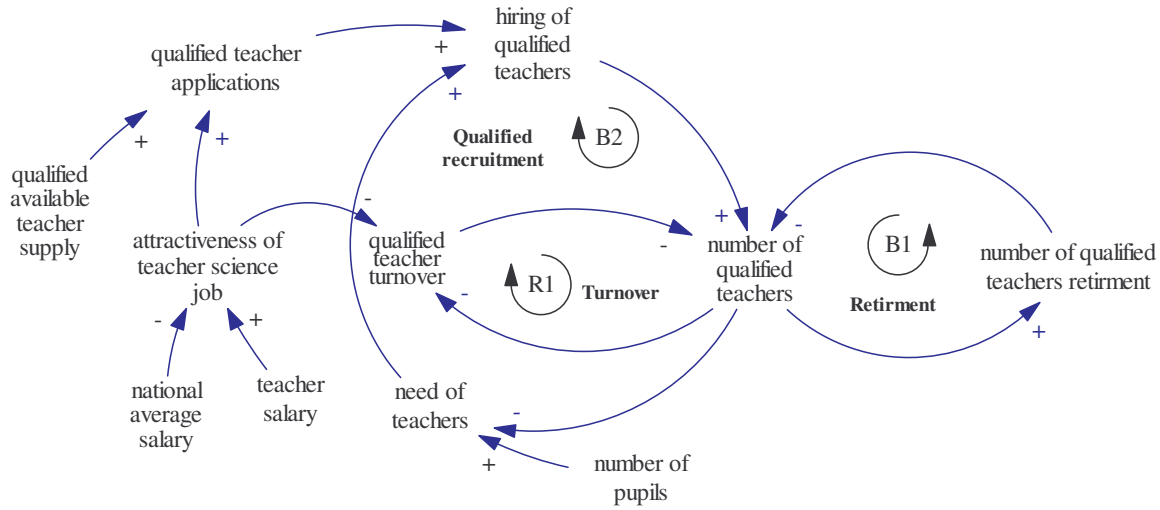

Figure 4: Complete CLD diagram, dynamic hypothesis of the problem

In this final CLD is possible to see all the loops linked together, representing the dynamic hypothesis we presented in the previous paragraph. As we wrote before the salary is a central point in our hypothesis, especially after the "school package 2" in 2001. The attractiveness of teacher job is linked to the remuneration, different researches demonstrate this relation[9]. If the salaries of teachers increase the attractiveness of the job increase and the supply of teachers will increase as well. If the market salary increase then the attractiveness to work as a teacher will decrease and so will do the available qualified workforce. The salaries of teachers have been always equal no matter what type of education or subject is known by the teacher. The future available workforce whit knowledge, skills and capacities that could be used in schools as well as in the market are not attracted to teacher profession. The supply of teachers

[9] Peter Dolton, A. T., Tsung-Ping Chung (2003). The Economic Cycle and Teacher Supply, OECD**:** 108. ; Schøne, P. (1999). Avgang og rekruttering i undervisningssektoren - hva betyr lønn? I. f. samfunnsforskning. Oslo, Insitutt for samfunnsforskning**:** 105 pages.

consequentially decreases, leading to difficulties in recruiting qualified teachers and creating a negative chain reaction in the system.

1.5 RESEARCH QUESTIONS

1. ***Are the concerns expressed in different national reports[10] justified? Is the Norwegian school system on the edge of a crisis in shortage of qualified secondary teachers in science subjects?***

2. ***Will there be enough available qualified teachers to replace the vacant places?***

3. ***If not, what will be the best policy to do not encounter a shortage of qualified secondary science teachers?***

The alarms and concerns expressed in the latest national reports on education and teaching background have resulted in much preoccupation on the future of education in Norway, which have been confirmed by the publication of the PISA 2003[11] results. This survey qualified Norway as the 25th country out of 40 that take part with regard to mathematical literacy. In the previous survey in 2000, Norway was ranked 18th in mathematical literacy, and therefore there has been a decline in the performance of Norwegian students as it is illustrate in Table 1.

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[10] The national reports take in consideration are:
Ministry of Education and Research, The Norwegian Center for Science Education, et al. (2004). Euroscene 2003. The Norwegian Project Report M. o. E. a. Research. Oslo, The Norwegian Center for Science Education, University of Oslo**:** 65 pages.
;
Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.
;
Ministry of Education and Research (2002). Math, science, and technology, naturally. Strategy for the strengthening of math, science and technology 2002 - 2007. Oslo.
; Ministry of Education and Research (2004). The development of education 2000 - 2004. National report of Norway. Oslo.

[11] PISA is a Program for International Students Assessment provided by the OECD in 2006 it has been published with a developed and expanded framework for scientific knowledge.
http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data.html

This could be considered a bad result and demonstrate how 15 years old students are not well prepared. The same trend could be found for scientific literacy[12].

Table 1: National Ranking from the PISA results 2000 – 2003. Last 11 countries are not included in this table

Ranking	Math literacy		Reading literacy		Science literacy*
	2000 PISA	2003 PISA	2000 PISA	2003 PISA	2003 PISA
	Countries		Countries		Countries
1st	Hong Kong-China	Finland	Finland	Finland	Latvia
2nd	Japan	Hong Kong-China	Korea	Korea	Greece
3rd	Korea	Japan	Hong Kong-China	Canada	Germany
4th	New Zealand	Korea	Canada	Liechtenstein	Switzerland
5th	Finland	Liechtenstein	Japan	Australia	Finland
6th	Australia	Macao-China	Ireland	Hong Kong-China	Brazil
7th	Canada	Netherlands	New Zealand	Ireland	Czech Republic
8th	Switzerland	Switzerland	Australia	New Zealand	Belgium
9th	United Kingdom	Canada	United Kingdom	Sweden	Poland
10th	Belgium	New Zealand	Sweden	Netherlands	France
11th	France	Australia	Belgium	Belgium	Italy
12th	Austria	Belgium	Austria	Macao-China	Portugal
13th	Denmark	Denmark	Iceland	Switzerland	Hungary
14th	Iceland	Iceland	**Norway**	**Norway**	Indonesia
15th	Liechtenstein	Czech Republic	France	Japan	Hong Kong-China
16th	Sweden	France	United States	France	Iceland
17th	Ireland	Austria	Denmark	Poland	Japan
18th	**Norway**	Sweden	Switzerland	Denmark	Australia
19th	Czech Republic	Slovak Republic	Spain	United States	Spain
20th	United States	Germany	Czech Republic	Germany	United States
21st	Germany	Luxembourg	Italy	Iceland	Denmark
22nd	Hungary	Poland	Germany	Austria	Sweden
23rd	Russian Federation	Latvia	Liechtenstein	Latvia	Thailand
24th	Spain	Spain	Poland	Czech Republic	New Zealand
25th	Poland	**Norway**	Hungary	Luxembourg	Ireland
26th	Latvia	Ireland	Greece	Spain	Korea
27th	Italy	Hungary	Portugal	Hungary	Canada
28th	Portugal	United States	Russian Federation	Portugal	Mexico
29th	Greece	Russian Federation	Latvia	Italy	**Norway**
30th	Luxembourg	Italy	Israel	Greece	Austria

*** Table adapted by the author. The original table shows the mean difference in scores per country**

In the following research we will test the theories and empirical evidence presented in different national reports to see how the system will be in the near future and determine if the concerns expressed by the media are indeed true.

System Dynamics is a powerful tool to predict possible future scenarios and test different policies which may correct the wrong decisions made in the past and re-conduct the system to a normal steady state. The system presents preoccupant lack of qualified teachers. We define "qualified" as not the pedagogical qualification but as the knowledge of the subject to be taught. The future retirement of qualified teachers must be used as a positive conjunction to

[12]Ministry of Education and Research (2002). Math, science, and technology, naturally. Strategy for the strengthening of math, science and technology 2002 - 2007. Oslo.

; OECD (2004). Learning for Tomorrow's world. First results from PISA 2003.

integrate new, possible young, qualified teachers in the school system and to re-new the education itself, keeping it upgraded and efficient.
The policies described and used will demonstrate different possible future situations as follows:

- ZERO POLICY: in this case the scenario will remain in the current situation, the system will not change and no policy will be applied;
- INCREASE WAGES: in this case the policy introduced in the model is influencing the remuneration of the teachers to see the effect of the recruitment, and to see also the sustainability of the policy;
- TEACHERS TRAINING/UPGRADING: in this scenario we present a policy which will involve the youngest teachers in school, and will provide them with further education training in science and mathematics;

1.6 METHODOLOGY

For the study the model we construct allows us to test different policies to see if the problem can be limited or avoided. The educational system itself presents characteristics that makes possible to use System Dynamics as a method of problem solving. There are feedbacks' relations, stocks of accumulation and time delays involved in the process for obtaining a good and prepared teaching work force.
System Dynamics is a "problem oriented" methodology and it approaches the system considering essential the factors that may have caused the problem to occur. For this reason this study is evaluated in an aggregated national context that will be defined better in the following chapters. Thus far it is important to underline that our aim is not to recreate reality but to identify the causes of the problem within the system.
In this particular case we are dealing with empirical evidence presented in reports and articles. They show a tendency of the system to reach a future point of shortage in qualified science teachers. The problem of teacher shortage has not yet occurred but it is reasonable to assume that it will be faced in the near future. With our model we will test the assumptions and present a future scenario for the Norwegian Education System if the policy is not changed.
This thesis has been developed in different steps starting with the collection of all the literature regarding the education system to the study of how it is built. Furthermore the

students development through the school years, including tertiary education and then was studied followed by the different ways students become teachers and enter the education work force.

The second step followed was to model the system as it has been presented in the literature, creating different sectors regarding the process of becoming qualified after school and tertiary education.

The model is implemented with feed back loops concerning the assumptions published in the reports which show the tendency of the system to run through a crisis. The model is then tested and certain parameters changed to see the effects of possible policies to improve the recruitment of teachers.

The final step was the consideration, evaluation and comparison of the different scenarios results to determine an explanation for why the problem has been increased by any of them.

2 HISTORIC FACTS OF THE NORWEGIAN EDUCATION SYSTEM

2.1 NORWEGIAN EDUCATION SYSTEM

2.1.1 Historical Facts

The population of Norway is approximately 4.5 millions; 900,000 people are under the education system. The number of pupils in primary schools is around 600,000 and in secondary schools approx 164,000. The adult population currently enrolled in education numbers 136,000. Pupils are taught by around 70,000 teachers.

The primary school system is divided into 10 grades and the secondary school is divided into 3 grades:

- Primary school: Grades 1 to 10, student age from 6 to 16
- Secondary school: Grades 11 to 13, student age from 17 to 19

In the history of Norway there has always been a spirit of equal opportunity for all, a democratic force that has been realized in other fields and not only in the education system. As an example, the right to vote for woman was introduced in the early 20th century, giving Norway the good primacy of being the second country in Europe, after Finland, to introduce it. Education rights for pupils, dated further back in the history of Norway; the first compulsory training in reading for pupils was established in 1736, in 1827 “folkeskole” was introduced a primary school which was mandatory for seven years under the first education act dated 1889, but was changed to nine years in 1969 when the school system took the shape it is today. The latest developments in education were applied in the late 20th century. In 1994, the secondary school education was reformed and the state acknowledged the rights of pupils to have three more years of secondary education after primary school. In 1997, primary education was changed from nine years to ten reducing the age of entering school from seven to six. Also during this time other main topics of education were discussed, such as the rights of adults to receive education and the equal treatment of special needs pupils.

During the 60's Norway discovered oil resources in the North Sea, which has resulted in a steady increase in the Gross Domestic Product (GDP) of the country. This new economic resource gave the government the ability to increase the expenditure for education. The investment in this sector is estimated around 7% of the national GDP, which is a high percentage if we consider that the OECD average is around 5.3%. Even if expenditure for education was increased in recent decades, it seems that other problems occurred in the system, demonstrating that increasing the investments does not automatically lead to an increase in the quality of education.

2.1.2 Demographic development

Norway has a small resident population spread through out the country; in fact the average inhabitants per square kilometre is 14, which is a really low population density compared to other European nations.

In modern history, except during periods of epidemic (latest date 1637), the great depression of the 30's and the Second World War where the country was occupied by Germany, Norway should be considered one of the countries with the highest living conditions in Europe. There are no problems of war, unemployment, over population, hostility or natural threats[13]. All these factors combined have given the Norwegian population the chance to have a slow steady increase growth rate over the last 100 years, and potentially for the future 60 as is shown in Figure 5[14]. Clearly this trend is reflected in the enrolment of pupils at school. The projection of the Statistic Sentral Byrå (SSB – Statistic Central Bureau) shows that, with a Medium National Growth rate, the population will increase in the future but without drastic changes to the different age cohorts. The main increase of cohorts seems to be into the group representative of the oldest part of the population. There is no drastic increase into the youngest cohort, which indicates an increased age of the population with a constant number of births.

[13] Norway has been acknowledged as most peaceful country in the Global Peace Index. http://www.visionofhumanity.com/rankings/ (30/05/2007)

[14] Data obtained by the Central Statistic Bureau. http://www.ssb.no/emner/historisk_statistikk/tabeller/3-3-1t.txt

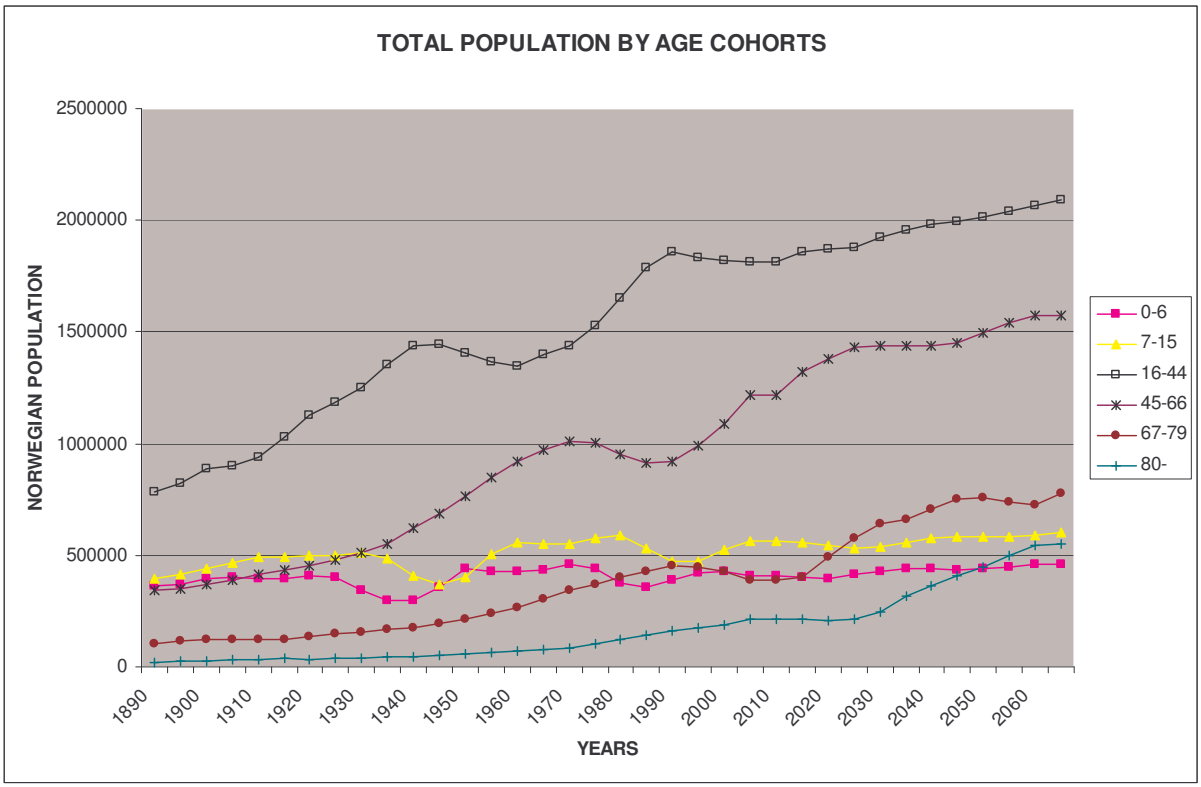

Figure 5: Norwegian national population by age cohorts, SSB historic data and projection 1890 - 2060

2.1.3 Pupils' population

The number of pupils in primary school education reflects the trend of the population and it has been steady increasing and oscillating but not having drastic changes, nor in the future is possible to see changes, as projected by the Statistikk Sentral Byrå (SSB) as shown in Figure 6. All the pupils in compulsory education receive a free state education. Due to the very low density of population through out the country the schools present differences dependant on geographical position, which in turn influences the decisions to hire teachers based on their type of knowledge. In our case we do not consider those different patterns and we assume that they are not influencing the system.

99% of pupils attend public school, and therefore only 1% receive education from a private institution[15]. However lately this percentage has been increasing but remains statistically irrelevant.

Pupils start compulsory school at age six and continue until they reach age 16 at which time they may choose to continue for three more years of high school. For those who decide to

[15] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

follow education, which is the vast majority, the career as a student will end when they sit for the national exams at the end of the high school.

The population of secondary school students contrary to the primary is decreased by a small percentage estimated at 2%[16], due to students who leave school prematurely ("dropping out").

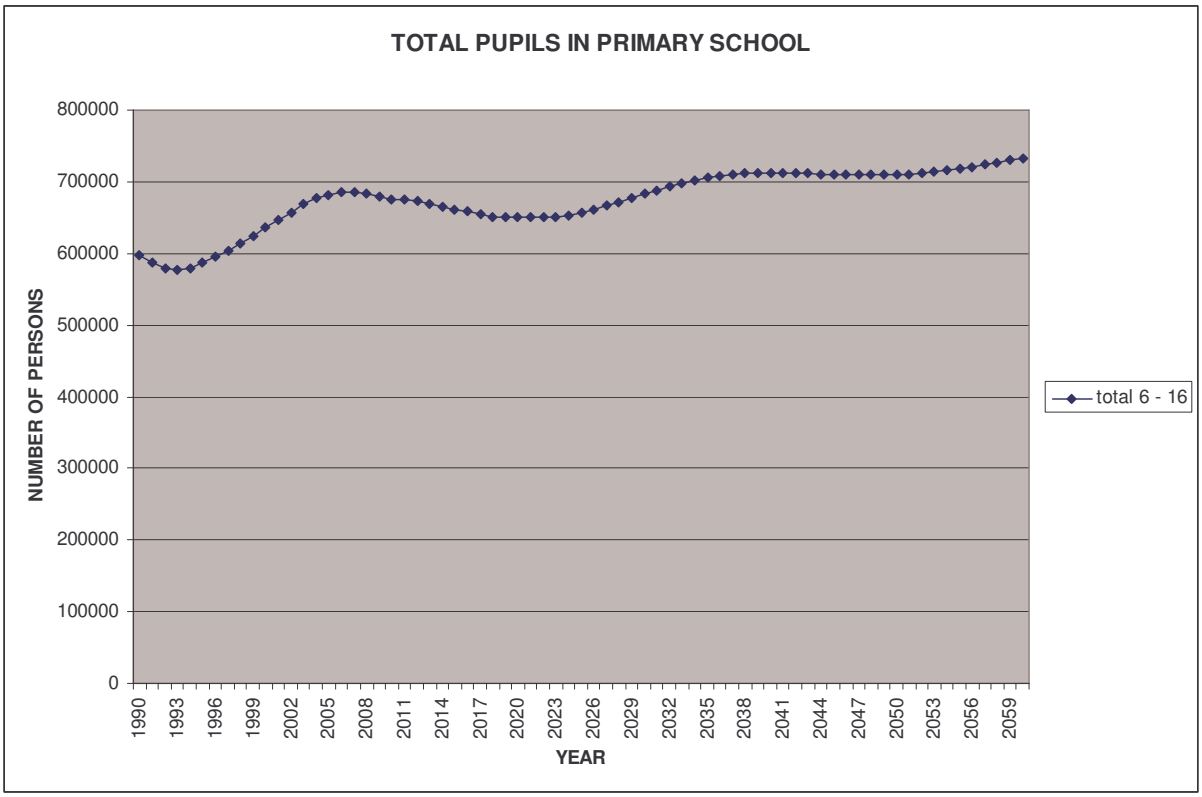

Figure 6: Pupils in primary education. SSB historic data and projection 1990 - 2060

The shape of the population of students attending primary school is really smooth and does not present any drastic change since the population has constantly increased. The wave that is seen in the figure is due to oscillation in the fertility rate. The data presented is from 1990, and the projection runs until the 2060. The model presented in this research will cover the same time, and the results of the model regarding this part of the total population will be shown and compared to the historic data and projection in chapter 6.

The population of secondary students is quite different from primary school and it is reported here in Figure 7, as the total number of pupils attending secondary school education. The figure presents statistic data from the SSB database. To calculate the number of students we

[16] The percentages of pupils that continue the primary education and attend are the 98%. Ministry of Education and Research, The Norwegian Center for Science Education, et al. (2004). Euroscene 2003. The Norwegian Project Report M. o. E. a. Research. Oslo, The Norwegian Center for Science Education, University of Oslo**:** 65 pages.

used population projection figure. The number of students attending secondary instruction is a fixed percentage as previously mentioned. To obtain the real number of attending students we multiply the percentage by the number of persons in the same age cohorts. The approximation to the real number of students should be quite close, as the percentage of dropping out students is not increasing in Norway, which it is most likely decreasing.

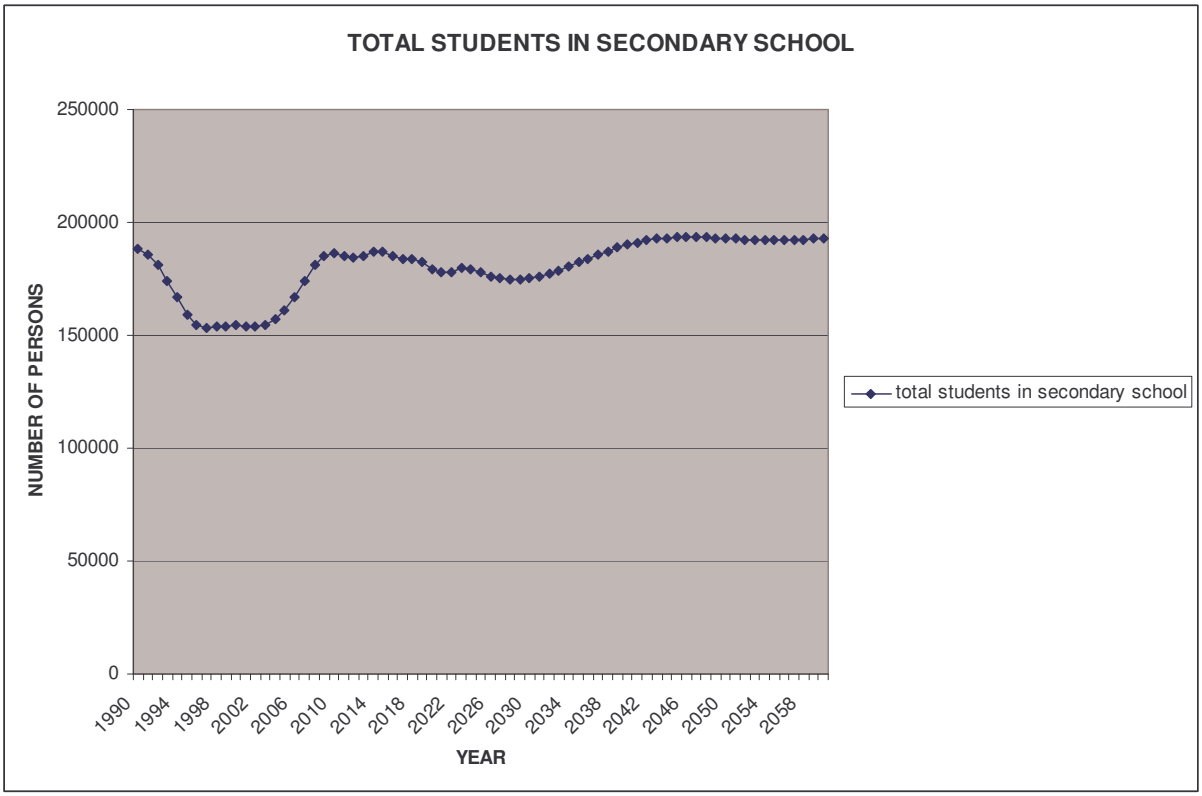

Figure 7: Total number of students in secondary school, SSB's historic data and projection 1990 - 2060

Figure 8 show the number of students in secondary schools divided the different type of educational institution. For our research the part of the population we consider is the total pupils in general secondary school. A very small number of the total students attend folk secondary high school and quite a large number attend vocational school, which was introduced in the system in 1972.

The folk high schools were opened in Norway in 1864, and have a long tradition with an aim which is not typical. As it reported on the main web page of those schools in Norway, the folk high schools "[…] are one-year boarding schools offering a variety of exciting non-traditional and non-academic subjects, as well as academic subjects. The idea of folk high schools is learning for life, an opportunity to grow both individually, socially, and academically in small learning communities where all students live on campus in close contact with staff and their

fellow students. One important part of the folk high school experience is to form a community, a common bond within the student body, in class and out of class. Learning for life happens all day long."[17]

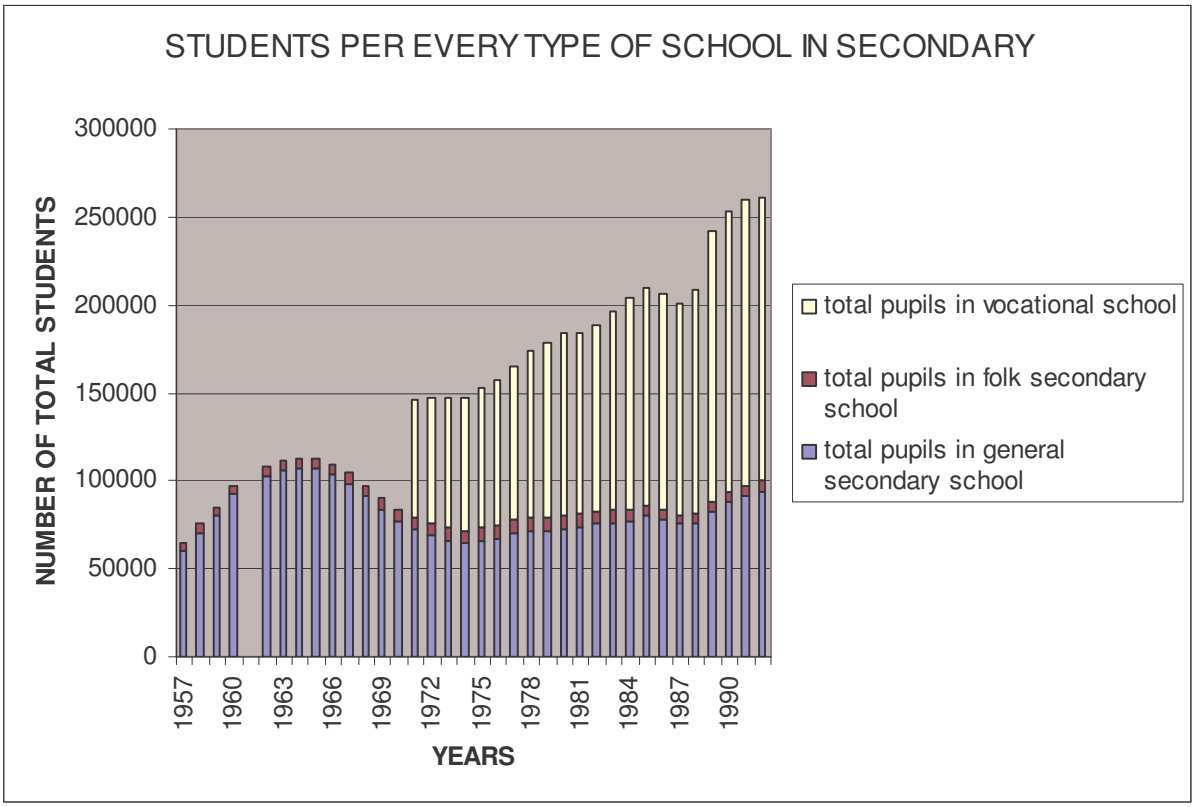

Figure 8: Students in secondary education by different schools. SSB's historic data 1957 - 1993

2.1.4 Teacher's population

The number of teachers independent of being a full-time employee or part time employee, is around 70,000 units. This is split in two distinct categories for the two types of education (primary and secondary). Of the 70,000 around 50,000 are teaching in primary and 20,000 in secondary school education. The population of teachers is basically aged from 22 to 67 where 67 is the obligatory retirement age in Norway. Dispute this, teachers may also retire earlier in their career at age 62. Lately an increasing number of employees decide to take this opportunity. Generally the competence of the employee depends on the type of qualification they received in university: if a Bachelor or a Master certificate. At the primary education level the vast majority are students from college with a general teachers education, or those holding a BACHELOR degrees from universities. Secondary teachers are mainly qualified by

[17] Description takes from the official Folkehøgskolen website. http://www.folkehogskole.no/

Master degree from university, and a smaller percentage of students who attend college and specialize in one subject to teach[18].

The age composition of the teaching population in primary school as in Figure 9, show the level of ageing. It seems to be quite constant and does not present a particular concern.

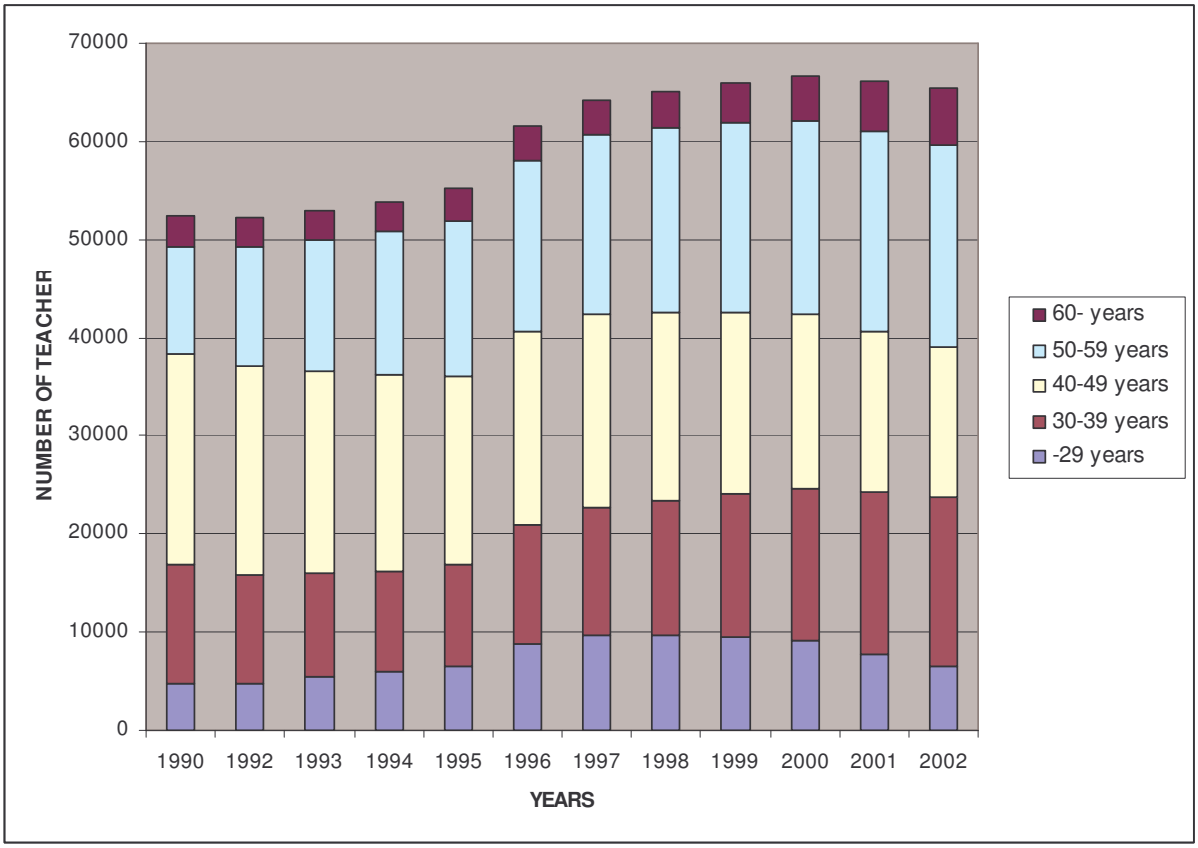

Figure 9: Teachers' population in primary education. Percentage of influence per every age cohorts. SSB historic data

The situation is not the same for teachers in secondary schools, for which aging is causing more concerns, as shown in Figure 10. In the graph it is possible to see the composition of the total staff by age cohort. Comparing it to the previous figure, it is clear that the secondary school teaching staff is showing an increase in people employed between 50 and 59 years of age. The increase in this cohort is due to a passage of teachers from primary education to secondary education level after some years of teaching. Alternatively the explanation could be the hiring of old work force, however this is not likely as one of the first goals is to try to keep the average age constant.

[18] In primary school 75% of teachers are trained at college, in secondary school more than 70% are teachers with a mater qualification from university. SSB statistic. http://www.ssb.no/english/subjects/06/05/lonnskole_en/arkiv

The passage of teachers from primary to secondary is a consequence of the lack of qualified teachers for secondary schools. The passage could be also linked to career advancement that a teacher may decide to take to increase their salary.

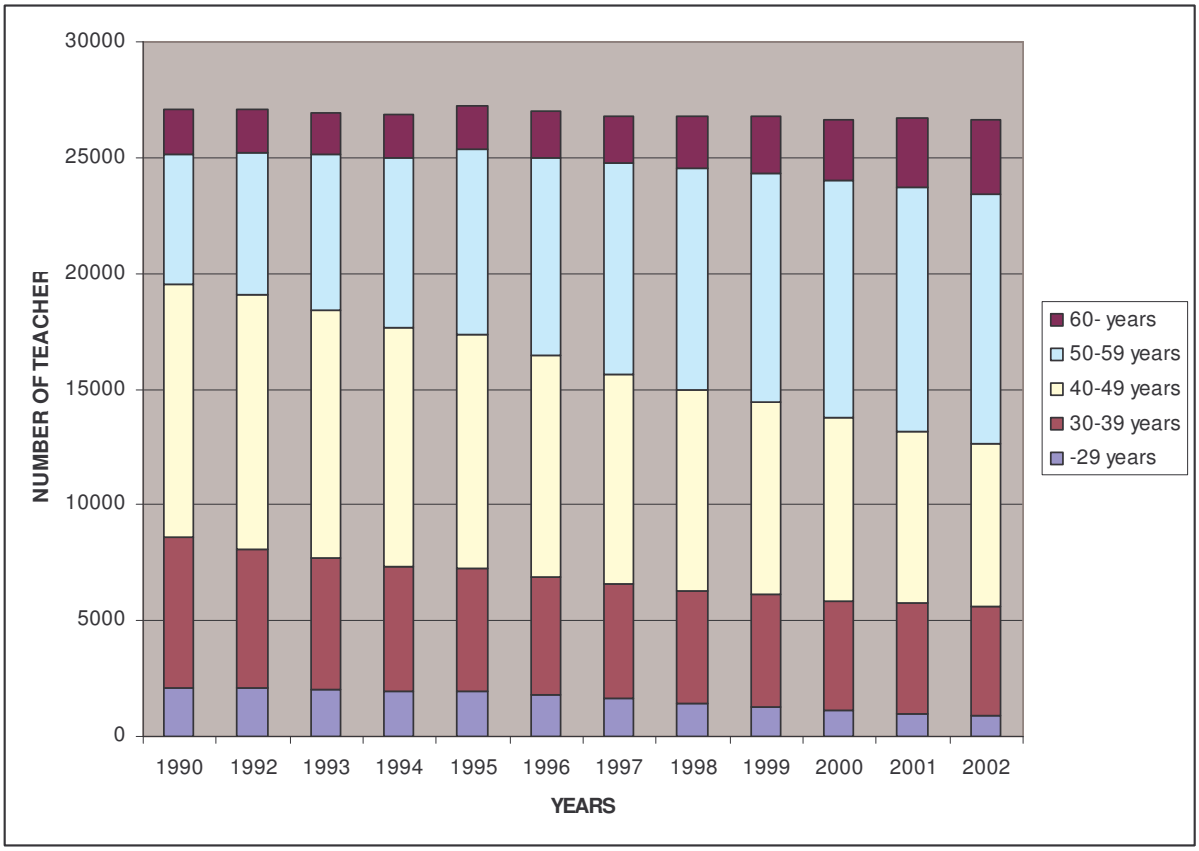

Figure 10: Teachers' population in secondary education. Percentage of influence per every age cohorts. SSB historic data

The repercussion of the increasing age in the secondary teachers population can be seen in Figure 11 where the mean age is presented by the different level of education. As mentioned in the introduction, the secondary school system seems to suffer more from the effect of "greying work force" and it is one of the first signs that indicates a possible future decrease in the number of qualified teachers of this level of education due to impending retirements.

Statistics Norway[19] refer to the issues within the teacher population as follows:

"Compared to primary and lower secondary schools there is a considerably lower proportion of younger teachers in upper secondary schools. From 1993 to 2003 the average

[19] . "http://www.ssb.no/english/subjects/04/02/utlaerer_en/main.html.

age of upper secondary school teachers has risen by four years to 48.5. The corresponding number for primary and lower secondary schools was 44.8 years."

Thus far we have discussed the total population of teachers in Norway. However we are more concerned with those teachers qualified to teach science, as this is where the projected lack of teachers is of most concern. This is illustrated in the following section.

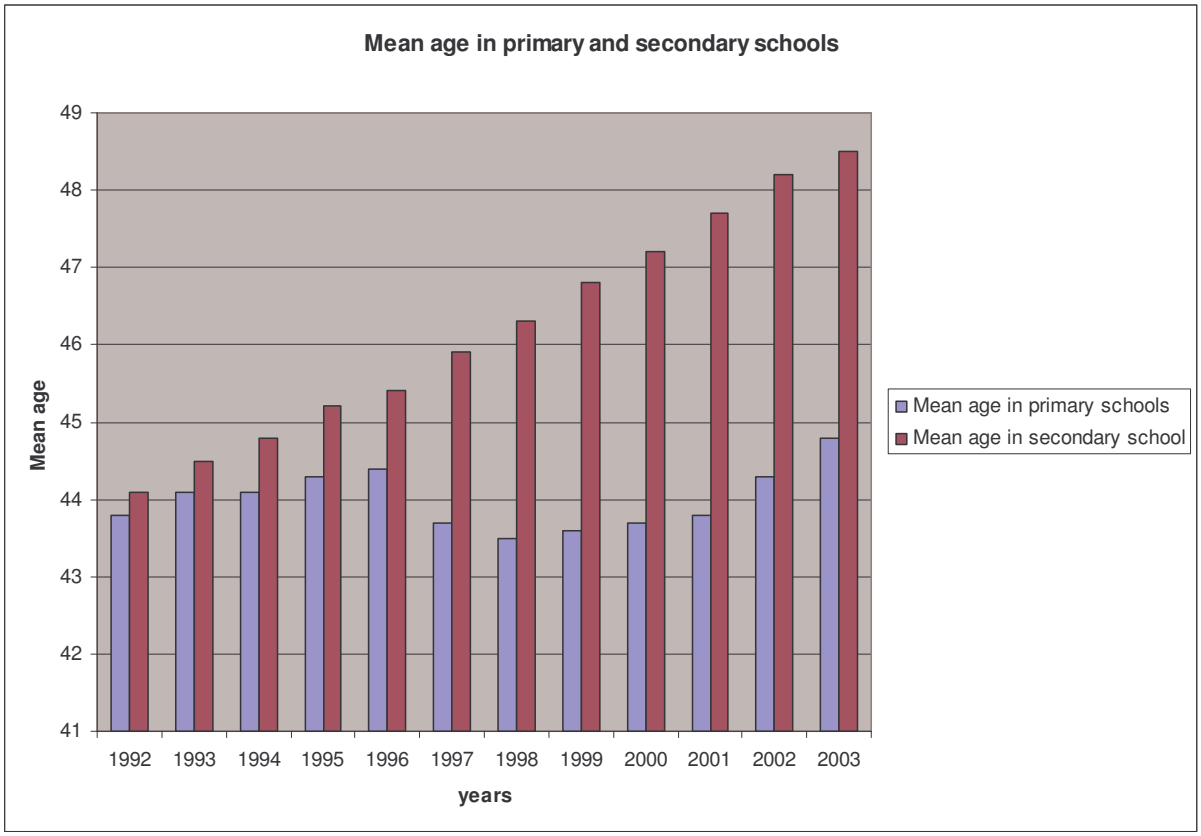

Figure 11: Mean age increase in teacher population. SSB statistic data

2.1.5 Science teachers' population

The previously presented data about teachers has included the general population; whereas this thesis focuses more on the branch of science teachers. It has been difficult to find data regarding this particular sector of qualified people, even when the available data is aggregated. The only available knowledge is the percentage of total employees that meet the requirements for a science teacher. These data show that a high percentage of this group is old and will soon retire[20].

[20] "…in upper secondary level, half of the teachers with master's degree in science are above fifty years of age." Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

To recreate the number of science teacher we had to make some assumptions. In general we consider that the number of teachers required to cover the lessons in a specific subject should be equivalent to the percentage of total teaching hours that the subjects must be taught. In addition we assume that a percentage of the teachers hired will be unqualified and will become qualified after some years of practice or "experience on field".

In primary education it was easy to calculate the number of desired science teachers as the pupils are grouped in one year class and every class has to follow a certain number of hours teaching per week[21].

Conversely, the number of teachers qualified in secondary education has been much more difficult to calculate. The reason is that there is no data available about them. The same method of estimation used for primary schools can not be applied due to the differences in the teaching hours between school levels. Further description of the teaching of science is to follow.

It is known that the persons qualified to teach secondary school science are students who have obtained at least a Master degree at the university, or college graduates qualified in specific science subjects. The number of students enrolled in science at university has been decreasing drastically as has the percentage of science graduates that decide to take the professional qualifications necessary to become a teacher.[22]

The use of System Dynamics to recreate the science teacher population has been helpful, we can assume that an initial percentage of the total population are qualified and can change this factor for every time we run a scenario. Due to a lack of statistical data, we do not have any historical figures that show the development of this sector of the population. The only table and graphics we have are those generated by the model, and are therefore included in the chapter results.

From the reports it can be assumed that the half of the qualified science teachers fall in the 60-67 year old cohort.

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[21] As we mentioned in the introduction, Norway has a geographical distribution of the population which is really spread, this fact imply the presence of "rural school" where the class of pupils in primary and secondary school could present more than one year students. In our research we aggregate the class and we do not take in consideration the presence of "rural class".

[22] "*The proportion of science graduates entering education fell from 30% at the end of the 70s to under 10% during the 80s, and since remained at the same low level.[…] Norway in the OECD Classification of 100.000 aged 25 to 34 of science graduates comes third last after Netherland and Denmark*"
Ministry of Education and Research (2004). The development of education 2000 - 2004. National report of Norway. Oslo.

The number of new qualified teachers entering the education work force is probably lower than that evident from statistic. This maybe due to unqualified teachers being labelled as qualified, in order to compensate the lack of teaching staff. The lowering of the qualification standard for science and mathematics teachers is not a restricted to Norway, but has recently spread through out Europe[23]. As evident from the PISA overview report, the decision to reduce qualification requirements has led to a decline in the quality of the education.

[23] "School system often responds to teachers shortages in the short-term by some combination of: lowering qualification requirements of entering to the profession; assigning teachers to teach in subjects areas in which they are not fully qualified […]" OECD (2005). OVERVIEW. Teachers matter: attracting, developing and retaining effective teachers.

3 THE STRUCTURE OF THE NORWEGIAN EDUCATION SYSTEM

3.1 COMPULSORY AND SECONDARY SCHOOL

The Norwegian school system as previously mentioned is composed of two main types of education: primary and secondary.

Primary school is compulsory for every pupil and it is free for the family. This first level of education lasts for ten years and is divided in two under group: low primary education and high primary education (*Barneskole* and *Ungdomsskole*).

The first branch of compulsory education (low) goes from grade 1 to grade 7 and the second (high) from grade 8 to grade 10. After the first ten years school becomes voluntary and the students can choose to take the last three years of high school (*Videregårskolen*).

After the reform of 1997, pupils start at age six and the majority finish school at age 19; sometimes gifted children can finish school early and get into tertiary education before others but as these cases are rare this is not taken into consideration in our model.

The Videregårskolen falls under the category of "general schools", but there are other types of institutions as seen in Figure 8. Since 1972 vocational school (*Yrkeskolen*) and also folk high school (*Folkehøyskole*) have given students the chance to follow different paths of education. In vocational school students learn a job such as: carpenter, electrician or mechanic. In these schools the subjects are different from a normal general school where the knowledge is centred more on classical subjects, however in the first year science and mathematics are compulsory for the students.

Folk high schools offer a particular training to the students who attend, these types of institutions give the opportunity for the students to grow as people and offers education for lifelong learning. At folk high school subjects such as science are often not taught, and where course are available they are limited compared to the rest of the schools and therefore folk high school has been excluded from our model.

The education system for primary and secondary education can be illustrated as in Figure 12. This scheme does not include the folk high school due to the small proportion of students who attend it.

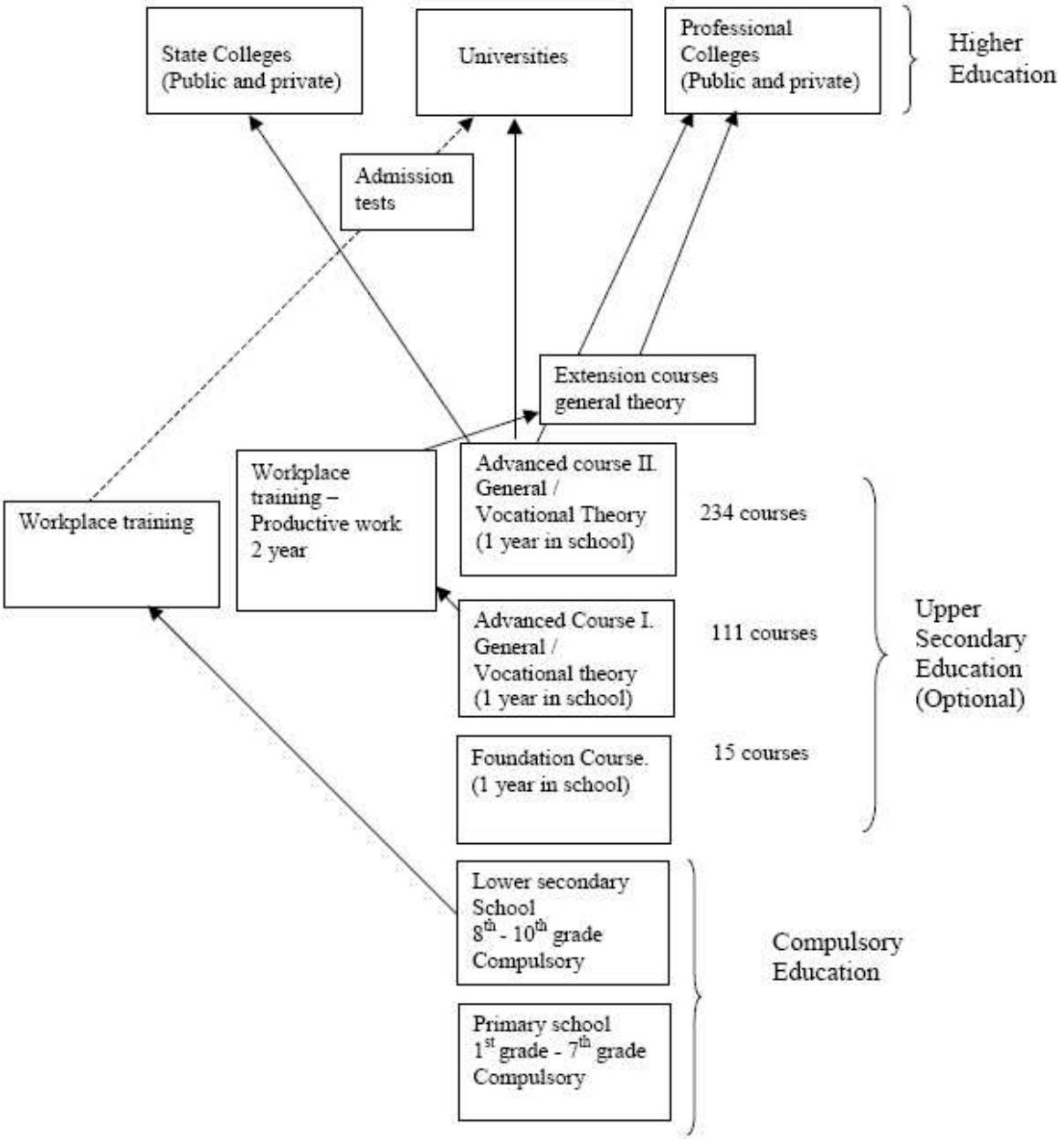


Figure 12: Norwegian educational system structure, compulsory, upper secondary and tertiary education

In the first ten years of education all subjects are compulsory and mathematics and science seem to represent a small percentage of the total number of hours. During the first four grades the total number of science hours per class is 760, whereas for grades five to seven the total number is reduced to 227,23. In the last three grades there are 253,3 hours of science teaching. From this data it is possible to see that science education of science is probably lacking during compulsory education, if we consider that, for the respective grades, the total number of

teaching hours: 836, 1026 and 1140 per class per year. The total number of teaching hours is presented in Table 2[24].

School years are grouped in three classes: grades 1-4; grades 5-7 and grades 8-10. This does not follow the division previous made and it is a further division of the primary school. The total number of hours presented in the table refers to the amount of the years which the group correspond. The last column is showing the total hours in the first ten years per each subject.

The hours in parenthesis are the number of hours per week that a student has to follow in that subject. One year of school is based on a minimum of 38 weeks of school. At the bottom of the table is possible to see between parentheses the average number of hours per week that a student take in the group of grades it corresponds. The number of teaching hours is related not only to a student but to a class, since that in primary school every class received lectures by one teacher.

Table 2: Number of teaching hours pro grades in compulsory education.

	Grades 1-4	Grades 5-7	Grades 8-10	Total hours per subject 10 years
Christian knowledge, religion and ethics	266	266	247	779
Norwegian	1140	589	532	2261
Mathematics	**608 total for 4 years (4) hours per week**	**437 total hours for 3 years (3.5 - 4) hours per week**	**418 total hours for 3 years (3 - 4) hours per week**	**1463**
Social Studies	190	285	380	855
Art and Crafts	228	380	228	836
Science and the Environment	**152 total for 4 years (1) hours per week**	**247 total hours for 3 years (2 - 2.5) hours per week**	**342 total hours for 3 years (3) hours per week**	**741**
English	95	266	344	703
Music	152	228	114	494
Home Economics	38	114	114	266
Physical Education	228	266	304	798
Compulsory additional subjects*			304	304
Optional activities	247			247
Student council work			95	95
Total hours	3344 (22)	3078 (27)	3420 (30)	9842 (25,9)

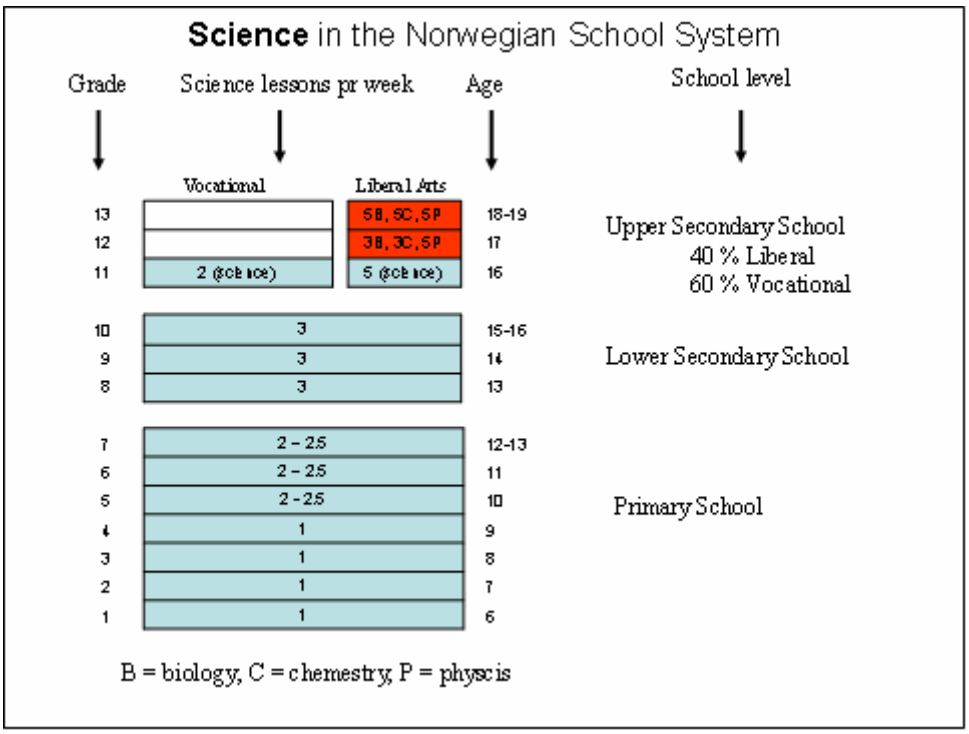
After the first year of secondary school science subjects are no longer compulsory and therefore the number of teaching hours change. Mathematics, chemistry, biology and physics

[24] Table 2 has been taken from the report Ministry of Education and Research, The Norwegian Center for Science Education, et al. (2004). Euroscene 2003. The Norwegian Project Report M. o. E. a. Research. Oslo, The Norwegian Center for Science Education, University of Oslo**:** 65 pages.

form the part of the group of optional subjects which are available for students to choose from. Mathematics and chemistry are five hours per week, whereas the other science subjects are three hours per week. A student must complete a certain number of hours, and it is not possible to finish by choosing only the three hour a week subjects.

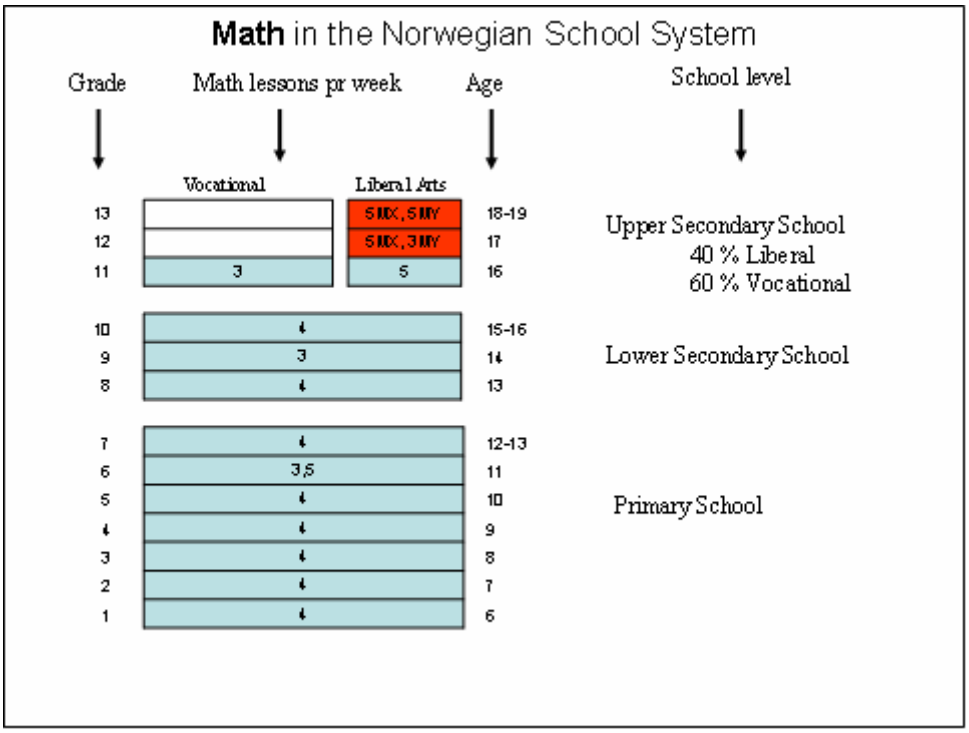
The number of teaching hours for science subjects in secondary education can be seen in Table 3[25]. In the last two years of education it is possible to see that there is no fixed number of hours and the two blank cells show the type of classes that are available for students. The same is true for mathematics as Table 4 illustrates.

Table 3: Number of science teaching hours in primary and secondary education



[25] Table 2 has been taken from the report Ibid.

Table 4: Number of mathematic teaching hours in primary and secondary education[26].



After secondary school education may sit on admission test to enter university or college, and there by start their tertiary education. In our research we had included this final step of the education system as this is where the future teacher will acquire their knowledge and their "quality" as a teacher.

3.2 TERTIARY EDUCATION SYSTEM

Norway currently has five universities which are the University of Oslo, University of Bergen, University of Tromsø, the Norwegian University of Science and Technology (NTNU formally known as University of Trondeheim) and the recently started University of Stavanger[27].
Beside the five universities, Norway provides students with a large choice of college (*Høgenskolen*) education. There are 26 institutions which provide tertiary education as

[26] In the last two years of high school mathematics is not a compulsory subject. Nevertheless there are two courses provided for those students who want to take more mathematics: MX and MY. MX courses are more focused on theoretical mathematics, while MY courses are approaching the subject in practical way using it as a tool for other subjects like: chemistry, biology ecc. Description take from Ministry of Education and Research (2000). Curriculum for Upper Secondary Education. Specialized Subjects in General and Business Studies. Mathematic. Oslo.

[27] Due to the recent acknowledgment of the University of Stavanger as university, for the purpose of the research we have not included data relative to this institution in the model.

colleges in the country, and a number of them provide teacher education as well. Universities may also offer teacher education, however this is a recent development.

In the last reform, dated 2002, the university and the college degrees were changed. Bachelors from universities now last for three years (previously four and five), and college education has been extended one year for a total of four years of instruction. For the students enrolled in universities there is the chance to continue with a master degree. Masters degrees are of two years duration which brings the total number of university semesters to the same level as it was before the reform. The change in the system of bachelor and master degree programmes has been introduced to align the tertiary education system with most European countries.

For our purposes we include the number of students attending university at the faculty of science and those students going through teacher education provided by the colleges (*Allmennlærerutdanning*). For science we consider those students who attend courses in biology, mathematics, physics and chemistry[28] since those are the subjects for which there is qualified teaching staff lacking.

Students coming from university, who decide to become a teacher, have two different choices depending on where they stop their education:

- if they decide to enrol in the education system after bachelor studies then the majority of them will be sent to compulsory education together with students coming out college teacher education;
- Master graduates will be sent to secondary education. Also at this level some college graduates students may decide to take one year at university to get a specialization and to increase their level of knowledge;

Those college students who upgrade their education by attending one year at university will get the chance to enter secondary education as well. Unfortunately to track the flow of these particular students was hard and we do not have data to estimate how many there are.

Basically, the final map of teacher's education can be seen in Figure 13[29].

[28] The courses offered by the faculty of science in every each university are more than the one mentioned, but some of the subjects like molecular-biology or geophysics ecc. are not subjects required as education in schools.

[29] Figure 9 is taken from the report Ministry of Education and Research, The Norwegian Center for Science Education, et al. (2004). Euroscene 2003. The Norwegian Project Report M. o. E. a. Research. Oslo, The Norwegian Center for Science Education, University of Oslo**:** 65 pages.

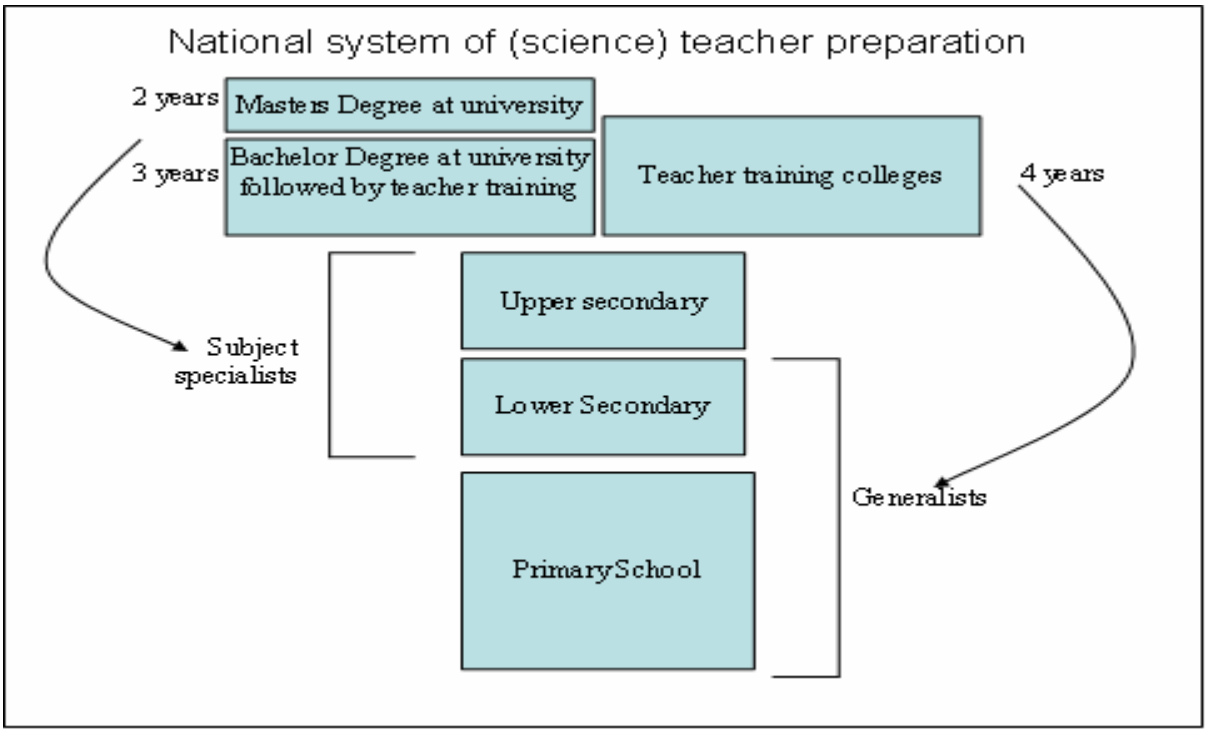


Figure 13: Scheme which represents the type of education that a teacher needs to have to teach a different level of the education system.

The students who decide to enter in the teaching work force and they are coming from university before they get their qualification they have to take one year of pedagogical education which is called Post Certificate of Education (PCE); this sort of compulsory year is not required for those teachers who came from college education.

4 MODEL STRUCTURE

In the following chapter we will introduce the structure of the model, the sectors present in it and the function that they have. The description of the structure and its internal relations will be carried as the following scheme:

- General introduction to the model structure;
- Population sector;
- Population in education sector;
- Teaching work force;
- Salaries sector.

The general introduction will show and describe the general relationships of the sectors and present the base behaviour of the structure compared to the reference mode of the problem. It will also illustrate the relationships that have not been considered in the model.
The population sector will be described for the important function it has for the purpose of the model, relationship that have not been taking in consideration regarding this sector will be clarified.
The education sector will be described presenting the different stage of education that is present

4.1 GENERAL INTRODUCTION TO THE MODEL STRUCTURE

Our model tries to reproduce the education system and the teacher workforce, integrating other influential sectors, such as salaries and the population.
In this paragraph we try to represent the main relations between the sectors, the feedback relationships will be described in the further paragraphs relative to the single sectors and their function for the model.
The construction of the structure has been done following the indication of the reports we collected. Nevertheless the model itself is not representing the reality but it tries to reproduce the problem. The reference mode of the model illustrates the problem as follow in Figure 14.

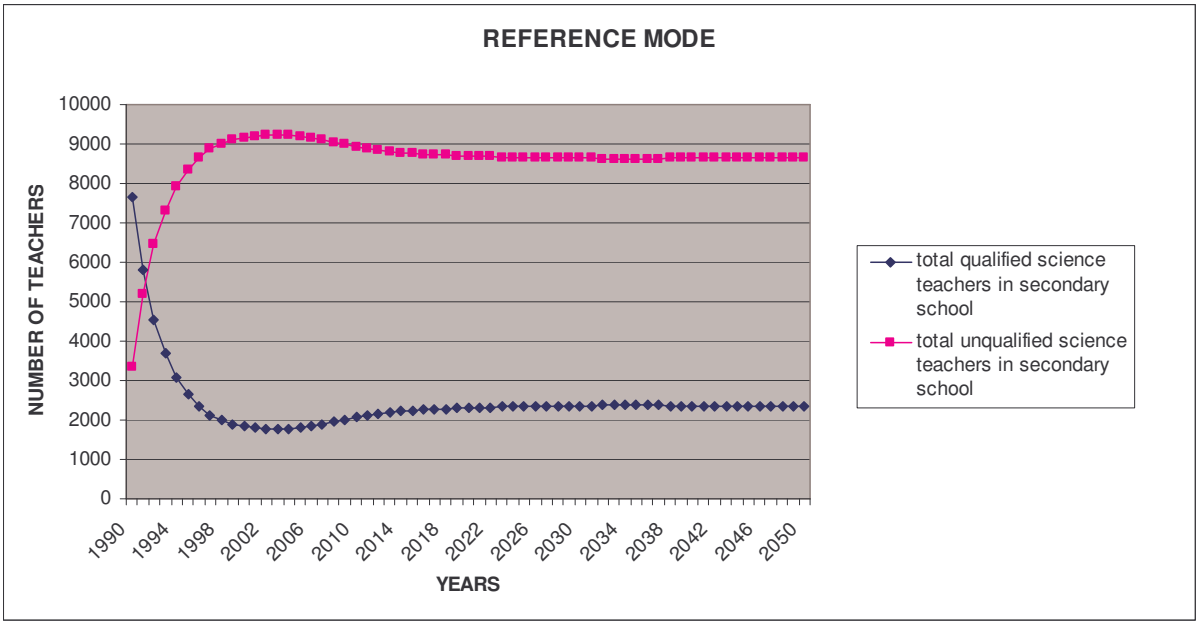


Figure 14: Reference mode, qualified and un-qualified teachers in science presence in secondary school

The reference mode is obtained by assuming the initial percentage of the science teachers qualified over the total number of teacher in secondary school.

The qualified teachers decrease drastically while the unqualified teachers increase. The reasons are to be found in the high turnover of teacher, the low supply of qualified and the constant retirement rate. The reference behaviour we obtained cannot be referred to historical data because there were and there are not available data that illustrate such division as qualified and un-qualified science teachers. The reason why the situation of science teacher is like this now can be also attribute to this motive, no institutions has controlled and collected data relative to the number of qualified teachers.

To represent the problem, as the reference mode shown, we did not re-create the system as it appears in reality. We established in our model the boundaries of the system, which can be represented by the main data taken as exogenous, those which are endogenously created and the one which are not included as Table 5 illustrates.

Table 5: Model Boundary Chart, data exogenous, endogenous and excluded in the model

Sectors name	Included as			Obmited
	Levels	Auxiliaris Variables	Constant External Variables	
Population	Norwegian Population	Childbearing women Births rate	Fertility rate Fertility age distribution Sex birth ratio Immigration Emigration Death rate	Immigrants population Effects of education on population
Education	Graduates Univ Bch Bch graduates Univ Mst Mst graduates Coll students Coll graduates	Pupils in primary school Pupils in secondary school Unavailable rate	Average students entering Univ Average students entering a Mst Age distribution of Univ students University drop out High school drop out Average % of Bch entering in education as teacher Average % of Mst entering in education as teacher Time to finish a Bch and a Mst Unavaiability age distribution	Teachers re-entering Uni Quality of education
Recruitment of teachers	Available positions	Desired number of teachers Total Mst Univ certified Total Bch Univ certified Total Bch Coll certified	Attraction of salaries Average of pupils per teacher Average teachers per class Total hours per class in low primary Total hours per class in high primary Total hours per class in low secondary	
Qualified Teachers	Teachers in primary Teachers in secondary	% of qualified teachers	Age distribution of hired teachers Quit rate distribution by age Effect of unqualified teacher Willingest to leave Unavaiability age distribution Retirment age	Re-entering teachers Quality of teachers Effects of the private market
Unqualified Teachers	Teachers in primary Teachers in secondary	% of unqualified teachers	Age distribution of hired teachers Quit rate distribution by age Willingest to leave Unavaiability age distribution Retirment age Average time to become qualified	
Salaries	Wage for Bch employee Wage for Mst employee	% of expenditure for salaries	Wage increases GDP increases	Wage differentation by gender

In the table presented above on the first column is possible to see the name of the sector of the model. The second column is the one which is refereeing to the number of “levels”, or stocks, present in the sector. The third column is showing the variables which are in the model auxiliaries. The fourth column is describing the number of variable which have been considered constant or external values. The last column is showing the variables which have been omitted. The table is important for defining the boundaries of the research and the model structure. Many variables have been taken as constant of as external values; the main reason to keep the model as simple as possible is to have to do not put to much complexity in recreating the system, especially if the data are already available on statistical sources.

In Figure 15 we could see the relationships taken in consideration between the sectors.

The first sector on the top of the drawing represents the total Norwegian population, which have important relationships with the two main sectors in the model, “Population in education system” and “Teaching work force”. As it was mentioned before, general population is

essential because it makes possible to create endogenously the population of pupils, students in higher education and the population of teachers.

Population through education is influencing the number of teaching work force since the number of pupils enrolled is defining the need of teachers for the schools. “Population in education system” is not only representative of the population of pupils but also of the population of students in universities and colleges. The sector is linked to the “Teaching work force” sector because it also provides the supply of students educated to teach.

The sector of salaries is calculated by exogenous data. The salaries are influencing the “Teaching work force” due to the attractiveness that they exert on the job position. The salaries are defined by the level of instruction that a person reach after the education received. This connection does not mean that the level or the increase of the salaries is drove by the level of education that an employee has. The relationship we describe in our model is simply reflected in the total costs of salaries, calculated by the number of employees with a level of education time the salary per person.

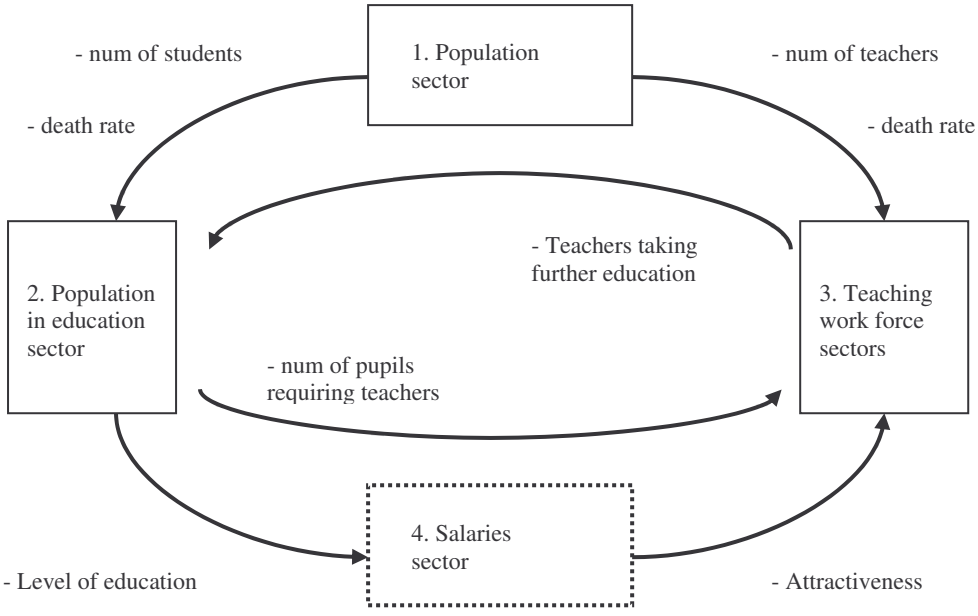


Figure 15: Model structure. The relationships between sectors. Doted circumferences represent exogenous sector of the model. Arrows represent the relation between the sectors. On every arrow there is the name of the linkage which correlates the sectors

After a general presentation of the model and all its sectors we proceed by describing the sectors involved into the model and the structural divisions we made in sectors. The names

used now to present the general concept of the model have been used to generalize the idea of how the system works. In the model some of the sectors present different sub-divisions based on the function they have in the structure. We are now introducing a description how the sectors work and which are the sub-divisions made and what their aim in the model is.

4.2 POPULATION SECTOR

The population sector as we presented previously is one of the two sectors which have important relation with the main two in the model. The population of Norway is essential for our purpose because the other population we deal with in the model are part of the general one. The use of the external data, as we mentioned and describe in chapter 4, was a decision due to simplify the model and to obtain the closest behaviour to the real data we collected. A population model which could generate a nice population trend simplifies the work to obtain endogenously the number of required teachers for the pupils.

For this reason population was the first sector of the structure that we decided to build, when we start the building process we have to take some decisions regarding the boundaries we have to respect for the final aim of the model.

In the sector one of the main “missing stocks” is the number of population of immigrants, and the so called “new immigrants. The Norwegian system regarding immigrants differentiate these two categories, the immigrants are the people not born in Norway and which moved to the country. The New immigrants are the son and daughter of the immigrants, they are also considered as the first immigrant generation. They are not considered Norwegian even if they are born in Norway if both parents are immigrants.

In the sector we do not divided the immigrants, the new immigrants and neither the naturalized immigrants. This last category is representing the number of immigrants that required and obtained the naturalization, which makes them a Norwegian citizen.

The immigration and emigration are nevertheless a central point for the re-construction of a clear and correct model of the population. We include then the flows regarding this migration of population, what we did not consider important was to divide the single group of populations, so we considered them in an aggregated level.

The immigration problem in one of the article we collected[30], identify the presence of immigrants as a key factors for the turnover rate of teachers in schools. The results of the research they conduct are reliable and the hypothesis that presence of immigrants in class room increase the willing of teacher to leave. This factor has not been taking in consideration because our model is based on a national level. We found that the percentage of immigrants is concentrated in the capital city, Oslo, so the effect of turnover is probably strong in this limited geographic area. The sector can be presented as the following Figure 16 is showing.

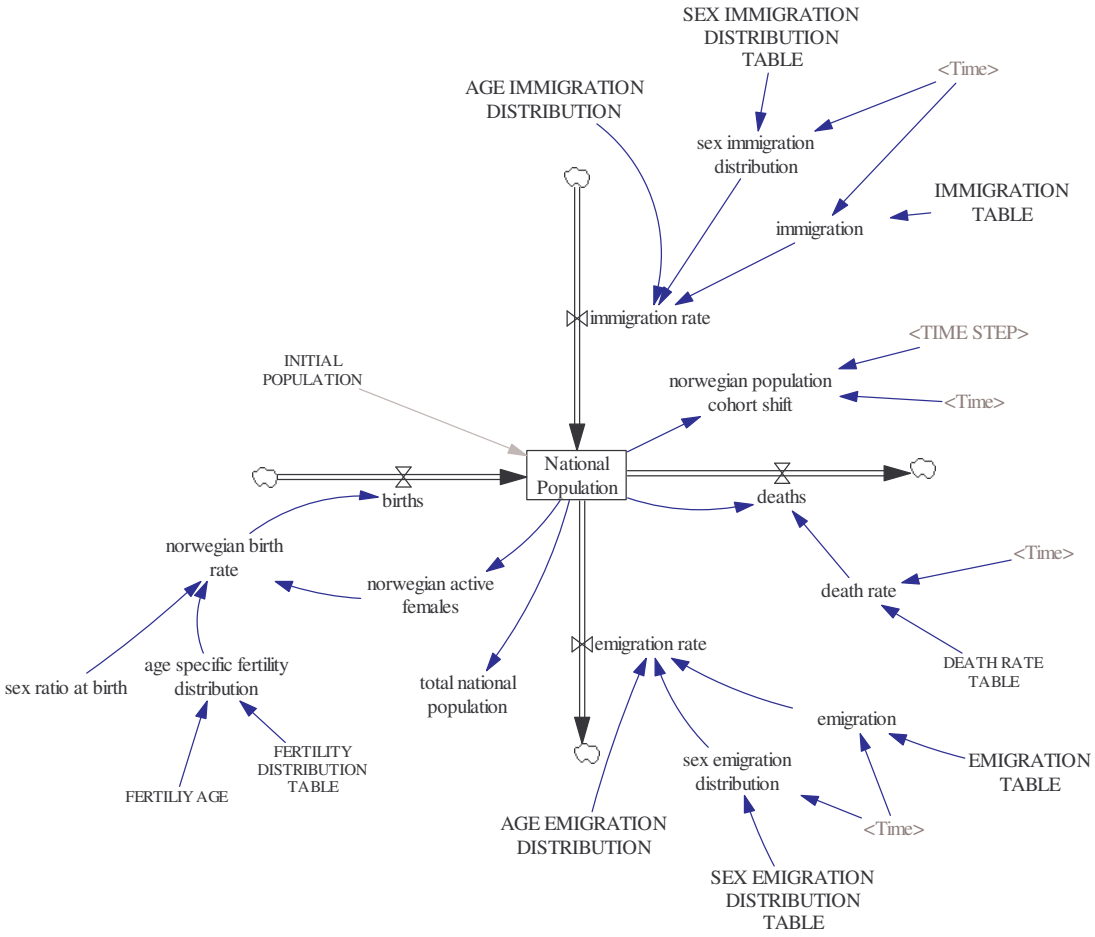


Figure 16: Norwegian national population structure

How is possible to see, the structure we create for the model try to represent the national population in the easier way. In this sector of the model there is not the presence of feedbacks deriving from other sectors in the model. The national population has been calculated by every single cohort because the age structure of the population is essential for our aim.

[30] Torberg Falch, B. S. (2004). Teacher turnover and non-pecuniary factors. Working paper series, Norwegian university of science and technology. Department of economics. **1/2004:** 38 pages.

The main goal of the population sector is to provide the rest of the model with data as much possible close to the statistic to obtain endogenously the other population present in the model. The behaviour of the structure seems to follow quite well the statistical data and projection edited by the SSB, as Figure 17 shows.

The structure seems to generate a behaviour which is close to the SSB statistic. There is only a higher increase in the population trough the central years of the run, probably due to the constant variables we assume and that we discussed in chapter 4.

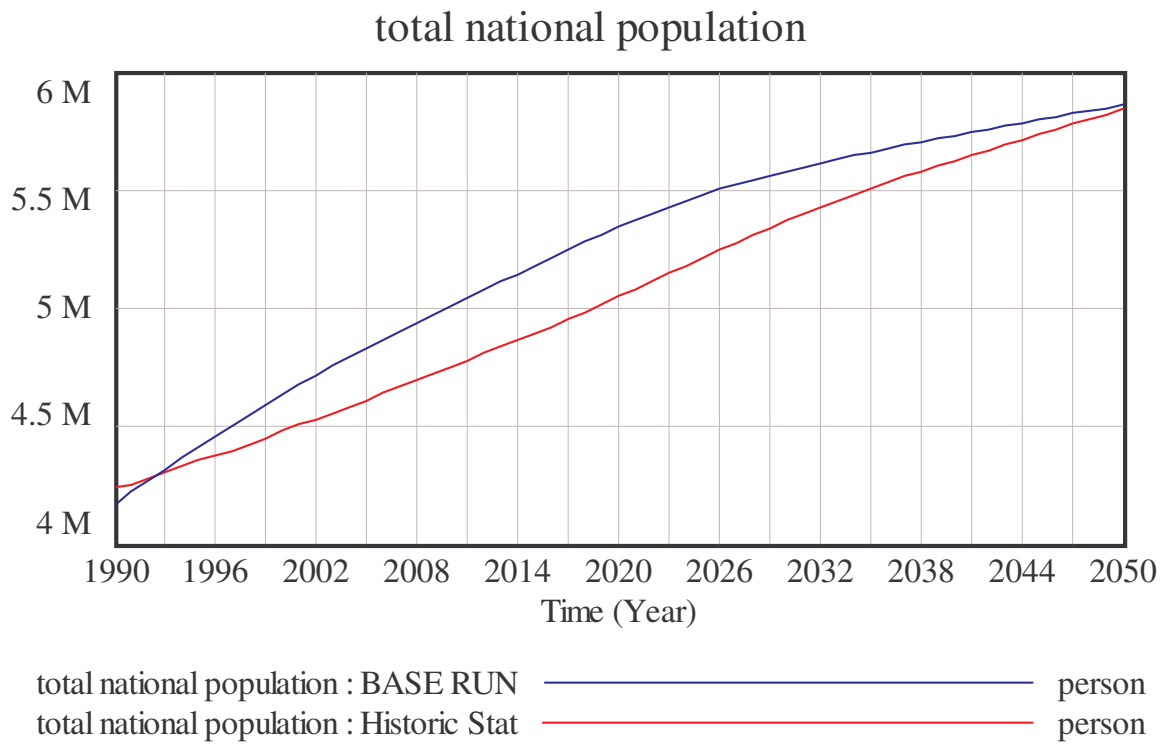


Figure 17: Population model data compared to statistical data from SSB

The population sector is presenting no drastic changes in the trend and this will effect on the pupils population, which we are going to discus in the next paragraph.

4.3 POPULATION IN EDUCATION SECTOR

The population in education sector was the second part of the model which was build during the modelling process. This part of the structure is one of the main important together with the teaching work force.

The sector can be divided into the different levels of education which are present in the system. These levels are basically the same that can be found in every other country:

- Pupils in primary and secondary school;
- Students in university and students in science faculty;
- Students in college and students in college education for teachers.

To obtain the number of student in every single grade in schools we use as point of connection with the population sector the age cohort. Following the above division the model will be presented in its sub-divisions.

4.3.1 Pupils in primary and secondary school

Primary education must be attended by all pupils included from age six to 16, the fact that school at this level is compulsory helped us in the construction of the model. It was decided that the number of pupils in primary and low secondary will be obtained by the population sectors because we did not want introduce more complexity and more stocks in the model.
The number of students present in the school is essential for the calculation of the teachers needed; this particular part of the model will be described more clearly in the next paragraph where the teaching workforce will be presented.
As we mentioned before the sector is divided into different education levels, which have been represented in the model by different auxiliary variables. The students, after primary school, attend the secondary school and we used the data coming from the population sector here as well. In this case the number of pupils was not easy to calculate as it was for the primary students. We have to subtract the percentage of those who leave earlier the school, due to the fact that secondary school is not anymore compulsory. The model structure for pupils in education has been drawn as Figure 18 is showing.

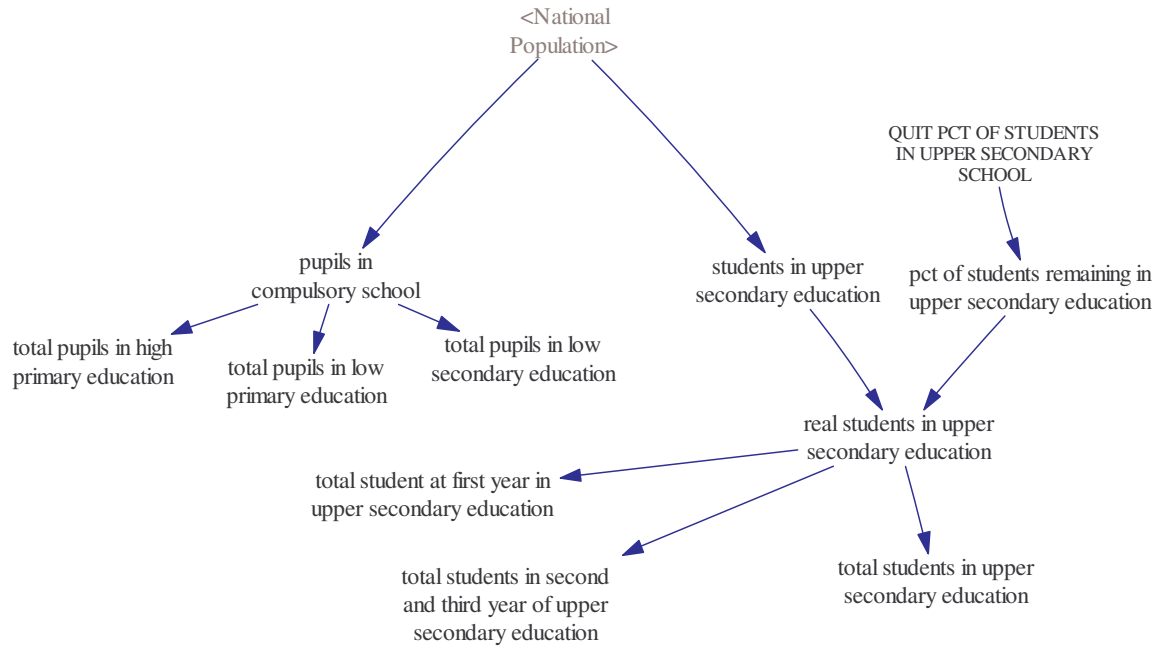


Figure 18: Model structure for pupils in primary and secondary education

The pupils in primary and secondary education were not difficult to model while the population of students in universities and in colleges was quite complicate. From the students in secondary school we obtain the number of new graduates which is the future supply of students in university or college.

4.3.2 Students in university and students in science faculty

In this paragraph it will be discussed and presented an incomplete outline of the structure of the university, while a more detailed description of the sector is given in Appendix II in the model documentation. Figure 19 is presenting the model of the university and it is represented by a structure chain where every stock represents a certain level of education that a student reaches in the course of his/her academic studies.

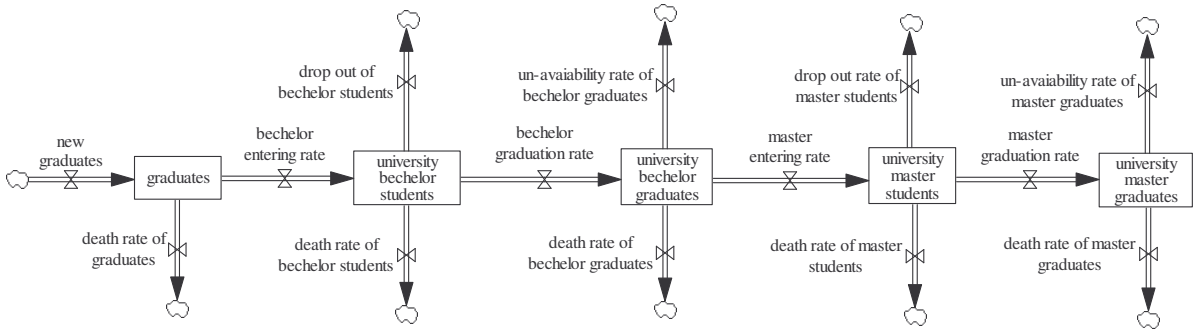


Figure 19: Model structure for tertiary education, University chain structure

The chain of education and each stock present in it, represent a delay to the formation of a qualified teacher. The effect that the chain introduces in the system and influences the work force is the natural delay which is necessary for a student to complete the university.

In the structure are not presents possible flows of re-entering students which have may drop the education early and after a period of time decide to come back to university. The reason why we choose not to include this particular flow of people was due to a lack of data regarding these students movements. In the cases where we found data it was difficult to classify them under a certain label, and make almost impossible to find them in the database.

The structure we just present was the university chain for the total students, for the students attending the faculties of science the structure is not changing. The science students are simply a minority of the total students in university, for this reason they will follow the same steps.

4.3.3 Students in college and students in college education for teachers

In the present sector also college education is included and for this type of education the structure change a little. The colleges offer only one level of qualification which implies a smaller delay for a student to obtain his/her final graduation. The reduction in time to obtain a former teacher has its influence in the total number of primary teachers hired in school. The college education has been represented in the structure of the model as Figure 20 illustrates.

It is possible to see in this case that the education offered by the institution is proceeding with fewer steps than for the university. Nevertheless the time to obtain the final graduation from a college is longer than the one at the university. The time period is now four years and it has been increased in the last years to give to the students a better education. Increasing the course

of study by one year has not brought to the college education the quality which is furnished by the master level of university.

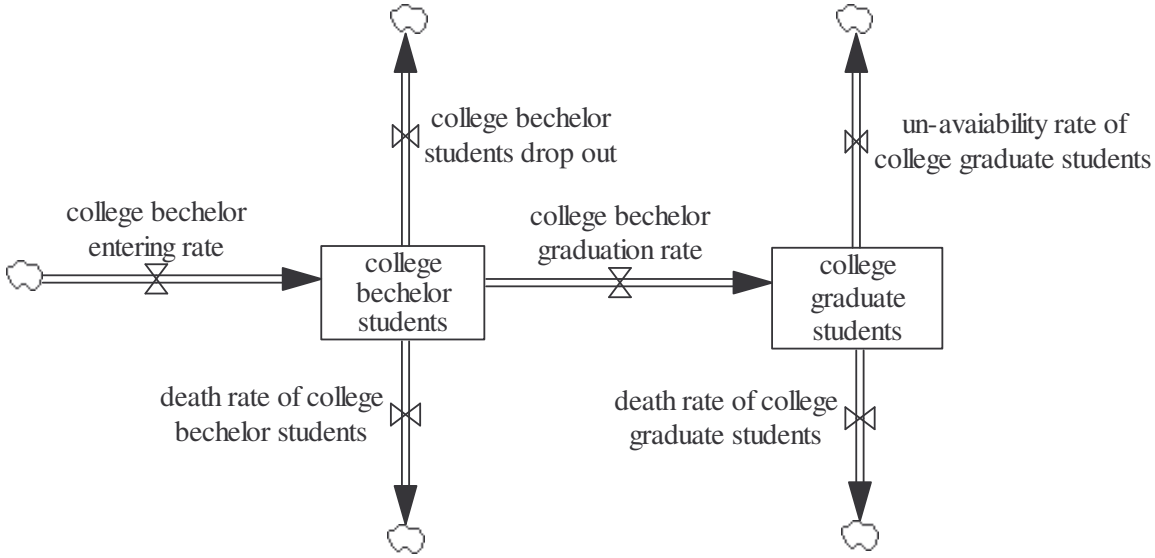


Figure 20: Model structure of tertiary education, College chain structure

Nevertheless it seems that primary school, which takes advance from the students coming from this particular education, will not present problems of shortage like the secondary schools. The shorter education seems to supply better the primary education, than the secondary. This trend is maybe due to the fact that in primary education the quality of education, with quality we mean a deep and wide knowledge, of one particular subject is not required.

Due to the shortage of teachers in secondary school for science subject also some students who have attended the college have been hired to teach. They have probably taken some courses at the university to increase the level of quality. As it is possible to see from the structure that we present in the picture we were not able to define the flow of students moving between the two institutions. This particular type of data seems not to be registered under any label in any of the database we consulted and probably the percentage of students is not high every year.

In this part of the sector as for the university we did not considered those students who may leave early the education and re-enter after a certain time period. The reason for this decision has been the same as it was for the university. The education of students in college for teachers is following the same steps as for the students in general professional college education. The same modelling process has been followed to create the structure for the students in science faculty.

4.4 TEACHING WORKFORCE SECTOR

The teaching work force is the main sector we have build in the model and it is the one which receive feedbacks or has relationships with every other sectors in the model.
The structure of this model will be described following the different sub-divisions present in the sector itself, which are the following:

- desired teachers to cover (Supply of teachers and Available Positions);
- general qualified teachers in primary and general qualified teachers in secondary;
- science qualified teachers in primary and science qualified teachers in secondary;
- general un-qualified teachers in primary and general un-qualified teachers in secondary;
- science un-qualified teachers in primary and science un-qualified teachers in secondary.

The sub-division of the sector is also reflecting the other division made in Chapter 4 in the paragraph 4.4 relative to the statistic data used for the teachers.
Every sectors described is presenting the stock of primary and secondary teachers while the sub-divisions have been done following different criteria. In this case the main division was the general instruction or the science specialization. The second main division was the qualification or not of the teachers present in the teaching work force.
Only the first sub-division is not presenting another further division, and it will be the first part of the sector that will be discussed.

4.4.1 Desired teachers to cover (Supply of teachers and Available Positions)

Before start describing the structure of teachers is important to introduce the structure we create to calculate the number of teachers required in primary school. The same method was applied to the secondary teachers. As it was mentioned before the number of teachers is first calculated by using the data of the pupils in primary and secondary school. The population data were not enough to define clearly the number of teacher; it was needed the number of teaching hours per subjects, the ratio of teachers per class and the teaching hours per teacher.

It was important to define the number of teacher not only on the base of the number of pupils because the number of teaching hours, the number of students per class and teacher per class are points of possible policies implementations. Often these particular values are use by the policy makers to increase or decrease the desired number of teachers in case of short supply.
The structure created to calculate the desired teachers is too wide to be described in one single chapter, so it has been divided into sub-parts.

4.4.1.1 Desired number of teachers

The first part of the structure that we define for calculating the number of teacher needed is shown in Figure 21 as follow. The number of needed teachers is not limited only by the number of pupils or classes, neither by the number of teaching hours that a single teacher has to take. Other variables are involved in the calculation of teachers. The main ones are the available positions and of course the supply of teacher. These other variables represent the other parts of the teaching work force sector and they will be described and commented later on this paragraph.

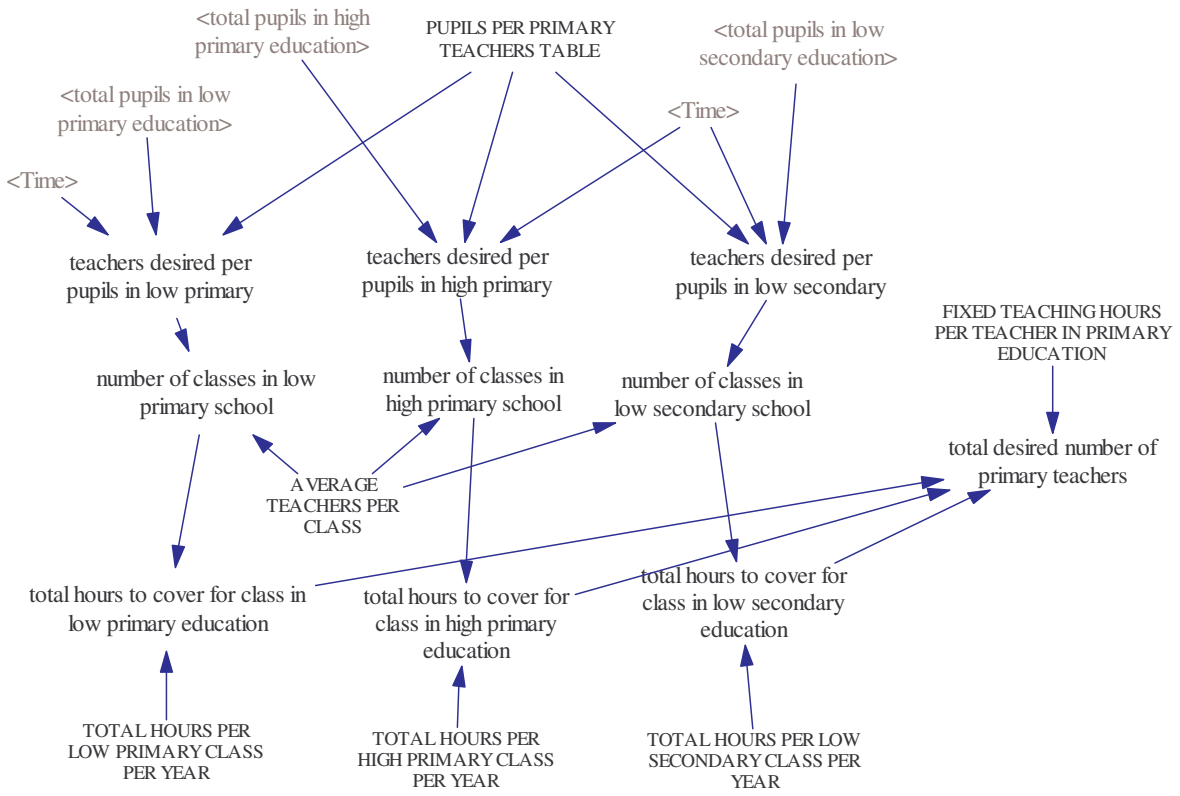


Figure 21: Model structure of desired teacher to cover, part I "Total desired teachers"

The first step in the calculation of the number of required teachers is to utilize the number of pupils in primary and secondary school. Using the data found in the SSB database we calculated the ratio of pupils per primary teacher, which is the labelled variable "pupils per primary teachers table" in the model. The original data found on the SSB website and the results of the ratio are available in Table 30 (Appendix I).

The population data only was not enough to clearly define the number of teachers; we also required the number of teaching hours per subject, the ratio of teachers per class and the number of teaching hours per teacher. It was important to define the number of teachers on more than just the number of pupils because the number of teaching hours and teachers per class are points of possible policy implementation. Often these particular values are used by the policy makers to increase or decrease the requirement for teachers in case of short supply

The number of teachers needed is limited not only by the number of pupils or classes, but also by the number of hours that a single teacher has to teach.

The figure above (Figure 21) represents the method we used to calculate the total desired number of primary teachers in the model. Combining the variable "pupils per primary

teachers table" with the different populations of pupils in primary schools, we first obtained a raw number of teachers needed in primary education.

The variable "average teachers per class" was obtained from statistical data from the SSB, the raw data and result of which are illustrated in Table 31 (Appendix I). With the variables "average teachers per class" and the raw number of teachers obtained before, it was possible to estimate the number of class for each level of primary education. From one of the report it was obtained the variable "fixed teaching hours per teacher in primary education"[31]; while the data regarding the total number of teaching hours per class in low primary, high primary and low secondary school can be found in Table 2 (Chapter 3). The use of these variables made possible to obtain the "total number of desired teachers in primary" with a precise method.

4.4.1.2 Available positions as teachers

The second element of the structure used in the model to calculate the desired number of teachers to cover is shown in Figure 22.

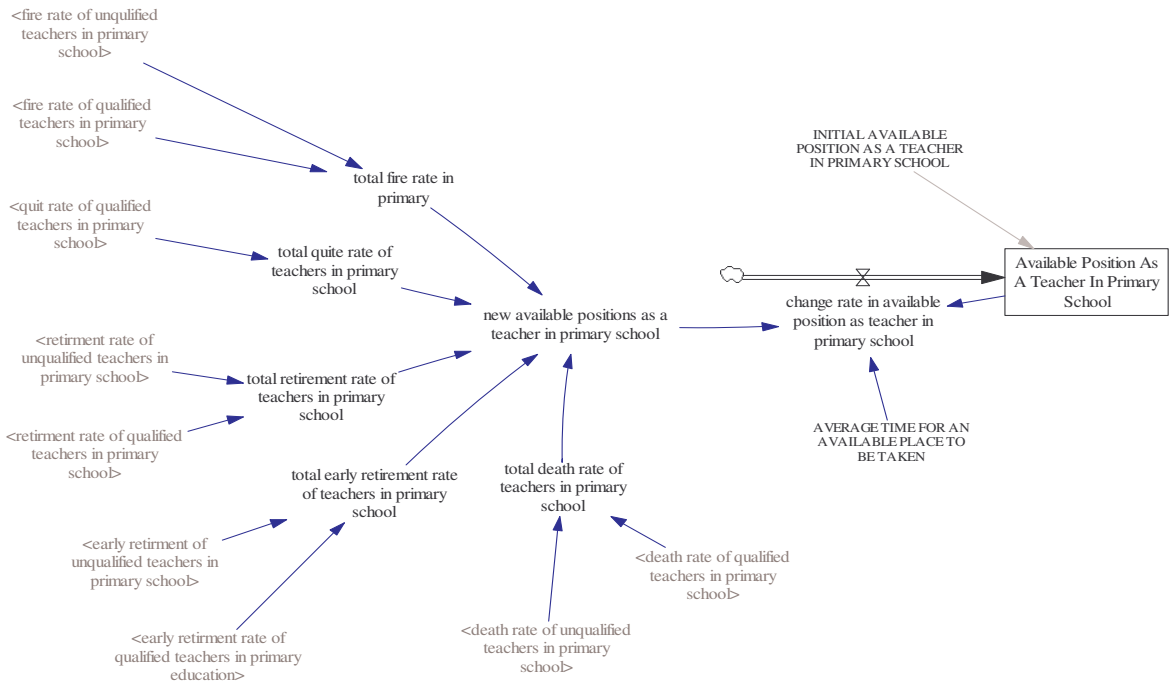


Figure 22: Model structure of desired teachers to cover, part II "Available positions as teachers in primary school"

[31] The data relative to "total fixed number of teaching hours per teacher in primary education" was found in the reports Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

This second part of the model sector of desired teachers to cover was used to calculate the number of available teaching positions. The total number of available positions is calculated by summing the outflows from the different stocks of teachers. The total "available position as a teacher in primary school" is the sum of the model variables "total fire rate in primary", "total quit rate of teachers in primary school", "total retirement rate of teachers in primary school", "total early retirement of teachers in primary school" and the "total death rate of teachers in primary school".

4.4.1.3 Perceived difference of teachers to cover and perceived number of teachers to fire

The stock of available positions is then used to calculate the difference of teachers in primary school to cover as it is possible to see in Figure 23.

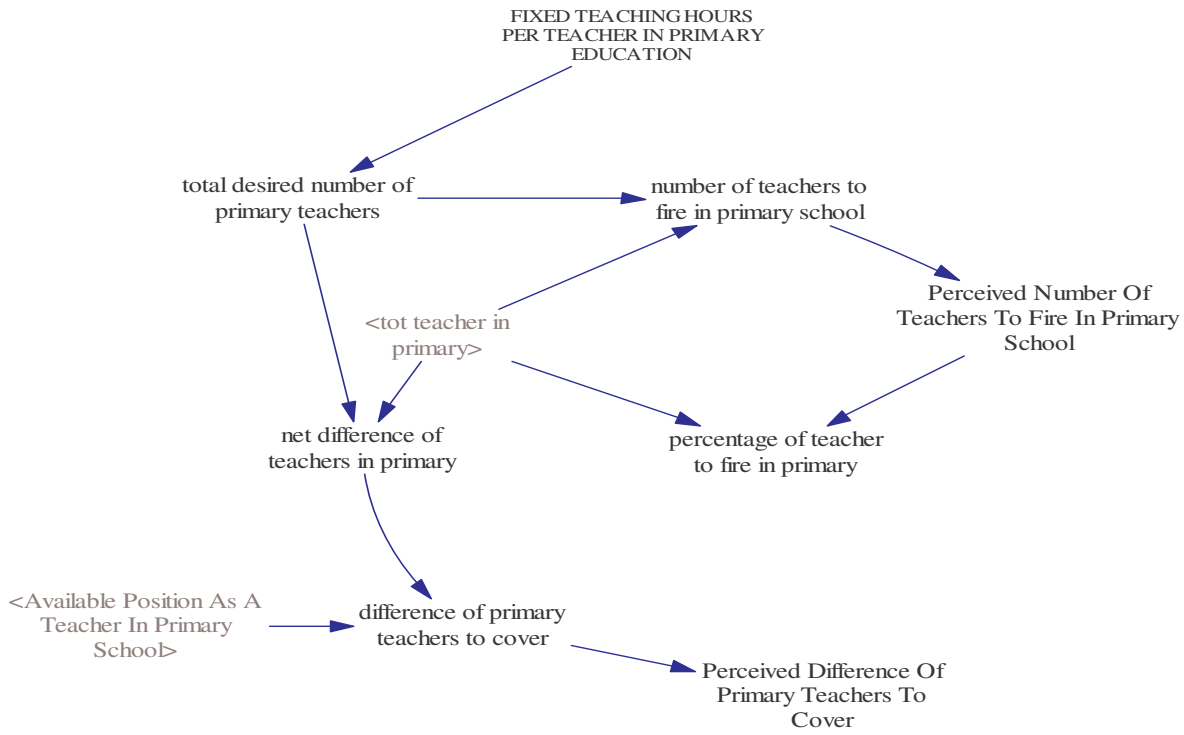


Figure 23: Model structure of desired teachers to cover, part III "Perceived difference of teachers to cover" and "Perceived number of teachers to fire in primary school"

Figure 23 shows the connection between part I of the education sector, the total desired teachers and part II, the available position as a teacher in primary school. The "net difference

of teachers in primary" is a variable which is calculated subtracting the "total desired number of primary teachers" from the "total teachers in primary", and then the variable "difference of primary teachers to cover" is the real number of available positions to cover. The "net difference of teachers in primary" can be a negative value so the real value is calculated with the variable "difference of primary teachers to cover" using a simple function. To establish the number of positions to cover is necessary the number of available position calculate in the second part presented before. The "perceived difference of primary teachers to cover" is a variable which introduce simply a delay function. The available positions are made available when the real need of covering those positions is perceived.

The "total desired number of primary teachers" may be lower than the "tot teacher in primary" in that case we have a situation where the number of teachers hired are higher that the one desired. For this reason the variable "number of teachers to fire in primary school" has been created. This variable is calculating the number of teachers in excess and the number of teachers to be fired. The need of firing teachers is, as the need to cover the vacant positions, perceived with a certain time delay and for this reason the variable "perceived number of teachers to fire in primary school" has been created and introduces the time delay for the firing rate. The number of teachers to fire is first applied to the teachers of course without qualification. If the number of total teachers is still higher than the one desired and all the unqualified teachers have been fired, the firing is applied to the qualified teachers.

4.4.1.4 Supply of teachers

The fourth and final section of the model structure regarding the number of desired teachers to cover is shown in Figure 24.

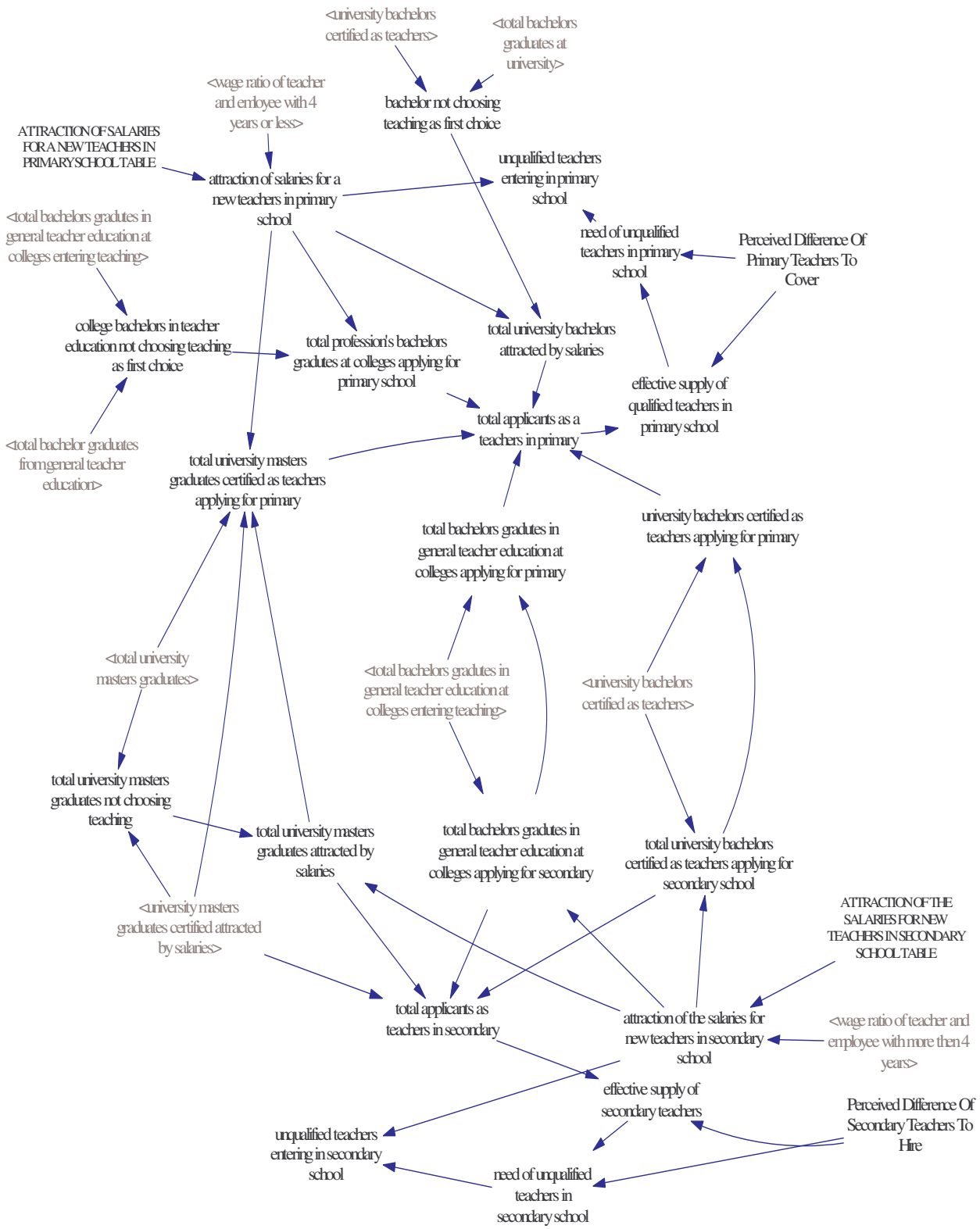


Figure 24: Model structure of desired teachers to cover, part IV "Supply of teachers for primary and secondary"

This last part of the model structure, for the calculation of teachers needed, is related to the number of people in the workforce who are certified teachers and the number of people which

is not certified but they are attracted by the salary. In the structure shown in Figure 30 it is possible to see the connection between the education sector and the requirement for teachers[32], as the available workforce is the sum of teaching-qualified graduates from universities and colleges and the graduates from university and college which are not qualified and attracted by the salaries. The variable called "available workforce" is not included in this particular sector of the model as the workforce must be divided in two – those persons who will teach primary school education, and those who will teach secondary school. Data from the SSB webpage[33] was used to correctly define what type of teacher that make up the group "total applicants as teachers in secondary". The SSB assumes that 25% of the students graduating as qualified teachers from colleges enter the secondary school system. The remaining 75% of college students are therefore assumed to be employed in primary schools. Conversely, there are students who are certified for secondary schools, with a master degree from university, that enter the primary school education system. There was no statistical information regarding this proportion and therefore it was assumed that of the total "university master graduates certified as a teachers" those who will apply for primary school will simply be the difference between the variables "university master graduates certified as a teachers" and "university master graduates certified as a teachers applying for secondary".

The variables "total applicants as teachers", in primary and in secondary school, have been then calculated by summing the variables relative to the total applicants, in primary and secondary, also qualified which have been attracted by the salaries. The variable "real supply of teachers" is obtained through the use of a simple function, which compares the "total applicants for teachers" and the "perceived difference of teachers to cover". The function always takes the smallest value between the two variables. In case the "perceived difference of teachers to cover" is higher than the "real supply of teachers" the difference will be calculated as the variable "need of unqualified teachers". A requirement for unqualified teachers arises when there is not a great enough supply of qualified teachers to fill all of the available positions.

Calculation of the real supply of teachers and the possible need for unqualified teachers was important for the section of the workforce sector regarding qualified and unqualified science and general subject teachers in primary and secondary education. This division will be presented in the following paragraph.

[32] In the picture the variable in gray except made for "wage ratio for teacher and employee with 4 years or less" and "wage ratio for teacher and employee with more than 4 years" the other variables are all from the education sector.

[33] http://www.ssb.no/english/subjects/06/05/lonnskole_en/arkiv/

4.4.2 Qualified general teachers in primary and secondary education

The first division we took into consideration when we were modelling the teaching workforce sector was the division based on the qualification and specialization. For each part of the sector two separate structures were created - one for teachers in primary school and one for teachers in secondary school. The subdivision of teachers based on being qualified or not qualified is essential to identify the problem we attempt to address in this thesis.

The following discussion relates to the general teachers qualified in primary and secondary school, while the other divisions, un-qualified and science, will be described and commented further in this chapter.

The sector which includes the stocks of general teachers qualified is represented in the structure as in Figure 25.

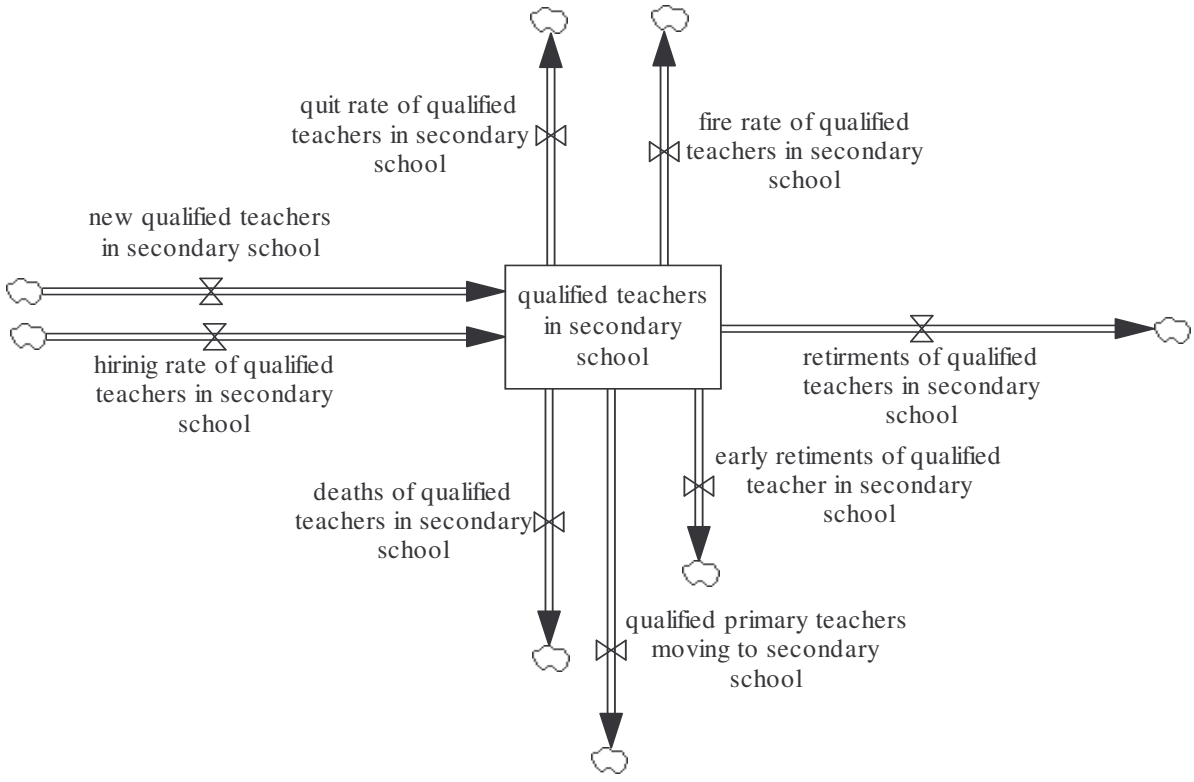


Figure 25: Model structure for qualified general teachers in primary school

Figure 25 is incomplete and a deeper description of the model and all the variables used in the sector, which regulate the inflows and outflows, is included in Appendix II.

Despite this, it is possible to see how the stock has been built, including those inflows and outflows that regulate the stock. The same basic structure is repeated for the qualified general

teachers in secondary school, but this particular structure will be presented further due to minor alterations.
The inflows present in the stock are:

- “new general qualified teachers in primary school rate” and
- “hiring rate of qualified general teachers in primary school rate”.

The first inflow represents the number of qualified general teachers that enter the qualified teaching workforce as new teachers. The inflow is used to control the number of unqualified teachers that become qualified after a period of time. There is no given time for an unqualified teacher to become qualified and therefore it was assumed that after 10 years of work experience an unqualified teacher can become qualified. The inflow of newly qualified teachers does not converge into the second inflow of new hired teachers because unqualified teachers are still considered employees.
The second inflow of the stock concerns hired qualified general teachers. This inflow represents the number of new employees that match the requirements for being considered qualified and that present their application to be hired as teachers.
The outflows present in the stock are:

- “fire rate of qualified general teachers in primary school”,
- “quit rate of qualified general teachers in primary school”,
- “retirement rate of qualified general teachers in primary school”,
- “early retirement rate of qualified general teachers in primary school”;
- “qualified primary teachers moving to secondary school” and
- “death rate of qualified general teachers in primary school”.

All of the outflows are important for the sectors described in paragraph 5.4.1.2. The sum of the outflows is required to calculate the available positions each year. The outflows show the different ways that a teacher may leave the teaching workforce. The fire rate (as in 5.4.1.3) will remove any excess qualified teachers when the “desired number of teachers” is lower than the “total number of teachers”. The fire rate for the number of qualified general teachers, as for the qualified science teachers, will only proceed to decrease the qualified stock after all unqualified teachers have been fired.

The quit rate ouflow is one of the most important in the model as there are non linear relationships between it and the variables which influence it depending on the presence of unqualified teachers, the age of teachers and the attractiveness of salaries in employment outside of the education sector. The retirement of teachers is the "natural" outflow that creates positions. It does not influence the entire teaching workforce; only that age cohort that defines the retirement age when pension is available. The other retirement rate outflow, called "early retirement" refers to teachers that decide to retire at 62 years, rather than 67. In recent years there have been an increasing number of employees retiring at this early age[34]. Early retirement, in combination with more attractive salaries outside of the teaching workforce, can increase the tendency for a shortage of teachers.

The out flow called "qualified primary teachers moving to secondary school" is calculating the number of teachers with enough experience to move to the secondary school. Usually are teachers which have been in education for at least 30 years. For this reason the age group which is affected by this outflow is the teachers between 50 and 59 years.

Death rate is the final outflow in the structure and links the sector of teachers to the population sector. The population of teachers is a subset of the general population and therefore the death rate applied to the population of teachers is the same as that of the general population.

The structure of qualified general teachers in secondary schools is slightly changed from the structure for primary school teachers. Figure 32 illustrates how the model has been built to represent the qualified general teachers in secondary school, with the change shown as the introduction of the variable "qualified secondary teachers in science training".

[34] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

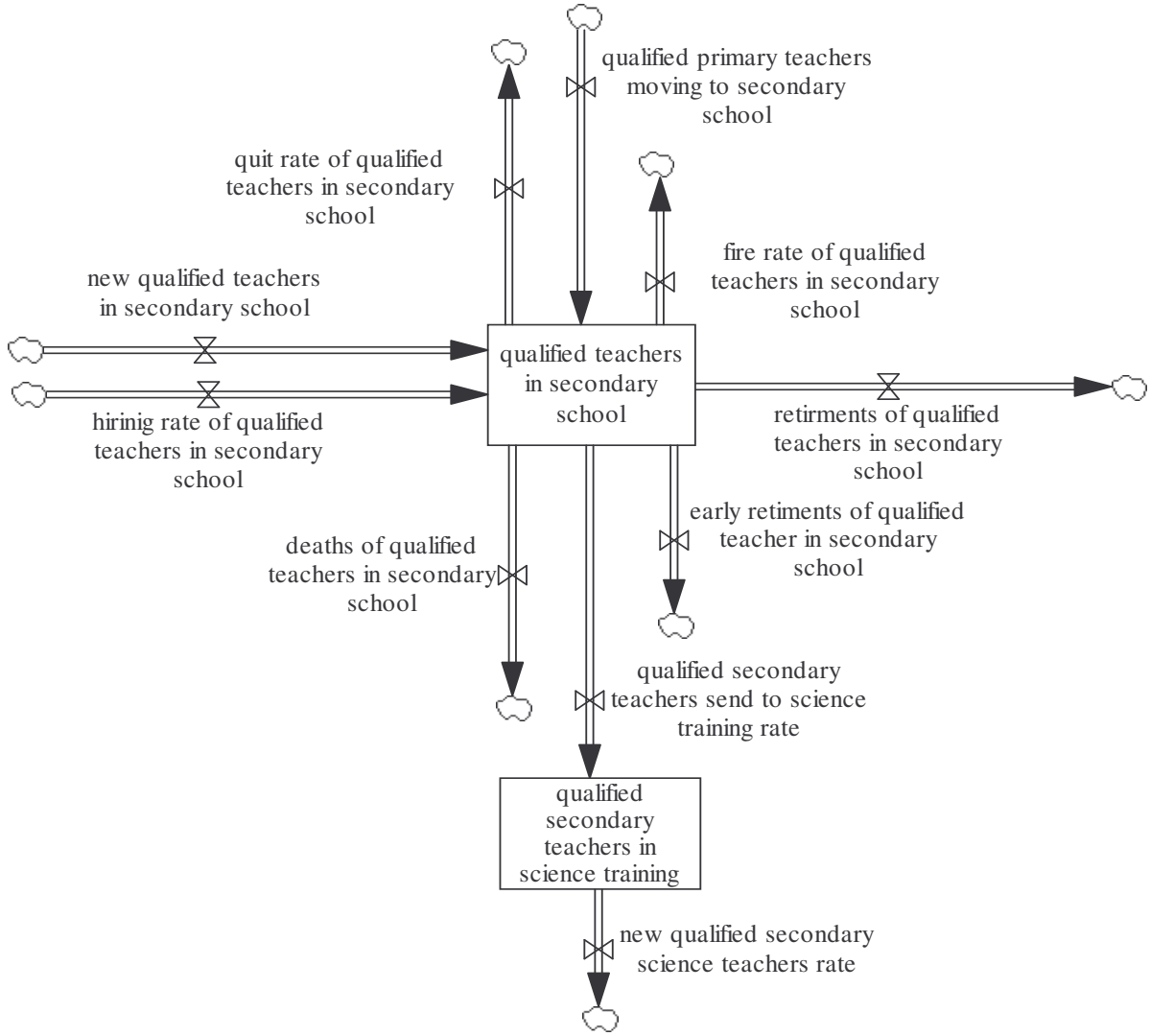


Figure 26: Model structure for qualified general teachers in secondary school

The "qualified secondary teachers in science training" has been created to test some policies that may positively influence the shortage of qualified science teachers in secondary schools. This particular stock has one inflow and one outflow. The inflow of for "qualified secondary teachers in science training" is called "qualified general secondary teachers sent to science training". The inflow maybe calculated by the policy maker and used to evaluate the effects of different scenarios. The outflow of the stock is called "new qualified secondary science teachers" and it represents the number of teachers that become qualified to teach science in secondary school. There is no established minimum amount of training time required to become qualified and therefore we assume that one year of training results in an upgrade from generally qualified to being a qualified science teacher.

4.4.3 Qualified science teachers in primary and secondary education

The science teacher sector is the central part of the model structure and it is the main section in which it will be possible to see the results of different policies.

The structure is not different from those previously presented as the "science teachers qualified" in primary and in secondary are simply sub groups of the same population of teachers. The structure relating to primary teachers qualified in science subjects will not be presented here due to its perfect similarity to that presented for generally qualified teachers. Nevertheless we will describe the stock of "science qualified teachers in secondary school" as it differs slightly when compared to the structure of "science qualified teachers in primary school" as shown in Figure 27.

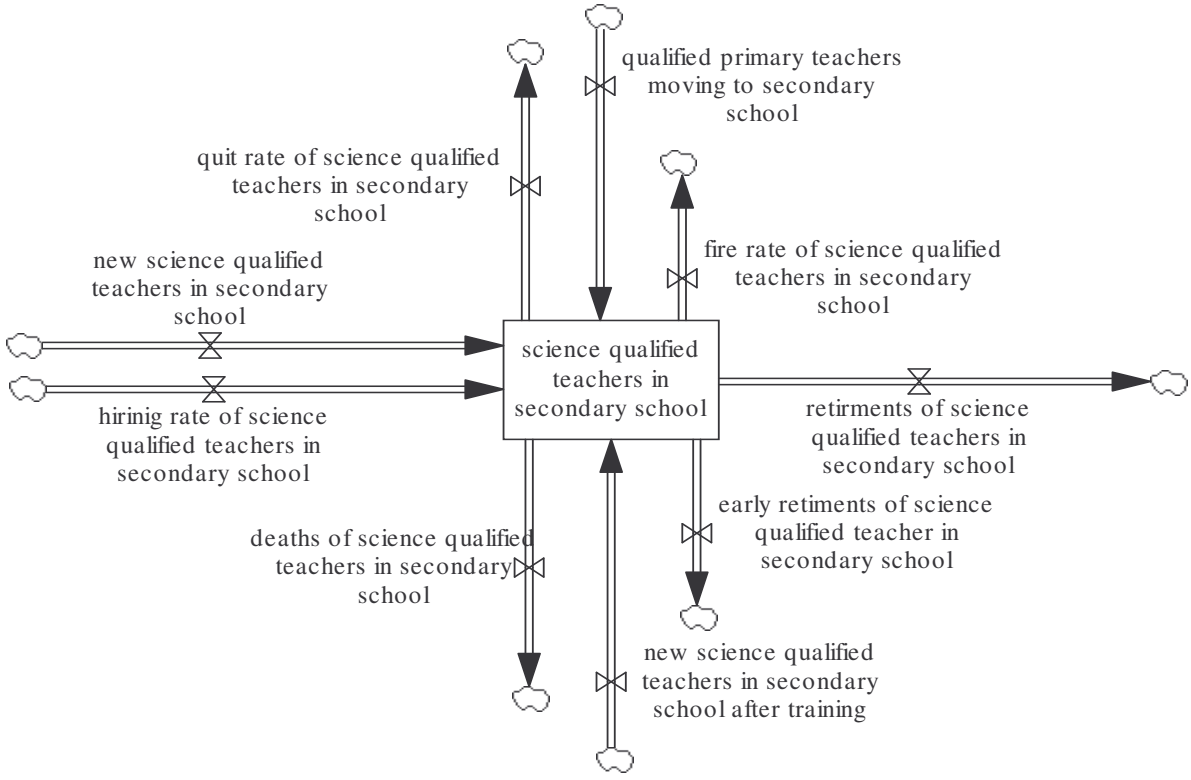


Figure 27: Model structure for qualified science teachers in secondary school

The stock of "science qualified teachers in secondary school" consists of three inflows and five outflows. The inflows are as follows:

- "new science qualified teachers in secondary school";
- "qualified primary teachers moving to secondary school";
- "hiring rate of science qualified teachers in secondary school" and

- "new science qualified teachers in secondary school after training"

The first two inflows are the same as for both the "science qualified teachers in primary school" and "general qualified teachers in primary school". The third inflow calculates the number of teachers, between age 50 to 59, which move from primary schools to secondary schools. The age group has not been choose randomly, from the SSB statistical data (Figure 10), it was possible to see a flow of older teachers joining the secondary education within that specific age group. The fourth inflow is the only small change in the structure. This flow is counting and adding to the stock those teachers who were qualified with general teacher education in secondary and that then spent one further year becoming qualified in science subjects. This inflow is equal to the outflow present in the stock of "qualified secondary teachers in training".

The outflows are the same as presented in the sector of "general qualified teachers in primary school and general qualified teachers in secondary school". The problem of a shortage of teachers seems to appear in this particular teaching workforce, and the inflow added to the stock structure is a change which was introduced to test a policy. The policy itself and the results obtained will be explained and commented on in a further chapter.

4.4.4 Unqualified general teachers in primary and secondary education

At the beginning of the chapter we mentioned that the first main division of the teaching workforce sector was based on having either a general qualification or a science qualification and that the second main division was whether the workforce was qualified or not. We now introduce the structure used to calculate the number of unqualified teachers needed in the system. As for the structure for the qualified teachers, this paragraph will only describe the structure relating to the "general unqualified teachers in primary school" as the same design is used for the unqualified teachers in secondary school.

The need for unqualified teachers arises, in both general and science subjects, when the "effective supply of qualified teachers in primary school" is less than the "perceived difference of primary teachers to cover". The presence of unqualified teachers is structured as a stock, as are all other employees in the education system, and in Figure 28 it is possible to see how this is presented in the model structure.

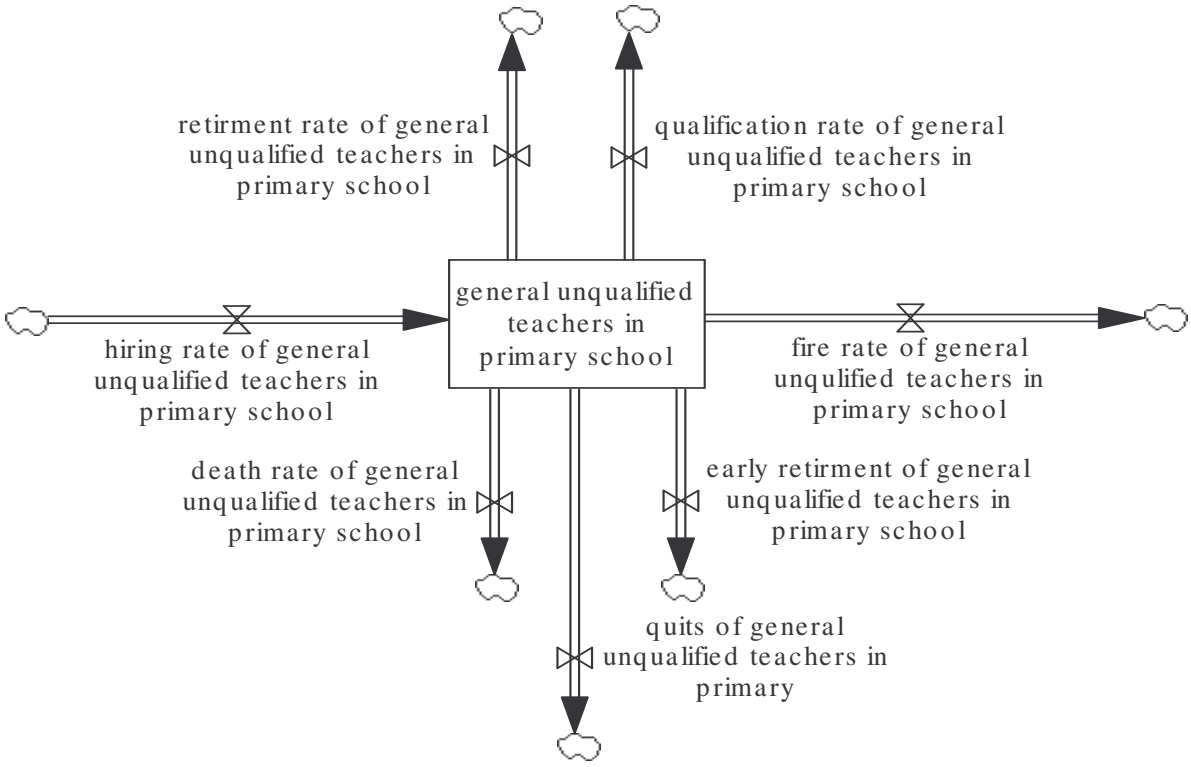


Figure 28: Model structure for unqualified general teachers in primary school

The stock of unqualified teachers has an ageing chain structure within it and presents different inflows and outflows for comparison between the stocks of qualified teachers in general subjects. The stock has one inflow and four outflows. The sole inflow is the "hiring rate of general unqualified teachers in primary school". This inflow rate is activated, as previously mentioned, when there are too few qualified students to apply for the available teaching positions. The stock presents only one inflow because, in a perfect scenario, there should not be the need for unqualified teachers, but in the case of a shortfall occurring, the hiring of unqualified personnel is the common solution.

The outflows present in the structure are as follows:

- "retirement rate of unqualified general teachers in primary school";
- "early retirement of unqualified general teachers in primary school";
- "fire rate of unqualified general teachers in primary school";
- "quits of general unqualified teachers in primary";
- "qualification rate of unqualified general teachers in primary school" and
- "death rate of unqualified general teachers in primary school".

The outflows presented deviate slightly from the structure of qualified general teachers. The "retirement rate of unqualified general teachers in primary school" is simply the outflow of unqualified employees that leave their positions after reaching retirement age (67). Early retirement is the outflow of unqualified teachers who leave the teaching profession prior to retirement age (62). The fire rate of unqualified teachers is important in the model structure because it is the outflow which decreases the stock faster. As mentioned in paragraph 5.4.1.3, when the number of teachers exceeds the number of teachers needed the model will calculate the number of teachers that should be fired. In this situation the unqualified teachers, because of their qualification status, will be fired first, and for this reason the firing rate is most important in this sector of the model. In case the number of unqualified general teachers is lower than the number of teachers to fire, qualified teachers will be fired in order to decrease the teaching workforce.

The outflow regarding the quits of unqualified teachers is a flow which is activated only in extreme cases. Generally we assume that there is no reason for an unqualified teacher to quit their job. In addition we do not have any data or reports with information related to a possible quit rate of unqualified teachers. Nevertheless this out flow is activated in those cases when the attraction of the salaries is zero. With no salaries even the non qualified teachers leaves their positions. Apart from this extreme condition test (see chapter 6) there were no known reason which may influence the decision for unqualified teachers to quit.

The out flow which varies in this stock, compared to other stocks, is the "qualification rate of unqualified general teachers in primary school". This outflow takes into account the number of unqualified teachers that become qualified. The qualification is obtained after a number of years of experience, rather than through training. A similar parameter is present in the sector regarding the "general qualified teachers in primary school" but in that case it represents an inflow.

The final outflow represents the death of unqualified teachers. To calculate the rate, as with other death rates presented in the model, the data from the population sector was used.

4.4.5 Unqualified science teachers in primary and secondary education

The sector of unqualified teachers in science subjects does not differ from the previous sector; the basic structure is the same. There are different two stocks, the first for those unqualified science teachers in primary schools, and the second for those in secondary schools. Both

stocks have the same number of inflows and outflows. The number of unqualified science teachers is necessary to be able to calculate the percentage of this group within the total number of teachers. The quit rate of qualified science teachers is dependant on this percentage. As it is mentioned in Appendix III, the paper written by Torberg (2004) demonstrates that there is a positive relationship between the quit rate of qualified teachers and the presence of unqualified teachers. This relationship was also mentioned in the first chapter, paragraph 1.4, and is one of the principal loops which explain the dynamic hypothesis of the problem.

4.5 SALARIES SECTOR

The last sector in the model is that which calculates the salaries. This part of the model was the last to be built during the process. The data used for recreating the monthly wage of employees was taken from the SSB database.

This section of the model was important to test the effect of the "increasing salary" policy that we planned to implement in the model. The remuneration system is quite complicated and many variables interact to calculate the monthly wage per person. For reasons of simplicity we do not take into consideration, for example, the tax system. The increase of the salaries as a result of inflation was also not included in the model. Therefore, we assume that the increase rate present in the model is due to government decisions to increase teaching salaries. Changes in salaries are infact the result of bargaining between the teachers union and government representatives. The "school package 2" was the last reform applied to teaching salaries in Norway.

As presented in Figure 15 the salaries sector has been built using external data in order to maintain simplicity in the model. Thus, the salaries stocks are not created endogenously.

There are three different factors which influence the level of salary that a given teacher will receive; the amount of experience, any positions held and the level of education achieved.

The sector of salaries has been modelled following some of these divisions, but also by taking into account the report by Schøn (1999). This report, described in more detail in Appendix III, demonstrates the existing attraction relationship in the education sector. It compares the wages as perceived by employees in schools and by employees outside the educational system. Due to the mentioned reasons the model was built using the following blocks:

- "wage for teachers";

- “wage for a full time employees” and
- “educational expenditure”.

4.5.1 Wage for teachers

The part of the sector regarding the salaries of teachers has been structured in the simplest way possible. The salaries have been separated into two stocks:

- “earnings for a teacher with a tertiary education 4 years or less” and
- “earnings for a teacher with tertiary education more then 4 years”.

The division is following the education level that each teacher has achieved. This division is necessary to be able to compare the wages in teaching positions with those in other professions, and to be able to recreate the non linear relationship so that we can estimate the attractiveness of the teaching profession based on salary. The model structure of the salaries is shown in Figure 29.

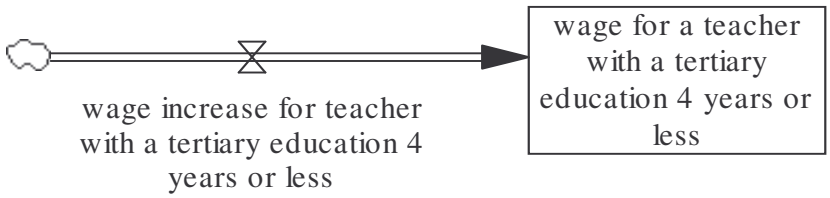


Figure 29: Model structure for teacher wage

This stock presented has one inflow only which calculates the increase in wage each year. The inflow is calculated using external variable and data obtained from the SSB database. The stock is representative of the gross monthly wage per teacher with a bachelor degree.
The other stock present in the model and related to the teacher with a higher level of education is exactly the same as the one represented in the figure above. It is merely labelled differently and is represented by “wage for a teacher with tertiary education more than 4 years”. This was also calculated using external data.

To obtain the yearly salary the stock was multiplied by 12 (months). The salary estimated is the gross salary per person, and therefore to calculate the total government expenditure on salaries we multiply the gross salary per person by the number of employed teachers with a bachelor or college degree. The same procedure was followed to calculate the total expenditure for teachers with a higher level of education, multiplying the gross salary by the number of teachers with a master degree.

4.5.2 Wage for a full time employee

The structure for wages for average employees is the same as the structure used for the wage of teachers. The data used in the calculation of the gross monthly wage are from the same database and follow the same division by level of education, which is measured by the SSB in years of tertiary education. Only the gross wage of a full employee was taken into consideration because we did not make any distinctions of this type for the teachers. We know that in the teaching workforce there are also part time teachers; nevertheless we decide to assume in the model that every teacher is employed as a full time teacher.
The gross salary per employee was also calculated, but there was no estimate of the total expenditure of employees as the total number of employees was unknown.

4.5.3 Educational expenditure

The education expenditure sector acts to control the salaries sector. In contrast to the rest of the structure, this small part, which was also created with external data, does not have any relationships with other sectors in the model. The structure is very simple is shown Figure 30.

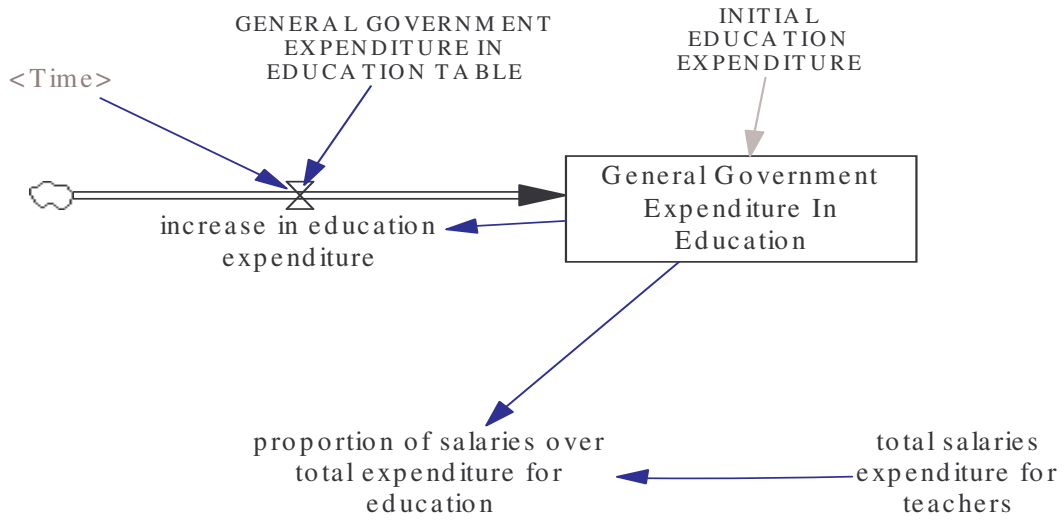


Figure 30: Model structure for education expenditure

The data for general government expenditure in education table was taken from the SSB database. The historical data found were only available up until 2003. After that date we assume that the expenditure will grow following the trend of the last year. The aim of this small section of the model is to calculate the impact of the total wage expenditure for teachers on the total expenditure for education. This part of the model is only used when a policy is implemented. The variable "proportion of salaries over the total expenditure for education" should measure the relationship between total salaries and total expenditure. As expected, the total salaries expenditure for teachers in primary and secondary can not exceed the general government expenditure for education, in fact it would be expected that at least 50% of this education expenditure would be on teacher remuneration.

The variable "total salaries expenditure for teachers" connects this structure to that regarding the wage for teachers. The sum of the total gross salaries expenditure for teachers with education 4 years or less and for those with 4 years or more will give us the values of the variable "total salaries expenditure for wages teachers" shown in Figure 30.

5 STATISTIC DATA AND RESOURCES

5.1 SOURCES OF DATA

In all research statistical data has major relevance in constructing the empirical evidence to support the theories or the assumptions which have generated all the processes from the beginning to the conclusion.

Due to the method we use, data has been essential for the definition of the problem to the construction of the model itself, and as a consequence to the results obtained.

The first step in the statistical research was to find reliable sources, because the amount of data accessible on the internet or on database is almost unlimited, but is important to have data from an acknowledged resource. Due to this requirement we decided to use two different databases both situated in Norway and both well known on a national level. The first is the Sentral Statistik Byrå (from now on called SSB) and the other is the Data Base Høgreutdanning (from now on called DBH)[35]. In addition we also used the reports to obtain important knowledge on how the system is structured; as well as first statistical averages to describe the behaviour of the system or to identify the percentages which influences the flows through the stocks. The reports used are in the reference list and a brief description about them in Appendix III.

The data collected have been divided and will be described following the same division of the sectors in the model, starting with the demographic population of Norway and ending with the salaries of the teachers and the national average salaries of employees outside the education sector.

The research of data relative to science teachers have been difficult regarding the definition of the problem. The use and help given by the reports was essential, we assumed that only available data found in there were acknowledge and for this reason we based our assumptions on them. Further research and collection of data by the assigned institutions must be done to improve the definition of the problem.

The data collected only provided information regarding the total number of teachers and there are no specific statistical data regarding the number of persons employed as qualified full-time or part-time science teachers. Databases held by the Norwegian teachers association here

[35] SSB is the Statistikk Sentralbyrå. (*http://www.ssb.no/english*) DBH is the Database for statistikk om høgre utdanning (*http://dbh.nsd.uib.no/dbhvev*)

also examined, does not include relevant information so we assume that the initial value for science teachers is equal to a percentage of the total number of teachers. This percentage will be illustrated and commented in the following paragraphs and in the conclusive chapter.

5.2 DEMOGRAPHIC DATA

The structure of the population and the data relative to it are essential. Having a good model which clearly represents the structure of the population and its trend is important because the population of teachers, pupils and students is strongly linked to the national one. A population is modified by four different flows: births and immigration, deaths and emigration. To calculate the size of the population in the future, data relative to the total population in a certain year by single age cohorts is also needed.

We will give a short description of the data we collected, and in some cases modified for the purpose of the model. Beginning with an introduction to the statistical data relative to the general population in Norway, we will after describe the data restricted to the population of pupils, students and teachers.

With regard to the general Norwegian population we collected the following data:

- the total population of Norway in1990;
- the fertility rate of Norwegian population (number of live births per 1000 females);
- the gender proportion at birth;
- the death rate and the future projections;
- the immigration and emigration data and the relative age and sex distribution percentage.

The general population data was obtained from the SSB historical records. Historical data is necessary as the model runs from 1990, and this is the year of an official census. It was not necessary to disaggregate the data as it was already kept divided by single age cohorts as it is possible to see in Table 8.

Figure 31 illustrates a recent increase in births which was preceded by a period of years where there was high children mortality[36]. Another anomaly in the population data is the decrease in

[36] From 1981 to 1985 the percentages of dead children were respectively 5.7 for the still births babies and 9.5 for perinatal mortality. This high child death rate in the 80's is reflected in the population graphic with a low number

the number of persons between 45 and 55 years of age. In this particular case the decrease of population is probably due to the depression which Norway faced in the 1930; whereby the number of births was reduced due to difficulties in maintaining a numerous family. The rest of the population seems to be close to a normal demographic development of a population. Females are fewer in the youngest age cohorts due to a sex ration at birth which benefits the male population; the trend is reversed in the elderly age cohorts where females outnumber the male population, due to a favourable life expectancy.

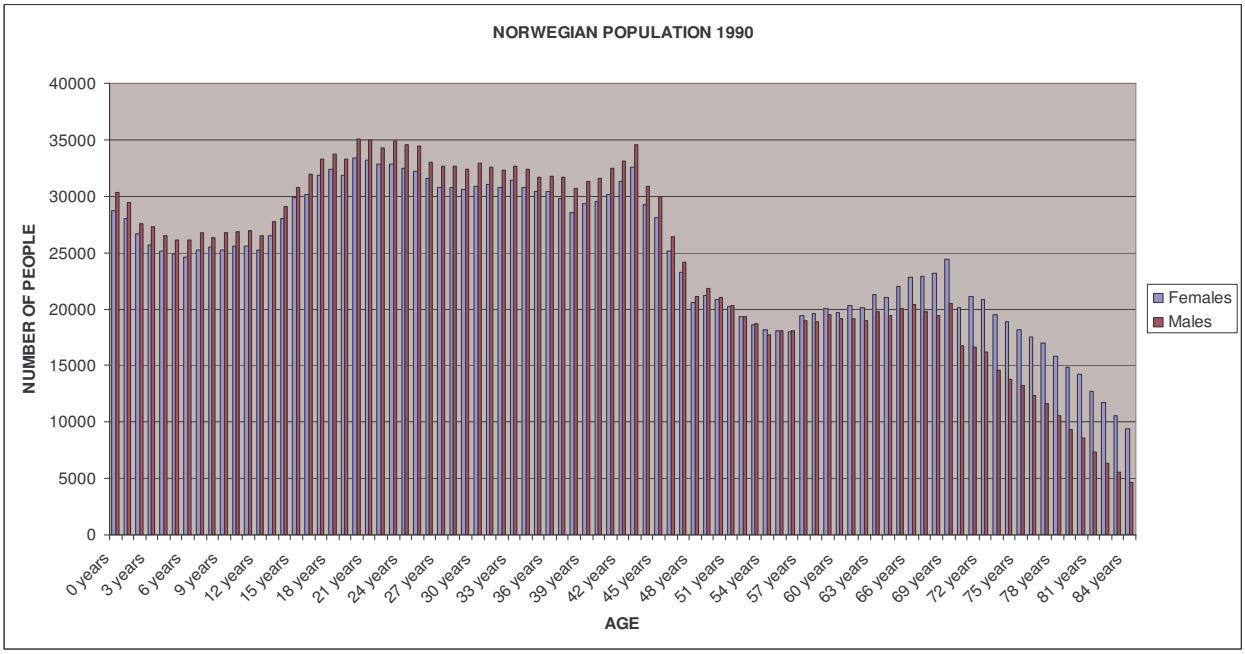


Figure 31: Norwegian population by gender and age cohorts. Data source SSB Stat Bank

The above mentioned data provided us with the 1990 start point for the model. As the model is was to run from this point until 2050 data for future projections was also required. This data was obtained by combining data from the SSB and the United Nation (UN) data base[37].

To calculate the future population for use in our model we assume that fertility rate, sex ratios, immigration and emigration remain constant through out time.

The fertility rate, for example, is a value that does not change over a short time period and does exhibit high oscillations. The fertility rate of Norwegian females in 1990 was the highest in all the historical data collected. The most successful reproductive age indicated by the

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of children around the age 5 and 6. Data source SSB (*http://www.ssb.no/english/subjects/02/02/10/dode_en/tab-2006-04-27-04-en.html*)

[37] The data of the UN data base were used since they provide a projection of death rate. The data base is different from the SSB and this create a small difference in the data for the elderly age cohort, due to this reason the data have been modified to match the previous historical data obtain from the SSB

highest fertility rate for an age cohort was shifted from 20-24 pre 1960 to its current cohort of 24-29 as seen in Table 9 (Appendix I).

The sex ratio at birth is important for having a clear division of the two genders. Having an image of how many females are present in the future population is essential because the births are strongly linked to the number of women in the childbearing age. The sex ratio does not oscillate through time. On average 48.5 % of children born are female, leaving 51.5% male. This pattern is evident in Figure 31 as the increased proportion of males in the youngest cohorts, at the beginning the males are more than the females.

Immigration and emigration data are important to accurately calculate the total number of people present in the country. The external data used for calculation was taken from the SSB database and is reported in Appendix I as Table 10. The sex distribution for immigrants and emigrants has been calculated using the same immigration and emigration data, and are reported in Table 11. The same procedure has been followed to obtain data regarding the age distribution as shown in Table 12, while in Table 13 it is presented the age distribution per 1000 people. For this data we could not find any future projection in the SSB data base, the only available data was regarding the immigrant population and not on the flows of immigration and emigration. In the UN data base this data is collected under the name of 'net migration', which is equivalent to the difference between immigration and emigration. With this type of data we could not properly calculate the size of the population therefore we exclude them. For this reason the rates of immigration and emigration after 2005 are considered constant values.

Converse to the previously mentioned demographic parameters, the death rate in the projected population for the model follows that projected in the UN data base. This is an attempt to ensure that the population used in the model fits, as closely as possible, the actual projected population. The UN data base was used to obtain these death rate projections as it was much clearer than the SSB. SSB data was utilized for death rates by cohort in 1990. The death rate data is presented in Table 14 and Table 15 for females and males respectively. It can been seen in these tables that the projections of death rate are grouped into age cohorts covering five years and averaged over a time period of five years. Death rate projections were only available until 2045 and for the final years of the model the death rate is taken as constant from the final projection.

The UN data base classifies death rates as low, medium and high. For the purpose of simplicity we do not explain how such classification is made and take the "medium" death rate for use in our research.

From the national population data we calculated the number of pupils in the two levels of education; the decision to use the population data was made for simplicity. The population of children attending school is equivalent to the number of persons grouped in the cohorts from age six to age 16 as is represented in Figure 6 Chapter 1. As primary education is compulsory there is no relevant 'drop out' percentage for these age cohorts.

The population of pupils in secondary education, on the other hand, is equivalent to the population present in age cohorts from 17 to 19 years. In this particular case, as we mention in chapter two, a small percentage of students 'drop out' of school. To estimate the population of students in secondary education we simply calculate the percentage of students remaining in school at age seventeen, therefore obtaining the percentage of those who leave prematurely, and then we are able to calculate the next cohort of students by following the same procedure. The percentage of drop outs is considered constant as this particular data does not change drastically through time and the rate is not so high that it may considerably influence the student population.

5.3 TERTIARY EDUCATION DATA

Tertiary education data, which is at a level beyond high school, was obtained from the DHB database. The DHB is responsible for collecting data regarding higher education in Norway.

From the data collected in the database we were able to closely examine the number of students entering science faculties at universities and the number of students who colleges to be educated as a teacher. It is this data which we present in the following paragraphs.

Data regarding colleges was different as the students follow a similar path for the first years before deciding on a subject to specialize in. The data were aggregated at this particular level, nevertheless we know that all who are accepted and finish college education as a general teacher are considered qualified to teach in primary school. We also know that 40% of students in this particular process for becoming a teacher specialize in scientific subjects. These students and those coming from science master degrees at university are the future of the qualified teaching workforce.

5.3.1 University data

The DBH database provides data for all of the tertiary education institutions in Norway. From this collection of data we obtained the total number of students in universities and in the science faculties. As the DBH started collecting data post-1990, and therefore the data used do not always match the initial year in the model. The DBH database was used to obtain the initial value for the stocks in the model. The population model and the school system data provide information regarding the future generation of students who will attend university. This is the main reason why the population sector is extremely important for the purpose of the model.

The total population of students at university in 1990 is assumed to be around 125.000, data for 1990 were either not available or not complete so the number of students has been calculated with the previous historical data obtained. In the same year the number of students in science faculties is around 20,000. The number of students in science as the number of students at university is an assumed value. With this data and the age distribution we were able to calculate the distribution of the students in the different levels (Bachelor or Master degree) of tertiary education. The age distribution was essential to recreate a population distribution similar to the general population.

The importance of DBH was to provide the data for the students in university and colleges. Due to data availability the age distribution of students at university was obtained using data from 1993. We assumed, by comparing historical data series that the age distribution percentage remains fixed as it does not change drastically through time. In Table 16 (Appendix I) is possible to see the age distribution of bachelor students at university in 1992, while in Table 17 (Appendix I) is possible to see the age distribution of master students at university. In Table 18 and Table 19 (Appendix I) are presented the data relative to the students in science faculties, bachelors and masters. The data illustrate the number of students per single age cohort, from 19 to 67 years. In Figure 32, Figure 33, Figure 34 and Figure 35 it will be presented the distribution and it will be illustrated the proportions of the total students in each age cohort.

The shape of the age distribution follows a similar pattern for males and females with a concentration of students in the first age cohorts as expected. There are significant variations between the genders, with the number of women higher than men in the first cohorts (Figure 32). In Norway, compulsory military service at approximately 19 years of age creates a sensitive delay in university start age for the male population.

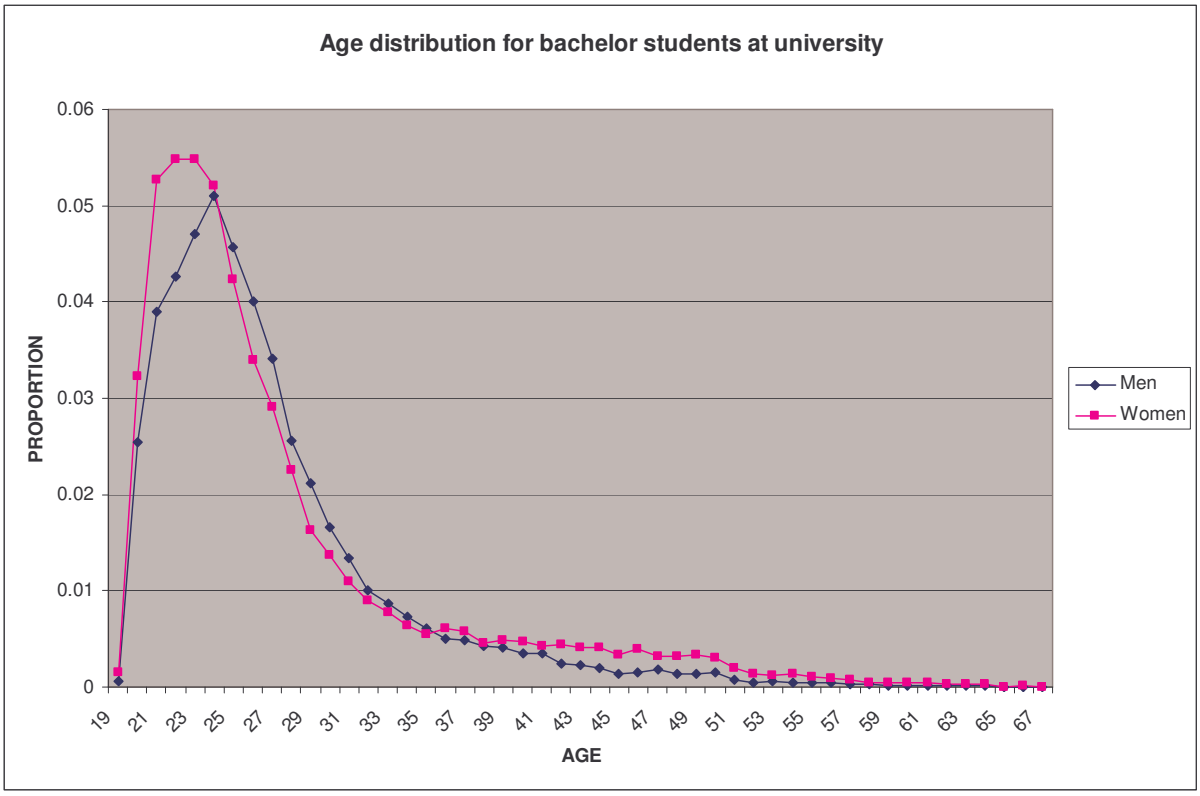


Figure 32: Age distribution of bachelor students at university, data source DBH

The age distribution of master students at university is represented in the following Figure 33.

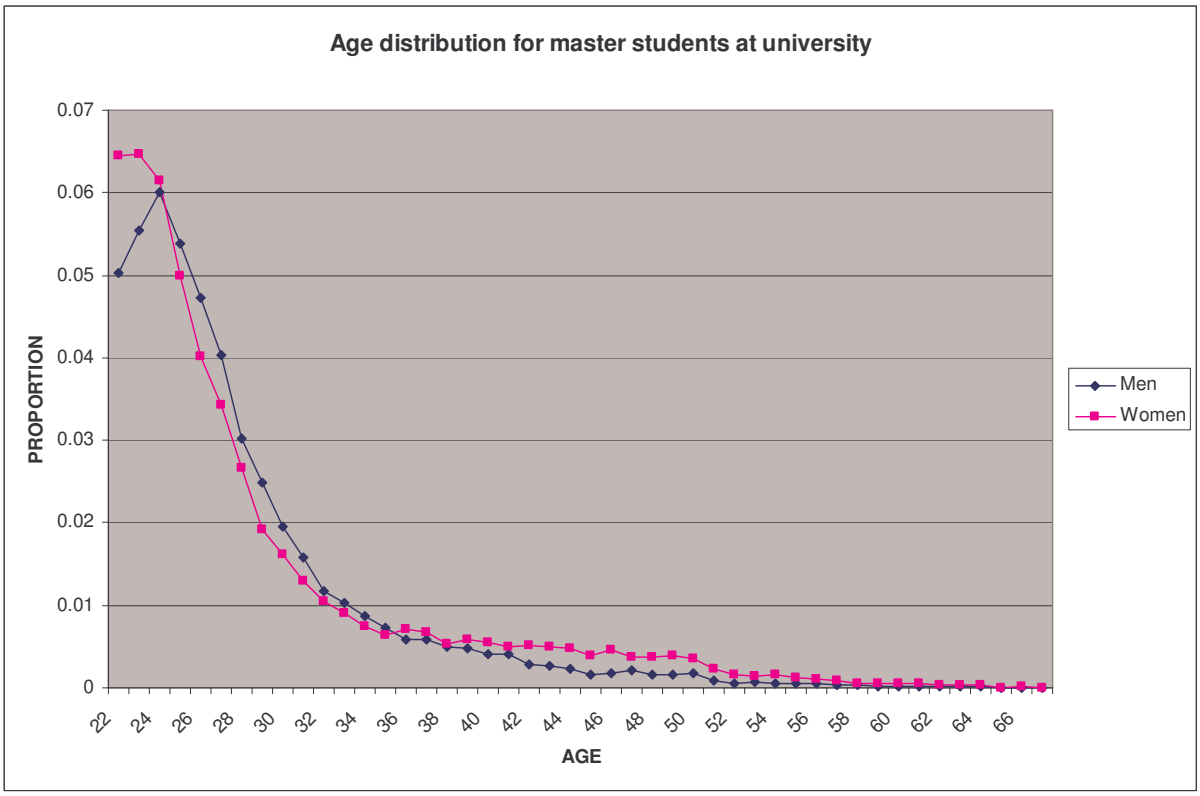


Figure 33: Age distribution of master students at university, data source DBH

The SSB database providing the data of age distribution relative to the students in tertiary education was not separate by the level of education of students. The data were aggregate including bachelor and master at the same time. Therefore it was difficult to establish the age distribution for master student. It was assume that from all the students registered by age those with an age over 21 were students in master education. The reason why this assumption was taken is because before entering a master the students must have completed the bachelor study. The age distribution was used in a first step for the bachelor and then it was used for the master students. From the original age distribution the first three cohorts were deleted and then the proportion of each cohort was re-distributed.

In Figure 33 it s possible to se the master age distribution used in the model to calculate the number of initial master students at university the distribution follow almost the same behaviour of the bachelor age distribution. In the first cohorts the number of males is lower than the females; the reason for this lower number of students can be lead back to the military service or to some years of work in companies before start the university or college.

In the faculties of science this trend seems to be reversed; male students represent a higher proportion of the total students enrolled in science faculties at university if we consider the age distribution by single cohorts as in Figure 34

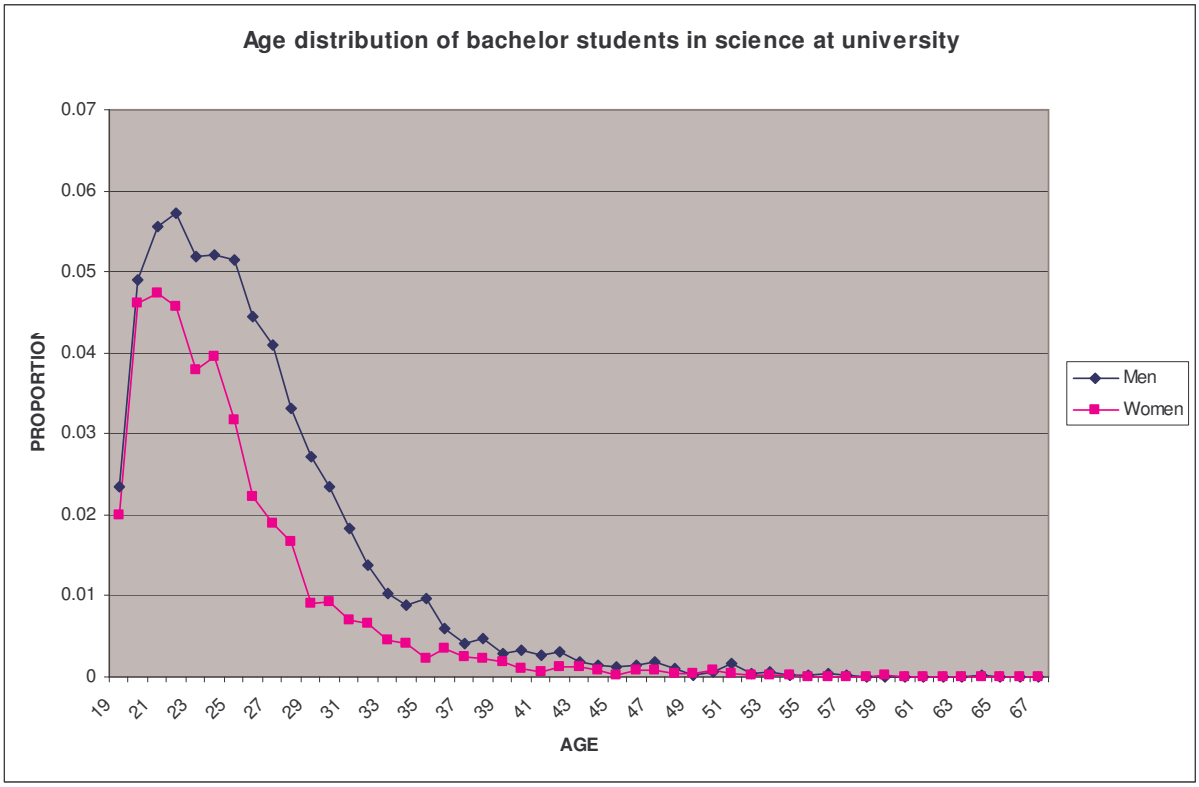


Figure 34: Age distribution of bachelor students in science faculty at university, source data DBH

The age distribution has also been used to calculate the number of students entering master degree programmes, however it is modified to reflect the fact that the start age is at least three years later, at age 21 instead of 19. This is due to entry requirements which state that a student must have a bachelor degree (three years duration) before entering a master degree. We assume that the age distribution of students only changes in this regard.

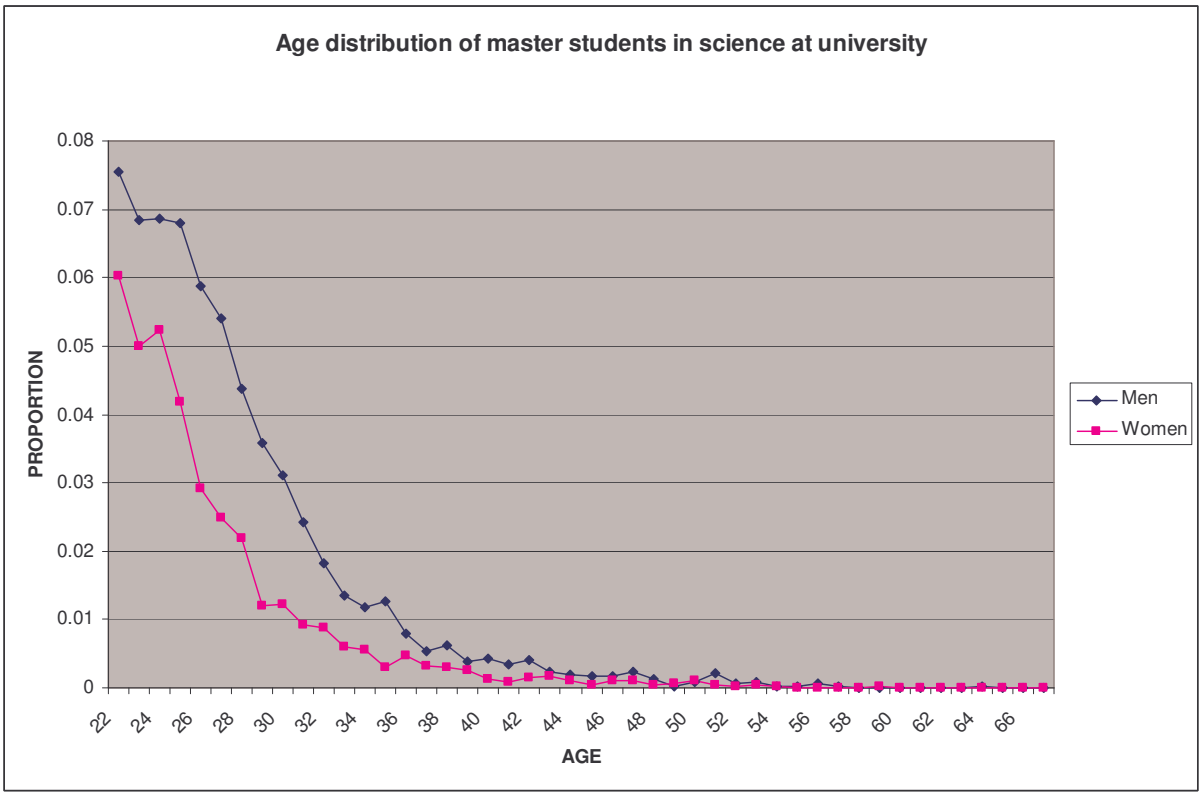


Figure 35: Age distribution of master students in science at university, data source DBH

The drop out data has been obtained by calibration of the model. The data relative to the drop out of students at university were not available, then we assumed them by calibrating the model, we made the data generate by the model fit the historical statistic. The same method has been applied to the students who proceeded with the studies and start a master degree.

The students also graduate and either continues with further education or enter the workforce. The number of students graduating is calculated using statistical data obtained from a Ministry of Education and Research report[38]. The percentage of students graduating every year is 22% percent for all the students in general university. The average percentage for the students attending science faculties is around 6%.

Students who wish to enter the teaching profession following university education, either bachelor or master degree, must apply for a one year Post Certificate of Education (PCE) programme. The percentage of students choosing this option is taken from the report edited by the NIFU (Næss, 2000) investigating the presence of science teachers in schools. The report presents historical data which shows that the percentage of students enrolling in schools is

[38] Ministry of Education and Research, The Norwegian Center for Science Education, et al. (2004). Euroscene 2003. The Norwegian Project Report M. o. E. a. Research. Oslo, The Norwegian Center for Science Education, University of Oslo**:** 65 pages.

relatively low as shown in Figure 36. The figure has been taken from the original paper and since there is not an English version of it, the labels on the axes are in Norwegian.

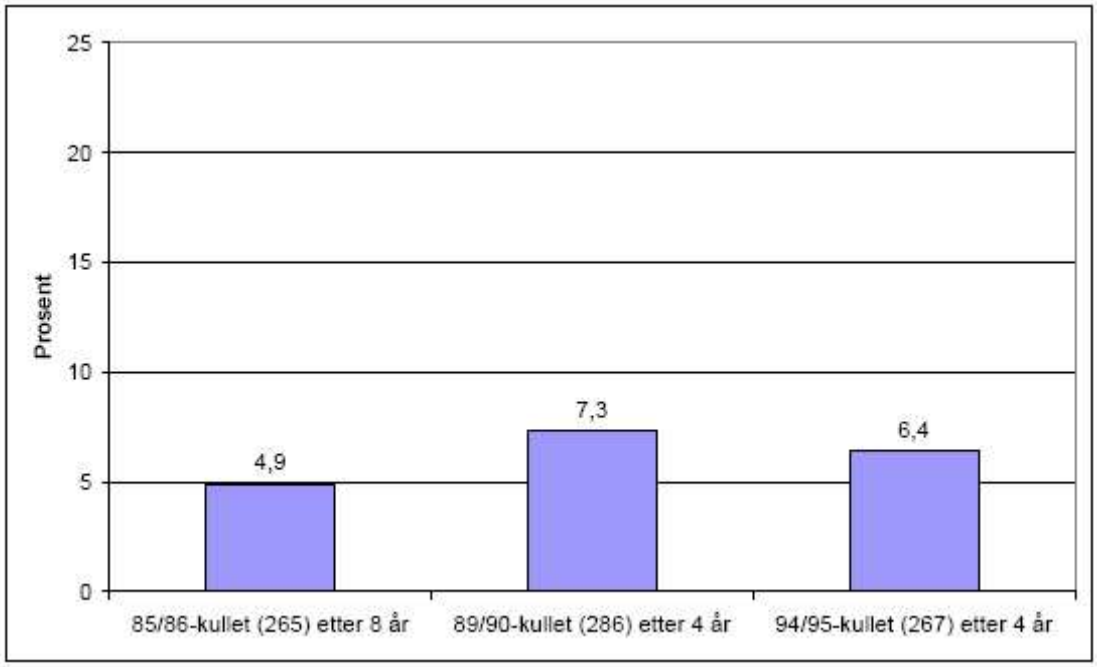


Figure 36: Percentage of students taking PCE after university, (Næss, 2000). Class of 85/86 8 years after graduation. Class of 89/90 4 years after graduation. Class of 94/95 4 years after graduation.

The report does not clarify if the values are relative to students who finish a bachelor degree, a master degree, or both. We assume that the percentage is the same for bachelor graduates and master graduates. We do not consider data for 1985/86. The above figure shows that there is a considerably delay of four to eight years after completion of studies before graduates enter the teaching workforce.

The population of students, as previously mentioned, is linked to the general population as it is a sub group of the national population. The same concept is applied to students in science faculties, which represent a sub group of the total number of students in universities. For this reason we apply the same death rate for the general population to the students at university.

In summary, the university sector presents the following statistical information:

- the initial number of students in bachelor education and in master education;
- the age distribution of students;
- the "drop out" percentage;
- the average percentage of new entrants at university;
- the average percentage of students entering a master degree;

- the graduation rate;
- average number of students certified to teach;
- the death rate for students.

In the next paragraph we introduce the data regarding college education. As the structure of colleges reflects that of universities the data presented are similar to that discussed in this paragraph.

5.3.2 College data

College data are also provided by the DBH database and this data was much easier to collect as college instruction and teacher college education are equal for all students enrolled. College education, as opposed to university, presents only one course which all students who want to become a teacher follow for the first three years. In the fourth year students specialize in one subject. Despite this, all students graduating from those courses are considered qualified to teach all subjects in primary school, irrespective of subject specialisation.

For the colleges, as for the universities, we were not able to find data matching the initial year of our model, only data starting in 1995. Therefore it was necessary to extrapolate backwards to calculate the data for 1991-1994. To do this we assumed that the student population increased at a similar rate to the historical data that was available. The number of students in college in 1991 was calculated as approximately 147,000, while the number of students in teacher college education was around 16,000.

The initial value of the stock of college students, as for the university students, has been calculated applying the age distribution; however this data was only collected by DBH from 2001. The age distribution was assumed constant, for the same reason as the university age distribution. There are a higher proportion of females in general college institution than there are males, as shown in Figure 37.

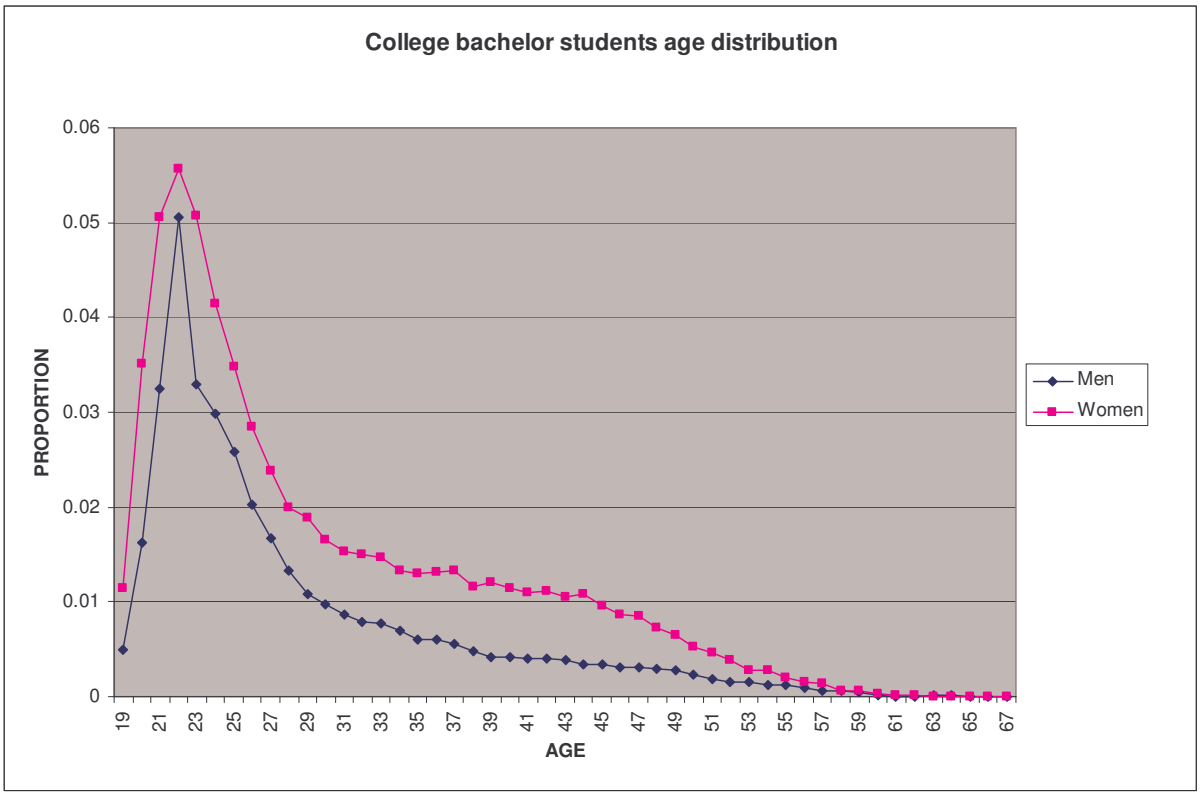


Figure 37: College age distribution for bachelor students, DBH data source

The discrepancy between females and males specifically in teacher education is even greater than in colleges in general (Figure 37). The age distribution by gender of this particular course of instruction shows that the number of future qualified teachers in primary education is mainly consisting of women. Women are still the predominant gender in primary education as SSB reports on the web[39]. The teaching profession is predominantly viewed as a profession for females, and this is illustrated by the greater proportion of females in colleges. There is some concern as the highest qualified teachers are those who graduate from science faculties at universities, and in this form of education the proportion of females is much lower.

[39] http://www.ssb.no/english/subjects/04/02/utlaerer_en/tab-2004-09-20-04-en.html

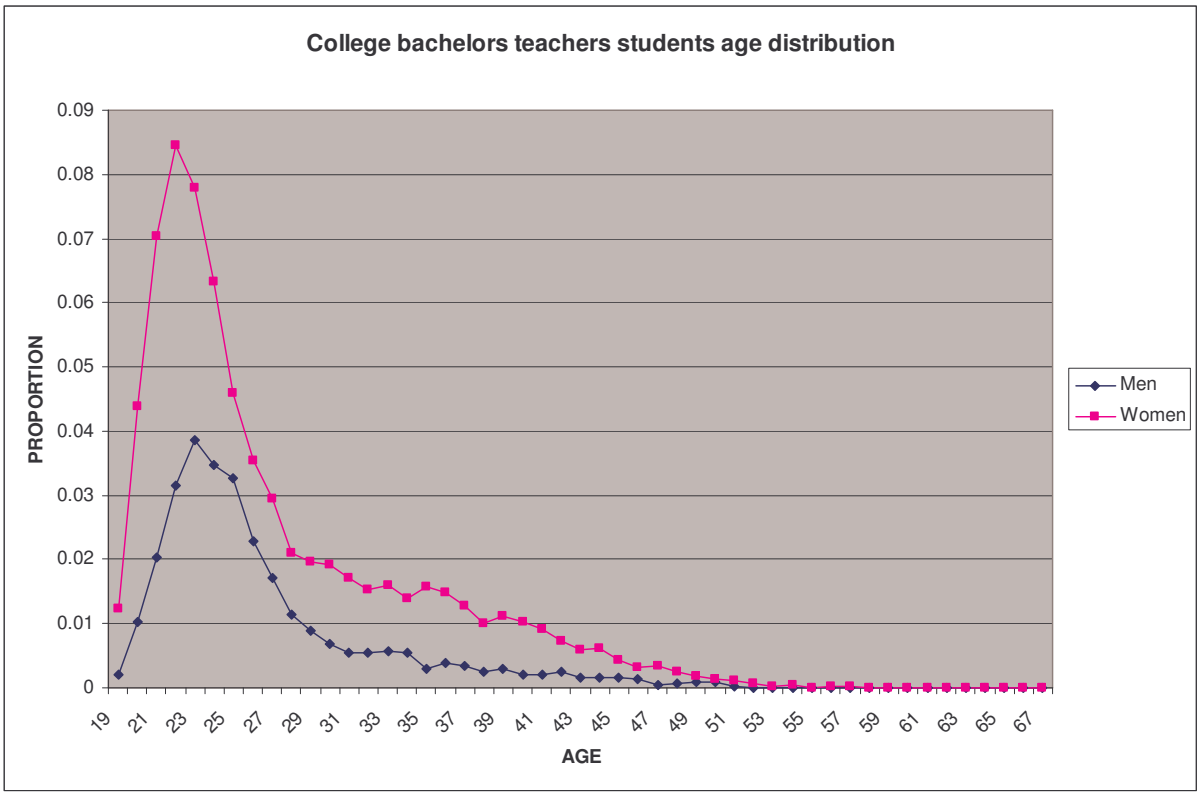


Figure 38: Age distribution for college teacher bachelor students, DBH data source

The age distribution has also been used to calculate the age of new students entering in college education.. The percentage of students entering college education is defined using the historical data obtained from the DBH database. We calculate the average percentage of new students and assume that this remains constant. Contrary to university enrolment rate, we did not found any data that could be used for colleges and it was therefore necessary to calculate a percentage ourselves. From the statistics in the SSB database we were able to calculate the enrolment rate of student in college as approximately 4% of the total number of high school graduates and an enrolment rate of students in teacher education at colleges equal to the 6% of the total number of students entering college.

The students in college education and those in teacher education are subject to the same death rate as the general population as they are a sub group, as was the case with university students. We do not find any data relative to the "drop-out" rate of college students, so we calculate it using the data available on the DBH data base, from the results estimated it seems that the drop out rate for students in college education is very low. We assume that from the autumn semester to the spring semester some of the students will leave the studies, and to calculate this we used the average difference in the number of registered students between the spring

and autumn semesters for all years. As with the university data, the drop out rate was spread over the age cohorts to obtain a more stable result in the model.

The rate of graduation for students attending college was determined by the average years needed to complete the course of study. College education to become a teacher is longer than university bachelor education. Teacher education is completed over four years, and there is no opportunity to obtain a higher degree, such as a master. For this reason some students, as previously mentioned, are attracted to university education, as opposed to colleges, by the opportunity to get a higher qualification and be hired in secondary schools.

After completing college education students are considered qualified to teach in primary schools, and a few in secondary schools. In the last year of teacher education students choose the subjects in which they want to have a deeper knowledge. The percentage of students choosing the specialization in scientific subjects is around 40% of the total number of student registered[40]. If we assume that a one year specialisation in a subject qualifies a teacher to teach that particular subject, then this percentage implies that, in primary schools, only 40% of the students are being taught by qualified teachers.

5.4 TEACHER'S DATA

Data for the population of teachers was collected from the SSB database. The data was found with certain classification, such as by primary or secondary school or distributed by age. In some cases the data lacked the sub-division necessary for use in our model. Where this was the case further data was collected and combined with the SSB data set. The modified SSB tables are found in Appendix I.

In this section the data is presented under the following divisions:

- Teachers in primary school;
- Teachers in secondary school;
- Qualified and Un-qualified teachers.

[40] NOKUT (2006). Evaluering av allmennlærerutdanningen i Norge 2006. Oslo**:** 86.

5.4.1 Teachers in primary school data

The data utilized for the sector relative to the teaching workforce are various and here they will be presented in the following order:

- Initial data for primary population of teachers;
- hiring age distribution;
- firing age distribution;
- quit rate relationships;
- retirement rate and early retirement rate.

In the stock of teachers is present also the death rate, as we mention before, the population of teachers is part of the general population and the death rate data used are the same used for the general population. For this reason the outflow was not included into the list and it will be not discussed here again. The method applied to obtain the inflow and outflows are the same for the teachers in primary as for the one in secondary school. The change will be simply in the data relative to the initial data of the population.

5.4.1.1 Initial data for primary population of teachers

The teacher population data is shown in Table 21 (Appendix I) and has been taken from the SSB database. As previously mentioned, the SSB have collected historical data regarding this population and other aspects of the education system. The data did not take the type of employment, full or part time, into account. The original data table was found on the internet[41] and included information from 1992 onwards. Therefore it was necessary for us to modify the table and include data for 1990 and 1991 by utilizing a historical archive from the same source[42]. The SSB data was not divided by gender and therefore we utilized other data from the SSB to calculate the proportion of males and females in the teaching population. In 1990 approximate 52% of teachers in primary school were females. The percentage of each gender is important for the initial value of the stock of primary teachers, as is the age distribution of those teachers.

[41] http://www.ssb.no/english/subjects/04/02/utlaerer_en/tab-2004-09-20-02-en.html
[42] http://www.ssb.no/english/subjects/00/histstat/

The original data grouped teachers in 10 year age categories, therefore it was necessary for us to reorganise the teachers into single year age cohorts Table 22 (Appendix I) collects the data while Figure 39 is showing the new age distribution of primary school teachers in 1990 following our modifications.

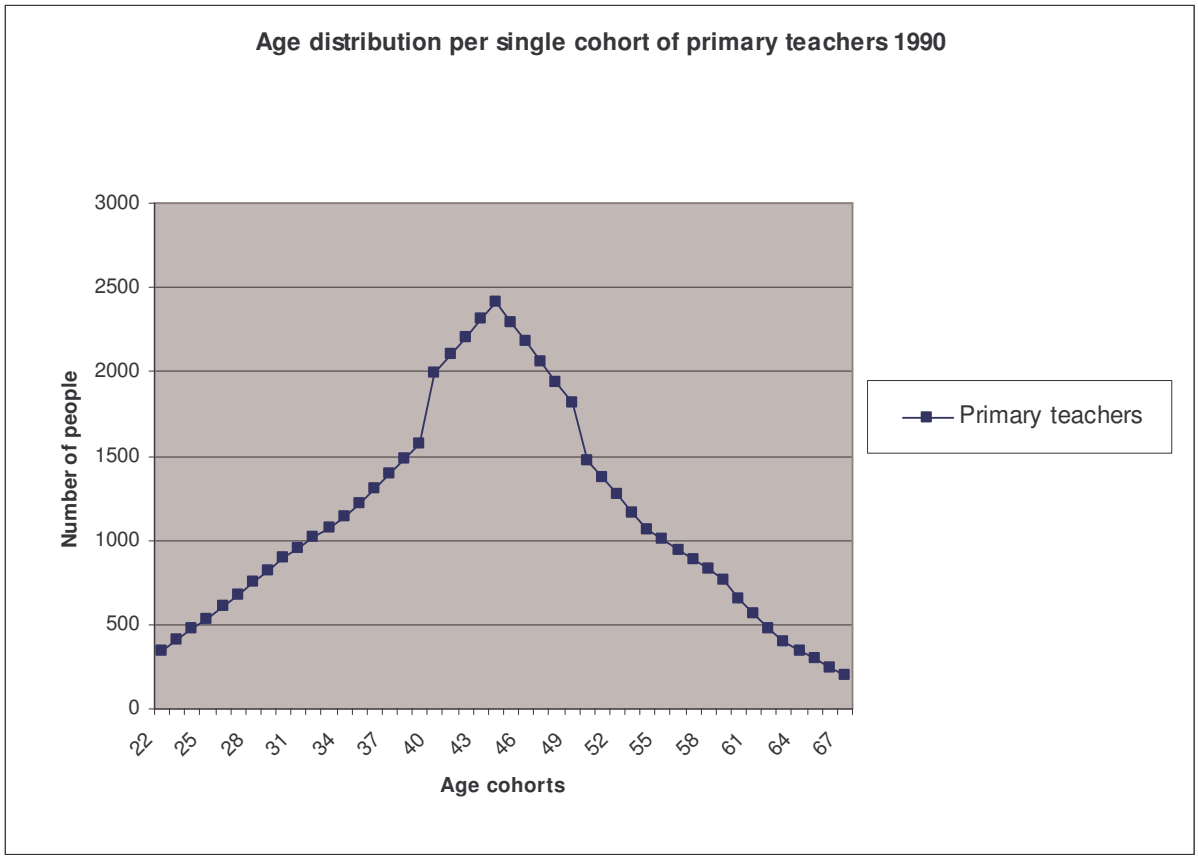


Figure 39: New age distribution of primary teachers, data source SSB

It was important to represent the exact percentage of elderly teachers which correspond to the age cohort group over 60 years old in the data for the model simulation. It was important because with the simulation model we will be able then to represent the future "greying workforce" especially for the population of secondary teachers. The first assumption made was that the age of teachers ranges from 21 to 67 years old. The age limit for working as a teacher has been set from the results of a report[43] which defines the retirement age in Norway at 67 years old. The youngest age at which a teacher may start was assumed to be at the age when a student may have completed a bachelor degree, the lowest qualification to be a teacher. We then proceeded to determine how many cohorts were present in the groups considered for

[43] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

age division. In each 10 year age group a central cohort was determined and the number of teachers within this cohort calculated as the total number of teachers divided by the number of cohorts in that group. The remaining cohorts were given a spread of the population which was assumed to be reasonable.

5.4.1.2 Hiring age distribution

The supply of future teachers was calculated using further statistical data which gave the flows of teachers entering and leaving the teaching population. The population of teachers is defined by different flows rate[44]. Every inflows and outflows are calculated by constant or auxiliary variable, constant variables are defined by statistical data we found and data we had to assume.

The main inflow for teachers is the "hiring rate of teachers" and since the population of teachers is spread through age cohorts, it was necessary to have a variable called "proportion of hiring teachers by age". The data present in the variable have been guessed and not found in any database. It was assumed that there are higher chances for young qualified teachers to be hired than for old teachers. The graphic relationship between age and the proportions of hiring by age is presented in Figure 40. Table 23 in Appendix I is showing the data relative to the proportion per every age cohort.

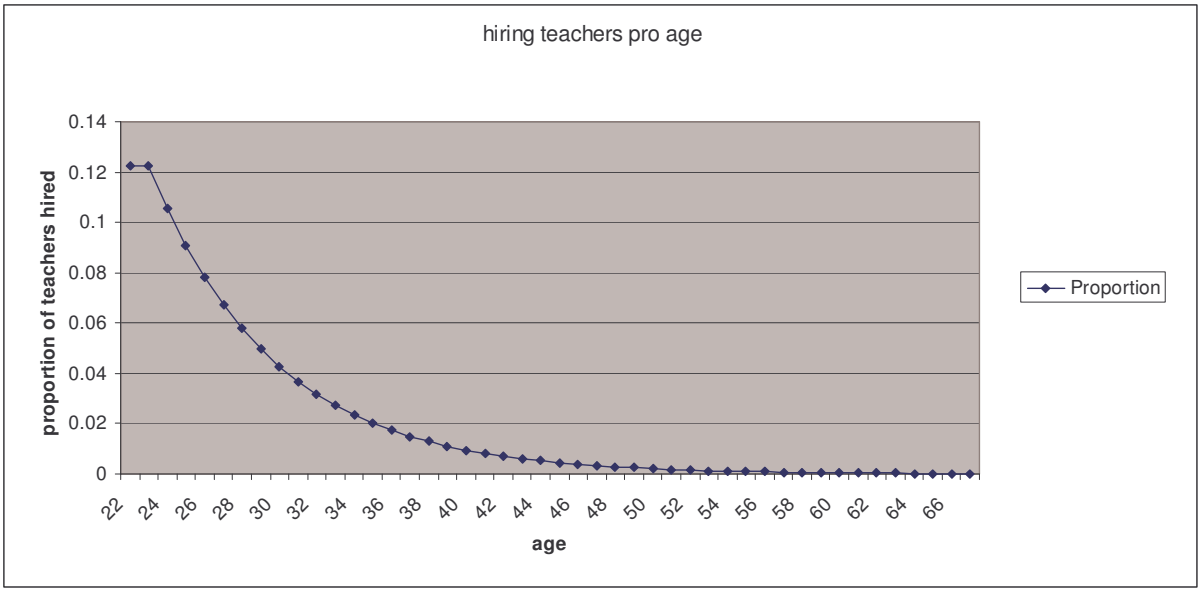


Figure 40: Hiring distribution of teachers by age

[44] For a more detailed description of the structure relative to the teaching workforse see chapter 5, paragraph 4.

As it possible to see the assumption it was taken is a relationship between age and proportion of being hired which is exponentially decreasing. The non linear relationship was obtained simply using an exponential function e^X . It was assumed also that for the first two cohorts the proportion chances to be hired were the same, since they represent the youngest workforce and young teachers are needed at the moment in the workforce.

5.4.1.3 Fire age distribution

The number of teachers, in some cases, is decreased by the firing rate. Especially the un-qualified teachers present in the working force are the one which are exposed to firing due to their unqualified skills. The fire rate of teachers as the hiring rate is the one of the main flow in the stocks of teachers at every level of education, primary or secondary. Since the population of teachers is distributed by age, also the fire rate as the hiring rate need to be distribute through the age cohorts. For this reason it was necessary to create a non linear relationship between age and chances to be fired by age. It is unknown how these proportions per every single age cohort are re-distributed, as for the hiring rate, it was necessary to assume a non linear relationship (Figure 41). In Table 24 Appendix I the data relative to the graphic are reported.

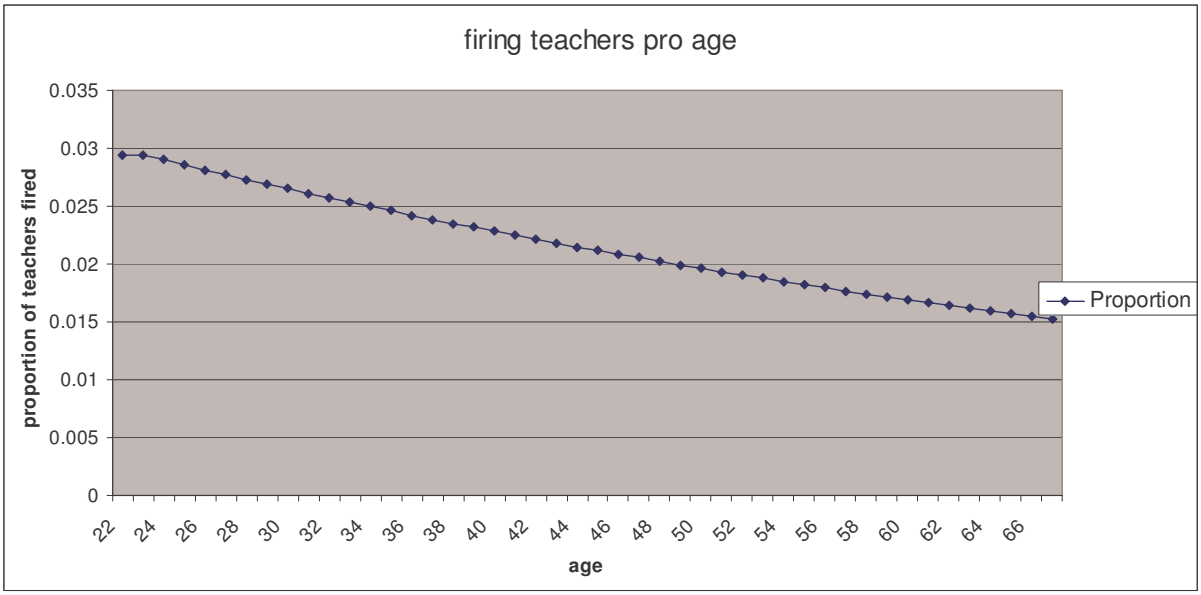


Figure 41: Firing age distribution of teachers

It was assumed that the chances for young teachers were higher to get fired due to the un-experience which they may have. In the Norwegian school system getting older means to obtain more years of employment which lead to a higher defence for not being fired.
The function used for drawing the curve was the same used for the graphic relative to the hiring rate. The exponential function tries to avoid firing of people with years of experience due to the long time of employment.
The fire rate decrease initially the stock of unqualified teachers, it is common in cases when there is an over number of teachers that unqualified personnel is the first to get discharged.

5.4.1.4 Quit rate relationships data

The quit rate of teachers in both level of education, primary and secondary, is one of the main outflows which seems to create the future shortage of science teachers. The quit rate is calculated by different variables and non linear relationships, which have been founded in two of the reports used[45]. The quit rate is depending on different factors such as:

- Age;
- presence of unqualified teachers in the workforce;
- leaving probability.

The age of the employees is one main factor which influences the decision of a teacher to leave or not the job. In the report "Teacher turnover and non-pecuniary factors" by T. Falch, B. Strøm (2004) two non linear relationships have been demonstrated. For the purpose of the model it was not needed a relationship precise as the one shows in the report, for this reason we use the main data obtained in the research.

[45] Torberg Falch, B. S. (2004). Teacher turnover and non-pecuniary factors. Working paper series, Norwegian university of science and technology. Department of economics. **1/2004:** 38 pages.
and Schøne, P. (1999). Avgang og rekruttering i undervisningssektoren - hva betyr lønn? I. f. samfunnsforskning. Oslo, Insitutt for samfunnsforskning**:** 105 pages.

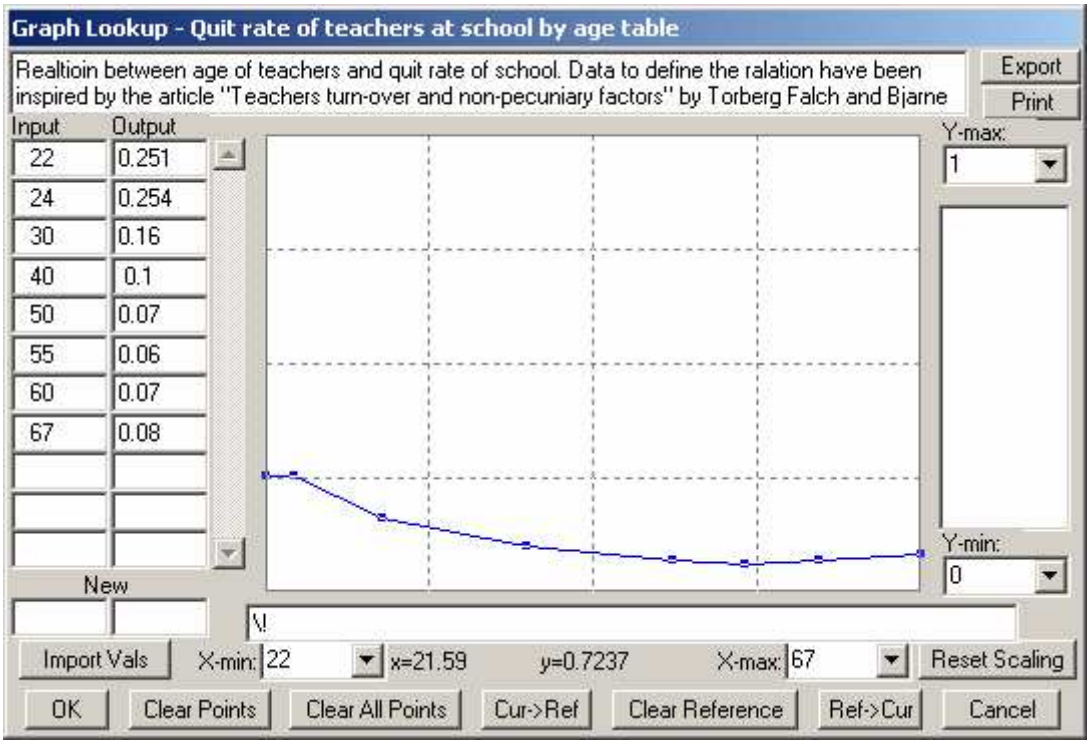


Figure 42: Non linear relationship between age of teacher and quit rate from the teaching profession

The relationship seems to show an inverse relation between age and leaving proportion of teachers (Figure 42). The 25% teachers within 22 and 24 years leave the profession for other job opportunities, the 7% leave at age 50 and the 8% will leave at the age of retirement. This trend is explaining in part the difficulties to have a young qualified workforce. The curve assumed the classical shape of a U which is basically the type of relationship that exists between age and leaving probability.

As we mentioned before other non linear relationships are involved and amplify the problem of teachers leaving. The second relationship found in the report is the one related to the presence of unqualified teachers. The report shows how the qualified teachers are leaving the job positions due to a higher percentage of unqualified colleagues (Figure 43).

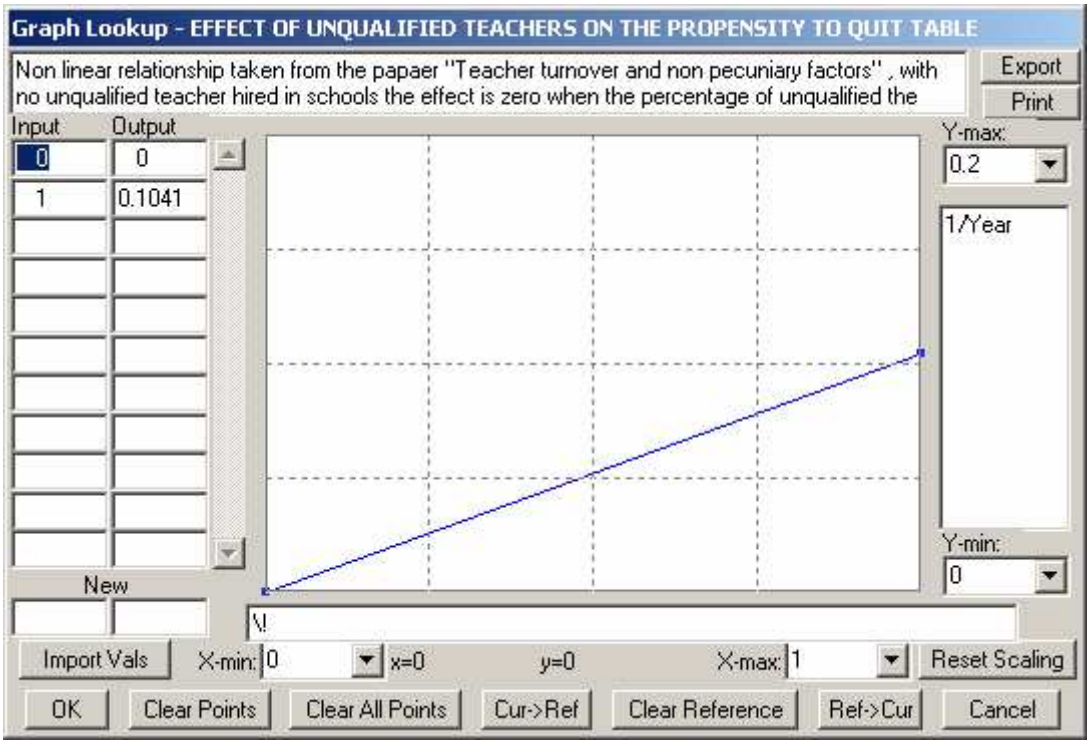


Figure 43: Non linear relationship between percentage of unqualified teacher and proportion of teachers leaving

The relationship shows a positive correlation between the percentage of unqualified teachers' presence and the proportion of qualified teacher leaving.

In the report a regression analysis was conducted and it was used a dummy variable to define the presence or not of unqualified teachers. The results shown that in schools were unqualified teachers were employed the percentage of qualified teachers leaving was 10.4%, while in all the other school 8.7%[46]. For our purposes, since our model does not produce a regression analysis, it was assumed that with 0% of unqualified teachers the percentage of qualified teachers leaving is equal to 0. The dummy variable used in the report assumed that when there are no unqualified teachers present (variable equal to 0), 8.7% of qualified teachers leave. This is a higher leaving percentage than that which was used in our model as there is a negative environment effect which influences the decision to stay or not.

When there are unqualified teachers employed then the 10.4% of the qualified teachers are assumed to leave. This percentage was set as the maximum if 99% of the teaching workforce was unqualified because if the percentage of unqualified teachers reaches 100% then the entire teaching workforce is unqualified, and therefore the quit rate of qualified teachers would be zero. In the graphic, when the percentage of unqualified teachers is equal to 1,

[46] Torberg Falch, B. S. (2004). Teacher turnover and non-pecuniary factors. Working paper series, Norwegian university of science and technology. Department of economics. **1/2004:** 38 pages.

which means 100% of unqualified teachers, then the percentage is 10.41% however this percentage is not applied as there are no qualified teachers to apply the quit rate to.

The last non linear relationship regarding the quit rate of teachers is showing the correlation between the salary attraction and the leaving probability for other job positions. This relationship has been demonstrated in the report "Avgang og rekruttering i undervisningssektoren – hva betyr lønn?" by Pål Schøne (1999) (Figure 83).

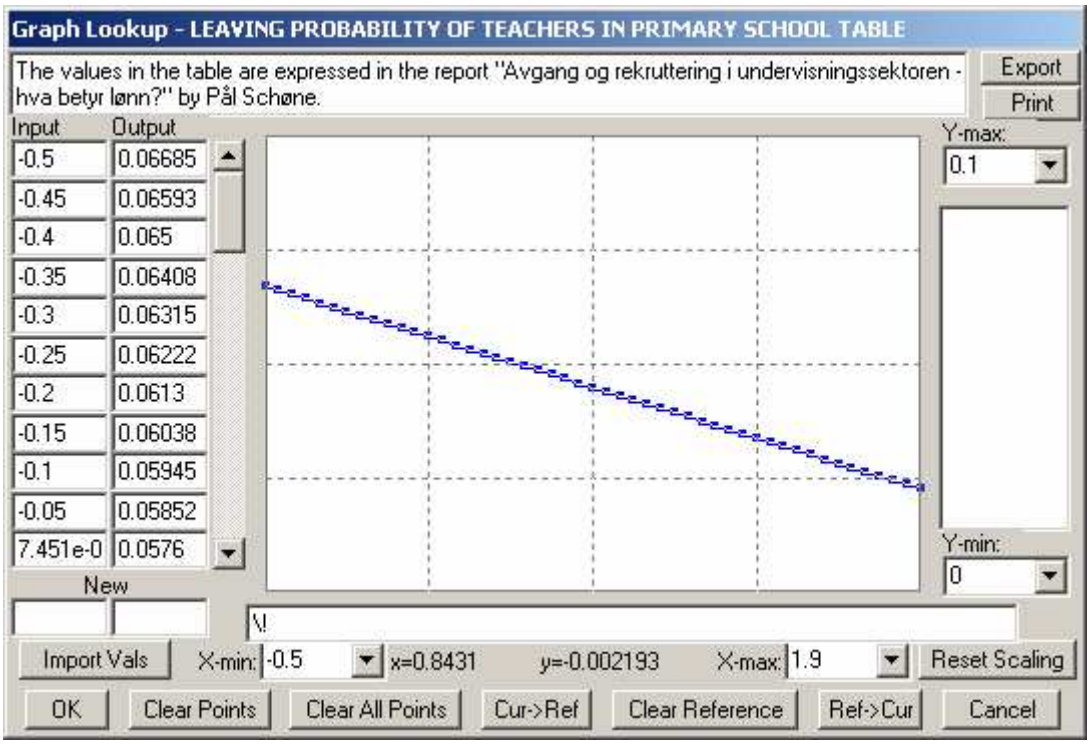


Figure 44: Non linear relationship between salaries ration and willingness to leave the job positions

The relationship graph in Figure 44 has been calculated using a linear extrapolation[47]. It shows that there is a reverse correlation between the two factors take in consideration. If the salaries ratio, between teacher salary and average employee salary, is increasing the tendency of teachers to leave the job position will decrease. The data found in the report are relative to the salaries prices of 1996, we could not find any other new research showing the relationship with latest data.

[47] The original relationship was limiting the dynamics of the model since it was a function calculated statistically and it was not considering the range of the X value in a long run

5.4.1.5 Retirement rate and early retirement rate

The data relative to the retirement and early retirement were found in the report "Attracting, developing and retaining teachers" by S.T. Lyng and J.F. Blitchfeldt (2003).
Basically in the Norwegian system the retirement for every employee in the education sector comes at age 67, but it is given also the chance to leave earlier the position held. The early retirement age, which is set at 62, is often used by teachers with health problem and lately the percentage of teachers retiring earlier for this reason has been increased[48].
The data presented in the report are showing that the 36% of teachers retire using the chance given for the early retirement, while less than 10% is retiring at age 67.
Few studies have been conducted to understand the reasons of leaving of teachers in school from one of the research conduct it results that the 50% of those who leave early motivate their decision due to working condition being worst. Out of this percentage the half of them is attracted by other job opportunities, in particular the teacher below age 55, and the remaining is leaving the position due to health conditions[49].

5.4.2 Teachers in secondary school data

The data for the population of teachers in secondary school were found with the population data of teachers in primary in the SSB database. Every sector in the model, which refers to the teaching workforce, has two stocks relative to the primary or the secondary teachers. The stock of population of teachers in secondary school is regulated by the same inflows and outflows present in the previous paragraph. For this reason in this paragraph we will introduce only the data relative to the initial population of teachers.
This data as the one used for the population of primary teachers has been found on the SSB database and the data are reported in Table 25 (Appendix I). The same procedure for obtaining the age distribution of the population of primary teachers has been followed. The data reorganized are shown in Table 26 (Appendix I). The population of secondary teachers at the beginning year of our simulation does not present the problem of a high percentage of

[48] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

[49] Blitchfeldt, J. F. (2002). En framtid som lærer? En studie i utviklingsarbeid ved åtte skoler med siket på kvalitativ forbedering og forlenging av yrkeskarrieren. . AFI-rapport. Oslo, Arbeidesforskningsinstituttet.

elderly teachers. The absence of the problem can be seen in the new age distribution (Figure 45) where the total population of teacher in secondary has been spread through the age cohorts. The difference between the secondary and primary teachers population is simply the total number of employees, while the different of age distribution are not evident in 1990.

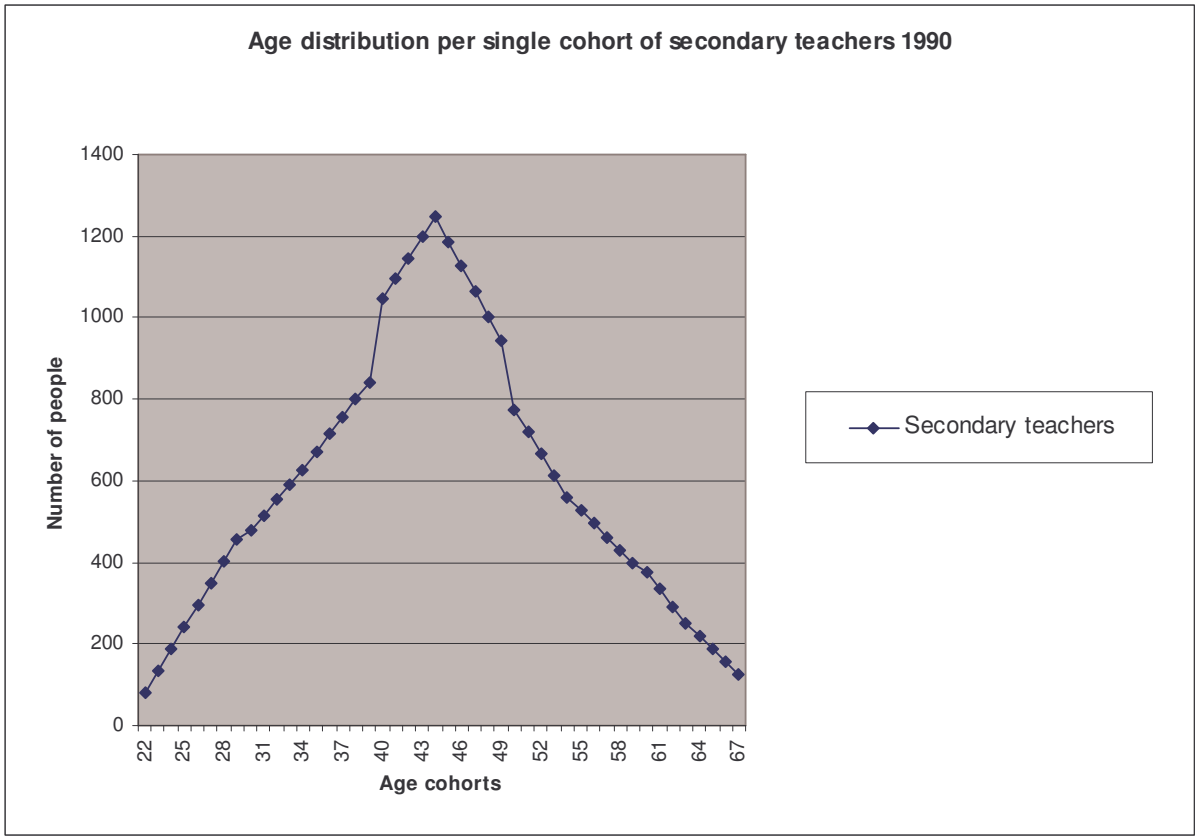


Figure 45: New age distribution of secondary teachers, data source SSB

As for the primary teachers the new distribution was made for two main reasons, first the data found in the SSB database were grouped as well in 10 years age categories, second it was required for the model a population by age cohorts so it was possible to track the ageing chain of teachers. With a model and data that can represent the aging chain of the working force then in the future scenarios it will be possible to see the effect of "greying workforce".

5.4.3 Qualified and unqualified teachers data

For the data relative to qualified and unqualified teachers we could not find a reliable source that could provide such type of data. SSB database does not keep such type of division and

the DBH is just a database collecting data for tertiary education. We also tried to look into the Utdanningsdirektoraret statistic but even in this case they have not such division. For this reason we have to assume that qualified teachers are those coming from college institutions and those with a bachelor or master degree which have taken the post certificate of education to be qualified for teaching.
The subdivision made between qualified and unqualified will be then reported in this paragraph giving an explanation on the data assumed for constructing the variable in the model and the initial values of the stocks of teachers.

5.4.3.1 Qualified teachers

As it was just mentioned it was not certain the proportion of qualified teacher workforce in over the total number of teachers obtained by the statistical data from the SSB. Therefore it was necessary to assume this initial value. The first problem to deal with was the number of unqualified teachers present in the system at the starting year of the simulation. The model in System Dynamic helps us for solving this problem, changing what was an initial problem to an advantage for the simulation. The number of initial qualified teachers will be decided by the policy maker. The variable called “fraction of qualified teachers”, which is present for both levels of education, is an auxiliary variable which will allow the policy maker to decide what type of initial scenario condition he desire to test. The only difference between the qualified teachers and the general teachers is in the initial number. The remaining data used for calculate the inflows and outflows are the same. The reason why they have been used the same data is because qualified or unqualified the teachers are still one group and the research made by Falch and Strøm (2004) was conducted over the total number of teachers and without regarding to their qualification.

5.4.3.2 Unqualified teachers

The number of unqualified teachers as for the qualified was not known. The decision taken to leave to the policy maker to define the percentage of qualified teachers over the total teachers was helpful also for calculate the remaining part of the teachers, which are obviously unqualified.

The initial value of the stock is obtained using the variable "fraction of qualified teacher". The unqualified teacher at the starting year will be equal to the initial teachers multiplying one minus the fraction of qualified teacher. Since the variable qualified teachers can be set by the policy maker as well it will be for the initial number of unqualified.
The stock of unqualified teachers differs from the stock of qualified only in small part (see paragraph 5.4.2 chapter 5) the main difference is one outflow which is not regulated by the same statistical data used for all the others. The outflow called "qualification rate of unqualified teachers" is an outflow which is not present in the other stocks of qualified teachers. The outflow is supposed to represent that percentage of unqualified teacher that after years of work can be considered qualified. From one of the report found the 35% of the unqualified teacher after a certain time spent in the education decide to get the qualification to become qualified teacher, the qualification is also reached by the "on field" experience that they acquire in the years of work as unqualified employee[50]. The definition of time spend on the job before getting the qualification was not clear therefore it was assumed that after a period of 10 years the 36% of unqualified teachers will enter the group of qualified. The variable which manage the time elapsed before one unqualified teacher will became qualified is also an auxiliary and it can be used by the policy maker to change the flow between the two stocks. In this case the policy maker has different chances to run different scenarios.

5.5 SALARIES DATA

The data relative to the salaries sector have been found, as most of the other data, in the SSB database. The data relative to the earning of teachers and employees were needed for calculate the ratio between them and so the relation of attraction that salaries exercise on the future new teachers. The data have been collected following different subdivisions:

- monthly earnings of teacher with tertiary education four years or less and more than four years;
- monthly earnings of full time employee with tertiary education four years or less and more than four years.

[50] Selma Therese Lyng, J. F. B. (2003). Attracting, developing and retaining effective teachers. Country background report for Norway, OECD and Work research institute.

The latest part of the sector data are not directly related to the salaries of teachers or full time employees. The last part of the sector use data relative to the expenditure for education, this data were used to control the total expenditure for salaries, and how it weight upon the total expenditure for education.

5.5.1 Monthly earning of teachers with tertiary education four year or less and more than four years

The first data collected were the one relative to the earnings of teachers in public school. The data were found in the SSB database and they were reported as monthly earning per person. We could found data from the year 1999 until the 2005 but not data from early year, so it was assumed that before the 1999 and after 2005 the percent of increase is a constant. In Figure 46 is possible to see that the trend of salaries in the latest year in Norway has been positive, and it increased.

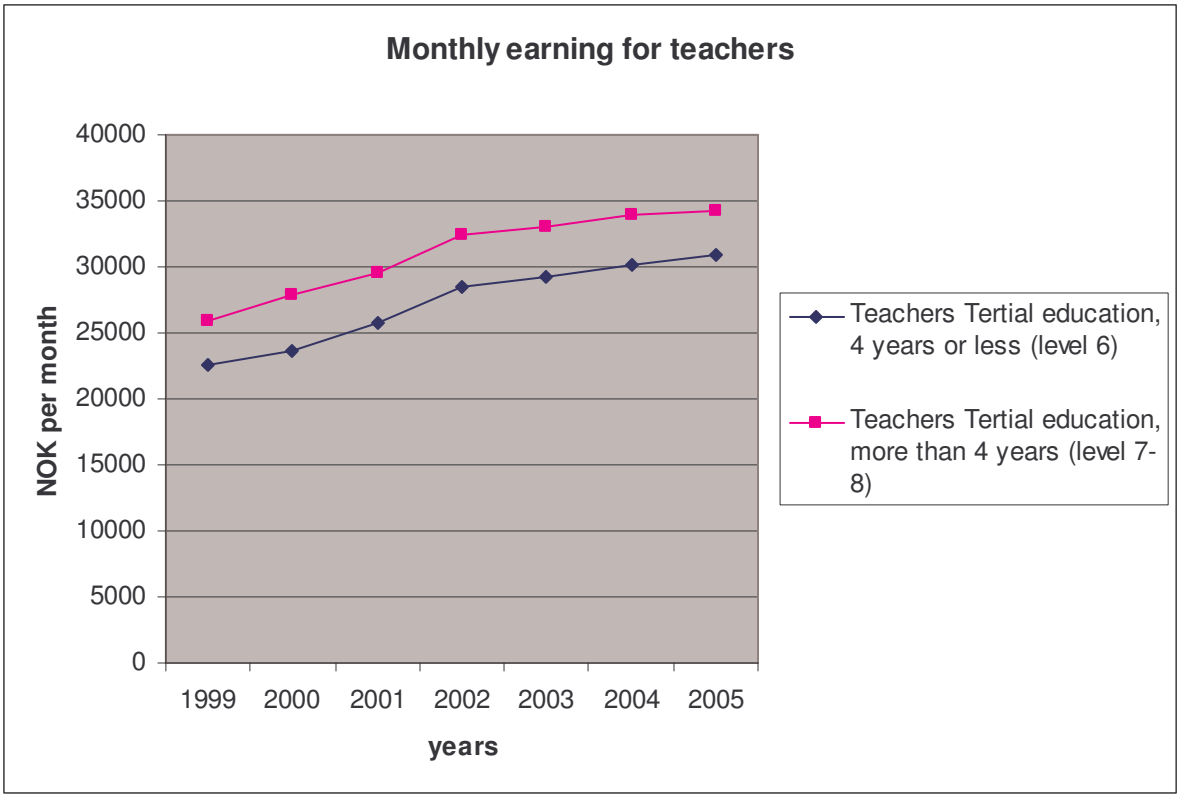


Figure 46: Monthly earning for a teacher with tertiary education, data source SSB

The structure of the model is reproducing the behaviour of the monthly earning every year. To obtain this trend the initial value of the stock for the monthly earning was not enough and it was required also the data relative to the yearly increase of salaries. The inflow presents in the stock which accumulate the monthly earning of teachers is called “increase rate of monthly earning for teachers”. The variables which regulate this inflow are the stock itself and the variable relative to the percentage of yearly increase. The data of this variable can be found in Table 27 (Appendix I). The percentage of yearly increase has been calculated after all the available data were collected. To obtain the yearly salary for a single teacher the stock was multiply by 12 and finally to have the total amount of salaries paid to teachers the yearly salary per teacher was multiply by the number of teachers with the correspondent level of education.

4.5.2 Monthly earnings of full time employee with tertiary education four years or less and more than four years

The data of the monthly earning for a full time employee were found on the SSB database as the other data relative to the salaries. Table 28 (Appendix I) is reporting the data collected from the statistical database, the table has been changed as it was for Table 27, the percentage of increase have been calculated using the data available and they were not found in the original tables. The monthly earning of a full time employee has the same trend of the earnings for the teachers and in the last years it has increased (Figure 47).

Figure 47: Monthly earning of a full time employee with tertiary education

The model is reproducing the behaviour of the earning of a full time employee but there were not data available before 1997 and after 2005, so before and after the percentage of increase is considered a constant in the model. Figure 48 shows the monthly earnings data confronted by teachers and full time employees.

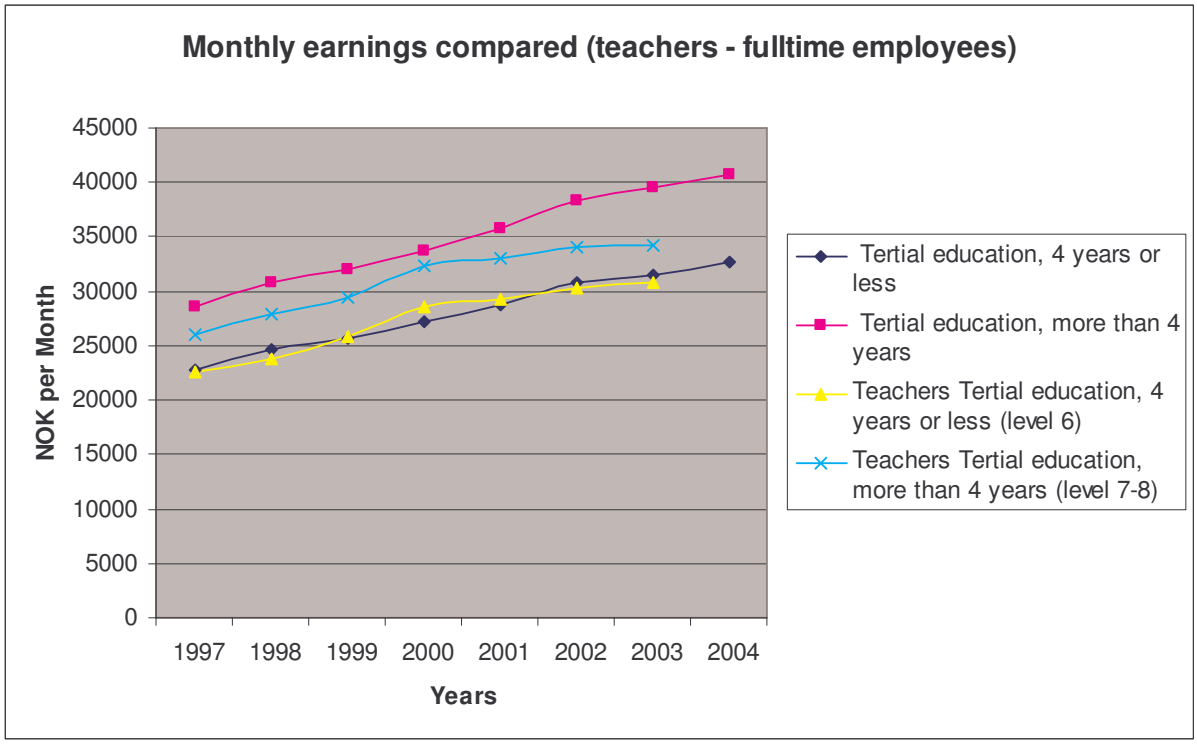


Figure 48: Teacher earnings and full time employee earnings compared

How is possible to see the national average of monthly earnings is most of the time higher for the full time employees than for the teachers. This difference is alarming if we consider that the attraction of salary to a job profession is always in a positive relation with increase of salaries compared to the other salaries. This is one of the main points in our policy testing and in chapter 7 the results will presented.

5.5.3 Educational expenditure

The final part of the data used in the sector is from the SSB database[51] as well and the main aim in the structure is to check the behaviour of the variable "total expenditure for salaries" when one of the policy is tested. The structure of the expenditure is simply an external variable with statistical data Table 29 (Appendix I), the data available were only covering the time period from 1990 until 2004, after that year the model is considering the expenditure as a constant.

[51] Data relative to the General Government Expenditure are including all the expenditure for all the Norwegian educational system, primary and secondary school and universities and colleges. The data used have been found in the SSB web page http://statbank.ssb.no//statistikkbanken/default_fr.asp?PLanguage=1

The expenditure for education has been always high in Norway, as it is shown in Figure X, which demonstrates the attention paid by the government to the educational sector.

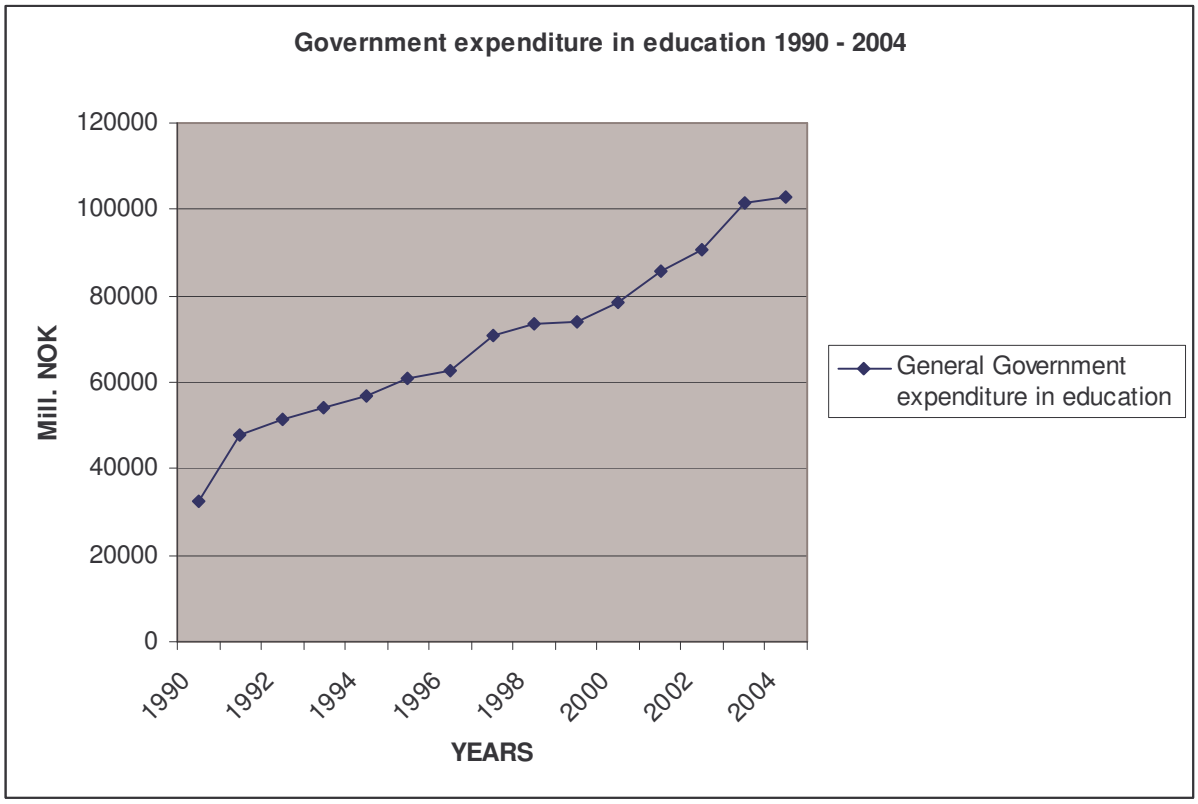


Figure 49: Norwegian expenditure for education, data source SSB

With this data the percentage of influence of the total salaries will be calculated in the model to make sure that the policy is reliable and applicable.

6 VALIDATION OF THE MODEL

The following chapter will introduce one of the most important steps in the System Dynamics (SD) methodology - the validation of the model. One researcher in particular seems to have faced the problem of validation more than any other SD researchers. Barlas with one of his main articles[52] has explained and try to formalize the theory behind the validation process, how it is important in SD methodology and how it should be conducted.
Following Barlas (1996) we decided to divided the chapter into three sub-paragraphs as follows:

- What is validation?
- Validation policies applied to the model and results;
- model validation.

6.1 WHAT IS VALIDATION?

Model-based studies, in particular, need to include a validation step. Validation is used to ensure that the results obtained in the model are accurate, and can lead to increased confidence in the structure. In our model we should validate the structure of the model as it is this which produces the results. In fact, in SD the validation of the model is mainly seen as the validation of its internal structure, more than the validation of the results obtained. The validation of a model is a prolonged and complicated process, involving both formal/quantitative and informal/qualitative tools[53]. Although the process appears to be a simple step in the methodology, confidence in the model is in fact achieved from the very first step of the SD methodology, the problem identification. The model structure in SD is problem oriented so that confidence in the model improves throughout the model building process. Validation, as a step of the process to obtain results, is not formally defined nonetheless Barlas (1996) attempts to summarize and discuss different steps in validation under the following divisions:

[52] Barlas, Y. (1996). "Formal aspects of model validity and validation in system dynamic." System Dynamic Review **12**(3): 183-210.

[53] Ibid.

- direct structure tests;
- structure-oriented behaviour tests and
- behaviour pattern tests.

6.1.1 Direct structure tests

Direct structure tests are divided in two sub-categories - empirical and theoretical. Empirical tests are further subdivided as follows:

- structure-confirmation tests and
- parameter confirmation tests.

The theoretical tests are, on the other hand, divided into four sub-categories:

- structure-confirmation tests;
- parameter confirmation tests;
- direct extreme-conditions tests and
- dimensional consistency.

"Structure-confirmation tests assess the validity of the model structure, by direct comparison with knowledge of the real system structure"[54], "Usually this process is done by comparing the equations of the model with the relationships that exist in the real system"[55]. Basically, structure-confirmation tests are empirical confirmations of the structure and runs of the model or simulations are not involved into the process. This particular step of the process is present in both categories because to conduct this type of analysis theoretical evidence is needed that can reflect the empirical.
Parameter-confirmation tests are empirical and theoretical confirmations of some of the model variables. These types of tests control the accuracy of the constant variables that have been

[54] Ibid.

[55] Forrester, J. W., Senge, P. M. (1980). "Tests for building confidence in system dynamic models " Ibid.

used in the model. The variables must be conceptually close to the real variables present in the real system, as well as numerically so that the values that are assigned to the variables are as close to the real value as possible.

"Direct extreme tests are conducted to evaluate the validity of the equations in the model under extreme conditions by assessing the plausibility of the resulting values against the knowledge/anticipation of what would happen under similar circumstances in the real life"[56]. Usually, extreme tests are the first to be applied to check the consistency of the structure, and they in general they put the structure under "impossible" circumstances. Examples of "impossible" circumstances include "no birth rate" or "no salaries". We have used extreme tests in the process of validating our model, however we did not include sensitivity tests, which will be described in further detail later in this chapter.

Dimensional consistency tests are controls which examine the unit dimension of the equations presented in the model. This type of test does not require vast explanation as dimensional checks are often included as a function of the software used for modelling. In our case Vensim presents this validation step.

6.1.2 Structure oriented behaviour tests

The structure oriented behaviour tests are the second step of model validation. These types of tests are different from the first category as they attempt to validate the model structure indirectly through behaviours generated by the model. These tests seem to be more adapted to quantification, as opposed to the direct structure tests, which seem to be closer to qualitative in nature.

Structure oriented behaviour tests are divided into different groups; however we limit our explanation to the following two groups:

- extreme condition test;
- behaviour sensitivity test;

In Barlas (1996) the second group of validation tests include "modified behaviour test", "boundary adequacy tests", "phase relationship test", "qualitative features test" and "turing

[56] Ibid.

test". We do not describe these tests in further detail as their specific application was not necessary for our model.

The extreme condition tests appear in both groups, and in this case the test is validating the model indirectly by "… assigning extreme values to the selected parameters and comparing the model generated behaviour to the observed (or anticipated) behaviour of the real system under the same extreme condition."[57]

Behaviour sensitivity tests are often conducted to see if in the model structure there are variables to which the model may be extreme sensitive. If the model shows these so called "soft" variables then the validation will be conducted relating the generate model behaviour to the real system behaviour to determine if, in reality, the system can present the same paths.

6.2 VALIDATION POLICIES APPLIED TO THE MODEL

As noted in the previous paragraph (6.1), the validation of the model is subordinate to the confidence which is built during the process of creating the structure of the model. For this reason the direct structure tests in our model will be briefly explained.

The knowledge of the educational system in Norway come from the collection of reports listed in Appendix III. The direct structure tests are empirical tests which are supposed to control the structure and the equations in the model comparing them with knowledge of the real system. In our case the process has been reversed and the model has been constructed after acquiring the basic knowledge regarding the system which was supposed to be modelled. With this method decision we clearly build the confidence in our model step by step during the process of creating the structure.

The direct extreme test conditions have been conducted in our model and they are the main validation tests applied to the structure. For extreme test policies (ETP) it was decided to control the population sector. The policies implemented in order to see the resulting behaviour were:

- no birth rate, no immigration and emigration;
- no salaries;
- population age cohorts missing, no immigration, no emigration and

[57] Barlas, Y. (1996). "Formal aspects of model validity and validation in system dynamic." Ibid. **12**(3): 183-210.

- population of teachers age cohort missing, no firing, no quitting.

In the first trial the extreme conditions were clear, we tried to have a decreasing population due to the zeroing of the inflows into the stock. In some case studies, especially in demography, the omission of immigration and emigration can be a reasonable assumption but in our case we attempted to keep the population behaviour as close as possible to the statistical data. The population data generated by the model are essential for other sectors of the structure, so testing this sector will also reveals if the structure presents flaws in other parts of the model. The decision to apply extreme test policy to the population is also because the predicted behaviour is easy to imagine.

The second extreme test policy we applied influenced the salaries sector. In this case we set the salaries to zero to see the population of teachers decreasing due to a loss of job attractiveness in the absence of compensation. This was used to test the assumption that salaries influences job attractiveness.

The second to last policy tested is another demographic test applied to the general population and to the population of teachers. In this case we attempt to test the structure behaviour if an entire age cohort group is set to zero.

The last policy is similar to the previous and it test also a demographic aspect of the population but in this case of the population of teachers.

6.2.1 ETP1: No birth rate, no immigration no emigration

The first extreme test conducted to validate the structure tested the population stock when the births and immigration inflows and emigration were set to zero. Under these conditions it was expected that the population size would decrease as the only available mechanism for population change is the death rate. It was also expected that all other stocks reliant on the main population stocks, such as students and teachers, would decrease, however there are differences in the rate at which the different stocks would decrease. The total national population stock decreases slowly, while the other stocks, after a time lag, would decrease drastically. Specifically, the number of students in primary education will suddenly decline after six years and reach zero after 10 years. The variable of students in secondary school will decrease after 17 years and reaches zero in three years. The stocks of students in university and students in college education will also decline, but not as fast as primary school student

and secondary school student stocks. This is due to integration of the stocks, a mathematical procedure that the software applies to count the number of students and move them into the next age cohort due to aging.

When ETP1 was applied to our model the total national population exhibited the expected behaviour described above (Figure 50).

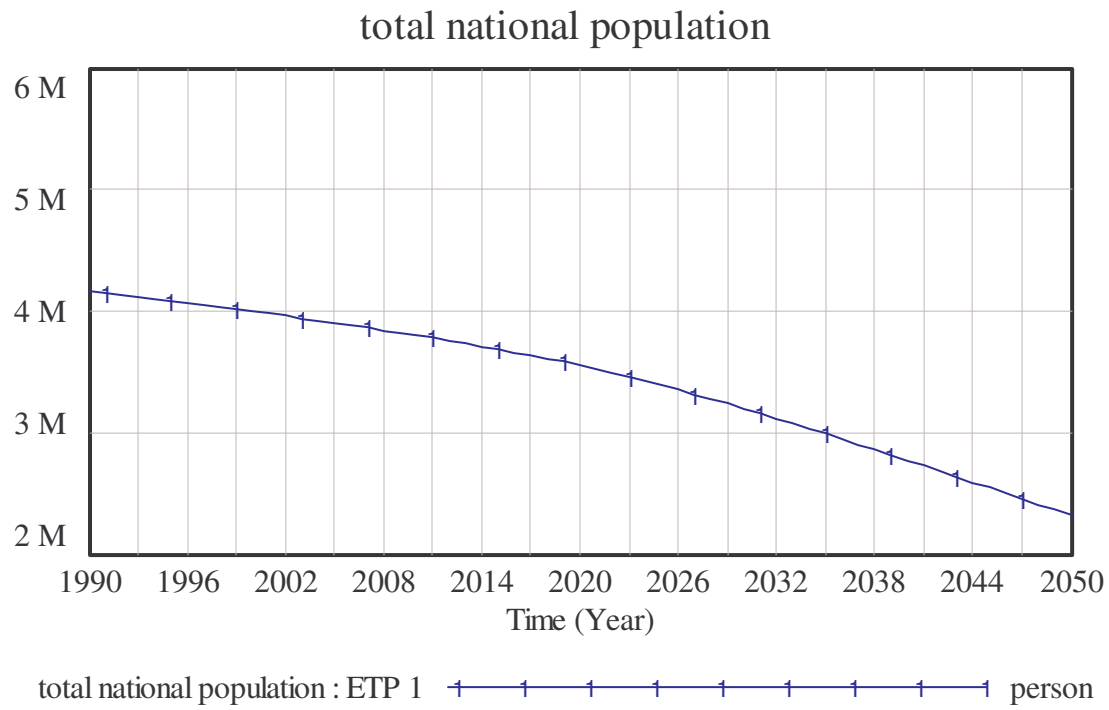


Figure 50: ETP1 Total National Population result

The population of students in primary school follows the predicted trend and suddenly declines to zero, due to no births and no immigration. The time that passes before the population reaches zero is equivalent to the number of school years that pupils must attend before they complete primary school education (Figure 51).

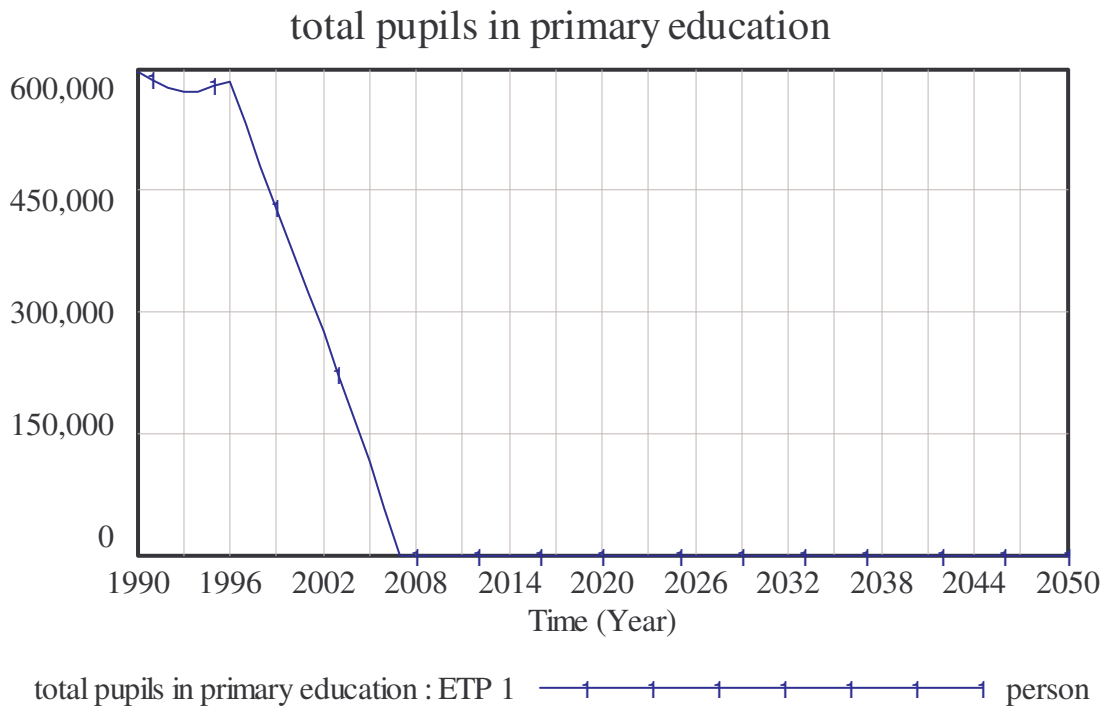


Figure 51: ETP1 Total pupil in compulsory education result

Similarly, the population of secondary students declines with a rapid decrease after 17 years. Following this rapid decline, the population size reaches zero after just three years (Figure 52).

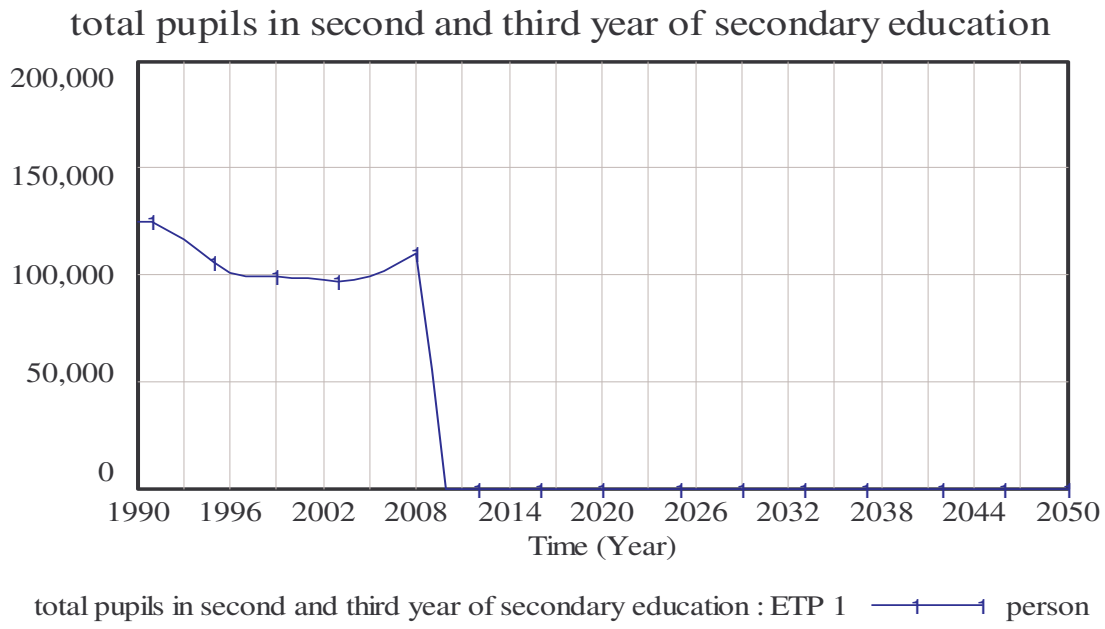


Figure 52: ETP1 Total students in upper secondary education result

The reduction of the student population, due to both birth rate and immigration rate being set to zero, directly influences the number of teachers required and consequently the size of the teaching population (Figure 53).

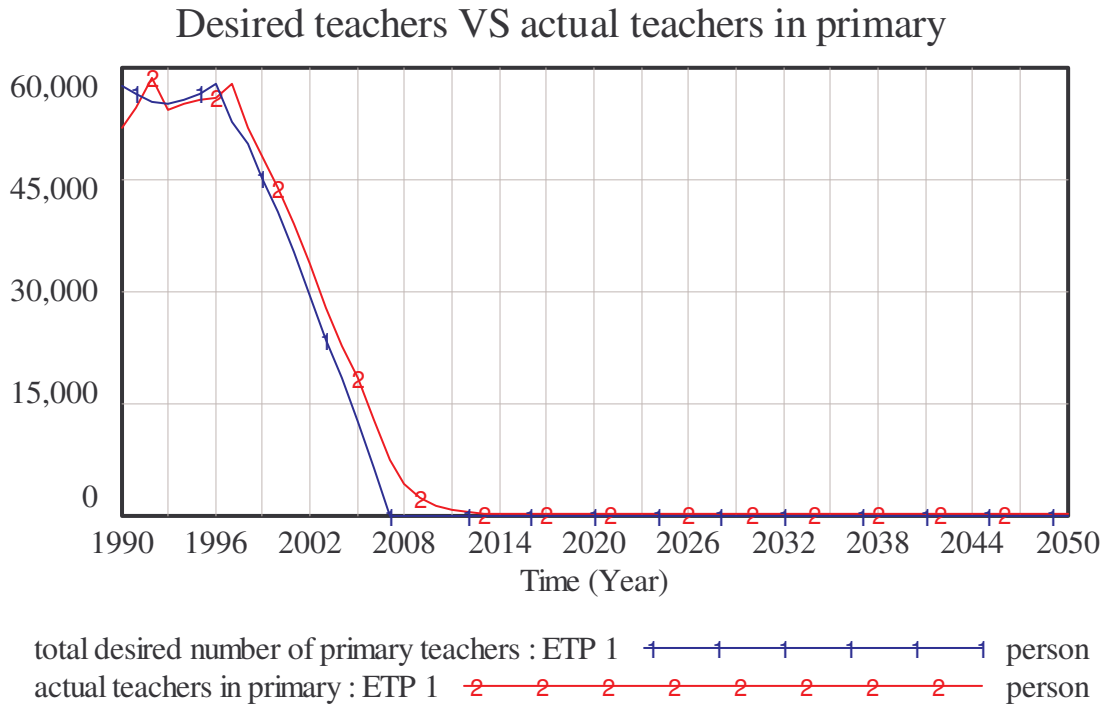


Figure 53: ETP1 Total teacher in primary education result

The results of ETP show the expected behaviour predicted as a result of the extreme test policy. The red line representing the total teachers in primary is reaches zero later then the blue line (total desired number of primary teachers). This is explained by the time delay that is present in the model. It was assumed that there is a delay of one year when a teacher is fired. The line for the total teachers in primary is smoother than the line for desired teachers. Again, the software treatment of stock integration explains this behaviour. The same trend can be seen for the desired secondary teachers and total number of teachers in secondary (Figure 54).

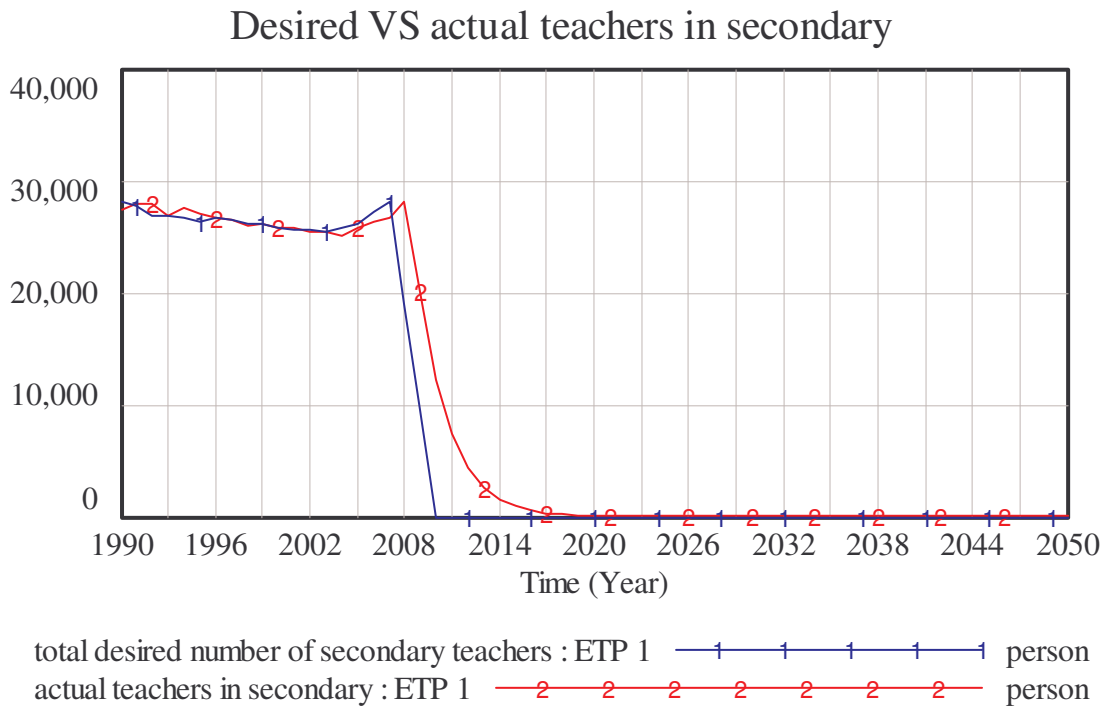


Figure 54: ETP1 Total teacher in secondary education result

6.2.2 ETP2: No salaries

The second extreme test policy applied to the model was to test the behaviour of the structure when the salaries were zero. Salary has an attraction[58] effect on the recruitment of teachers (Schone 1999), and this attraction is calculated based on the ratio of the salaries increase for teachers and employees outside of the education field. Due to the fact that attraction is a ratio we could not set the percentage of increase of salaries to zero. Therefore, to test the policy the increase was set to 1 for both salaries. The equation in the variable which calculates the ratio is equal to the increase of the salaries of teachers divided by the increase of salaries of employee with the same level of education minus one. Therefore setting to one the percentage of increase of salaries to one will give a zero result in the variable which calculates the attractiveness of salaries to the teaching profession.

The results expected are similar to ETP1 however they should present a drastic decreasing behaviour. The number of teachers will decrease but the level of desired teachers will remain stable. The teachers will decrease because there are neither new qualified or unqualified teachers entering education employment. Those teacher, both unqualified and qualified will

[58] With "attraction" we define the calculate probability for recruitment of teachers in education sector

not move from their stocks. It was assumed that moving to another level is a decision driven by economic reasons, particularly better salaries. The result of this extreme test on the number of teachers in primary education is illustrated in (Figure 55). With no salaries compensation all the teachers will leave almost simultaneously the job because it is not possible to survive without any salary.

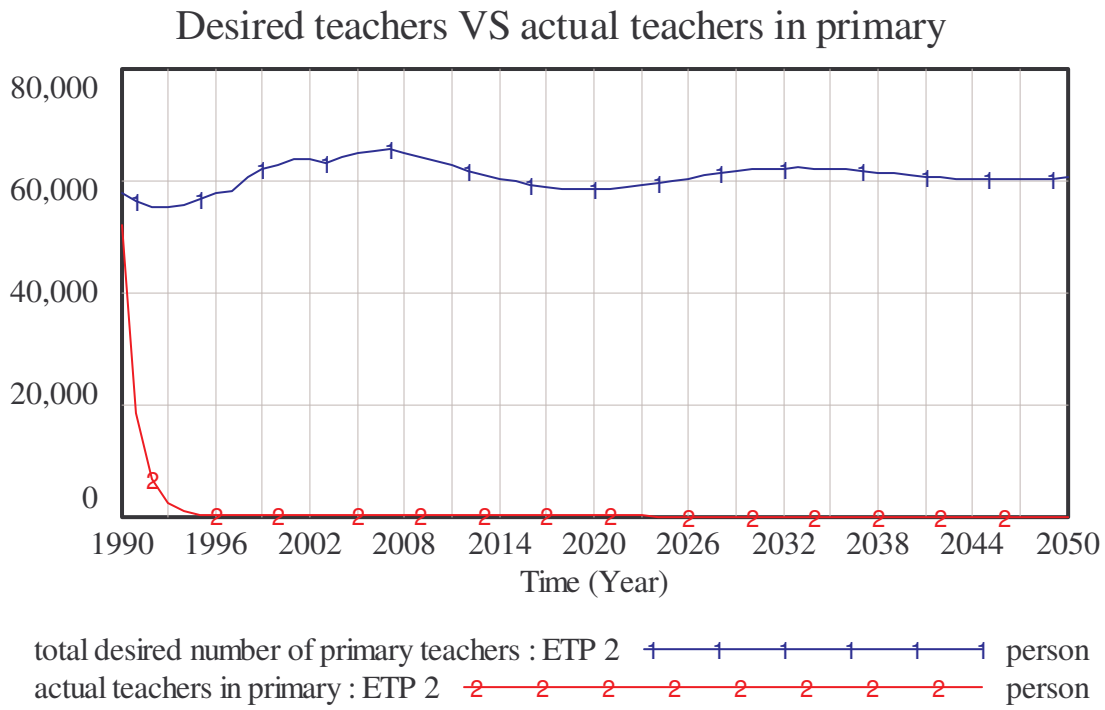


Figure 55: ETP2 Total teachers in primary education result

The number of teachers in primary school will reach zero in 5 years later and this confirms our hypothesis that the behaviour in this case will be faster. The number of desired teachers follows the normal trend as in this test the birth rate and immigration are not set to zero. Similar results can be seen in Figure 56 for secondary school teachers.

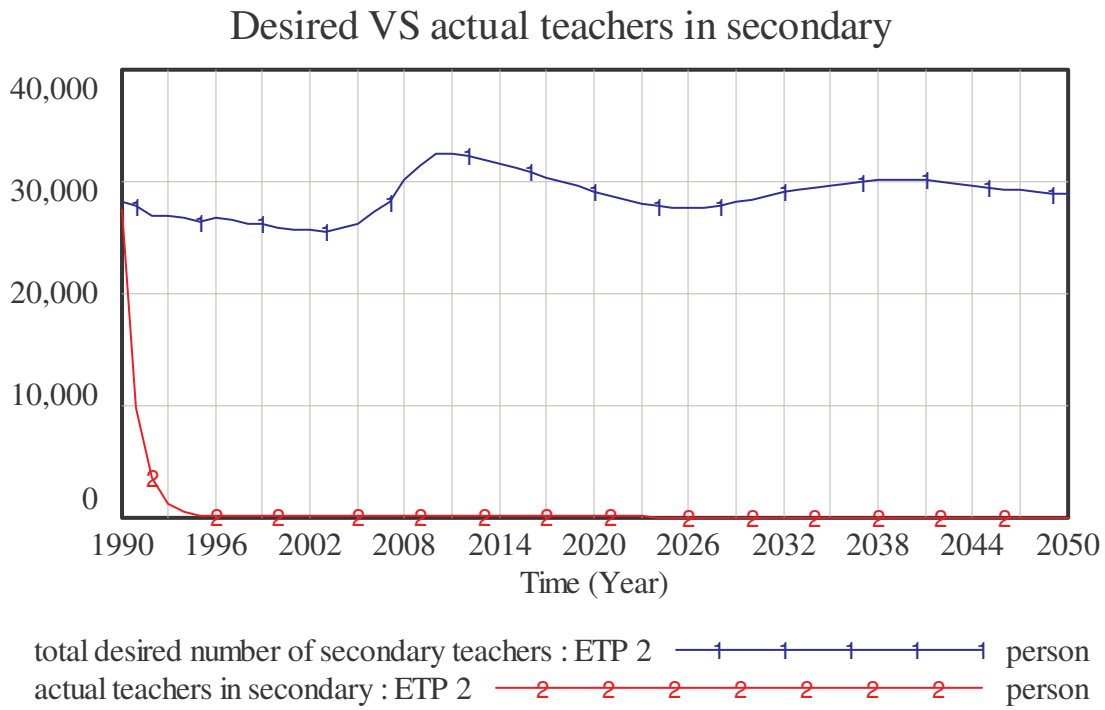


Figure 56: ETP2 Total teachers in secondary education result

Both of these results for ETP2 show that the structure seems to behave correctly, validating our model for two different extreme tests policy.

6.2.3 ETP3: Population age cohort missing, no immigration, no emigration

The second to last extreme test policy applied further tested the population sector of the model. For ETP3 some of the cohorts in the general population were set to zero, to simulate if they were missing. The immigration and emigration flows were also set to zero. We expected extreme condition to result in the zero cohorts spreading through the population as the model runs the simulation (Table 6).

Table 6: ETP3 Population age cohort missing, no immigration, no emigration result

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
[female,age40]	0	29339	28490	29736	30335	30307	30659	31228	30665	30855	30725	30434	30625	30610	31435	32048	32302	32624	32652	32974
[female,age41]	0	0	29304	28457	29702	30300	30273	30628	31198	30637	30829	30700	30410	30602	30587	31412	32024	32279	32601	32629
[female,age42]	0	0	0	29270	28424	29668	30266	30242	30598	31170	30611	30805	30676	30387	30579	30564	31389	32001	32256	32578
[female,age43]	0	0	0	0	29236	28391	29635	30235	30212	30570	31144	30587	30781	30653	30364	30556	30542	31366	31978	32233
[female,age44]	0	0	0	0	0	29203	28360	29604	30206	30185	30545	31120	30564	30757	30630	30342	30534	30520	31344	31956
[female,age45]	0	0	0	0	0	0	29170	28331	29575	30179	30160	30521	31095	30540	30734	30607	30319	30512	30498	31322
[female,age46]	0	0	0	0	0	0	0	29123	28288	29534	30141	30124	30485	31060	30505	30700	30573	30286	30478	30465
[female,age47]	0	0	0	0	0	0	0	0	29079	28249	29497	30105	30089	30450	31024	30471	30666	30539	30253	30445
[female,age48]	0	0	0	0	0	0	0	0	0	29039	28213	29462	30070	30055	30416	30990	30438	30632	30506	30220
[female,age49]	0	0	0	0	0	0	0	0	0	0	29002	28180	29428	30035	30021	30382	30955	30404	30598	30472
[female,age50]	20861	0	0	0	0	0	0	0	0	0	0	28968	28147	29394	30001	29987	30348	30921	30371	30565
[female,age51]	20184	20798	0	0	0	0	0	0	0	0	0	0	28915	28096	29342	29949	29935	30296	30868	30319
[female,age52]	19336	20124	20736	0	0	0	0	0	0	0	0	0	0	28863	28046	29291	29897	29884	30244	30816
[female,age53]	18594	19278	20063	20673	0	0	0	0	0	0	0	0	0	0	28812	27998	29240	29846	29833	30192
[female,age54]	18201	18538	19220	20002	20609	0	0	0	0	0	0	0	0	0	0	28761	27949	29190	29795	29782
[female,age55]	18085	18146	18482	19161	19941	20546	0	0	0	0	0	0	0	0	0	0	28712	27901	29140	29744
[female,age56]	18028	17999	18061	18396	19073	19850	20456	0	0	0	0	0	0	0	0	0	0	28630	27823	29059
[female,age57]	19406	17942	17914	17977	18312	18986	19763	20374	0	0	0	0	0	0	0	0	0	0	28550	27745
[female,age58]	19642	19314	17858	17831	17894	18228	18903	19684	20299	0	0	0	0	0	0	0	0	0	0	28470
[female,age59]	20006	19549	19223	17775	17749	17813	18148	18827	19611	20232	0	0	0	0	0	0	0	0	0	0

The ETP3 also has an effect on the pupils population, there is a slightly difference in birth, since the female age cohort group from 40 to 49 is missing. Nevertheless this age group is the last one in the fertility distribution and the number of birth per 1000 women is extremely low. For this reason, since the difference from a normal run where the group is present is so minimal, no figure is presented.

6.2.4 ETP4: Population of teacher age cohort missing, no firing, no quitting

The final extreme test policy applied to the model was to test the structure of the aging chain in the teacher population stock. The same parameters as those used in ETP3 were implemented. For the initial value of the teachers stock the cohort group from 30 to 39 years was set to zero59. We expected a slightly different result to that of ETP3, as in ETP4 we expected that the number of teachers would increase as a result of the hiring rate which continues to hire teachers within that age cohort. Therefore, the difference in the values between the 29 and 40 age cohort and the 30 and 39 age cohort will remain close to constant (Table 7).

Table 7: ETP 4 Population of teachers age cohorts missing, no firing, no quiting result

[59] The decision to use the age cohort 30 to 39, rather than 40 to 49 as in ETP3, because in the stock of population of teachers the age cohort 50 to 59 is decreased further by the outflow of teachers moving from primary to secondary schools. Therefore the difference between the numbers of people in every single cohort was expected be to small to see.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
[female,tAGE 30]	**0**	**204**	365	532	715	861	1031	1151	1235	1319
[female,tAGE 31]	0	**116**	**300**	491	682	832	1008	1142	1249	1359
[female,tAGE 32]	0	69	**228**	**426**	628	788	969	1113	1236	1368
[female,tAGE 33]	0	52	175	**356**	**559**	728	914	1067	1203	1350
[female,tAGE 34]	0	45	145	298	**487**	**655**	846	1006	1151	1311
[female,tAGE 35]	0	42	128	257	423	**581**	**768**	932	1085	1253
[female,tAGE 36]	0	39	117	229	373	513	**689**	**851**	1008	1181
[female,tAGE 37]	0	36	109	209	335	457	617	**769**	**924**	1098
[female,tAGE 38]	0	34	101	194	306	412	554	693	**840**	**1011**
[female,tAGE 39]	**0**	32	94	180	282	376	501	625	760	**923**
[female,tAGE 40]	**559**	**234**	163	194	271	349	459	568	688	839
[female,tAGE 41]	588	**461**	**320**	271	295	342	430	522	627	763
[female,tAGE 42]	618	591	**491**	**401**	368	370	424	493	580	698
[female,tAGE 43]	647	651	616	**543**	**480**	438	451	488	550	648
[female,tAGE 44]	677	686	690	658	**601**	**536**	513	513	545	617
[female,tAGE 45]	643	693	726	732	704	**643**	**599**	569	568	609
[female,tAGE 46]	610	674	732	769	774	735	**692**	**646**	618	629
[female,tAGE 47]	576	643	715	775	810	801	775	**729**	**686**	673
[female,tAGE 48]	543	608	685	759	817	836	835	803	**760**	**733**
[female,tAGE 49]	509	573	650	730	801	843	868	858	827	**799**

The blue numbers are referred to the age cohorts which preceded and follow the first and the last one that we took in consideration in our age group test (30 to 39). The black and bold numbers are the first and the last age cohorts of the group tested. With the two colours it was tried to highlight the difference between the age group cohort tested and the rest of the age cohorts.

6.3 OTHER VALIDATIONS

To ensure that a model structure is solid and appropriate compared with the real system, a further type of analysis can be performed during the validation process. This last validation test consists of comparing the model behaviour to the historical data and determing if the model accurately represents and fits the main trends in the real data.

Our conclusion that the model structure is sound is further reiterated by a model run for the bachelor students in university. Figure 57 shows that the trend in the size of this population generated by the model is similar to that in the historical data. The same is true for students at university in a master level (Figure 58)

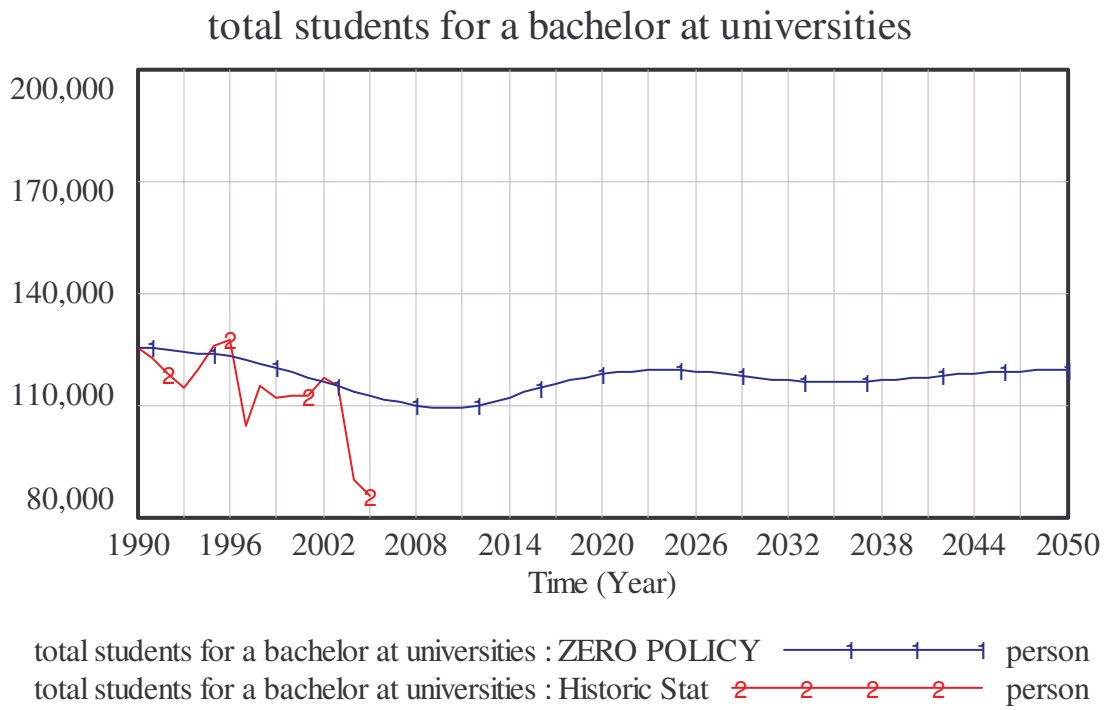


Figure 57: Total students for a bachelor at university, at year 1994 one university did not provide the data, in 1997 the NTNU (Trondheim University) was formed and in 2005 data were not all registered

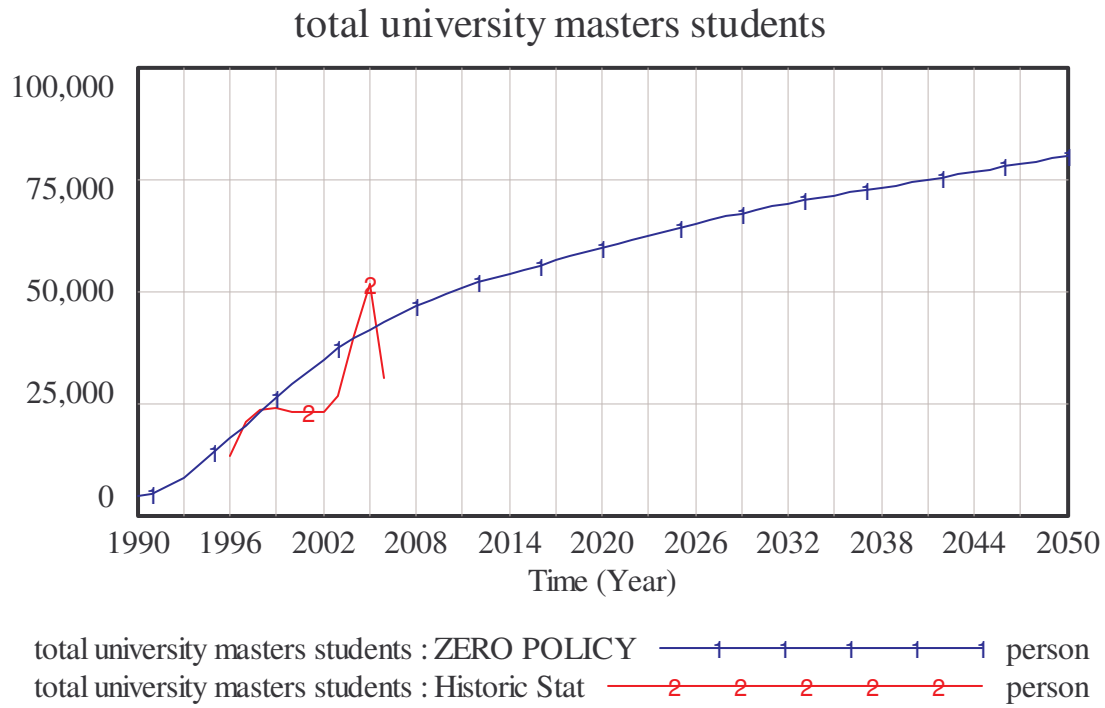


Figure 58: Total university master students. The fast increase between years 2002 till 2005 is due to the last university reform where the courses were changed from five to three years the bachelors and masters programs were considered the additional two years after the bachelor

The model also seems to fit the historical data for the population of students at university in the faculty of science (Figure 59) and for the graduates from the same faculties (Figure 60)

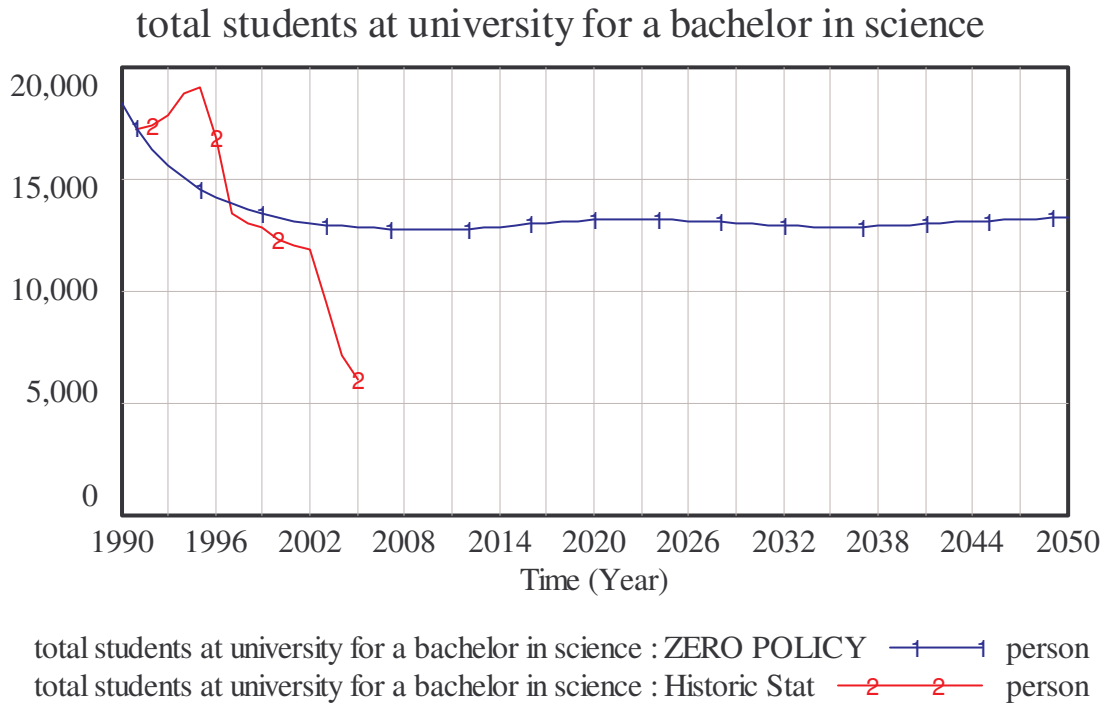


Figure 59: Total students for a bachelor in science faculties, in the first year some university had delivered partial data while in the last year the data are missing. Nevertheless is possible to see that there was a decreasing trend in enrolling of students in science faculties, but it tends to stabilize

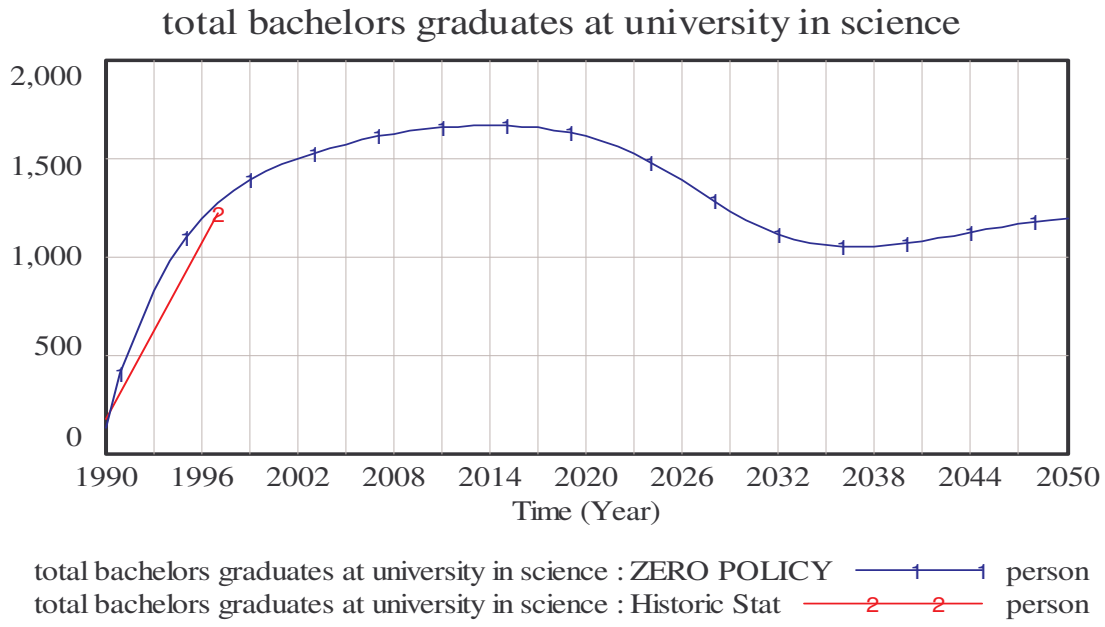


Figure 60: Total bachelors graduates at universities in science

Due to a lack of data, we do not illustrate all the other variables in the model that present behaviour which reflects the relevant historical data. It is not necessary to show every single variable or stock to validate the structure, and for this reason it was decided to show only a part of the structure. The university sector was one of the most difficult to build in the model for a number of reasons. Nevertheless it seems that although the structure does not perfectly represent the statistical data it is reasonably accurate.

For correctness to the central point of this thesis the number of desired teachers is also compared to the historical teacher data found in the SSB database (Figure 61).

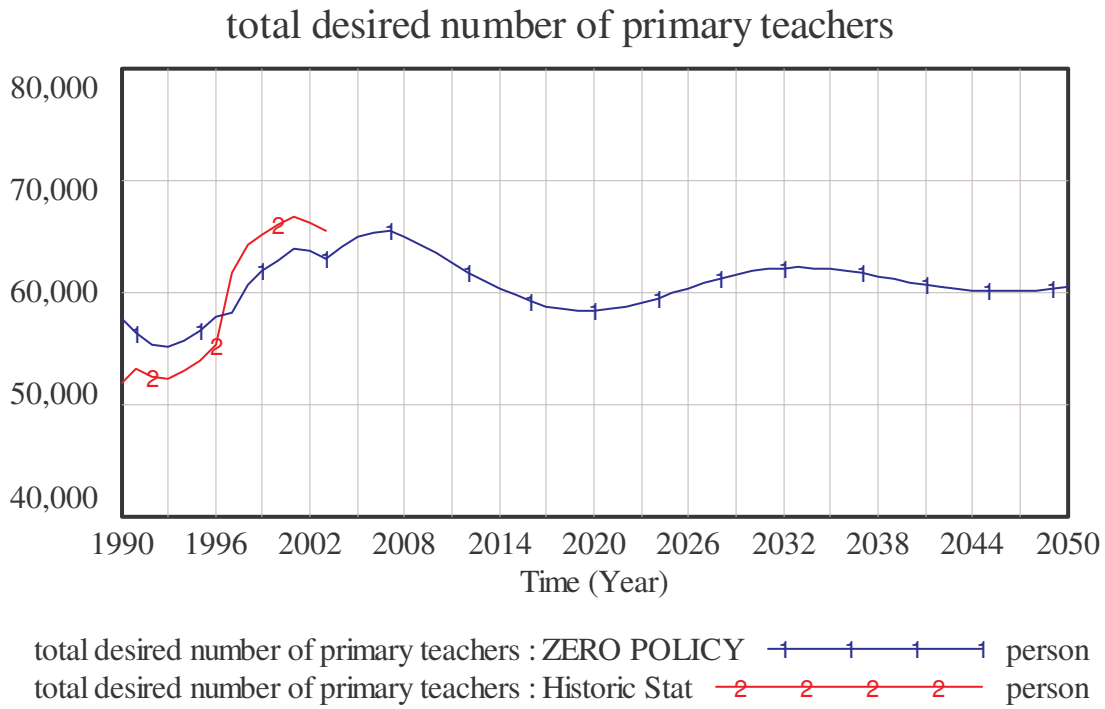


Figure 61: Total desired teachers in primary, SSB provide the number of teachers employee in the primary education, our model calculates this desired level using different passages (chapter 5 paragraph 4.1.1). The model behaviour seems to follow a similar behaviour to the statistical data

The model reproduces the number of total teachers in primary based on the desired level generated by the model itself. For this reason if the desired level is following a similar path as the statistical data then the total number of teachers in primary will follow a closer behaviour (Figure 62).

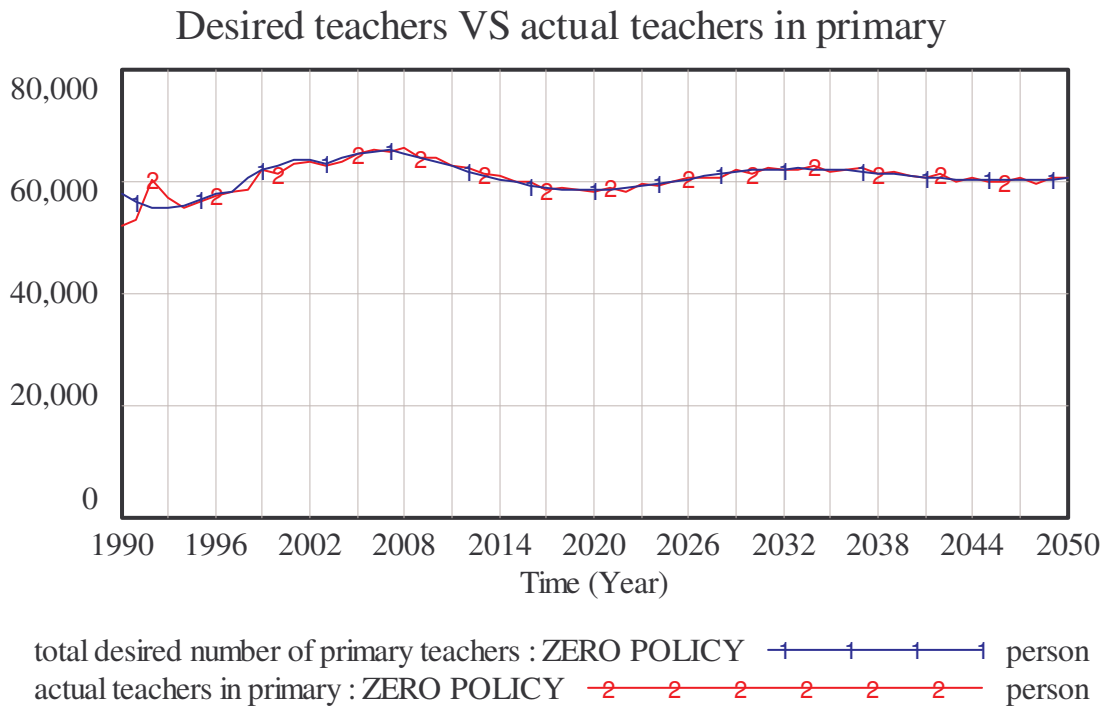


Figure 62: Desired teachers in primary VS actual teachers in primary. The two lines show the progress in the future of the desired population of teachers versus the actual population of teachers in primary, as it possible to see the model seems to recreate an accurate behaviour

The same types of behaviours are also present in the sector related to the total science teachers in primary and secondary. The following chapter will present the problem that lies in the number of qualified science teachers in secondary.

In this section no sensitivity tests were conducted, for three main reasons. Firstly, there is no available data for the system to suggest that it is sensitive to some variables. Therefore without a reference mode of the system, which may indicate the presence of sensitive variation in the behaviour, is impossible to run a sensitivity test. Secondly, those parameters such as the non-linear relationships found in the report and discussed in paragraph 4.4.1, do not cause large changes. This indicates a solid structure which is not sensitive to smaller changes. Finally, our structure is mainly constructed of an ageing chain which is a solid structure that is generally not sensitive.

7 POLICIES TESTED AND RESULTS OF THE MODEL

The following chapter has been divided into subsections which refer to the model behaviour in cases that policies have been applied or not. Every paragraph represents one particular scenario, one particular run of the model with determinate initial condition. The effects of the policies and their sustainability will be the discussed in every paragraph. . As it was reported in the first chapter, paragraph 1.7, we are going to present four different policies to see if the problem can be avoided. We will also describe the possible negative effects that these policies may provoke in terms of plausibility.

- In the first paragraph it will be illustrated the future scenario of the educational system in Norway if there is not going to be any change "ZERO POLICY" and it will be discuss where the problem is laying and if there are more concerns in the system that should be considered;
- The second paragraph will show the first policy applied to the model. In this case the policy try to avoid the problem by affecting the salaries, which from the previous knowledge acquired from the report, seemed to be a central point for the recruitment of teachers. This policy "INCREASE WAGES" will show the results if the wages of all teachers will be further increased, following the trend of the last years;
- The third paragraph illustrates the second policy "TRAINING/UPGRADING" which is affecting directly the teaching work force. It was not possible to track down the number of teachers which every year are following training courses so in our base model we assume that there are not teachers completing these types of courses. The policy tried to see the effect of recruiting general qualified teachers in secondary into training to decrease the shortage of qualified science teachers in secondary. It also explain what are the possible repercussions on the general qualified teachers in secondary if a major percentage of the workforce is moving to recruitment and leave their general positions to cover the available science positions;
- The fourth paragraph is presenting a policy which is a combination of the first and second. This third policy "INCREASE WAGES and TEACHER TRAINING" will see the effect of the two previous policies if they are not effective enough separately.

7.1 ZERO POLICY

This first scenario is intended to illustrate the situation in the educational system if changes are not implemented in the current system. It is important for us to present this type of scenario as it is our aim to determine whether there is, or will be in the future, a shortage of qualified teachers. In the previous chapter we tested the validity of our model and in the final paragraph (6.3) it was shown that the model behaviour compared well with the historical data[60]. This type of validation allowed us to assume that the generated data in the model are approximately realistic, and allow us to see where any problems may lie.

The first research question (Chapter 1 paragraph 1.5), "Are the concerns expressed in different national reports justified? Is the Norwegian school system on the edge of a crisis in shortage of qualified teachers in science subjects?", seems to be confirmed by the results of our model (Figure 63).

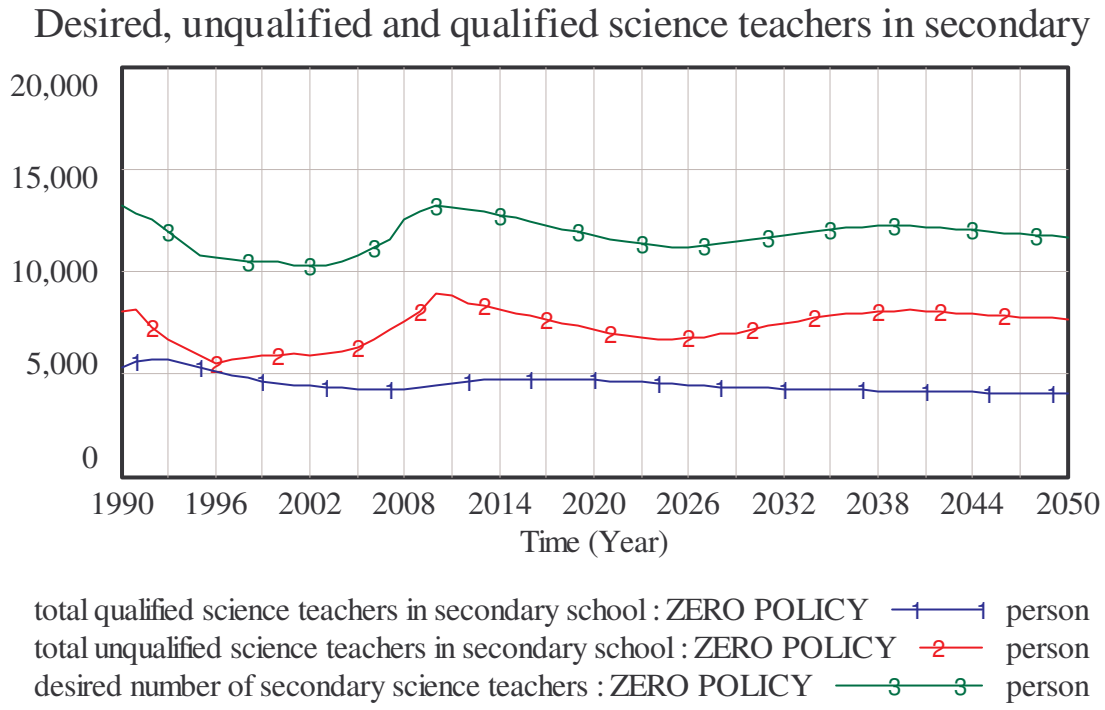


Figure 63: Desired, unqualified and qualified science teachers in secondary schools. As the graphic confirms there is a lack of qualified science teachers in secondary

[60] Not for all the stocks we have the historical statistic so only a part of them were presented. Since the model seems to fit those data we assume that also for the other stocks the behaviour could be realistic.

The results show that there is clearly a problem in the educational system and that there is a lack of qualified science teachers in secondary school education. The situation seems to appear even worse than what was expected from the reference mode (chapter 5, paragraph 1). From the reference mode we expected that the level of qualified teachers would decrease suddenly while the unqualified would increase rapidly. The model seems to illustrate this problem but the exact pattern of the results are different. Figure 63 shows that the number of qualified teachers is not higher than the unqualified in the starting year. The two lines of the unqualified and the qualified do not cross. There is a constant shortage of teachers, also compared to unqualified workforce, and it is demonstrated that this problem has not arisen recently. The results of the model suggest that not only are the concerns raised in the media justified, they have infact been delayed in receiving mainstream attention. The low numbers of qualified science teachers can be traced back to the short supply of qualified scientific work force (Figure 64).

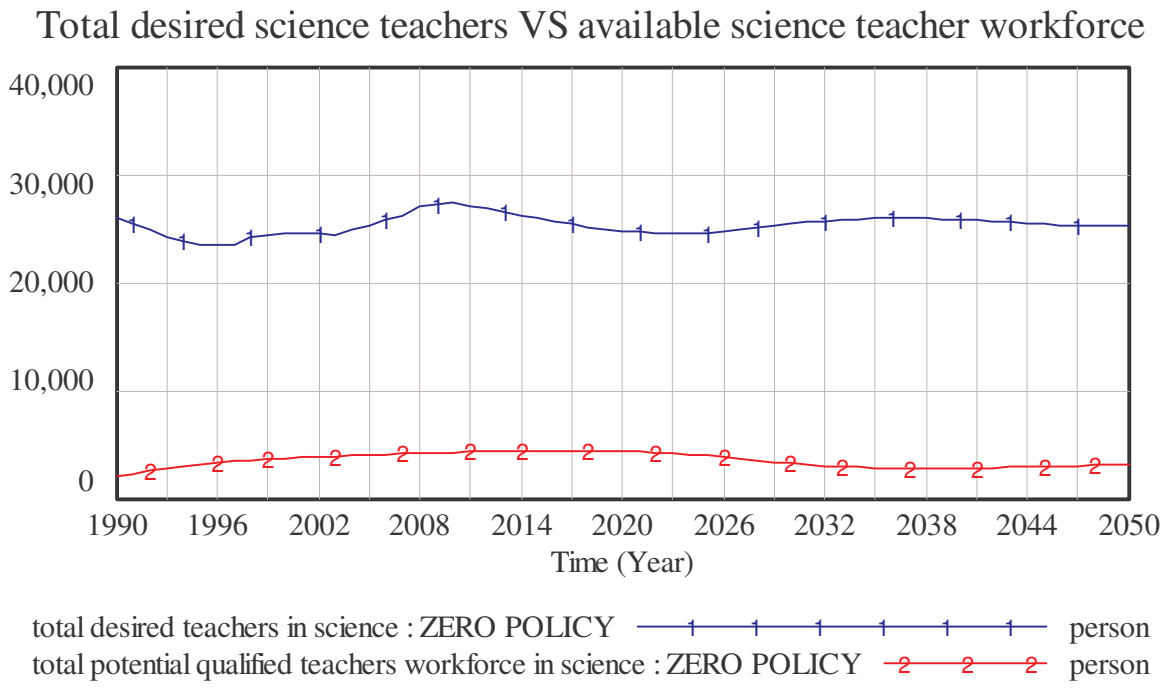


Figure 64: Total desired level of science teacher VS total potential qualified workforce in science

The situation is different for science teachers in primary education, and in this part of educational system there is not a drastic teacher shortage problem as in secondary schools. The model results demonstrate that this assertion is correct (Figure 65).

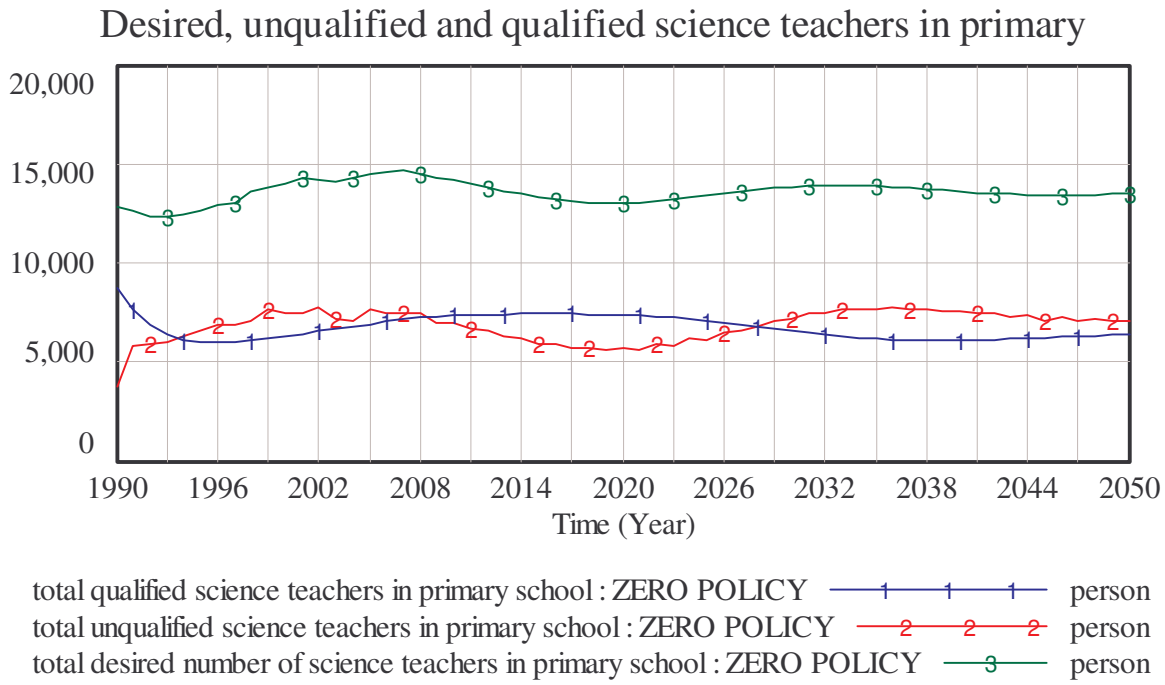


Figure 65: Desired, unqualified and qualified science teachers in primary. The graphic is illustrating the future trend of the teaching work force in primary schools. As it possible to see the qualified teachers are almost half of the total population of teachers, which can be considered not a problem. From 2008-2009 the system seems to face a positive trend and the number of qualified teachers will be higher than the unqualified

It could be said that the number of qualified teachers should be improved to guarantee a higher level of teaching for pupils. Nevertheless the "ZERO POLICY" scenario has illustrated some positive effects on the teaching workforce. The "ZERO POLICY" scenario includes variation in the salaries after the agreement called "school package 2". This implementation seemed to decrease the numbers of staff leaving the teaching profession. However this effect was no longer evident after a short time (Figure 66). The rate of leaving the profession is one of the main causes for the turnover of teachers. The other causes, such as the presence of unqualified teachers and age, have a negative influence on the population of qualified teachers. As we reported in the first chapter we wanted to highlight the importance of changes in salaries to reduce the rate of turnover.

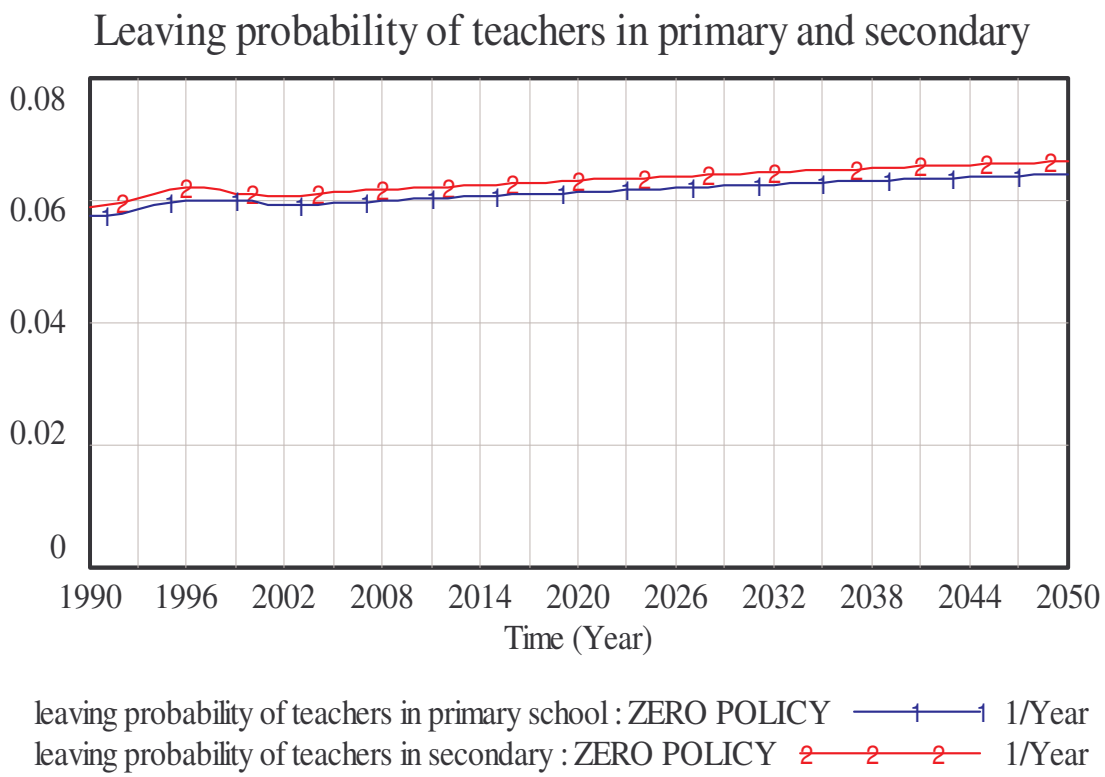


Figure 66: Leaving probability of teachers in primary and secondary results, "ZERO POLICY scenario

In 2001 an agreement between the government and the teachers union was signed and the "school package 2" was implemented, along with an increase in salaries. It appears that salaries of teachers in primary (red line) has been rising, which corresponds to a decrease in the probability of staff leaving before the "school package 2" was applied. We did not have any information about this positive trend which corresponded with an increase in wages before 2001. Nonetheless, as previously mentioned, the "school package 2" seemed to have a very slight and short lived effect on retaining teachers. Both lines are decreasing from 2001 until 2002 but after this they constantly increase. Figure 66 illustrates that in the future, after 2002/03, the ratio between wages of teachers and national wages will be in favour of employees outside the educational system. This increase in salaries, which will be presented in the following paragraph (7.2.1), is suggested to decrease the probability of staff leaving as shown in (Figure 72). This trend suggests that if a policy which increases wages is implemented in the future then it is unlikely that it will be effective if it takes a similar form to the current policy. For this reason the first policy we have tested has focussed on the wages of teachers and is referred to as "INCREASE WAGES".

7.2 INCREASE WAGES

From the time when the first information about the system was collected the salaries of teachers and their attractiveness[61] has played a central role in the model. Schøen (1999) conducted research on the relationship between salaries and job attractiveness in the education industry, and its importance in retaining or gaining staff. Salaries have an important role in all employment sectors, not only in education, however in recent time the salaries of teachers have been increasing every year suggesting that recruitment policy has attempted to use increased salaries as an incentive.

In this "INCREASE WAGES" policy the percentage increase in teachers wages was changed so that we could see what the effect on the number of new applicants would be. The increase percentages in the model are constant variables that are not created endogenously. A table function in Vensim, which is a constant variable, takes the values per year and when it reaches the final value it uses this as a constant for the future.

7.2.1 Wages situation with "ZERO POLICY"

The salaries of teachers in the "ZERO POLICY" scenario followed an exponential increase[62] as did the salaries of full time employees outside of the education sector (Figure 67).

[61] With "attraction" we define the calculate probability for recruitment of teachers in education sector

[62] The last value of the time table data is equivalent to the average percentage of increase in the historical data we found. Vensim use that value as a constant so in the following years the gross salaries has been increased of the same percentage every year. The same effect is present in the salaries of employee out side education.

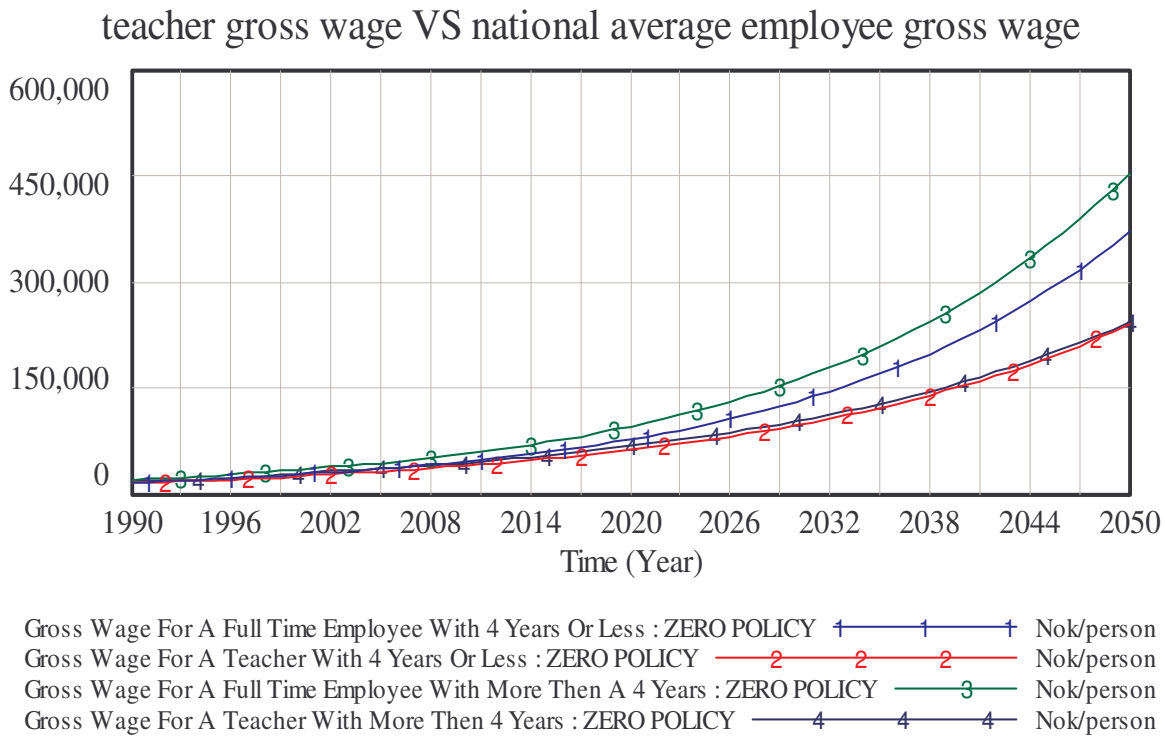


Figure 67: Teacher gross wage VS employee gross wage by education level reached. The salaries follow an increasing trend as in the last year, until they exponentially grow.

The wages seem to increase faster for employees outside of the education sector and this trend seems to reflect what is happening in reality. The wages of teachers are low compared to the national standards and the trend of growth is slow compared to wages in other jobs which require the same level of education. The increasing difference in wages between sectors is problematic for teachers in both levels of education; primary and secondary (Figure 68). This disadvantage reduces the attractiveness of salaries to the lowest level (Figure 69).

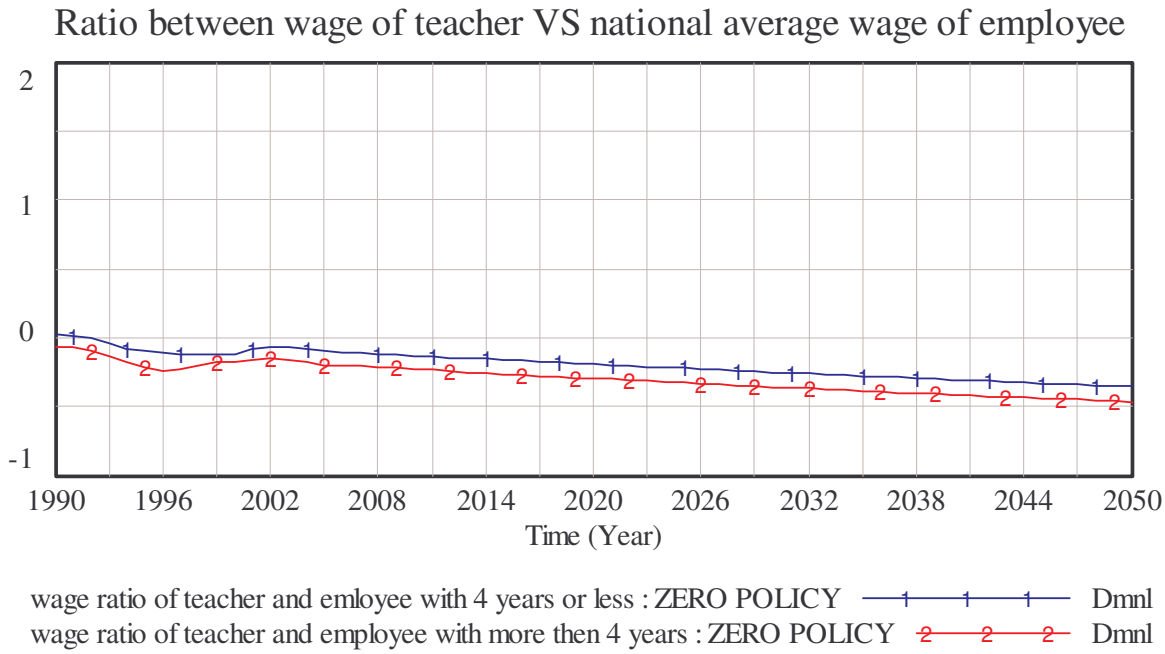


Figure 68: Wages ratio between teacher and employee. The trend of the ratio between the wages is showing a decreasing behaviour and this shows a clear disadvantage for the teachers and the attractiveness to the job

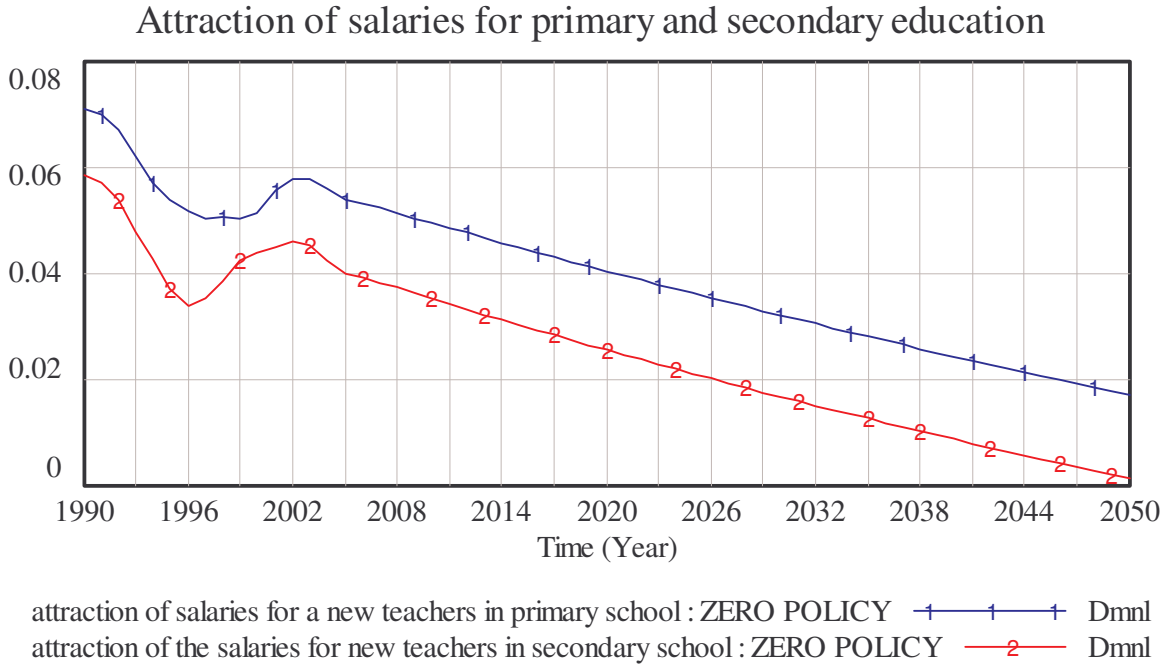


Figure 69: Attraction of wages for primary and secondary teachers, blue line for teachers in primary school and red line for teachers in secondary school. The attraction of salaries is calculated using a non linear function found in Schøen (1999) (see chapter 4)

7.2.2 Wages situation with "INCREASE WAGES" policy

The "INCREASE WAGES" policy attempted to change the behaviour seen in Figure 69 to determine if increasing wages leads to any positive and visible changes in the population of science teachers. The policy applied simply changed the final value of the time table variable for the percentage of increase in wages for teachers. The values for the "ZERO POLICY" run were equal to 4.5% for the teachers with four years or less of education and 4.2% for the teachers with more than four years of higher education. These final values did not correspond to the final increase in the teacher wages but to the average increase applied in recent years. In the policy the values for the teachers with four years or less was increased from 4.5% to 6.8% and for the teachers with four years or more from 4.2% to 8%.

The results of the model show that the difference between the wages in the different sectors changed and moved closer to being in favour of teachers (Figure 70).

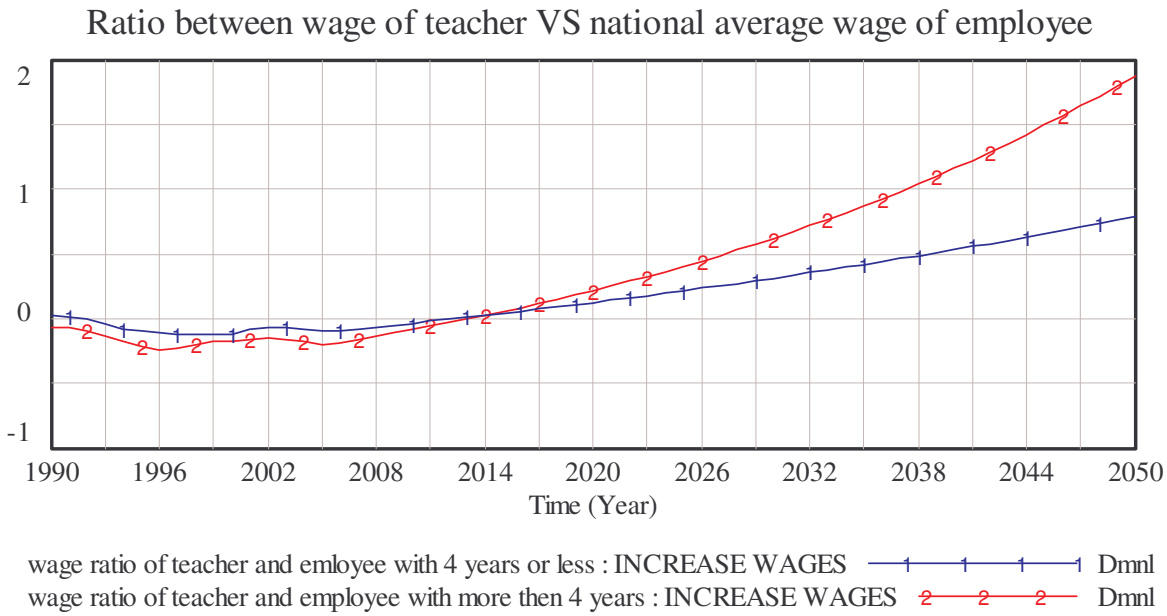


Figure 70: Wages ratio between teachers and employee results of the "INCREASE WAGES" policy, the ratio in this case is in advantage of teacher.

With this new ratio between the two wages it is possible to also see differences in the attractiveness of salaries which directly influences the attraction of new teachers (Figure 71).

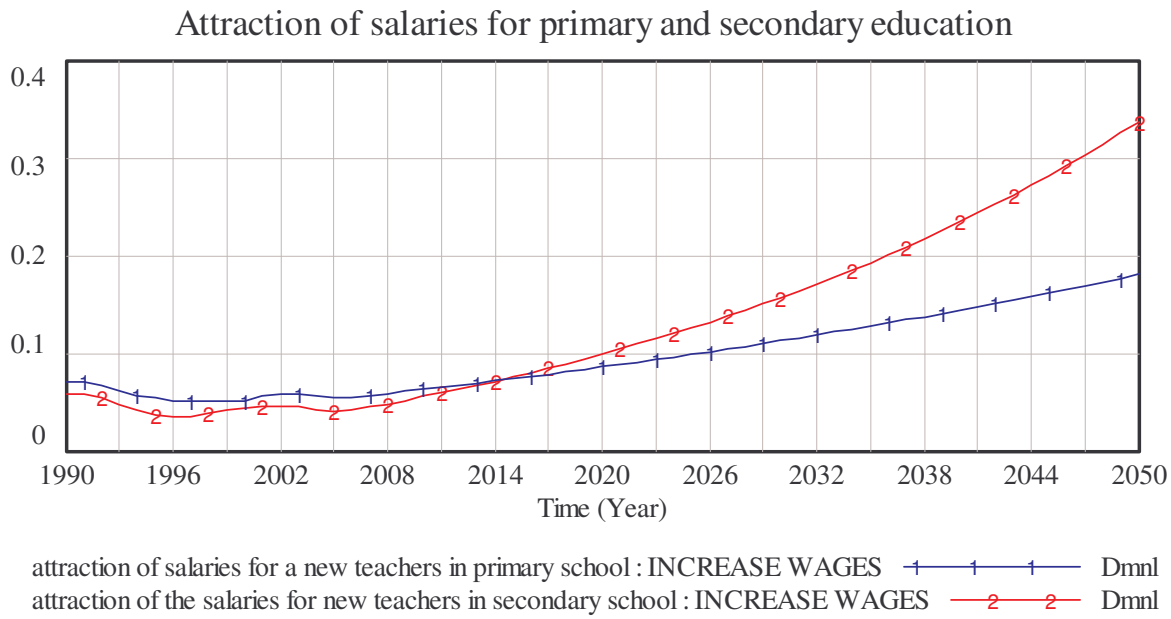


Figure 71: Attraction of wages, blue line attraction of teachers in primary school and red line attraction of teachers in secondary school

Therefore it can be said that this policy helps the recruitment of teachers into secondary schools (Figure 73) and assists with the retention of teachers, as increased wages reduces the probability of staff leaving (Figure 72). This effect is double sided; on one side it is positive because the education workforce is not moving in other work positions. Alternatively, if no teachers leave their employment no positions will become available for newly qualified teachers.

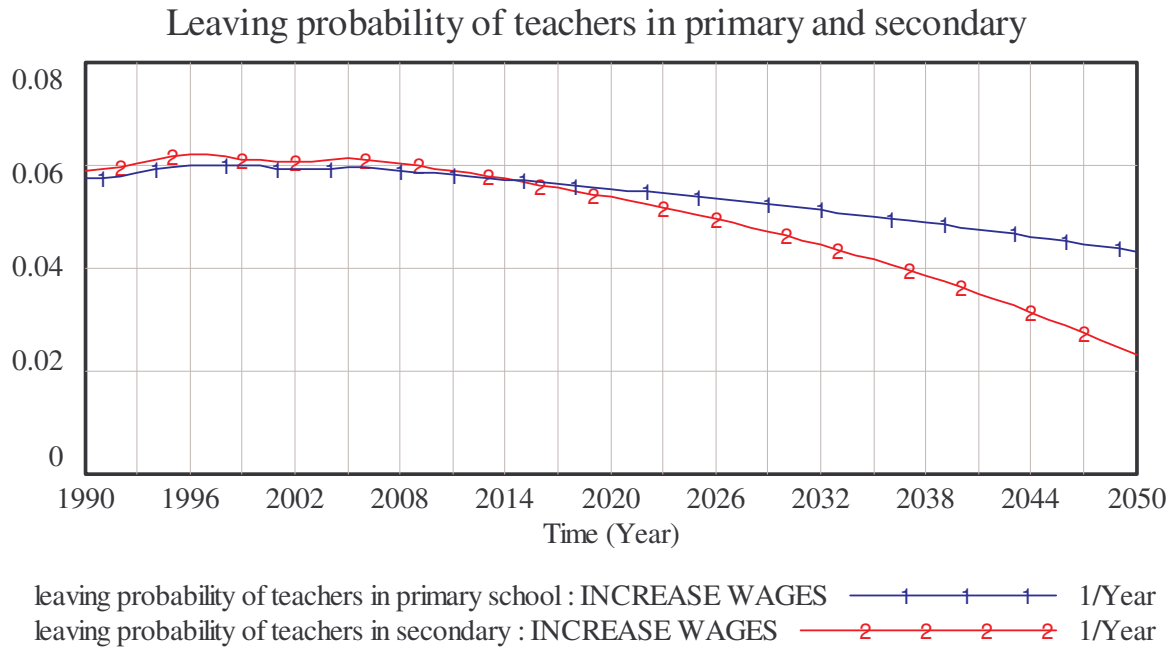


Figure 72: Leaving probability of teachers in secondary and primary results, "INCREASE WAGES" scenario

Nevertheless the two main effects of the policy (attraction and retention), even if we consider their effect as positive, seem to be too weak to increase the number of science teachers in secondary school. That is, the general results of the policy do not provide sufficient improvement.

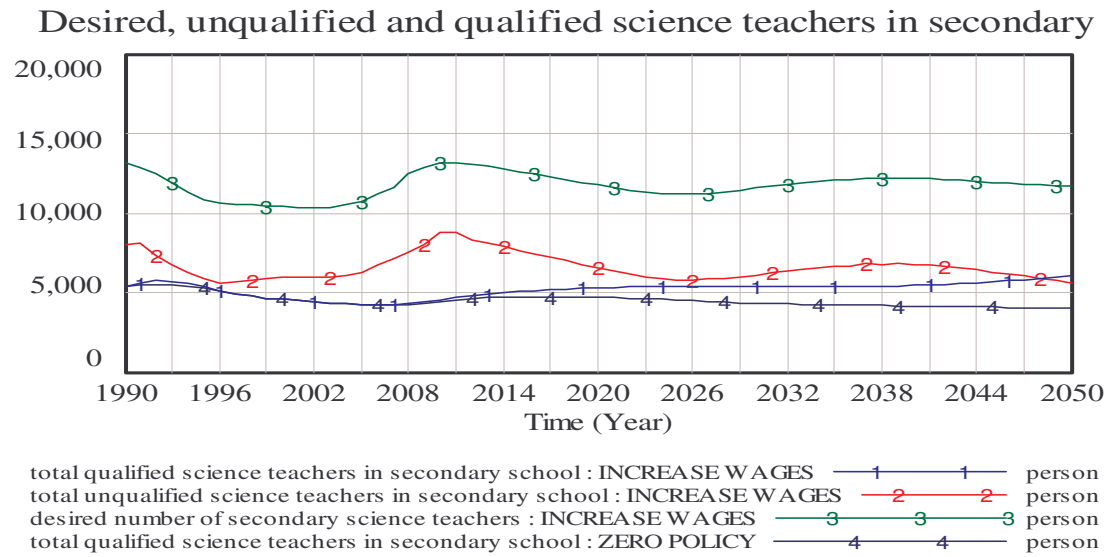


Figure 73: Desired, unqualified and qualified science teachers in secondary after the policy "INCREASE WAGES". The graphic shows that the policy has a positive impact as expected. The two lines (qualified and unqualified) are closer comparing the results with "ZERO POLICY" run. There is an increase in recruitment and in retaining, but the shortage of qualified teachers is still present

As previously mentioned, the wages in the education sector appear to be increasing, although not as fast as the wages in other employment sectors. Increasing wages, and the rate with which they increase over time, as carried out in our policy, effects the recruitment and the retention of teachers and will produce a positive effect on the recruitment where there is a shortage. However this policy alone does not represent a total solution to the shortage of teachers nor improvements to the qualification level of the workforce. The numbers of qualified and unqualified teachers became closer but the number qualified teachers remained lower than the unqualified until the last three or four years of the model simulation. In addition, the policy did not seem to eliminate the shortage of teachers. However the small increase in teachers can be considered positive even if the shortage is far from be fulfilled. For example, the higher number of qualified teachers means that a higher percentage of students will be taught by a qualified workforce.

This policy also caused another effect that should be highlighted. The higher the rate of increase in secondary school teacher salaries the lower the supply of qualified primary school teachers. In chapter 5 we presented the structure of the supply of qualified teachers in primary and secondary. A percentage of secondary teachers are qualified to teach in primary school, and this part of the workforce is attracted by the salaries. If the salaries of secondary teachers are increasing faster than those in primary, there will be a negative effect on the qualified teaching workforce in primary (Figure 74).

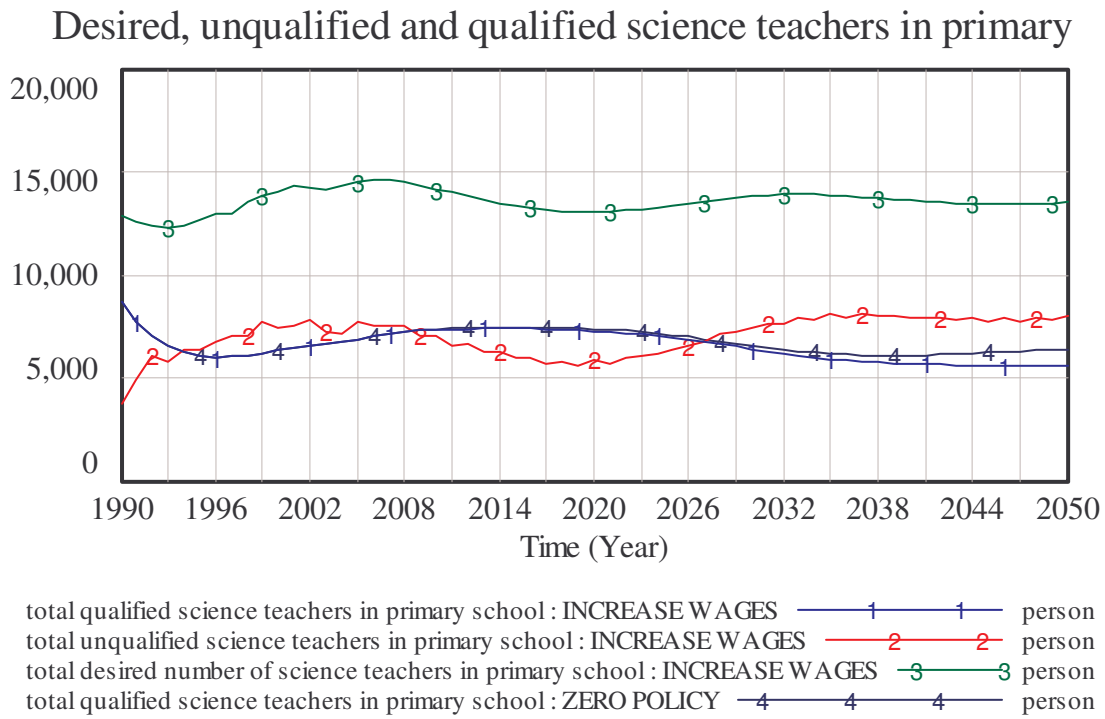


Figure 74: Desired, unqualified and qualified science teachers in primary. This graph is illustrating the negative effect of increasing salaries on the teaching workforce in primary schools. Even if the policy is influencing the recruitment the rate increase of salaries for qualified teachers in secondary is absorbing part of the supply intended to primary schools

The results of the "INCREASE WAGES" policy imply a further important point - the sustainability[63] of the policy in terms of state finances (see Chapter 5 paragraph 5.3). The total salaries of teachers in primary and secondary schools are a percentage of the total expenditure for education allocated by the government[64]. As mentioned in paragraph 5.5.3, we assume that the total salaries, for teachers in primary and secondary schools, should not equal more than 50% of the total government expenditure in education. Comparing the proportion of the total salaries, for teachers in primary and secondary, in the different scenarios (Figure 75), "INCREASE WAGES" and "ZERO POLICY", it is evidentent that the cost of the implemented policies is too high to justify in light of the small increase in the recruitment of teachers.

[63] For sustainability we mean the capacity of the policy to be sustained by the economy without compromising the future expenditure and costs.
[64] In the presented Figure 71 the expenditure of education are the total Government Expenditure for all the educational system, including university and college.

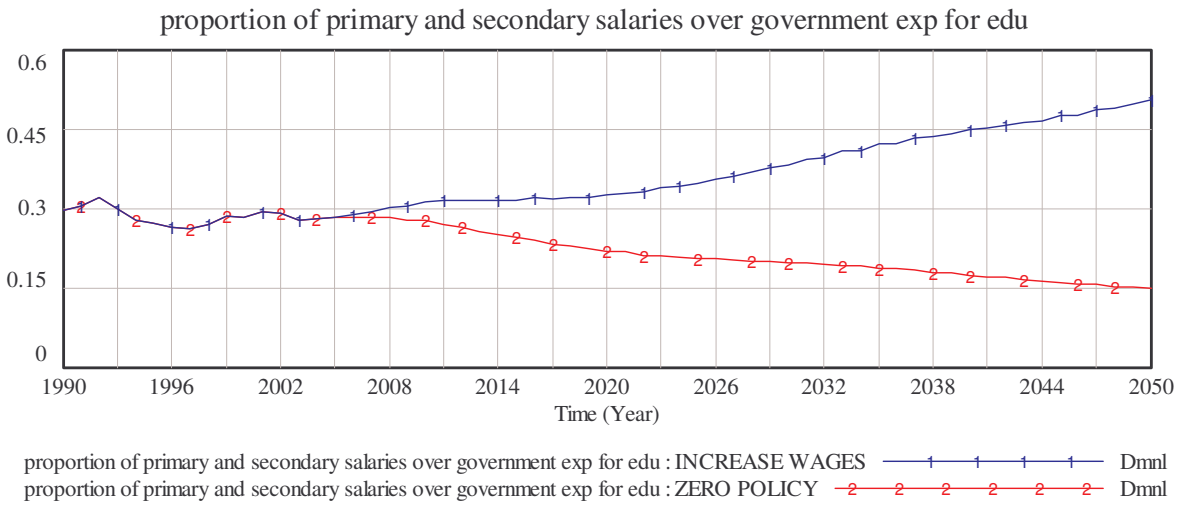


Figure 75: Proportion of wages over total expenditure for education, results compared between "ZERO POLICY" and "INCREASE WAGES" policy.

In the "INCREASE WAGES" policy the total salaries were approximately 45% of the total government expenditure for education. In the "ZERO POLICY" scenario the total salaries decreased to 15%. Comparing then the results obtained from the two policies, in Figure 63 to those in Figure 73, it is possible to deduce that an increase of 30% in expenditure is probably too high to maintain when compared to the results obtained.

These results suggest that the policy of increasing salaries for teachers followed in recent years had a small positive effect, but it seemed to be ineffective in maintaing high recruitment and retention in the teaching population. With our model simulation it was possible to see the impacts if the policy was kept and reinforced. The results were not as expected. Even with a major increase in salaries the number of qualified teachers did not change enough to eliminate the shortage and bring the number of qualified teachers higher than the unqualified workforce.

7.3 TRAINING/UPGRADING

The third policy tested in the model was regarding the upgrading of general secondary teachers into science subject qualifications. The basic idea of the policy is to train the qualified teachers in general subjects into science subjects to create a new supply of qualified teachers in science. In reality there is a small percentage of teachers which take courses to upgrade their education of their own freewill, but in our model we did not consider this segment of the population due to a lack of statistical data. In most cases teachers attend

courses in order to advance their knowledge in the subject that they are already specialised in. The data regarding teachers in science was not clear, and the data regarding teachers in training was inconsistent. For this reason the percentage of general qualified teachers in secondary moving to training was an external variable in the model which could be modified to test different possibilities. In addition, we assumed that not all of the qualified general teachers in secondary schools take further training. It was assumed that 20% of the 30 to 39 year age group would be trained every year in science subjects. This particular age group was chosen because the teachers in the cohort have already accumulated teaching experience and are not too old as to increase the age of the qualified science teachers in secondary school. Following training all of these teachers are assumed to join the science teacher workforce.

The population of qualified general teachers in secondary in the scenario "ZERO POLICY" did not seem to suffer from the same problems as the specific science population (Figure 76). Figure 75 also illustrates the number of general qualified teachers after implementation of the "TRAINING/UPGRADING" policy. This policy appeared to decrease the number of staff in this part of teaching workforce but to an alarming extent. Even so the policy applied clearly negatively impacts on the population of qualified general teachers in secondary, drawing the numbers of these teachers below that of unqualified teachers for some years.

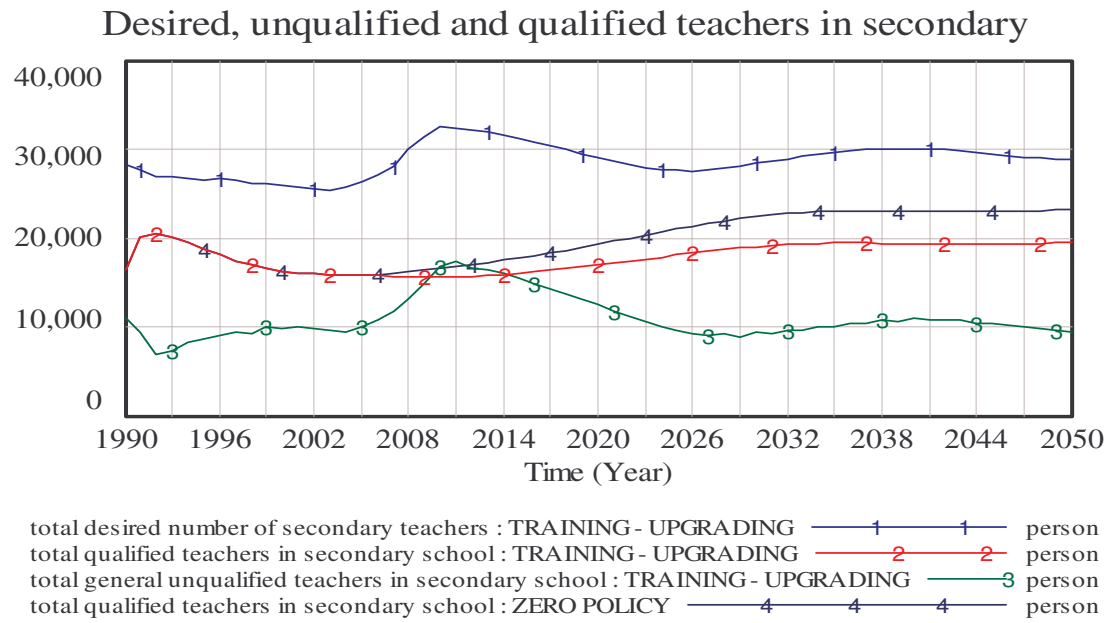


Figure 76: Desired, unqualified and qualified general teachers in secondary. The figure shows that contrary to the science teachers in secondary the general teachers at the same level of education do not present a continuous problem of shortage. Except for a short period around 2008 and 2014 where the number of pupils is rapidly increasing the presence of unqualified teachers. Figure also shows the "ZERO POLICY" scenario compared to the "TRAINING/UPGRADING" scenario. General qualified teachers decrease but the situation should not yet be considered alarming.

In the base run, “ZERO POLICY”, the population of qualified general teachers in secondary schools presents no problem, contrary to science teachers qualified with the same level of education. The number of qualified teachers remains above the number of unqualified, with the exception of a short period of 2 years. During this time there is an increase in the number of desired teachers due to demographic reasons, driving the unqualified teachers in employment up.

There is a positive effect on the number of qualified science teachers (Figure 77), increasing their numbers, similar to the previous policy. However, the increase is not enough to solve the shortage problem.

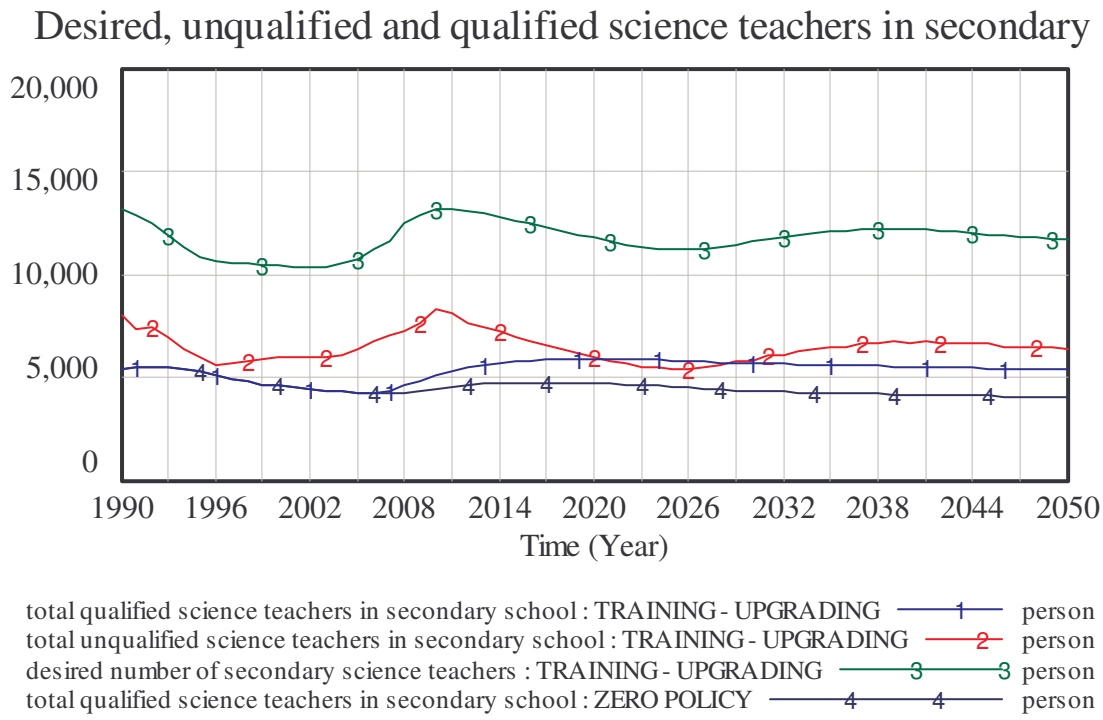


Figure 77: Desired, unqualified and qualified science teachers in secondary after “TRAINING/UPGRADING” policy. The graph shows an improvement but the results seem to be similar to the one from the policy “INCREASE WAGE” they do not solve the problem

Similar to the previous policy (see Figure 73), it is possible to notice an improvement in the teaching workforce but a shortage of qualified teachers remains and the number of qualified teachers does not begin to exceed the number of unqualified workforce. The effects of both policies “INCREASE WAGES” and “TRAINING/UPGRADING” are not strong enough to eliminate the problem of shortages in the science teacher workforce. In addition, both policies have negative effects on other sectors of the model. These effects set the limits of the policies.

The first policy recognised the sustainability of the costs of increasing wages due to equal payment for all teachers. In the second policy the sustainability level is the number of the general qualified teachers. The policy results in a shift of the problem from a lack of qualified science teachers to a lack of qualified general teachers. We have seen (Figure 76) that this second policy does not reduce the number of qualified general teachers to an alarming level, however the policy is not sufficient to bring the number of qualified teachers above the unqualified. Increasing the percentage of general teachers that take further training will perhaps solve the issue of a lack of qualified teachers in science subjects, but as previously mentioned this will result in a lack of qualified general teachers.

Thus far we have illustrated that no single policy has the ability to solve the problems of staffing shortages and high proportions of unqualified teachers in the education sector. Therefore our third policy investigates the effects of a third policy which combines the previous two policies.

7.4 INCREASE WAGES AND TEACHER TRAINING

This third policy demonstrated the results when both policies were applied at the same time[65]. The parameters used in the current policy were set differently from the previous policies in an attempt to control the negative impacts that the previous values had on education expenditure and on the population of qualified general teachers in secondary.

For this policy we reduced the increase in average percentage wage increase for teachers, so that for teachers with four years or less of tertiary education the average was set at 5.8% (6.8% in first policy), and with more than four years of tertiary education was set to 7% (8% in first policy). The percentage of teachers that were sent to additional training was kept at 20%, the value used in the second policy.

The third policy seemed to give better results (Figure 78) compared to the previous policies (Figure 73 and Figure 77). It also seemed to partially solve the problem in the long run. The union of the two policies resulted in the number of qualified science teachers exceeding the number of unqualified. The goal of the policy was to replace the all of the unqualified

[65] In the model we called the run for this policy "INCREASE and TRAINING" due to reasons of space in the graphic we shorten the name.

teachers with qualified; however as the supply[66] of qualified science teachers remains below the level of desired teachers (Figure 64), the results in the long run can be considered a positive step towards achieving this goal.

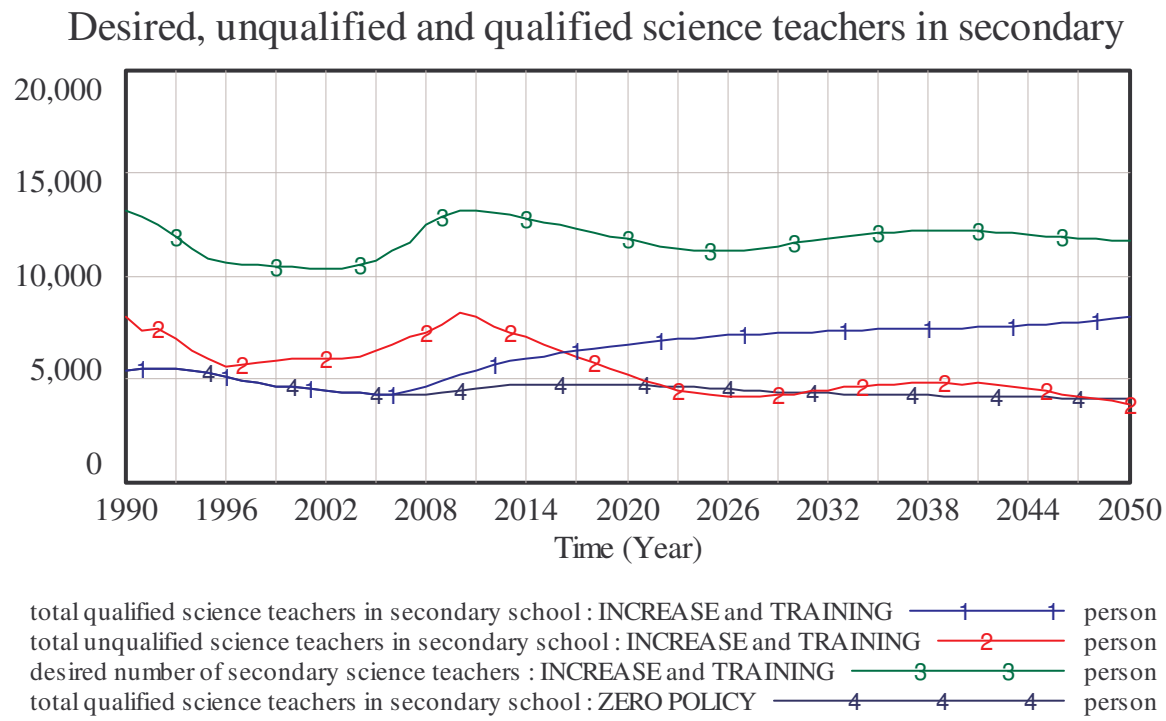


Figure 78: Desired, unqualified and qualified science teachers in secondary results after "INCREASE and TRAINING" policy

Despite this, the results of the third policy still do not fully solve the teacher supply issue at present and in the near future. Within that period of time the number of unqualified teachers is still higher than the qualified. This particular behaviour may be due to a number of reasons. Firstly, it may take time for changes in the salaries ratio to affect the attractiveness of salaries to the teaching profession, and secondly there is a delay period in acquiring and upskilling a large enough supply of qualified teachers. This third policy does not create a decrease in the population of general secondary teachers, as seen in the policy "TRAINING/UPGRADING", as the population of general qualified teachers takes advantage of the increases in wages. It is possible to see the improvement in relation to this as a result of this policy in Figure 79.

[66] We define "supply" of qualified science teachers as the number of students which have finished the master level at the university or the college students which have chosen mathematic or science as main subject in their course of study. The supply is defined also by the number of these particular students matching the requirement and which are available on the employment market.

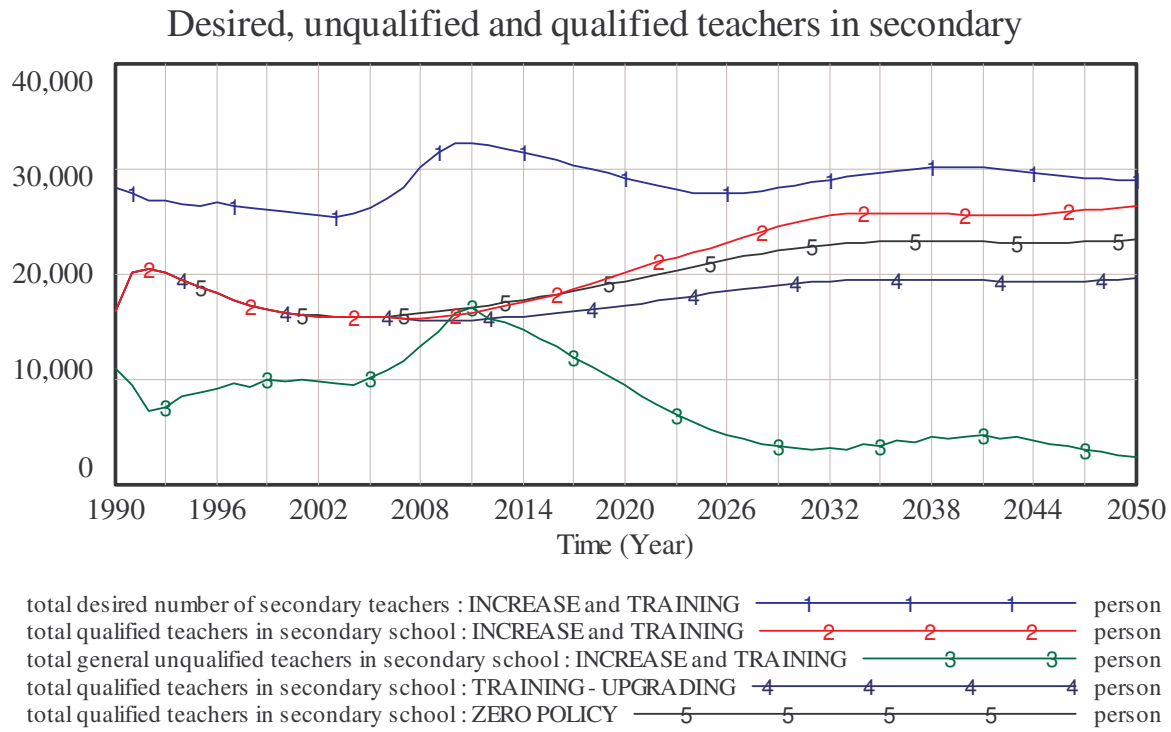


Figure 79: Desired, unqualified and qualified teachers in secondary results for the first three different policies

The third policy appears to be economically sustainable, or at least more sustainable than the first policy implemented "INCREASE WAGES". The economic cost of the third policy (Figure 80) equated to 15% of the total education expenditure, as opposed to the first policy which cost 35%.

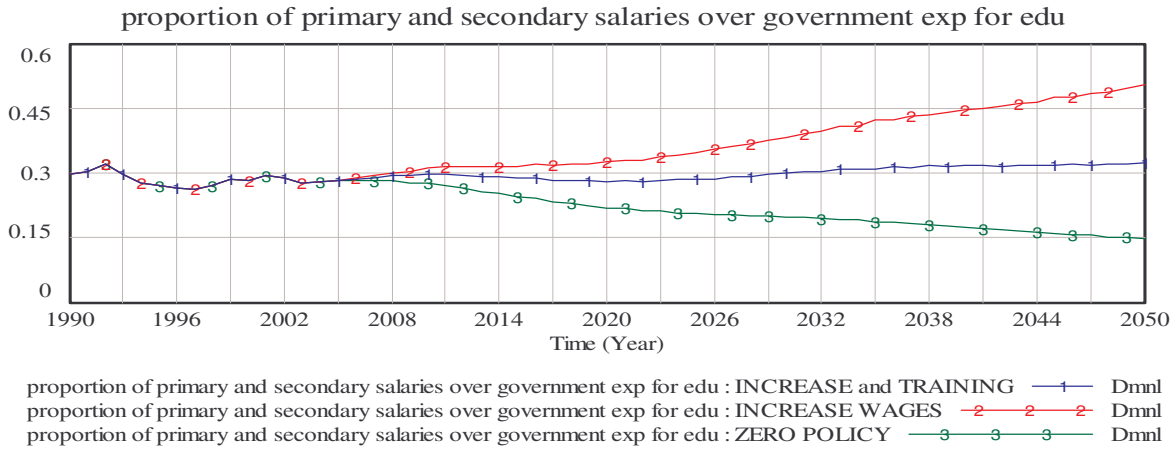


Figure 80: Proportion of salaries over the total expenditure for education. Results of the first three policies compared

The results show that the policy solves the problem, at least in the long run, which is part of our aim. The combined effects of the two policies has a positive impact on the supply of science teachers without any undue negative impact on the economic cost of wages, as well as on the number of general teachers in secondary schools. In fact, the combined policy appears to be one that has been attempted in reality. Due to lack of data we could not consider this as our base run. In addition, to obtain these results the wages had to be increased more than what they had been in recent years. It is possible to say that the right policies have been applied but there may be a need to increase one of the variables to fully solve the problem of shortage of science teachers.

8 CONCLUSIONS

This last chapter will conclude this thesis and will present the conclusion after the work carried out. The chapter will be divided into two sub paragraphs as follow:

- Conclusion of the research and
- Further research and development.

The conclusion of the research will bring the attention back to our research questions and comparing the results of the policies and the hypothesis described at the beginning to see how they answer the questions.

8.1 CONCLUSION OF THE RESEARCH

The starting questions of this research were:

- *Are the concerns expressed in different national reports justified? Is the Norwegian school system on the edge of a crisis in shortage of qualified secondary teachers in science subjects?*
- *Will there be enough available qualified teachers to replace the vacant places?*
- *If not, what will be the best policy to do not encounter a shortage of qualified secondary science teachers?*

The hypotheses for the problem that we defined were the following:

- Lack of supply of qualified teachers;
- The agreement called “School Package 2” positively influenced the retention of teachers but not the recruitment and
- high turnover.

8.1.1 Are the concerns expressed in media justified?

Our first research question was focused on the concerns expressed by the media and by the reports we found. The structure of the model has been constructed using information from the reports (Appendix III) and it was built with the aim of representing the system in the most accurate way possible considering the data and notions available.

The "ZERO POLICY" scenario in our model showed that the concerns expressed by the media and claimed in the different reports are justified. The educational system is going through a period of shortage in the teaching workforce especially for secondary schools and this symptom is particular evident in science subjects (Figure 63).

The system is not currently on the edge of a potential shortage crisis, but it is already in a situation of lack of work force, for a variety of reasons.

The situation is similar to that evident in the reference mode (Figure 14) the only changes seems to be in the initial years where the number of qualified teachers is lower than the unqualified and there will be no improvements to the situation if no changes are made.

8.1.2 Will there be enough available qualified teachers to replace the vacant places?

The first scenario we presented "ZERO POLICY" demonstrated one of the main causes for the shortage of qualified teachers, which confirmed our first hypothesis. The supply of qualified teaching workforce available is not sufficient to satisfy the demand of teachers (Figure 64). The supply of teachers, which is already limited, is reduced by effects of salary attractiveness outside of the education sector. In fact the salaries, despite being on the rise recently due to the implementation of "school package 2" (Table 27), are still lower than the national average salary in Norway (Table 28). The attraction to teaching profession was, and still is, decreasing drastically (Figure 69) which means that the number of new teachers recruited will also decrease. The probability of leaving has been decreasing in the last one or two years, however the trend of increasing average national wage reverses the positive effects of the change in leaving probability, continuing the negative impact on the number of teachers who leave employment in the education sector (Figure 66). Creating an major effect of turnover. The increase in salaries for teachers is limiting the attractiveness and thereby the recruitment of new teachers because the salaries can not increase too much. This is due to limits in the possible expenditure for the salaries of teachers in primary and secondary school. This particular hypothesis will be explained in further detail with our second policy.

Our hypotheses were confirmed with the "ZERO POLICY" scenario, but in order to be more accurate we also ran different policies that could eliminate any doubts.

8.1.3 What will be the best policy to do not encounter a shortage of qualified secondary science teachers?

The results presented in our first policy shown that the system is undergoing a period of crisis. As the improvements that have been implemented in recent years do not appear to have helped the situation of a lack of science teachers, we have utilized some additional policies (Chapter 7).

8.1.3.1 Increase wages policy conclusion

The second policy scenario we presented "INCREASE WAGES" was used in an attempt to see the effect on recruitment of teachers if increasing salaries (such as in "School Package 2") were continued as they have been in recent years. We tested this policy because it seemed to be the main policy applied in reality. The results showed that increases in salaries positively influences the teacher supply situation by increasing retention (Figure 72), but it also demonstrated that the recruitment, even if the attraction to the job is considerably increasing (Figure 71), is not sufficient to completely solve the shortage problems (Figure 73). The increased retention has to be considered carefully, as to retain teachers is a positive solution but retaining too many teachers also reductions the number of available positions. We could also say, from the results obtained, that the policy of increasing salaries involves risk on the economic front (Figure 75); increasing salaries for all teachers is economically unsustainable. In addition, if the salaries in secondary schools are higher than those in primary schools then it could be expected that this might negatively impact on the primary school teacher population by encouraging those primary school teachers that are qualified to work in secondary schools to leave. It is not viable to sustain a policy where the salaries are increased, especially if the results compared with the cost are out of proportion. This unsustainable situation is caused by the equal payment of teachers which is negatively impacts on recruitment. Increasing salaries in the current situation must be applied to all teachers as the teachers union has requested, but this restriction will further limit the sustainability of the policy in the long run. The favourable economic situation of Norway can be of great help for the sustainability of this policy. Increases in the GDP has moved the point of sustainability for

the salaries as government spending on education has increased (Table 29). It is essential to remember that the problem is the lack of qualified teachers, a problem which directly influences the education of the future generations. Even if the data, relative to the proportion of salaries over the general government expenditure in education, obtained by the model in the second policy reached a level which could be considered unsustainable, it must be always be taken into consideration that the education of children is a "priceless resource".

8.1.3.2 Training/upgrading conclusion

In our model we also ran a futher policy in which we wanted to investigate the changes in recruitment without the effects of increasing salaries. For this reason we tested a policy whereby a proportion of the teachers were sent to training in order to become specialised as science teachers. The policy showed positive results (Figure 77) however the results were almost the same as for the second policy applied. Furthermore, the general teacher population that supplied the teachers entering training, sustained a decrease in numbers (Figure 76). This could result in a shortage of qualified general teachers similar to that the science teacher workforce is currently facing. This result illustrates how one policy alone is not enough to relieve the shortage of qualified science teachers, and only the combined effects of different policies could give better results with less negative impacts on other sectors in the model.

8.1.3.3 Increase wages and teacher training conclusion

The fourth, and final, policy "INCREASE WAGES and TEACHER TRAINING" is the policy which seemed to give the best results. This policy is the preferred one to follow, if it was to be applied in reality. The policy seemed to be the best action that it can be taken, at least, to increase the number of qualified science teachers in secondary (Figure 78). The problem is partially avoided, and only in the long run. This means that, contrary to the "ZERO POLICY" scenario, the number of qualified teachers exceeds the unqualified. The union of the previous policies made it possible to reduce the proportion of salaries for teachers in primary and secondary school over the total government expenditure for education (Figure 80), and also to limit the impact on the number of qualified teachers in secondary school (Figure 79).

The main goal, replacing all unqualified teachers in science with qualified teachers, has not been achieved with any of the three policies applied. The percentage of qualified teachers in

science increases with all three policies applied the general qualified teachers does not always increase but it is never reaches an alarming low level.. Figure 81 shows the populations of qualified general and science teachers as a percentage of the total population of teachers in secondary school. The varying behaviours are attributable to the policies: “ZERO POLICY”, “INCREASE WAGES” and “INCREASE WAGES and TEACHER TRAINING”.

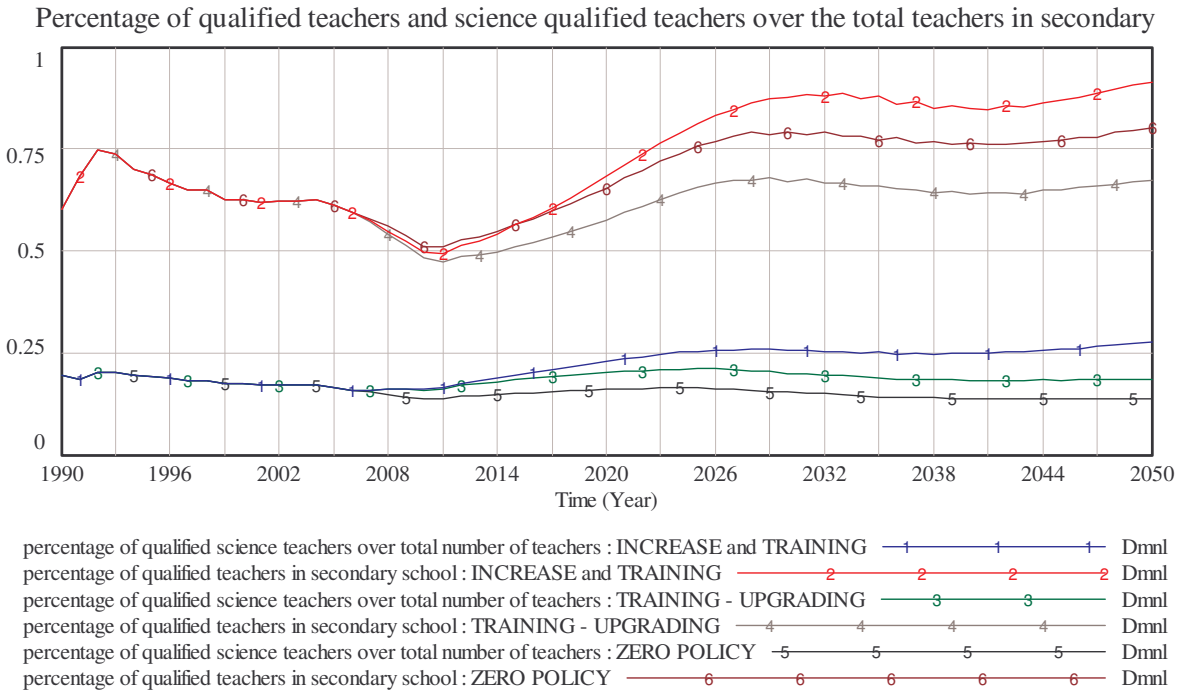


Figure 81: Percentage of general qualified secondary workforce in general subjects and in science subjects over the total teachers in secondary

The number of qualified science teachers in secondary school seemed to be less than a quarter of the total population of teachers. The effects of the policies for the qualified science teaching workforce seemed to be positive under each policy, increasing the size of the population, and the percentage of the total population. The number of the qualified general teachers in secondary only decreased under the “INCREASE WAGES and TEACHER TRAINING” policy because 20% of the teachers were sent to science training. The difference between that policy and the “INCREASE WAGES” policy can be traced back to the effect that the unqualified teachers have on the population of qualified teachers. The removal of 20% of the general teachers for training in the “INCREASE WAGES and TEACHER TRAINING” policy opens up positions for new unqualified teachers. Consequently the number of qualified teachers is reduced due to the non linear relationship between presence of unqualified teachers and qualified teachers leaving (Figure 43). Even if the number of

qualified general teachers in secondary is decreasing, it does not reach a level where the number of unqualified teachers exceeds it (Figure 79).

The policies implemented all positively impact on the parts of the model where the problem is, however none of them eliminates the problem completely. Nonetheless, situation is improving. The problem appears to be difficult to solve, but the system is on the right direction to obtain positive results, and these efforts must be increased.

8.2 FURTHER RESEARCH

Our model is limited to only a part of the education system and the real complexity in the system is far from complete in the structure presented in this work. The structure of the model however, depends on the purposes of the research and the purposes establish the boundaries of the research.

According to our purposes we hope to have contributed to the explanation of the problem: the shortage of qualified science teachers in secondary education. We also aspired to explain some possible solutions to the problem, which in spite of a number of policies being tested seems far from being solved in entirety.

We did not present a possible solution which could be interesting to test and explore. This solution has been suggested by the government and is regarding the salaries. During the last agreement the government representatives suggested that salaries be differentiated for science teachers. We did not present this policy and the resulting scenario because the teachers union has always been strongly against this possible solution. Nevertheless we think that in a situation where the outside work market is searching for the same available work force as the educational system, it is impossible for the schools to compete against the external market. The attractiveness of salaries between teachers and the national Norwegian average salary is a fact that proves this weakness in the educational system. For this reason the education sector should adopt a system of differentiated salaries. The teachers union has been afraid of the possible negative repercussions that this policy may have inside the teaching workforce. Therefore the model should be reinforced with feedback loops which include the possible repercussion of this policy if applied.

More statistical data should be found, as the resources used for the statistical data were limited in their capacity and not sufficient in providing reliable data. Better data should also

be used to adjust the model and change the calibration of the structure to produce more accurate results.

An analysis of the external market and the requirements of the workforce outside of the education sector should also be conducted to calculate the probability of staff leaving the teaching workforce and thereby allowing the modeller to create the non linear relationship endogenously. Similar work should be carried out on the effect of salaries on the attractiveness of employment in the education sector.

Another interesting solution could be the effect of increased salaries for those who decided to leave their positions as qualified general teachers for going through training in science. There is research[67] which indicates the presence of a non linear relationship between training and salary increases in light of the Human Capital Theory[68]. It would be interesting to modify the model and highlight this relationship including the feedbacks which influence attractiveness and retention of the job.

Many changes can be made to one research and especially to one model to create a better structure and find a solution to the problem but it depends on the researchers and their interests; for this reason we hope that the problem of education, especially the lack of qualified teachers in science, will not be abandoned for more remunerative problem solutions.

[67] Veum, J. R. (1995). Training, wage, and the Human Capital Theory, U.S. Department of Labour (Bureau of Labour Statistic)**:** 29.
; Søresen, M. R. (2000). Training, wage and the human capital theory. Labour Market Policy, The Danish National Institute of Social Research. **9:** 36.

[68] The Human Capital Theory has been developed by Americans economists G. Backer and T. Shultz in the 60's. It postulates the relationship between training and increase of personal income such as wage.

APPENDIX I – STATISTIC TABLES[69]

Population statistic data

Table 8: Norwegian population by single age cohorts 1990, data source SSB

1990	Males	Females	1990	Males	Females
0 years	30325	28733	43 years	34541	32570
1 year	29434	27988	44 years	30854	29279
2 years	27599	26670	45 years	29937	28056
3 years	27295	25714	46 years	26411	25180
4 years	26520	25175	47 years	24145	23273
5 years	26086	24912	48 years	21115	20571
6 years	26145	24573	49 years	21842	21179
7 years	26742	25238	50 years	21042	20861
8 years	26325	25463	51 years	20322	20184
9 years	26781	25234	52 years	19356	19336
10 years	26825	25552	53 years	18736	18594
11 years	26978	25562	54 years	17695	18201
12 years	26489	25256	55 years	18045	18085
13 years	27724	26485	56 years	18073	18028
14 years	29121	27968	57 years	19008	19406
15 years	30746	29851	58 years	18867	19642
16 years	31921	30166	59 years	19473	20006
17 years	33269	31819	60 years	19108	19709
18 years	33717	32391	61 years	19129	20272
19 years	33324	31853	62 years	18958	20146
20 years	35107	33373	63 years	19792	21275
21 years	34974	33189	64 years	19443	21051
22 years	34256	32863	65 years	20079	22027
23 years	34855	32833	66 years	20422	22788
24 years	34573	32506	67 years	19796	22884
25 years	34465	32246	68 years	19424	23135
26 years	33024	31625	69 years	20509	24463
27 years	32705	30791	70 years	16759	20121
28 years	32634	30803	71 years	16672	21142
29 years	32349	30608	72 years	16222	20847
30 years	32922	30898	73 years	14600	19531
31 years	32577	31020	74 years	13796	18884
32 years	32328	30818	75 years	13249	18183
33 years	32647	31372	76 years	12393	17505
34 years	32421	30786	77 years	11600	16968
35 years	31704	30416	78 years	10528	15875
36 years	31784	30422	79 years	9351	14857
37 years	31648	29800	80 years	8607	14208
38 years	30731	28531	81 years	7324	12667
39 years	31331	29360	82 years	6395	11710
40 years	31554	29518	83 years	5574	10523
41 years	32495	30166	84 years	4626	9380
42 years	33146	31288			

[69] All the tables with an explicit reference to the SSB in this appendix have been copied and pasted into excel then modified by the author, the originals can be found on the SSB database. Those which do not present the SSB reference in the caption are tables made by the author using data from the SSB statistic on the same file in excel.

Fertility rate of Norwegian females' population

Table 9: Norwegian fertility rate per 1000 women, source SSB (http://www.ssb.no/emner/historisk_statistikk/tabeller/3-3-16t.txt)

Annual average Year	Live births per 1 000 women. Age of women						
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1961-1965	37.9	178.8	177.3	112.7	58.1	18.7	1.3
1966-1970	43.7	175.8	164.6	98.5	48.7	14.1	1
1971-1975	44	151.8	140.6	73.7	31.3	7.6	0.4
1976-1980	29.9	115.5	120.7	62.4	22.1	4.4	0.2
1981-1985	20.5	99.8	122.6	67.2	22.3	3.9	0.2
1986-1990	17.8	93.2	136.9	85.2	27.3	4.4	0.2
1991-1995	15.2	82.6	137.7	100.2	37.2	5.6	0.2
1996-2000	12.4	70.6	130.9	107.8	43.5	6.9	0.2
2001-2005	9.3	59.9	123.3	113.2	47	7.8	0.3
1981	23.8	107	120.5	63	22	3.9	0.2
1982	22	104.7	123	65.8	22.4	3.8	0.3
1983	19.7	97.3	120.3	67.8	22.4	3.6	0.2
1984	19.2	93.9	123.7	68.2	22.2	4.1	0.2
1985	17.8	94	125.5	70.9	22.7	4.2	0.2
1986	18.2	93.2	129.4	74.4	22.2	4.1	0.2
1987	17.7	91	131.7	79.7	24.6	4.1	0.3
1988	18.2	94.3	138.6	85.1	27.7	4.6	0.2
1989	17.7	94	140.6	91.3	29.7	4.4	0.1
1990	17.1	93.4	144	95.2	32.2	4.7	0.3
1991	16.7	89.7	140.3	98.3	34.3	5.1	0.2
1992	16	85.7	137.5	98.3	35.2	5.3	0.2
1993	15	81.8	134.8	99	37.1	5.7	0.3
1994	14.4	77.9	135.7	101.6	39.1	5.8	0.2
1995	13.5	77.5	134.3	103.6	40.2	6.2	0.2
1996	13.5	75.3	135.9	106.7	41.4	6.5	0.2
1997	12.7	72.6	131.6	106.3	42.8	6.9	0.2
1998	12.4	68.7	128.2	105	43.3	6.9	0.2
1999	11.7	68.3	129.3	110.3	44.2	7	0.2
2000	11.7	67.3	129.3	110.5	45.7	7.3	0.2
2001	11	62.7	123.6	107.9	45.6	7	0.3
2002	10.1	59.5	121	109.3	44.1	7.7	0.2
2003	9.1	58.9	123.6	113.2	47.5	7.7	0.3
2004	8.2	59.6	123.9	117.1	49.1	7.9	0.3
2005	8	58.6	124.4	118.6	48.6	8.6	0.4

Immigration statistic data

Table 10: Historic Immigration and Emigration data by gender, data source SSB

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Immigration, total	25494	26283	26743	31711	26911	25678	26407	31957	36704	41841	36542	34264	40122	35957	36482
Immigration, males	13171	13835	13737	15650	13005	12268	12451	15590	18312	20864	19140	16882	19341	17572	17829
Immigration, females	12323	12448	13006	16061	13906	13410	13956	16367	18392	20977	17402	17382	20781	18385	18653
Emigration, total	23784	18238	16801	18903	19475	19312	20590	21257	22881	22842	26854	26309	22948	24672	23271
Emigration males	12880	9539	8829	10127	10062	9802	10393	10524	11526	11342	13731	13614	11851	13026	11981
Emigration females	10904	8699	7972	8776	9413	9510	10197	10733	11355	11500	13123	12695	11097	11646	11290
Net migration, total	1710	8045	9942	12808	7436	6366	5817	10700	13823	18999	9688	7955	17174	11285	13211
Net migration, males	291	4296	4908	5523	2943	2466	2058	5066	6786	9522	5409	3268	7490	4546	5848
Net migration, female	1419	3749	5034	7285	4493	3900	3759	5634	7037	9477	4279	4687	9684	6739	7363
Norwegian citizens, immigration	9800	10209	9581	9416	9044	9196	9211	9931	9957	9611	8757	8852	9334	9170	8618
Norwegian citizens, emigration	14016	9881	8744	8452	9892	10320	10558	11223	10876	10152	11923	11093	10675	10327	9415
Foreign citizens, immigration	15694	16074	17162	22295	17867	16482	17196	22026	26747	32230	27785	25412	30788	26787	27864
Foreign citizens, emigration	9768	8357	8057	10451	9583	8992	10032	10034	12005	12690	14931	15216	12273	14345	13856

Immigration sex distribution

Table 11: Sex percentage distribution of immigrants and emigrants, data source SSB

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Immigration PCT of MALE	0.516631	0.526386	0.513667	0.49352	0.48326	0.477763	0.471504	0.487843	0.49891	0.49865	0.523781	0.492704	0.482055	0.488695	0.488707
Immigration PCT of FEMALE	0.483369	0.473614	0.486333	0.50648	0.51674	0.522237	0.528496	0.512157	0.50109	0.50135	0.476219	0.507296	0.517945	0.511305	0.511293
Emigration PCT of MALE	0.541541	0.523029	0.525504	0.535735	0.516662	0.50756	0.50476	0.495084	0.503737	0.496541	0.51132	0.517466	0.516428	0.527967	0.514847
Emigration PCT of FEMALE	0.458459	0.476971	0.474496	0.464265	0.483338	0.49244	0.49524	0.504916	0.496263	0.503459	0.48868	0.482534	0.483572	0.472033	0.485153

Immigration and Emigration age distribution

Table 12: Immigrant and Emigrant distribution by age cohort, source SSB

Sex Age	Immigration			Emigration			Net migration		
	Total	Norwegian citizens	Foreign citizens	Total	Norwegian citizens	Foreign citizens	Total	Norwegian citizens	Foreign citizens
Both sexes	40148	8793	31355	21709	9081	12628	18439	-288	18727
0 to 4	3478	1540	1938	1440	723	717	2038	817	1221
5 to 9	2419	619	1800	1099	629	470	1320	-10	1330
10 to 14	1973	488	1485	734	406	328	1239	82	1157
15 to 19	2750	490	2260	1233	491	742	1517	-1	1518
20 to 24	6312	786	5526	3746	1326	2420	2566	-540	3106
25 to 29	7494	1141	6353	3816	1351	2465	3678	-210	3888
30 to 34	5474	941	4533	2744	1007	1737	2730	-66	2796
35 to 39	3548	681	2867	1849	741	1108	1699	-60	1759
40 to 44	2397	517	1880	1322	540	782	1075	-23	1098
45 to 49	1550	371	1179	1003	441	562	547	-70	617
50 to 54	965	318	647	735	361	374	230	-43	273
55 to 59	655	289	366	727	407	320	-72	-118	46
60 to 64	437	233	204	575	347	228	-138	-114	-24
65 to 69	303	153	150	362	187	175	-59	-34	-25
70 to 74	198	110	88	192	77	115	6	33	-27
75 to 79	105	59	46	73	26	47	32	33	-1
80 to 84	90	57	33	59	21	38	31	36	-5

Age distribution of immigrants and emigrants per 1000 people

Table 13: Age proportion of immigrants and emigrants per 1000 people

Percentage	immigration	emigration
Both sex	1	1
0 to 4	0.086629471	0.066331936
5 to 9	0.060252067	0.050624165
10 to 14	0.04914317	0.033810862
15 to 19	0.068496563	0.05679672
20 to 24	0.157218292	0.172555161
25 to 29	0.18665936	0.175779631
30 to 34	0.136345522	0.126399189
35 to 39	0.08837302	0.085172048
40 to 44	0.059704095	0.060896402
45 to 49	0.038607154	0.046202036
50 to 54	0.024036067	0.033856926
55 to 59	0.016314636	0.033488415
60 to 64	0.010884727	0.026486711
65 to 69	0.007547076	0.016675112
70 to 74	0.004931753	0.008844258
75 to 79	0.002615323	0.003362661
80 to 84	0.002241706	0.002717767

Female death rate data

Table 14: Females Norwegian population death rate per 1000 persons, source data UN and SSB

AGE COHORTS	FEMALES											
	1990 - 1995*	1995 - 2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025 - 2030	2030 - 2035	2035 - 2040	2040 - 2045	2045 - 2050
0 to 4	0.0012	0.00088	0.000745	0.000669	0.000637	0.000634	0.000635	0.000616	0.000576	0.000533	0.000501	0.000481
5 to 9	0.00016	0.00011	0.000056	0.000044	0.000037	0.000031	0.000028	0.000026	0.000024	0.000022	0.000019	0.000017
10 to 14	0.00011	0.00012	0.000074	0.000064	0.000056	0.000047	0.000041	0.000037	0.000035	0.000034	0.000031	0.000028
15 to 19	0.00028	0.00031	0.000128	0.000117	0.000109	0.000094	0.000078	0.000067	0.000061	0.000057	0.000053	0.000048
20 to 24	0.0003	0.00029	0.000162	0.000147	0.000148	0.000139	0.000121	0.000103	0.000091	0.000085	0.000081	0.000076
25 to 29	0.00033	0.00036	0.00022	0.000177	0.000172	0.000175	0.000166	0.000146	0.000127	0.000113	0.000106	0.000101
30 to 34	0.00053	0.00048	0.000335	0.000268	0.000227	0.000219	0.00022	0.000208	0.000184	0.00016	0.000142	0.000132
35 to 39	0.00071	0.00073	0.000508	0.000453	0.00038	0.000318	0.000304	0.000305	0.000289	0.000255	0.00022	0.000194
40 to 44	0.0012	0.00114	0.000795	0.000737	0.000691	0.000578	0.000482	0.000459	0.000462	0.000438	0.000385	0.000331
45 to 49	0.00196	0.00182	0.00119	0.001111	0.001088	0.001024	0.00086	0.000722	0.000695	0.000705	0.000671	0.000593
50 to 54	0.00299	0.0031	0.001877	0.001731	0.001698	0.001672	0.001583	0.00134	0.001134	0.001099	0.00112	0.001073
55 to 59	0.00479	0.00454	0.002796	0.002864	0.002756	0.002715	0.002684	0.002554	0.002177	0.001854	0.001803	0.001845
60 to 64	0.00778	0.00709	0.003699	0.004256	0.004531	0.004379	0.004331	0.0043	0.00411	0.00352	0.00301	0.00294
65 to 69	0.01259	0.01129	0.005088	0.005384	0.006439	0.006885	0.006703	0.006672	0.006669	0.006409	0.005521	0.004753
70 to 74	0.02112	0.01935	0.008403	0.007609	0.008308	0.009971	0.010731	0.010487	0.01048	0.010511	0.010141	0.00877
75 to 79	0.03847	0.03461	0.015022	0.012495	0.011683	0.0128	0.015395	0.016593	0.016257	0.016275	0.016353	0.015797
80 to 84	0.07036	0.06615	0.021761	0.019638	0.017023	0.016093	0.017818	0.021595	0.023367	0.023066	0.023242	0.023512

Male death rate data

Table 15: Males Norwegian population death rate per 1000 persons, data source UN and SSB

AGE COHORTS	MALES											
	1990 - 1995*	1990 - 2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025 - 2030	2030 - 2035	2035 - 2040	2040 - 2045	2045 - 2050
0 to 4	0.00147	0.001032	0.00092	0.00081	0.000761	0.00075	0.000743	0.000713	0.000654	0.000593	0.000551	0.000523
5 to 9	0.00016	0.0001	0.000089	0.00007	0.000058	0.00005	0.000045	0.000041	0.000038	0.000034	0.00003	0.000027
10 to 14	0.00022	0.000159	0.000148	0.000128	0.000108	0.000092	0.000079	0.000071	0.000064	0.000058	0.000052	0.000045
15 to 19	0.00074	0.000388	0.000332	0.00029	0.000259	0.000219	0.000181	0.000149	0.000126	0.000113	0.000103	0.000089
20 to 24	0.00091	0.000565	0.000439	0.000378	0.000365	0.000337	0.000285	0.000235	0.000195	0.000172	0.00016	0.000145
25 to 29	0.00093	0.000683	0.000535	0.000417	0.000393	0.000392	0.000365	0.000312	0.000258	0.000223	0.000203	0.00019
30 to 34	0.00113	0.000881	0.000769	0.000595	0.000493	0.00047	0.000468	0.000434	0.000369	0.000311	0.000272	0.000247
35 to 39	0.00144	0.001132	0.001049	0.000916	0.000756	0.000635	0.000606	0.000603	0.000562	0.000487	0.000417	0.000364
40 to 44	0.00205	0.001578	0.001478	0.001387	0.00129	0.001082	0.000915	0.000879	0.000886	0.000843	0.000743	0.000641
45 to 49	0.00337	0.002411	0.002211	0.00209	0.002059	0.00193	0.001627	0.001385	0.001341	0.001365	0.001308	0.001158
50 to 54	0.00523	0.003343	0.003437	0.003183	0.003141	0.003114	0.002936	0.002491	0.002137	0.002086	0.00214	0.002064
55 to 59	0.00909	0.004457	0.005287	0.005521	0.005308	0.005266	0.00525	0.004993	0.004275	0.003686	0.003614	0.003732
60 to 64	0.01549	0.006555	0.007093	0.008465	0.0091	0.008775	0.008736	0.00874	0.008331	0.007147	0.006191	0.006095
65 to 69	0.02576	0.01034	0.009488	0.010393	0.012808	0.0138	0.013401	0.013422	0.013512	0.012935	0.011152	0.009726
70 to 74	0.04222	0.016343	0.013976	0.013057	0.014823	0.018376	0.019959	0.019556	0.019753	0.020013	0.019279	0.016761
75 to 79	0.06921	0.020907	0.019426	0.016955	0.016455	0.0189	0.023682	0.025889	0.025685	0.026169	0.026757	0.026001
80 to 84	0.11308	0.019953	0.020594	0.019592	0.017823	0.017585	0.020611	0.026226	0.029006	0.029198	0.030148	0.031307

University age distribution for bachelor

Table 16: Age proportion of bachelor students at university

BACHELOR STUDENTS AGE DISTRIBUTION	19 Men	20 Men	21 Men	22 Men	23 Men	24 Men	25 Men	26 Men	27 Men	28 Men	29 Men	30 Men	31 Men	32 Men	33 Men
	0.000609	0.025439	0.039035	0.04271	0.047051	0.050993	0.045738	0.04012	0.03416	0.025592	0.021136	0.016642	0.013348	0.009978	0.008721
	19 Women	20 Women	21 Women	22 Women	23 Women	24 Women	25 Women	26 Women	27 Women	28 Women	29 Women	30 Women	31 Women	32 Women	33 Women
	0.001447	0.032256	0.052745	0.054763	0.054877	0.052116	0.042367	0.034027	0.029133	0.022583	0.016357	0.013748	0.011025	0.00893	0.007693

34 Men	35 Men	36 Men	37 Men	38 Men	39 Men	40 Men	41 Men	42 Men	43 Men	44 Men	45 Men	46 Men	47 Men	48 Men	49 Men	50 Men	51 Men
0.007331	0.006131	0.004989	0.004932	0.004284	0.004132	0.003466	0.003427	0.002437	0.002266	0.002018	0.00139	0.001542	0.001828	0.001352	0.001352	0.001485	0.000819
34 Women	35 Women	36 Women	37 Women	38 Women	39 Women	40 Women	41 Women	42 Women	43 Women	44 Women	45 Women	46 Women	47 Women	48 Women	49 Women	50 Women	51 Women
0.00636	0.005446	0.006036	0.005731	0.004551	0.004932	0.004684	0.004284	0.004418	0.00417	0.004037	0.003351	0.003942	0.003161	0.003142	0.003313	0.003028	0.001923

52 Men	53 Men	54 Men	55 Men	56 Men	57 Men	58 Men	59 Men	60 Men	61 Men	62 Men	63 Men	64 Men	65 Men	66 Men	67 Men
0.000495	0.000609	0.000381	0.000438	0.000381	0.000324	0.000248	0.000133	0.000114	0.000114	7.62E-05	0.000152	0.000171	3.81E-05	9.52E-06	3.81E-05
52 Women	53 Women	54 Women	55 Women	56 Women	57 Women	58 Women	59 Women	60 Women	61 Women	62 Women	63 Women	64 Women	65 Women	66 Women	67 Women
0.001409	0.001162	0.00139	0.001085	0.000895	0.000724	0.000419	0.000457	0.000457	0.000495	0.000343	0.000248	0.000248	2.86E-05	0.000105	9.52E-06

University master student age distribution

Table 17: Age proportion of master students at university

MASTER STUDENTS AGE DISTRIBUTION	22 Menn	23 Menn	24 Menn	25 Menn	26 Menn	27 Menn	28 Menn	29 Menn	30 Menn	31 Menn	32 Menn	33 Menn	34 Menn	35 Menn	36 Menn
	0.050324	0.05544	0.060084	0.053892	0.047273	0.04025	0.030154	0.024904	0.019609	0.015728	0.011757	0.010276	0.008638	0.007224	0.005878
	22 Kvinner	23 Kvinner	24 Kvinner	25 Kvinner	26 Kvinner	27 Kvinner	28 Kvinner	29 Kvinner	30 Kvinner	31 Kvinner	32 Kvinner	33 Kvinner	34 Kvinner	35 Kvinner	36 Kvinner
	0.064526	0.064661	0.061408	0.04992	0.040093	0.034327	0.026609	0.019273	0.016199	0.012991	0.010523	0.009064	0.007494	0.006417	0.007112

37 Menn	38 Menn	39 Menn	40 Menn	41 Menn	42 Menn	43 Menn	44 Menn	45 Menn	46 Menn	47 Menn	48 Menn	49 Menn	50 Menn	51 Menn	52 Menn
0.005811	0.005048	0.004869	0.004083	0.004039	0.002872	0.00267	0.002378	0.001638	0.001817	0.002154	0.001593	0.001593	0.00175	0.000965	0.000583
37 Kvinner	38 Kvinner	39 Kvinner	40 Kvinner	41 Kvinner	42 Kvinner	43 Kvinner	44 Kvinner	45 Kvinner	46 Kvinner	47 Kvinner	48 Kvinner	49 Kvinner	50 Kvinner	51 Kvinner	52 Kvinner
0.006753	0.005362	0.005811	0.005519	0.005048	0.005205	0.004914	0.004756	0.003949	0.004644	0.003724	0.003702	0.003904	0.003567	0.002266	0.00166

53 Menn	54 Menn	55 Menn	56 Menn	57 Menn	58 Menn	59 Menn	60 Menn	61 Menn	62 Menn	63 Menn	64 Menn	65 Menn	66 Menn	67 Menn
0.000718	0.000449	0.000516	0.000449	0.000381	0.000292	0.000157	0.000135	0.000135	8.97E-05	0.000179	0.000202	4.49E-05	1.12E-05	4.49E-05
53 Kvinner	54 Kvinner	55 Kvinner	56 Kvinner	57 Kvinner	58 Kvinner	59 Kvinner	60 Kvinner	61 Kvinner	62 Kvinner	63 Kvinner	64 Kvinner	65 Kvinner	66 Kvinner	67 Kvinner
0.001369	0.001638	0.001279	0.001054	0.000853	0.000494	0.000538	0.000538	0.000583	0.000404	0.000292	0.000292	3.37E-05	0.000123	1.12E-05

University bachelor students in science age distribution

Table 18: Age proportion of bachelor students in science faculty at university

BECHELOR STUDENTS IN SCIENCE AGE DISTRIBUTION	19 Men	20 Men	21 Men	22 Men	23 Men	24 Men	25 Men	26 Men	27 Men	28 Men	29 Men	30 Men	31 Men	32 Men
	0.023474	0.048984	0.05563	0.057238	0.051932	0.051986	0.051557	0.044536	0.041053	0.033121	0.027225	0.023528	0.018329	0.013881
	19 Women	20 Women	21 Women	22 Women	23 Women	24 Women	25 Women	26 Women	27 Women	28 Women	29 Women	30 Women	31 Women	32 Women
	0.01999	0.046198	0.047377	0.045769	0.037944	0.039606	0.031674	0.022188	0.018865	0.016614	0.009057	0.009272	0.007021	0.006592

33 Men	34 Men	35 Men	36 Men	37 Men	38 Men	39 Men	40 Men	41 Men	42 Men	43 Men	44 Men	45 Men	46 Men	47 Men	48 Men	49 Men	50 Men
0.01029	0.00895	0.009593	0.006002	0.00402	0.004663	0.002948	0.003216	0.002626	0.003055	0.001822	0.001447	0.001233	0.00134	0.001822	0.001018	0.000161	0.000643
33 Women	34 Women	35 Women	36 Women	37 Women	38 Women	39 Women	40 Women	41 Women	42 Women	43 Women	44 Women	45 Women	46 Women	47 Women	48 Women	49 Women	50 Women
0.004609	0.00418	0.002358	0.003591	0.002465	0.002358	0.001876	0.001018	0.000697	0.001179	0.001233	0.000804	0.000268	0.00075	0.00075	0.000322	0.000429	0.000804

51 Men	52 Men	53 Men	54 Men	55 Men	56 Men	57 Men	58 Men	59 Men	60 Men	61 Men	62 Men	63 Men	64 Men	65 Men	66 Men	67 Men
0.001608	0.000482	0.00059	0.000107	0.000107	0.000429	0.000214	0	0	0	5.36E-05	0	0	0.000107	0	0	0
51 Women	52 Women	53 Women	54 Women	55 Women	56 Women	57 Women	58 Women	59 Women	60 Women	61 Women	62 Women	63 Women	64 Women	65 Women	66 Women	67 Women
0.000375	0.000107	0.000268	0.000214	5.36E-05	0	0	0	0.000107	0	0	0	0	0	0	0	0

University master students in science age distribution

Table 19: Age proportion of master students in science faculty at university

MASTER STUDENTS IN SCIENCE AGE DISTRIBUTION	22 Menn	23 Menn	24 Menn	25 Menn	26 Menn	27 Menn	28 Menn	29 Menn	30 Menn	31 Menn	32 Menn	33 Menn	34 Menn	35 Menn
	0.075477	0.068481	0.068551	0.067986	0.058728	0.054134	0.043675	0.035901	0.031025	0.02417	0.018304	0.013569	0.011802	0.01265
	22 Kvinner	23 Kvinner	24 Kvinner	25 Kvinner	26 Kvinner	27 Kvinner	28 Kvinner	29 Kvinner	30 Kvinner	31 Kvinner	32 Kvinner	33 Kvinner	34 Kvinner	35 Kvinner
	0.060353	0.050035	0.052226	0.041767	0.029258	0.024876	0.021908	0.011943	0.012226	0.009258	0.008693	0.006078	0.005512	0.00311

36 Menn	37 Menn	38 Menn	39 Menn	40 Menn	41 Menn	42 Menn	43 Menn	44 Menn	45 Menn	46 Menn	47 Menn	48 Menn	49 Menn	50 Menn	51 Menn
0.007915	0.0053	0.006148	0.003887	0.00424	0.003463	0.004028	0.002403	0.001908	0.001625	0.001767	0.002403	0.001343	0.000212	0.000848	0.00212
36 Kvinner	37 Kvinner	38 Kvinner	39 Kvinner	40 Kvinner	41 Kvinner	42 Kvinner	43 Kvinner	44 Kvinner	45 Kvinner	46 Kvinner	47 Kvinner	48 Kvinner	49 Kvinner	50 Kvinner	51 Kvinner
0.004735	0.003251	0.00311	0.002473	0.001343	0.000919	0.001555	0.001625	0.00106	0.000353	0.000989	0.000989	0.000424	0.000565	0.00106	0.000495

52 Menn	53 Menn	54 Menn	55 Menn	56 Menn	57 Menn	58 Menn	59 Menn	60 Menn	61 Menn	62 Menn	63 Menn	64 Menn	65 Menn	66 Menn	67 Menn
0.000636	0.000777	0.000141	0.000141	0.000565	0.000283	0	0	0	7.07E-05	0	0	0.000141	0	0	0
52 Kvinner	53 Kvinner	54 Kvinner	55 Kvinner	56 Kvinner	57 Kvinner	58 Kvinner	59 Kvinner	60 Kvinner	61 Kvinner	62 Kvinner	63 Kvinner	64 Kvinner	65 Kvinner	66 Kvinner	67 Kvinner
0.000141	0.000353	0.000283	7.07E-05	0	0	0	0.000141	0	0	0	0	0	0	0	0

College bachelor students

Table 20: Age proportion of bachelor students in college for teacher

COLLEGE BACHELOR STUDENTS	19	20	21	22	23	24	25	26	27	28	29	30	31
TEACHER EDUCATION	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men
AGE DISTRIBUTION	0.002031	0.010212	0.020311	0.031426	0.038648	0.034642	0.032555	0.022794	0.017152	0.011397	0.008971	0.00694	0.005416
	19	20	21	22	23	24	25	26	27	28	29	30	31
	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women
	0.012356	0.043839	0.070357	0.084631	0.077917	0.063191	0.045814	0.035376	0.029564	0.021101	0.019634	0.019183	0.017095

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men
0.005416	0.005642	0.005529	0.00299	0.003893	0.003385	0.002426	0.00299	0.001975	0.002031	0.002595	0.001636	0.001693	0.001693	0.001411	0.000564	0.00079	0.000846
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women
0.01529	0.015911	0.013823	0.015741	0.014895	0.012751	0.010043	0.011228	0.010325	0.009084	0.007278	0.005924	0.006263	0.004288	0.003272	0.003385	0.002426	0.001918

50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men	Men
0.000846	0.000226	0.000113	0.000113	0.000113	0	0	0	0	0	0	0	0	0	0	0	0	0
50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women	Women
0.001354	0.001072	0.00079	0.000339	0.000451	0.000113	0.000282	0.000226	0	5.64E-05	0	0	0	0	0	0	0	0

Primary teacher data by age group

Table 21: Table of the population of teachers in primary school by age, SSB data source

Year and type of school		Total	Age				
Primary			-29 years	30-39 years	40-49 years	50-59 years	60- years
	1990	51957	4617	12057	21322	10774	3186
	1991	53109	4719	12325	21795	11013	3257
	1992	52490	4664	12181	21541	10885	3219
	1993	52287	4820	11065	21288	12050	3064
	1994	52977	5528	10542	20591	13373	2943
	1995	53878	5944	10323	19917	14574	3120
	1996	55296	6532	10295	19158	15967	3344
	1997	61620	8753	12145	19795	17363	3564
	1998	64205	9594	13086	19701	18231	3593
	1999	65158	9622	13792	19167	18760	3817
	2000	66015	9559	14557	18499	19207	4193
	2001	66658	9069	15641	17623	19811	4514
	2002	66072	7721	16472	16461	20294	5124
	2003	65376	6431	17241	15457	20442	5805

Primary teacher population by single age cohort

Table 22: Population of primary teacher new age distribution

Primary teachers	1	2	3	4	5	6	7	8	9	10
less than 29 years	344.7379	408.6631722	472.58842	536.51367	609.57109	673.496337	748.188667	822.880998		
30-39 years	893.2981	953.8202724	1014.3425	1074.8647	1135.38686	1222.63111	1309.87535	1397.11959	1484.36383	1571.60807
40-49 years	1996.529	2101.533189	2206.5369	2311.5407	2416.54441	2297.00169	2177.45897	2057.91625	1938.37353	1818.83081
50-59 years	1476.962	1373.059718	1269.1573	1165.255	1061.3526	1002.81397	944.27534	885.736711	827.198081	768.659451
over 60 years	650.6237	566.0344652	481.44521	396.85596	347.248968	297.641973	248.034977	198.427982		

Proportions of hiring teachers by age

Table 23: Hiring age distribution of teachers

Age	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Proportion	0.122388	0.122388	0.10534	0.090667	0.078038	0.067168	0.057812	0.049759	0.042828	0.036862	0.031728	0.027308	0.023505	0.020231	0.017413	0.014987	0.0129

39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
0.011103	0.009556	0.008225	0.007079	0.006093	0.005245	0.004514	0.003885	0.003344	0.002878	0.002477	0.002132	0.001835	0.00158	0.00136	0.00117	0.001007

56	57	58	59	60	61	62	63	64	65	66	67
0.000867	0.000746	0.000642	0.000553	0.000476	0.00041	0.000352	0.000303	0.000261	0.000225	0.000193	0.000166

Proportion of firing teachers by age

Table 24: Firing age distribution for teachers

age	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Proportion	0.0294387	0.029439	0.029	0.028569	0.028143	0.027724	0.027312	0.026905	0.026504	0.02611	0.025721	0.025338	0.024961	0.024589	0.024223	0.023863	0.023507

39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
0.023157	0.022813	0.022473	0.022138	0.021809	0.021484	0.021164	0.020849	0.020539	0.020233	0.019932	0.019635	0.019343	0.019055	0.018771	0.018491	0.018216

56	57	58	59	60	61	62	63	64	65	66	67
0.017945	0.017678	0.017415	0.017155	0.0169	0.016648	0.0164	0.016156	0.015916	0.015679	0.015445	0.015215

Secondary teacher data by age group

Table 25: Table of the population of teachers in secondary school by age, SSB data source (adapted by the author)

Year and type of school	Total	Age				
Upper secondary		-29 years	30-39 years	40-49 years	50-59 years	60- years
1990	27341	2148	6550	11056	5641	1946
1991	28021	2202	6713	11331	5781	1994
1992	27047	2125	6480	10937	5580	1925
1993	27119	2096	6000	11006	6091	1926
1994	26968	2054	5677	10698	6693	1846
1995	26843	1938	5373	10356	7331	1845
1996	27231	1970	5304	10046	8005	1906
1997	26994	1782	5101	9574	8565	1972
1998	26808	1638	4953	9071	9088	2058
1999	26802	1458	4821	8697	9572	2254
2000	26750	1298	4802	8318	9919	2413
2001	26632	1131	4725	7878	10271	2627
2002	26671	998	4746	7433	10557	2937
2003	26618	909	4704	7054	10749	3202

Secondary teacher population by single age cohort

Table 26: Population of secondary teachers with new age distribution

Secondary teachers	1	2	3	4	5	6	7	8	9	10
less than 29 years	82.68594	135.7791924	188.87245	241.96571	295.058964	348.152221	401.245478	454.338735		
30-39 years	479.2655	516.283776	553.30208	590.32039	627.3387	670.487598	713.636496	756.785393	799.934291	843.083189
40-49 years	1044.699	1095.562837	1146.4272	1197.2915	1248.15579	1187.02046	1125.88514	1064.74981	1003.61449	942.47916
50-59 years	772.4193	718.8395949	665.25994	611.68028	558.100616	526.357394	494.614171	462.870948	431.127725	399.384502
over 60 years	375.8	334.3455978	292.89118	251.43677	220.007175	188.577579	157.147982	125.718386		

Yearly increase of salary for teachers with tertiary education

Table 27: Monthly earnings for teachers by level of education and yearly increase (adapted by the author)

YEAR		1990	1991	1992	1993
	Monthly earnings, total (NOK)		Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)
Teachers Tertial education, 4 years or less (level 6)		15951.6864	16711.73616	17508	17888
Teachers Tertial education, more than 4 years (level 7-8)		18320.12188	19151.68818	20 021	20 219
Percentage of increase for teachers w/ tertiari education 4 yr or less		0.047646985	0.047646985	0.021704364	0.01693873
Percentage of increase for teachers w/ tertiari education more than 4 yr		0.045390872	0.045390872	0.009889616	0.005143677

1994	1995	1996	1997	1998	1999	2000	2001
Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)
18191	18589	19363	19998	21737	22618	23700	25783
20 323	20717	20597	21880	23851	25951	27935	29494
0.021878951	0.041637528	0.032794505	0.086958696	0.040529972	0.047838005	0.087890295	0.105108017
0.019386902	-0.005792344	0.062290625	0.090082267	0.088046623	0.076451774	0.055808126	0.097545263

2002	2003	2004	2005
Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)	Monthly earnings, total (NOK)
28493	29178	30227	30861
32371	32985	34008	34248
0.024040993	0.035951744	0.020974625	
0.018967594	0.031014097	0.007057163	

Yearly increase of salaries for full time employee

Table 28: Monthly earnings for full time employee and percentage of yearly increase (adapted by the author)

Sex and educational level	Monthly earnings, total							
	1997	1998	1999	2000	2001	2002	2003	2004
Males and females, total	20665	22263	23176	24404	25535	27232	28120	29175
Primary and lower secondary education	18085	19425	20128	20960	21886	23111	23781	24649
Upper secondary education	19278	20731	21555	22587	23543	24920	25623	26541
Tertial education, 4 years or less	22823	24707	25694	27177	28687	30723	31561	32628
Tertial education, more than 4 years	28561	30750	31996	33754	35728	38279	39487	40723
Unknown or no completed education	21607	22367	22883	23645	23786	25054	26069	26814
Males, total	21726	23418	24393	25678	26873	28583	29512	30589
Primary and lower secondary education	18784	20171	20901	21796	22776	23995	24700	25568
Upper secondary education	20128	21666	22525	23622	24624	26022	26733	27677
Tertial education, 4 years or less	25016	27112	28265	29942	31730	33803	34755	35825
Tertial education, more than 4 years	29682	32107	33525	35477	37611	40365	41577	42944
Unknown or no completed education	22499	23331	23742	24497	24713	25962	27011	27641
Females, total	18557	19977	20788	21951	22981	24595	25429	26480
Primary and lower secondary education	16385	17610	18256	18968	19739	20866	21458	22359
Upper secondary education	17405	18668	19407	20293	21153	22402	23095	23977
Tertial education, 4 years or less	20115	21756	22565	23984	25221	27166	27888	28973
Tertial education, more than 4 years	24955	26732	27635	29271	31055	33124	34415	35558
Unknown or no completed education	19708	20149	21061	21597	21750	22937	23912	24824
PCT of IN CREASE for tertiari education 4 years or less	0.082548307	0.039948	0.057718	0.055562	0.070973	0.027276	0.033808	
PCT of IN CREASE for tertiari education more then 4 years	0.076642975	0.04052	0.054944	0.058482	0.071401	0.031558	0.031301	

Norwegian educational expenditure

Table 29: Total government expenditure for education in Norway (million of NOK), data source SSB

Years	1991	1992	1993	1994	1995	1996	1997	1998
General Government expenditure in education	46162	49292	51259	54184	59087	61264	69380	72614

1999	2000	2001	2002	2003	2004	2005	2006
74655	79162	86213	91451	102771	104207	107916	114442

Pupils pro teacher in primary and secondary schools

Table 30: Pupils pro teacher ratio, data source SSB (number of secondary pupils have been already calculated considering the dropout)

PUPILS AND TEACHERS RATIO	**YEAR**	1992	1993	1994	1995	1996	1997	1998	1999
Primary teachers		52490	52287	52977	53878	55296	61620	64205	65158
Primary pupils		527326	523318	524548	528355	534353	604035	614451	624761
Pupils pro teachers primary		**10.04621833**	**10.008568**	**9.9014289**	**9.80650729**	**9.66350188**	**9.80258033**	**9.57014251**	**9.5884005**
Secondary teachers		27047	27119	26968	26843	27231	26994	26808	26802
Secondary pupils		181191	173958	166986	158818	154750	153315	153936	153954
Pupils pro teachers secondary		**6.699113632**	**6.4146142**	**6.1919872**	**5.91653331**	**5.68286041**	**5.67958838**	**5.74215037**	**5.74411467**

2000	2001	2002	2003
66015	66658	66072	65376
635796	645876	655986	668063
9.63108384	**9.68939962**	**9.92835089**	**10.2187806**
26750	26632	26671	26618
154418	153717	153617	154287
5.77261867	**5.77190872**	**5.75969313**	**5.79633069**

Teachers pro class in primary

Table 31: Ratio teacher per class, data source SSB

year	class in primary	total teachers in primary	RATIO TEACHERS PER CLASS
1960	23161		
1961	23112		
1962	22853	23158	1.013346169
1963	22791	24229	1.063095081
1964	22684	25014	1.10271557
1965	22837	25992	1.138152997
1966	23291	27341	1.173886909
1967	23743	28964	1.219896391
1968	24332	30539	1.25509617
1969	24916	32274	1.295312249
1970	25728	34336	1.334577114
1971	26868	37666	1.401890725
1972	27134	39092	1.440701703
1973	27671	41081	1.48462289
1974	27728	41464	1.495383728
1975	27677	42082	1.520468259
1976	28097	43139	1.535359647
1977	28359	45303	1.597482281
1978	28576	47485	1.661709127
1979	28577	47986	1.679182559
1980	28574	49143	1.719850213
1981	28436	49129	1.727704318
1982	28135	49468	1.758237071
1983	27821	49622	1.783616692
1984	27288	50099	1.83593521
1985	26559	50144	1.888022892
1986	26318	51711	1.964852952
1987	26011	53043	2.039252624
1988	25591	53614	2.09503341
1989	25036	52191	2.084638121
1990	24692	51957	2.104203791
1991	24302	53109	2.185375689
1992	23870	52490	2.198994554
AVERAGE			**1.606406358**

APPENDIX II – MODEL DOCUMENTATION

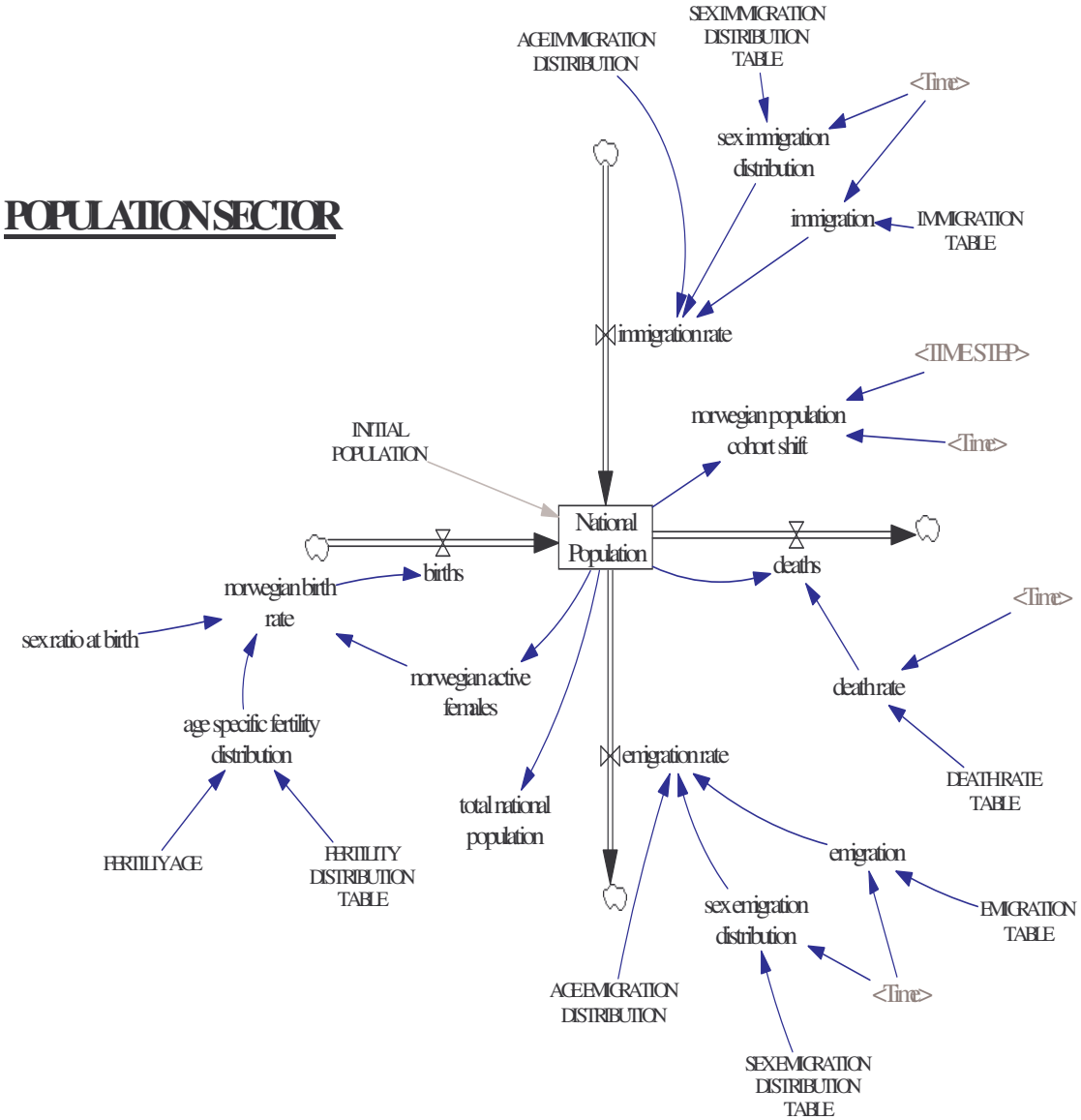
In this appendix it will be reported the model documentation. The documentation is divided in two main parts:

- Sketches[70] of the model structure and
- description of all the variables in the model, grouped by sketches.

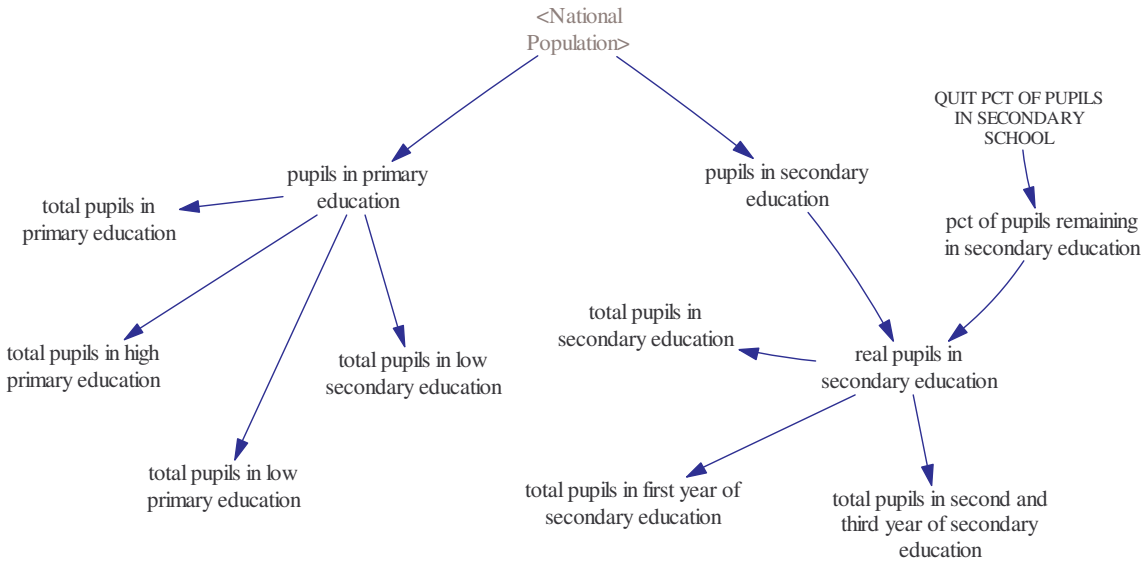
In chapter five we presented the models structure in the main lines and we grouped all the sketches into four main sectors (Population, Population through education, Wages and Teachers workforce). The present documentation therefore is illustrating the model structure as it appears in Vensim file.
The second part of the appendix presents the list of variables that compose the whole structure. For most of the variable, especially for those with complex equation, a description was given to clarify the meaning. The variables have been assembled in subgroups of the main sectors. There are 25 subgroups and they have been alphabetically ordered.

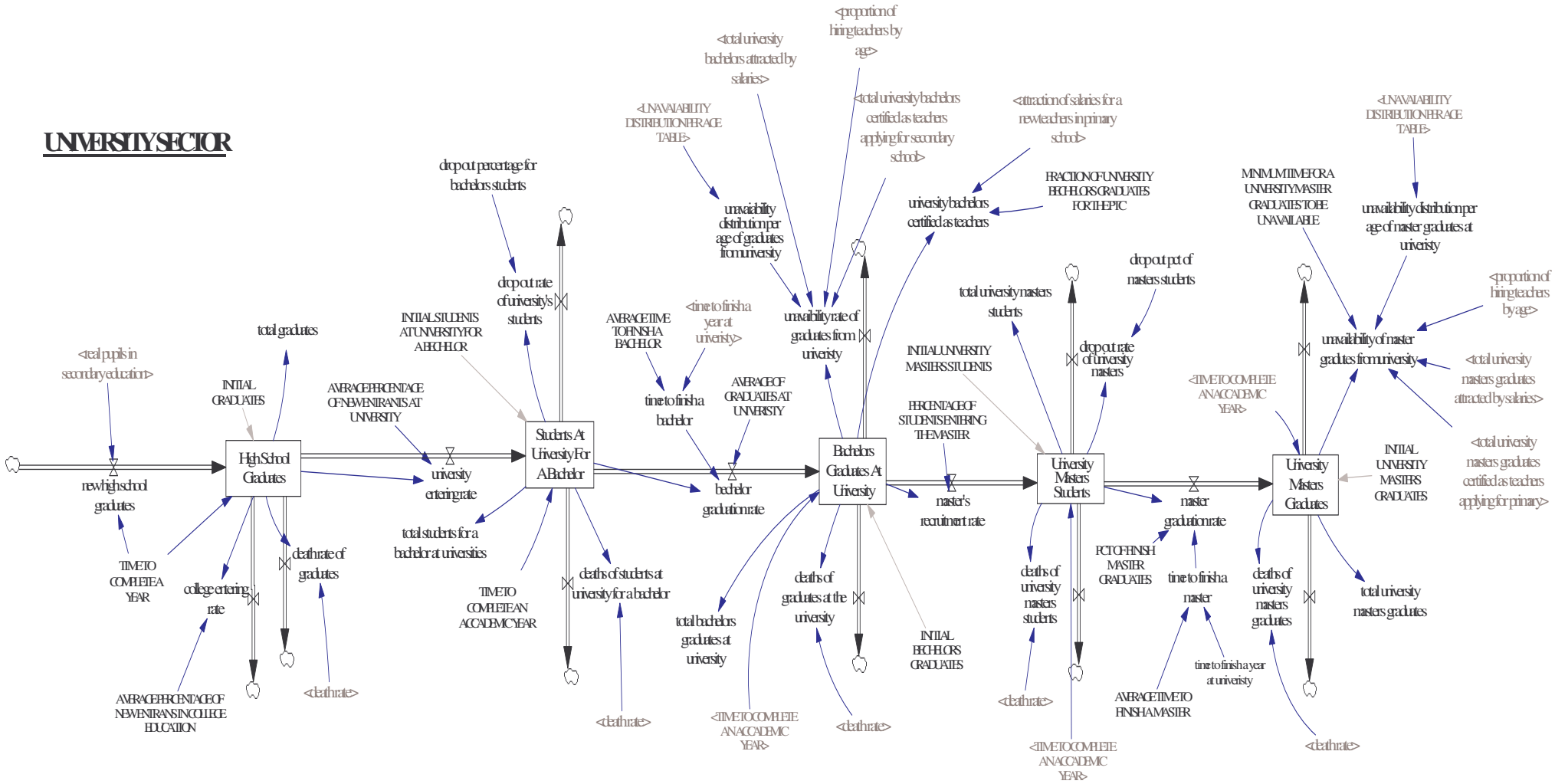
[70] In Vensim every sketch correspond to a part of the model, due to the size of the model it has been divided into different sketches to make the comprehension much clear

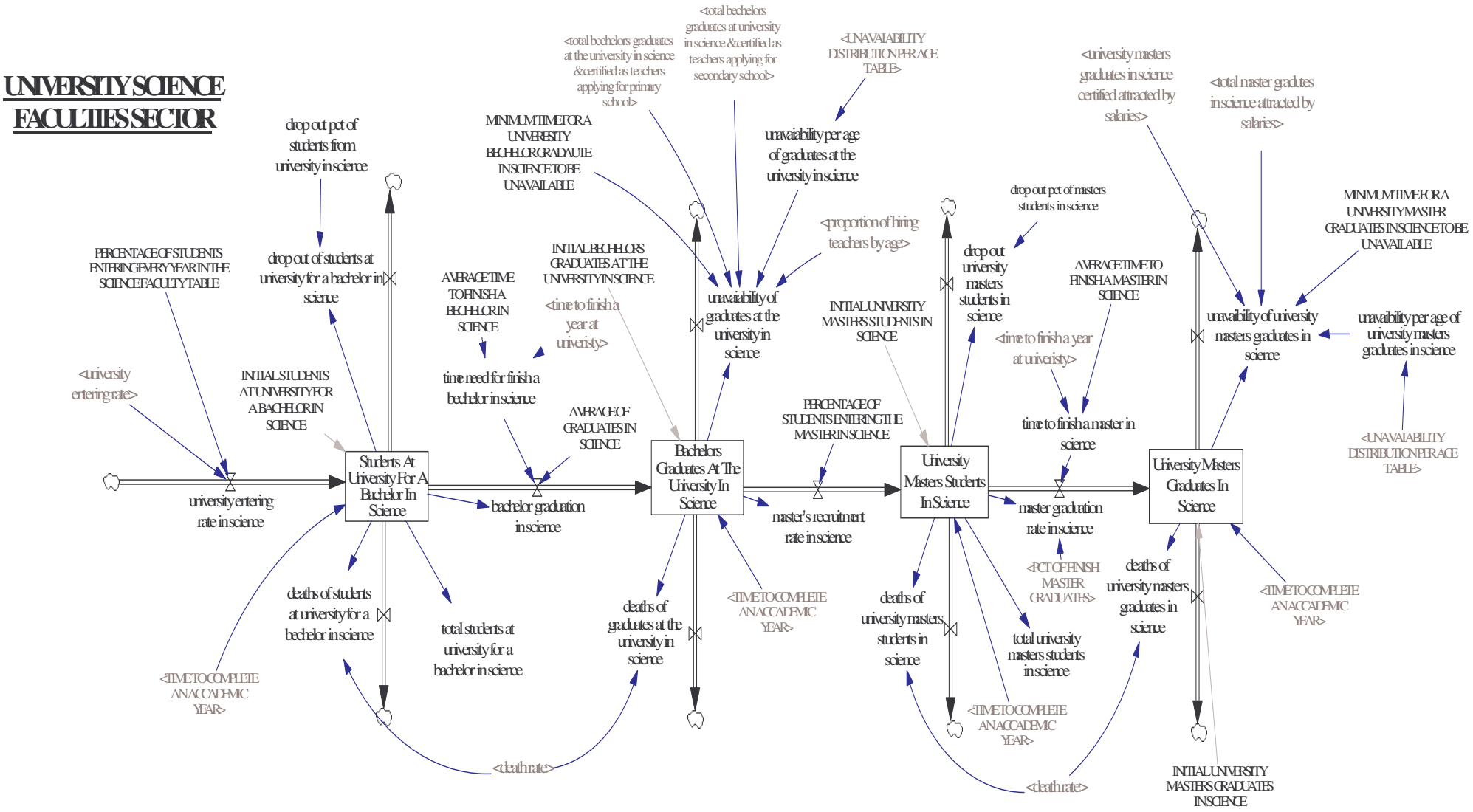
POPULATION SECTOR



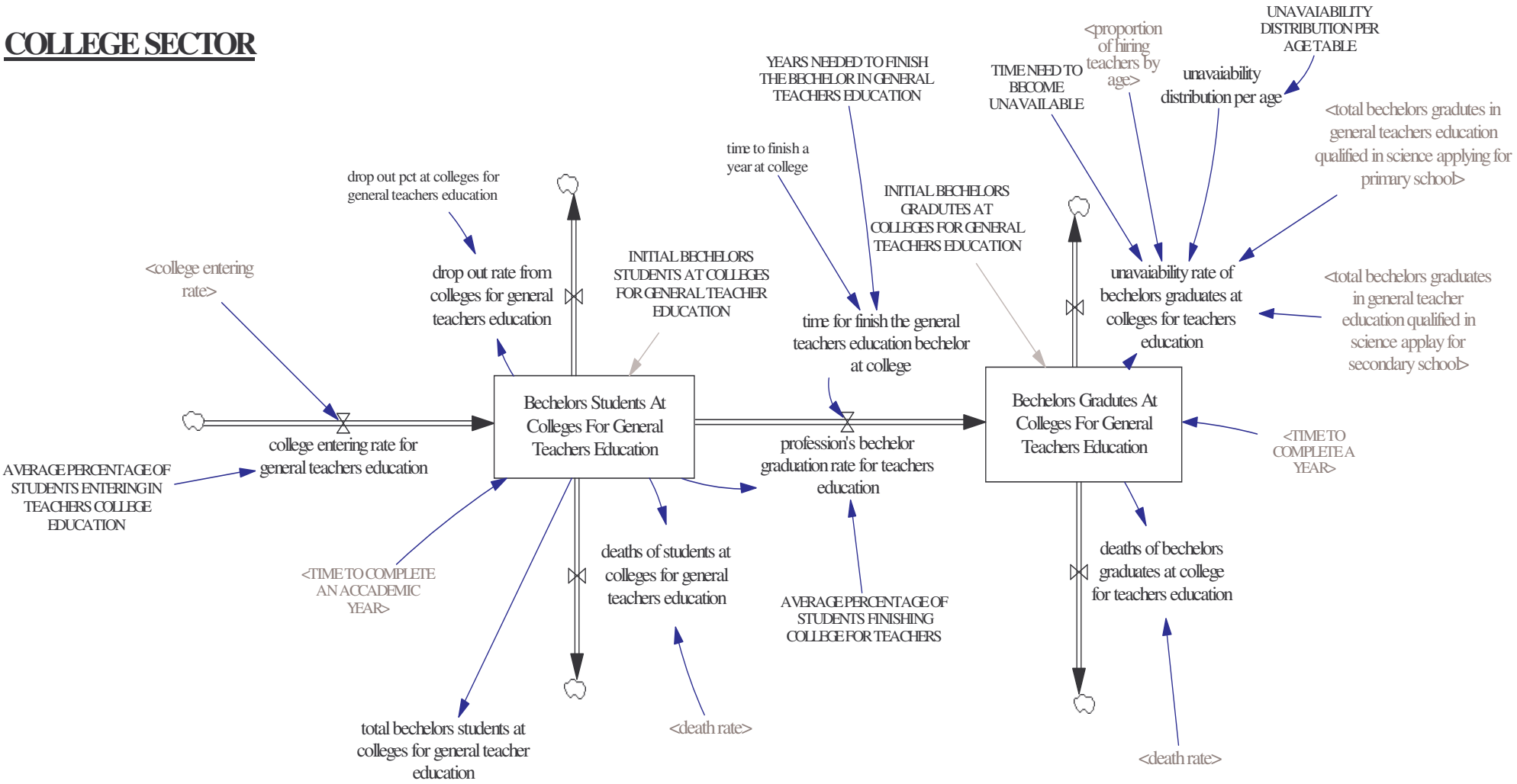
PRIMARY AND SECONDARY EDUCATION SECTOR



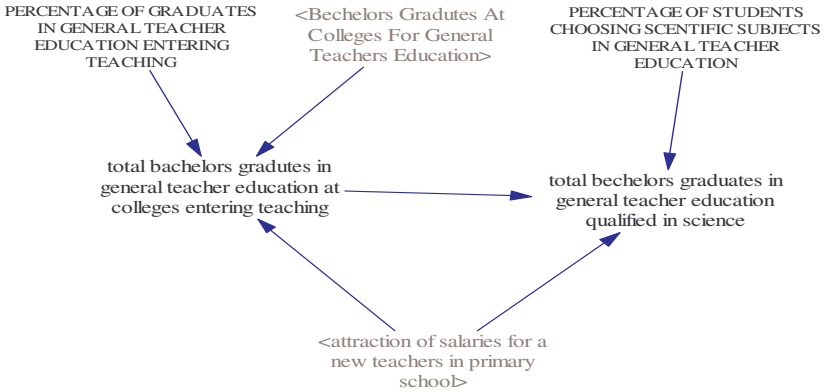

UNIVERSITY SECTOR
<real pupils in secondary education>
new highschool graduates
TIME TO COMPLETE A YEAR
High School Graduates
INITAL GRADUATES
total graduates
college entering rate
AVERAGE PERCENTAGE OF NEW ENTRANS IN COLLEGE EDUCATION
death rate of graduates
<death rate>
AVERAGE PERCENTAGE OF NEW ENTRANTS AT UNIVERSITY
university entering rate
INITAL STUDENTS AT UNIVERSITY FOR A BECHLOR
drop out percentage for bachelors students
drop out rate of university's students
Students At University For A Bachelor
total students for a bachelor at universities
TIME TO COMPLETE AN ACCADEMIC YEAR
deaths of students at university for a bachelor
<death rate>
AVERAGE TIME TO FINISH A BACHELOR
<time to finish a year at university>
time to finish a bachelor
AVERAGE OF GRADUATES AT UNIVERSITY
bachelor graduation rate
<UNAVAILABILITY DISTRIBUTION PER AGE TABLE>
unavailability distribution per age of graduates from university
<total university bachelors attracted by salaries>
<proportion of hiring teachers by age>
<total university bachelors certified as teachers applying for secondary school>
unavailability rate of graduates from university
Bachelors Graduates At University
total bachelors graduates at university
<TIME TO COMPLETE AN ACCADEMIC YEAR>
deaths of graduates at the university
<death rate>
<attraction of salaries for a new teachers in primary school>
FRACTION OF UNIVERSITY BECHLORS GRADUATES FOR THE PIC
university bachelors certified as teachers
INITIAL BECHLORS GRADUATES
PERCENTAGE OF STUDENTS ENTERING THE MASTER
master's recruitment rate
INITIAL UNIVERSITY MASTERS STUDENTS
total university masters students
drop out rate of university masters
drop out pct of masters students
University Masters Students
deaths of university masters students
<death rate>
<TIME TO COMPLETE AN ACCADEMIC YEAR>
FCT OF FINISH MASTER GRADUATES
master graduation rate
time to finish a master
AVERAGE TIME TO FINISH A MASTER
time to finish a year at university
MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES TO BE UNAVAILABLE
<UNAVAILABILITY DISTRIBUTION PER AGE TABLE>
unavailability distribution per age of master graduates at university
<proportion of hiring teachers by age>
unavailability of master graduates from university
<total university masters graduates attracted by salaries>
<total university masters graduates certified as teachers applying for primary>
<TIME TO COMPLETE AN ACCADEMIC YEAR>
University Masters Graduates
INITIAL UNIVERSITY MASTERS GRADUATES
deaths of university masters graduates
<death rate>
total university masters graduates


UNIVERSITY SCIENCE FACULTIES SECTOR
drop out pct of students from university in science
<total bechelors graduates at the university in science &certified as teachers applying for primary school>
<total bechelors graduates at university in science &certified as teachers applying for secondary school>
<UNAVAIABILITY DISTRIBUTION PER AGE TABLE>
MINIMUM TIME FOR A UNIVERSITY BECHELOR GRADAUTE IN SCIENCE TO BE UNAVAILABLE
unavaibility per age of graduates at the university in science
<university masters graduates in science certified attracted by salaries>
<total master gradutes in science attracted by salaries>
drop out pct of masters students in science
MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES IN SCIENCE TO BE UNAVAILABLE
PERCENTAGE OF STUDENTS ENTERING EVERY YEAR IN THE SCIENCE FACULTY TABLE
drop out of students at university for a bachelor in science
AVERAGE TIME TO FINISH A BECHELOR IN SCIENCE
INITIAL BECHELORS GRADUATES AT THE UNIVERSITY IN SCIENCE
<time to finish a year at univeristy>
<proportion of hiring teachers by age>
unavaibility of graduates at the university in science
drop out university masters students in science
AVERAGE TIME TO FINISH A MASTER IN SCIENCE
unavaibility of university masters graduates in science
unavaibility per age of university masters graduates in science
<university entering rate>
INITAL STUDENTS AT UNIVERSITY FOR A BACHELOR IN SCIENCE
time need for finish a bechelor in science
AVERAGE OF GRADUATES IN SCIENCE
INITIAL UNIVERSITY MASTERS STUDENTS IN SCIENCE
<time to finish a year at univeristy>
time to finish a master in science
<UNAVAIABILITY DISTRIBUTION PER AGE TABLE>
PERCENTAGE OF STUDENTS ENTERING THE MASTER IN SCIENCE
Students At University For A Bachelor In Science
Bachelors Graduates At The University In Science
University Masters Students In Science
University Masters Graduates In Science
university entering rate in science
bachelor graduation in science
master's recruitment rate in science
master graduation rate in science
<PCT OF FINISH MASTER GRADUATES>
deaths of students at university for a bechelor in science
total students at university for a bachelor in science
deaths of graduates at the university in science
<TIME TO COMPLETE AN ACCADEMIC YEAR>
deaths of university masters students in science
total university masters students in science
deaths of university masters graduates in science
<TIME TO COMPLETE AN ACCADEMIC YEAR>
<TIME TO COMPLETE AN ACCADEMIC YEAR>
<TIME TO COMPLETE AN ACCADEMIC YEAR>
<death rate>
<death rate>
INITIAL UNIVERSITY MASTERS GRADUATES IN SCIENCE

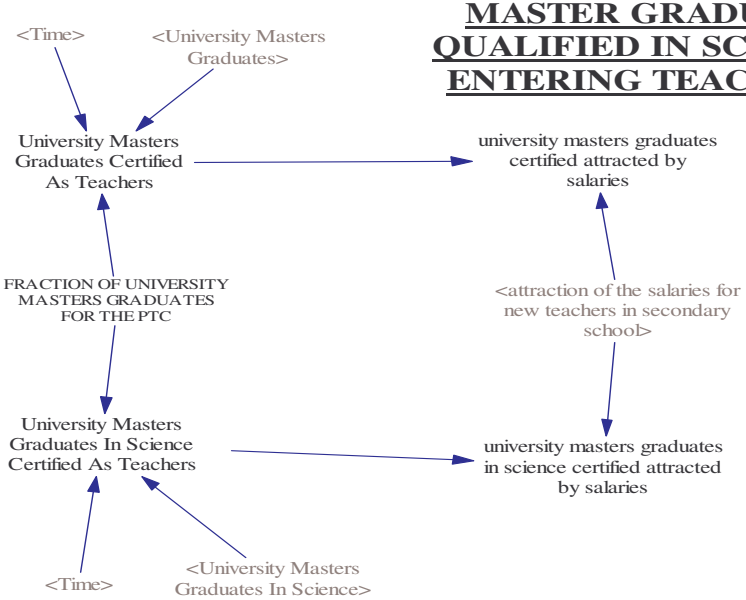
COLLEGE SECTOR



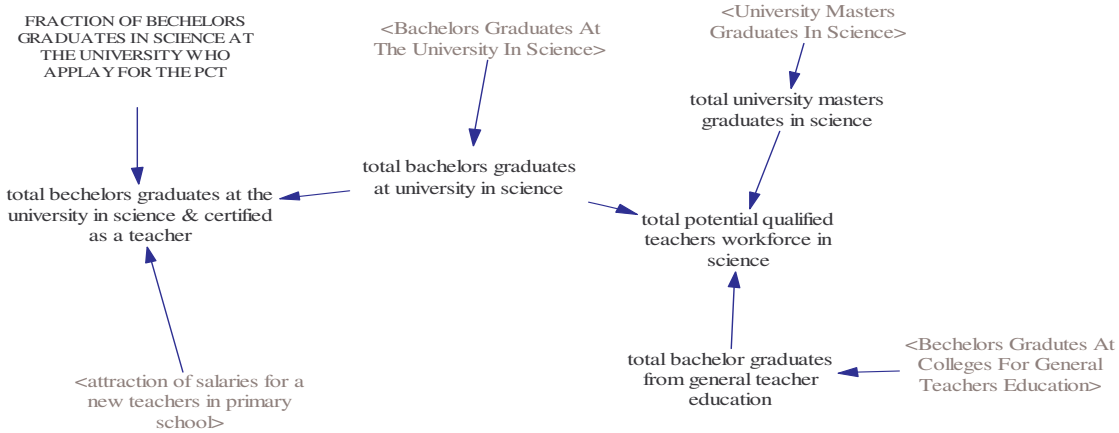
COLLEGE GRADUATES QUALIFIED IN SCIENCE ENTERING TEACHING

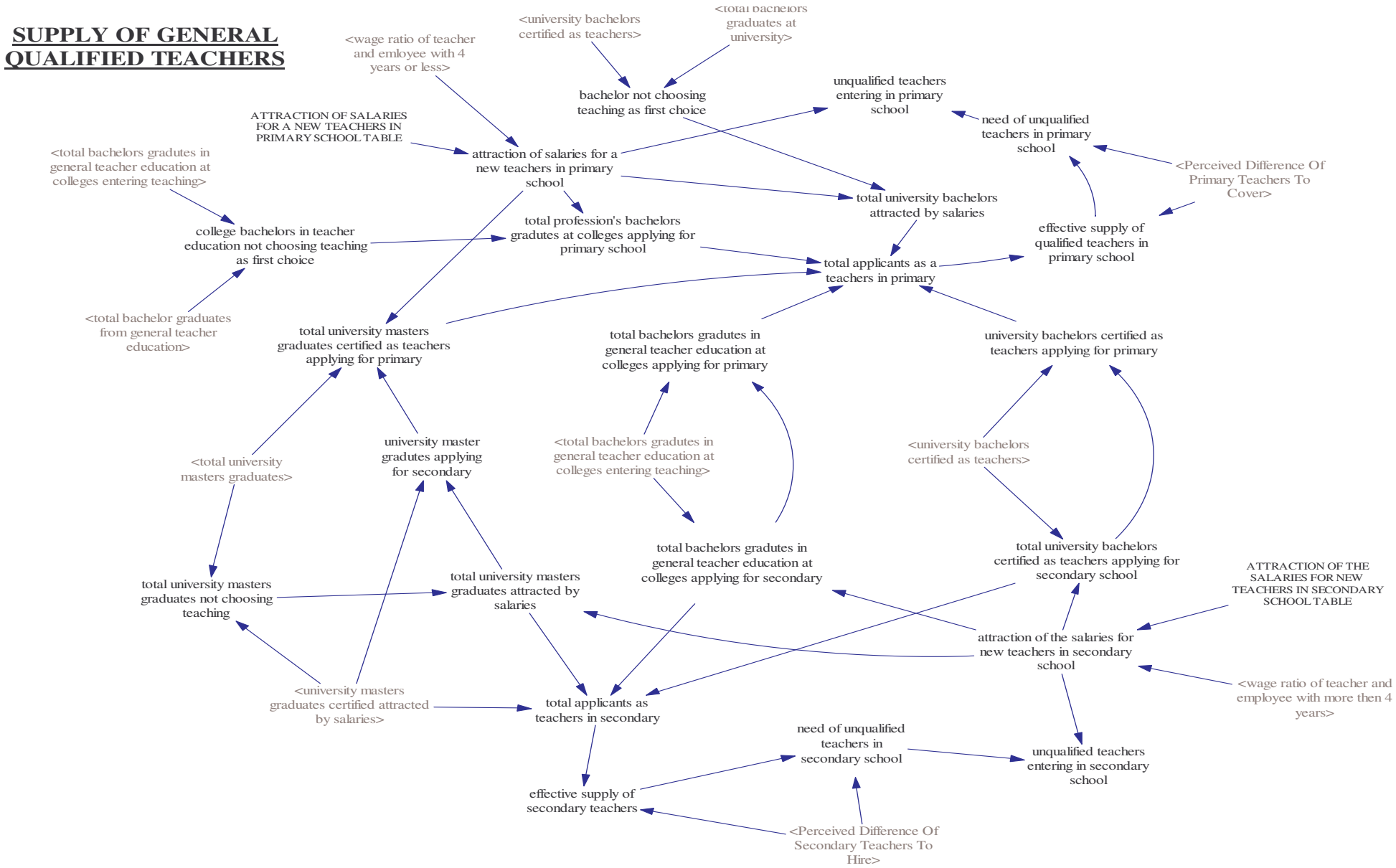


MASTER GRADUTES QUALIFIED IN SCIENCE ENTERING TEACHING

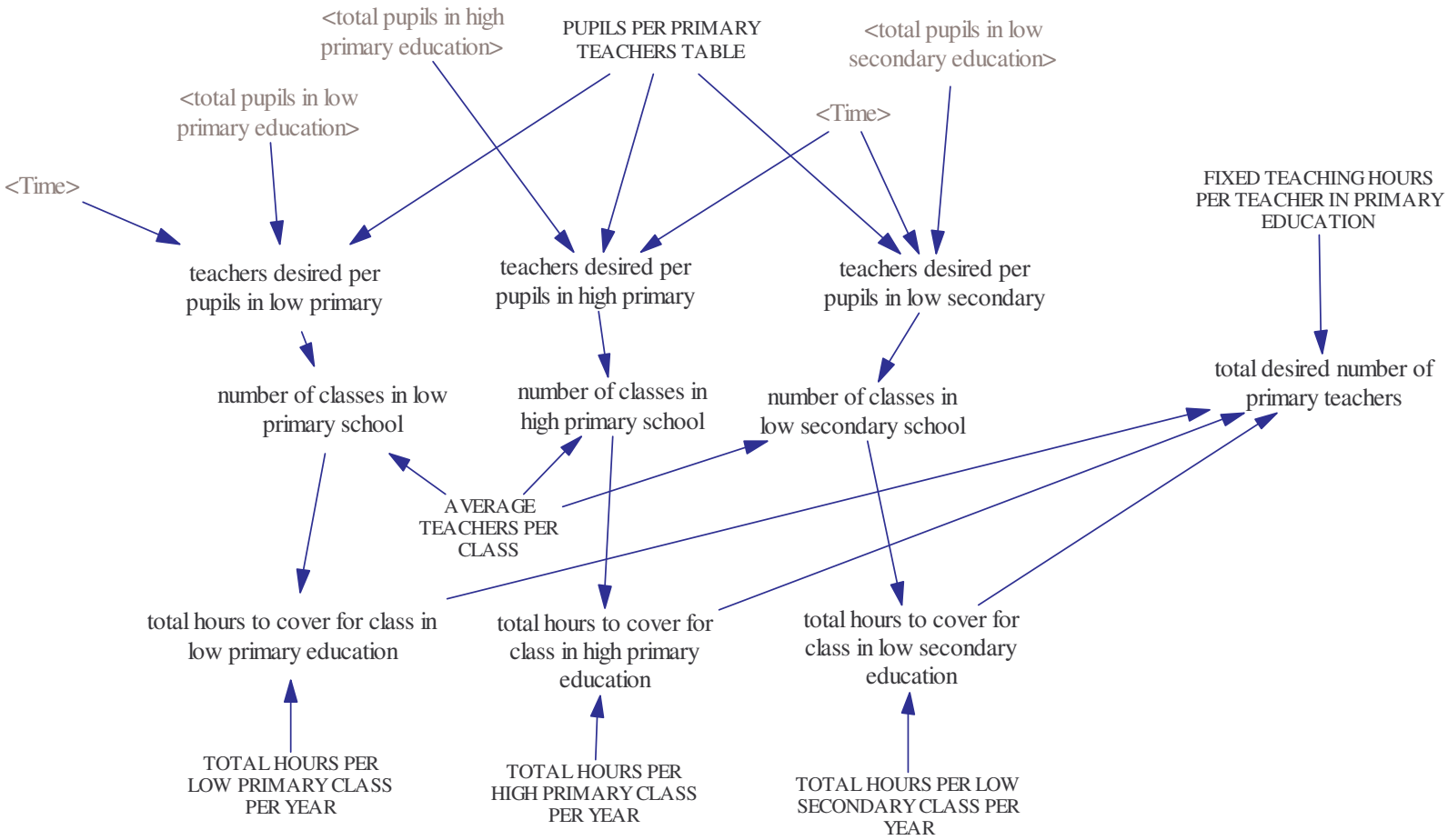


TOTAL AVAILABLE POTENTIAL WORKFORCE IN SCIENCE

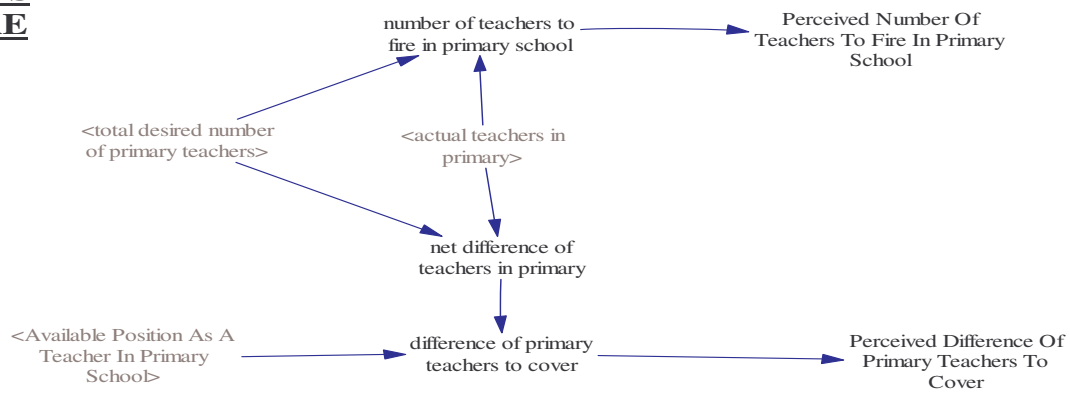



SUPPLY OF GENERAL QUALIFIED TEACHERS
<wage ratio of teacher and emloyee with 4 years or less>
<university bachelors certified as teachers>
<total bachelors graduates at university>
bachelor not choosing teaching as first choice
unqualified teachers entering in primary school
need of unqualified teachers in primary school
<Perceived Difference Of Primary Teachers To Cover>
ATTRACTION OF SALARIES FOR A NEW TEACHERS IN PRIMARY SCHOOL TABLE
attraction of salaries for a new teachers in primary school
<total bachelors gradutes in general teacher education at colleges entering teaching>
total university bachelors attracted by salaries
college bachelors in teacher education not choosing teaching as first choice
total profession's bachelors gradutes at colleges applying for primary school
effective supply of qualified teachers in primary school
total applicants as a teachers in primary
<total bachelor graduates from general teacher education>
total university masters graduates certified as teachers applying for primary
total bachelors gradutes in general teacher education at colleges applying for primary
university bachelors certified as teachers applying for primary
university master gradutes applying for secondary
<total bachelors gradutes in general teacher education at colleges entering teaching>
<university bachelors certified as teachers>
<total university masters graduates>
total bachelors gradutes in general teacher education at colleges applying for secondary
total university bachelors certified as teachers applying for secondary school
ATTRACTION OF THE SALARIES FOR NEW TEACHERS IN SECONDARY SCHOOL TABLE
total university masters graduates not choosing teaching
total university masters graduates attracted by salaries
attraction of the salaries for new teachers in secondary school
<wage ratio of teacher and employee with more then 4 years>
<university masters graduates certified attracted by salaries>
total applicants as teachers in secondary
need of unqualified teachers in secondary school
unqualified teachers entering in secondary school
effective supply of secondary teachers
<Perceived Difference Of Secondary Teachers To Hire>

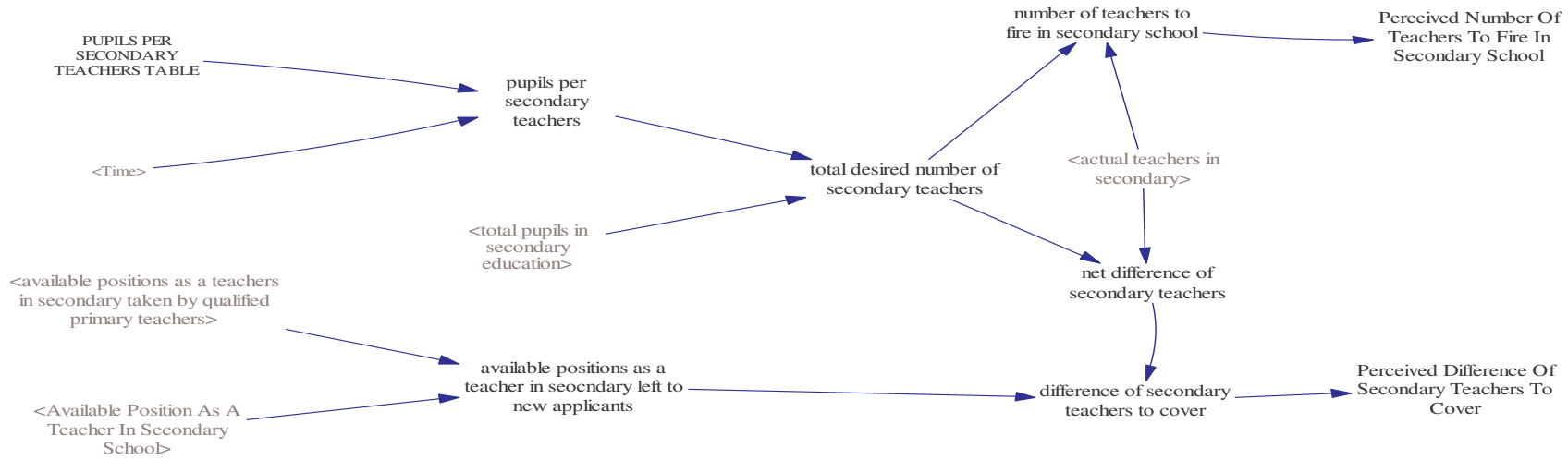
DESIRED GENERAL PRIMARY TEACHERS



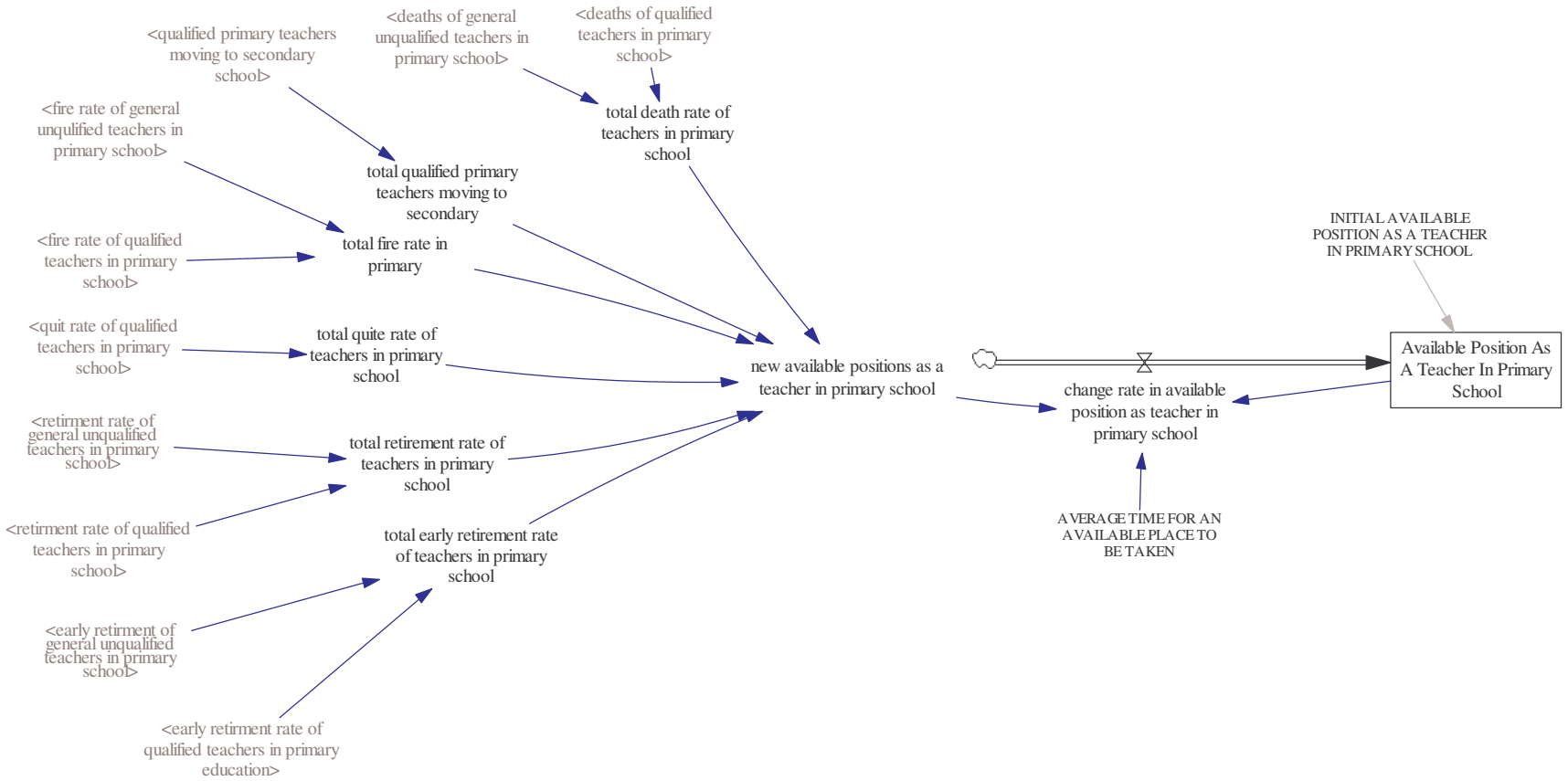
PRIMARY TEACHERS TO COVER AND FIRE



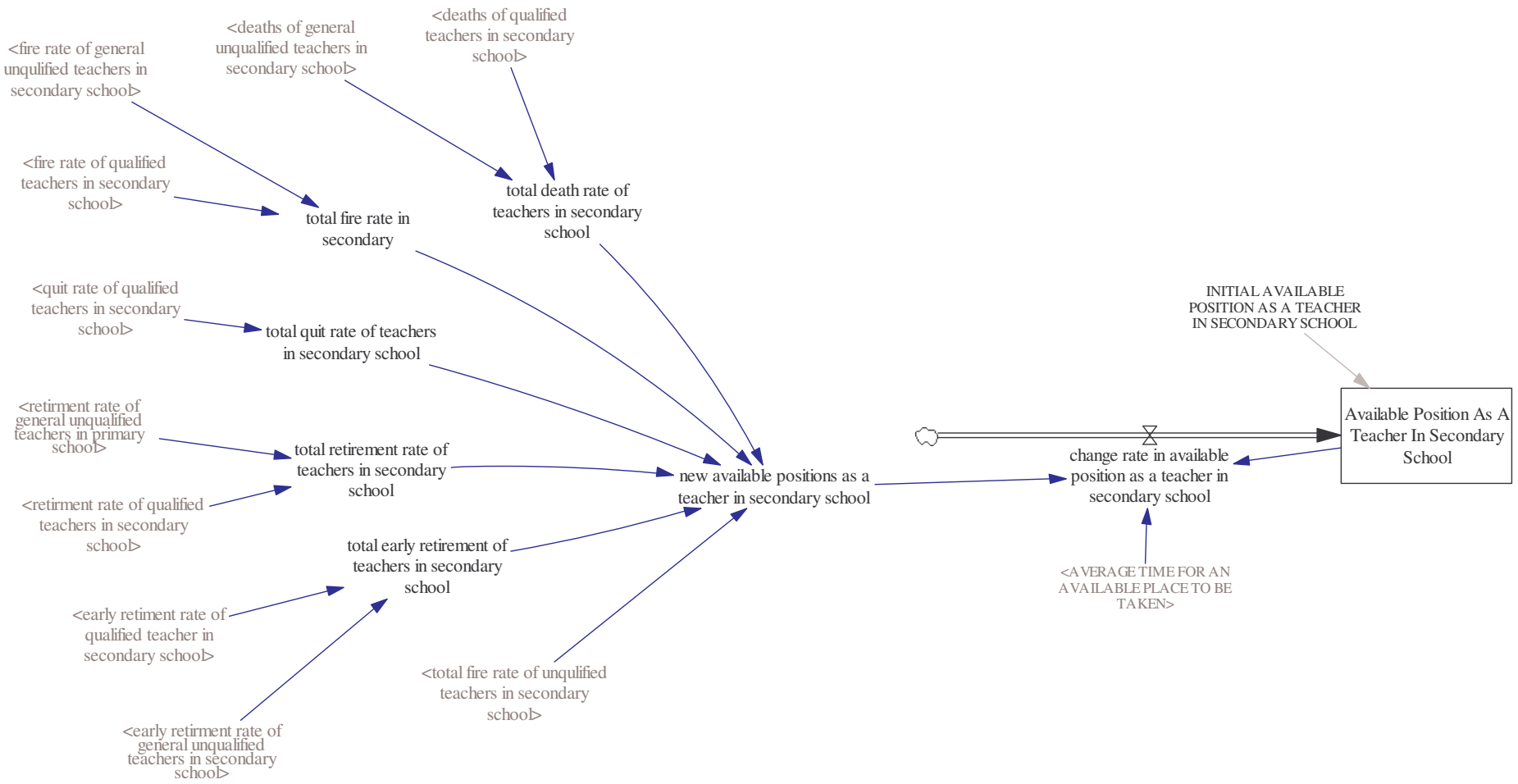
DESIRED SECONDARY TEACHERS TO COVER AND FIRE



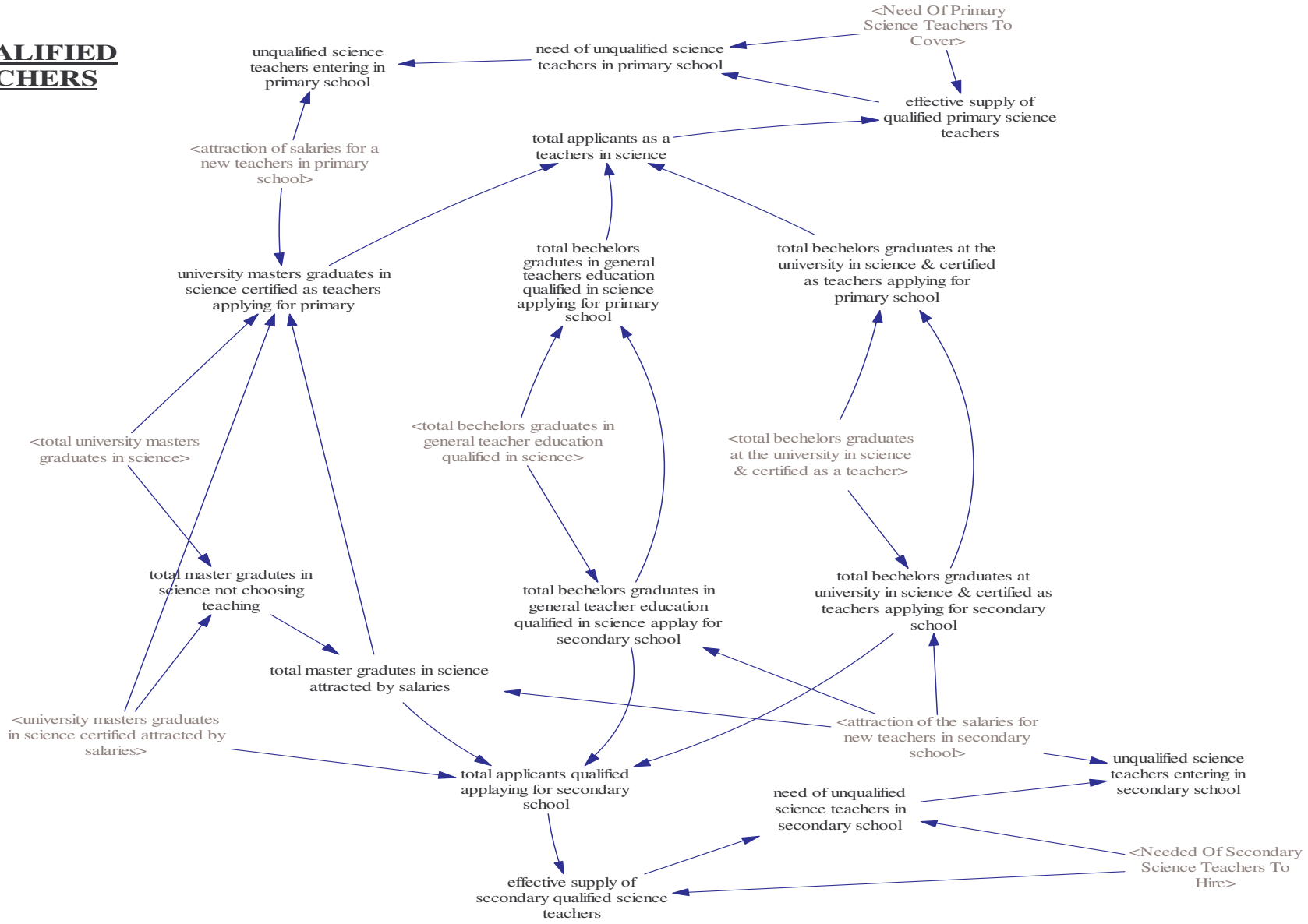
AVAILABLE POSITIONS IN PRIMARY



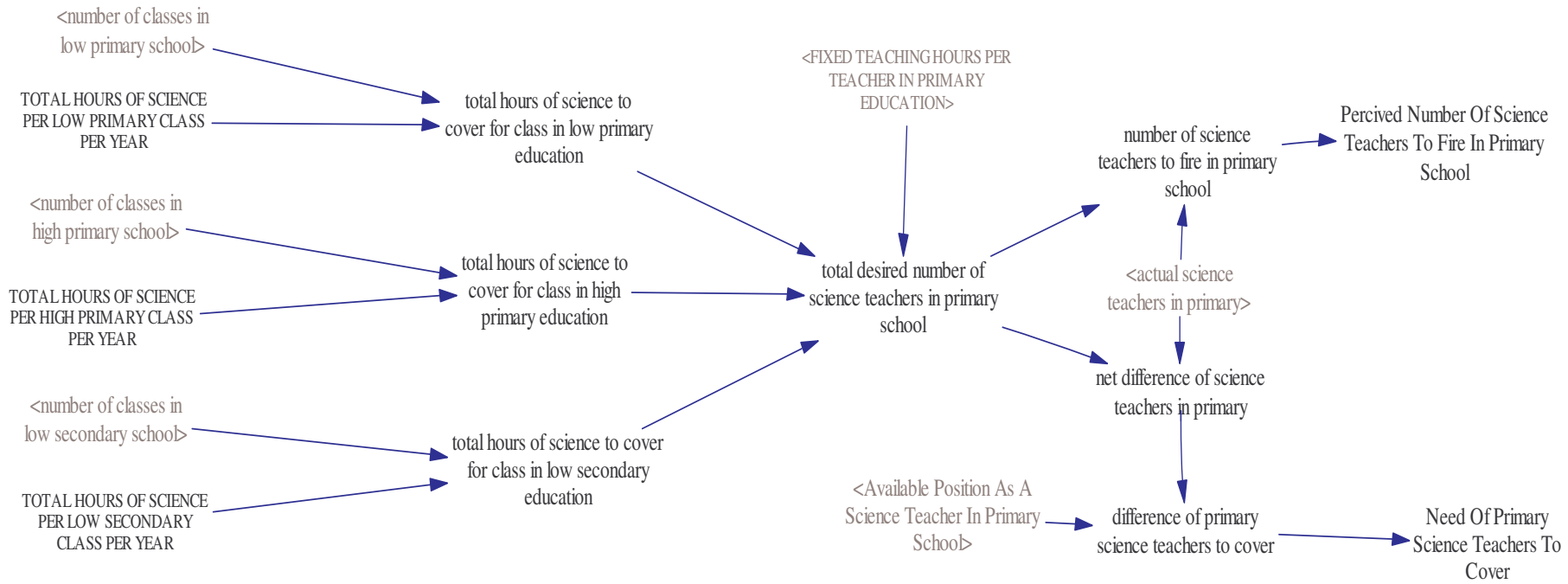
AVAILABLE POSITIONS IN SECONDARY



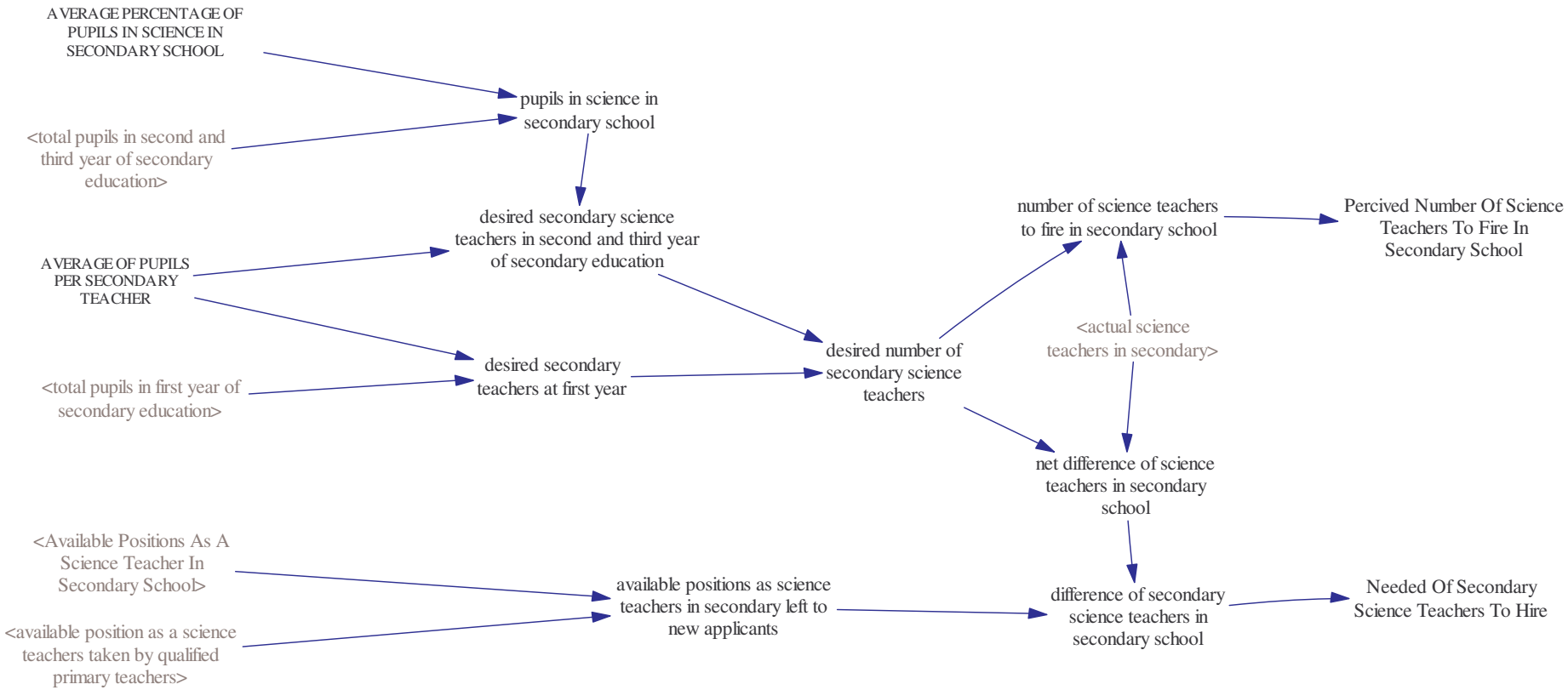
SUPPLY OF QUALIFIED SCIENCE TEACHERS



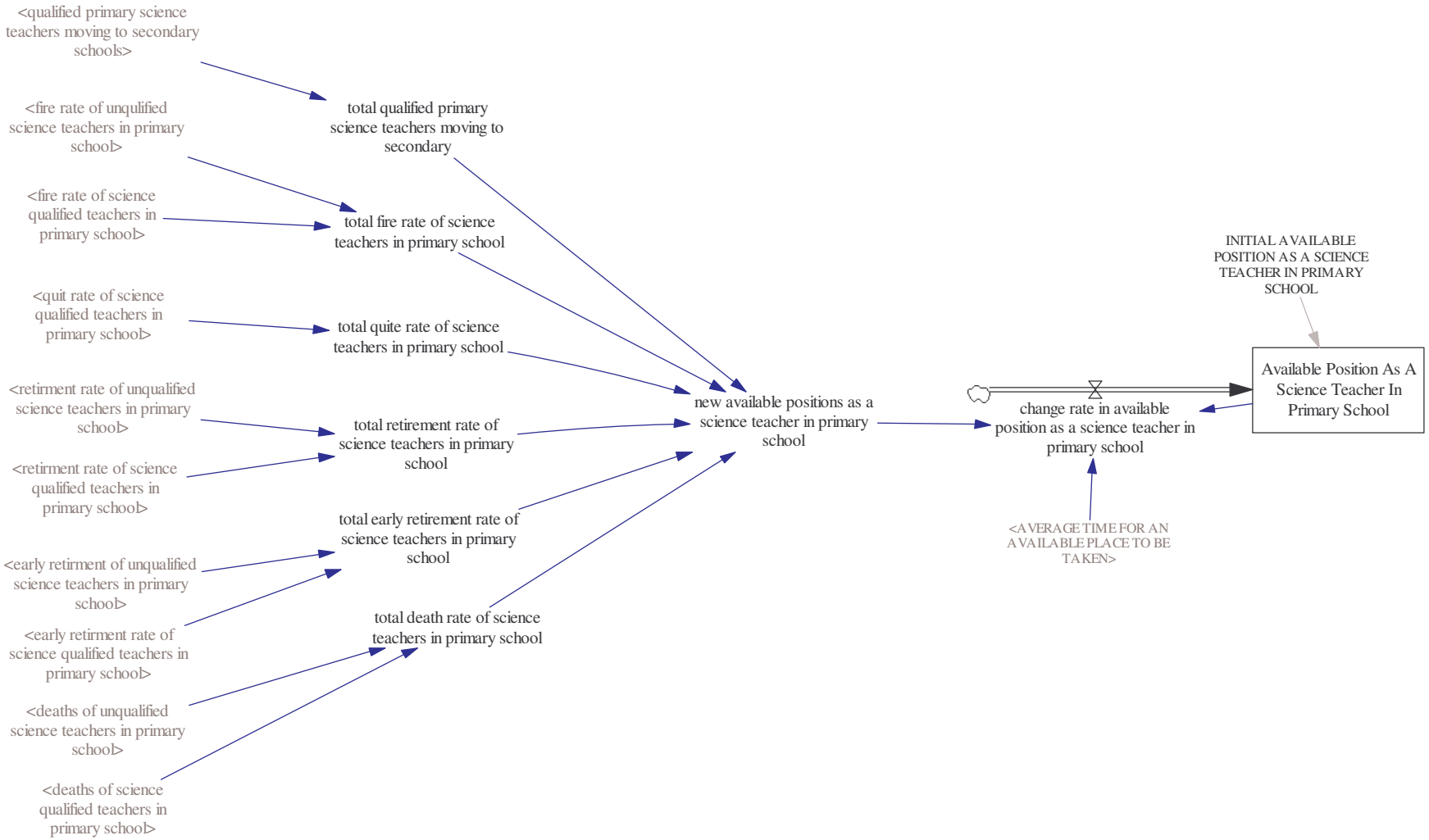
DESIRED PRIMARY SCIENCE TEACHERS

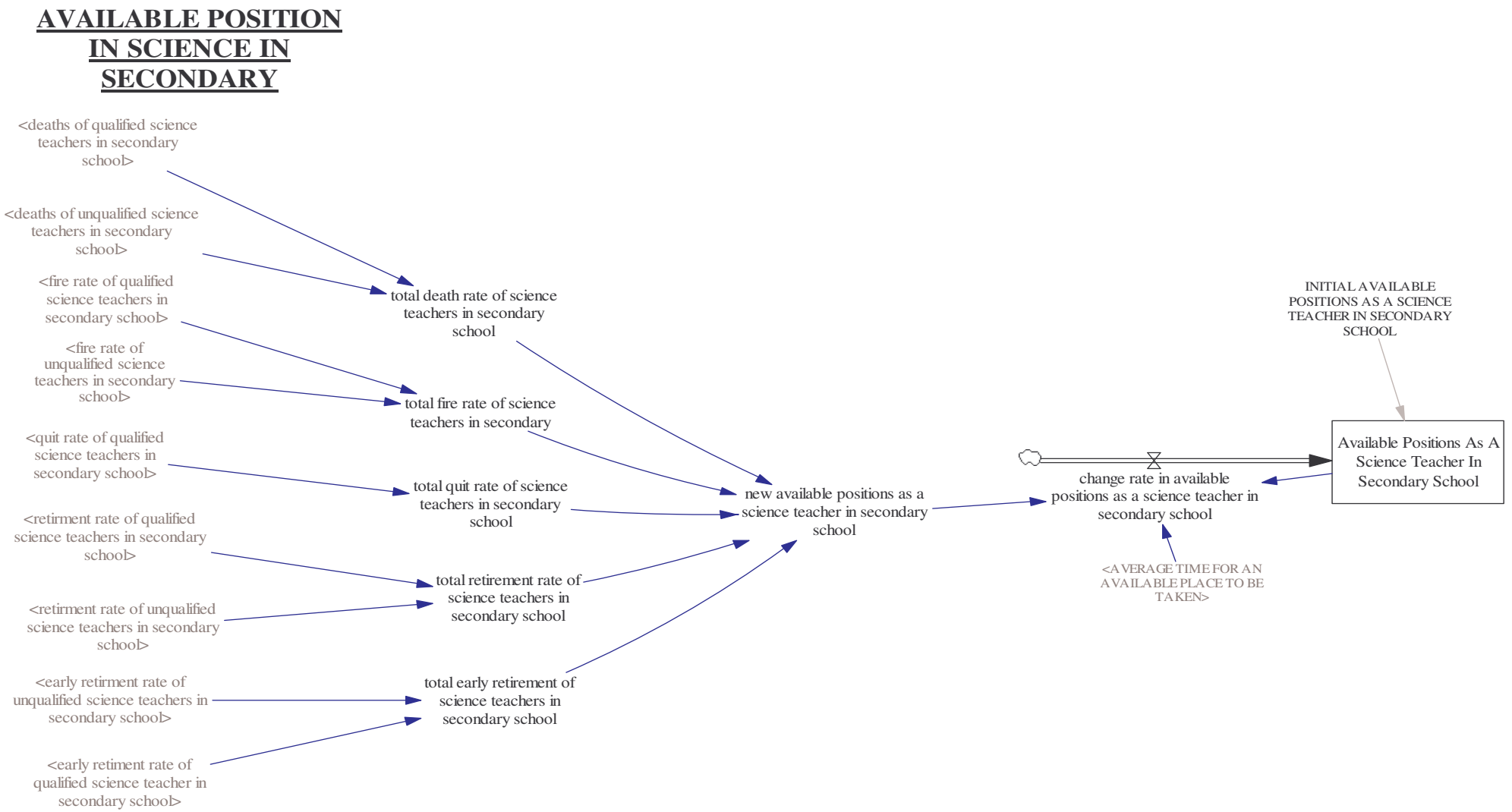


DESIRED SECONDARY SCIENCE TEACHERS

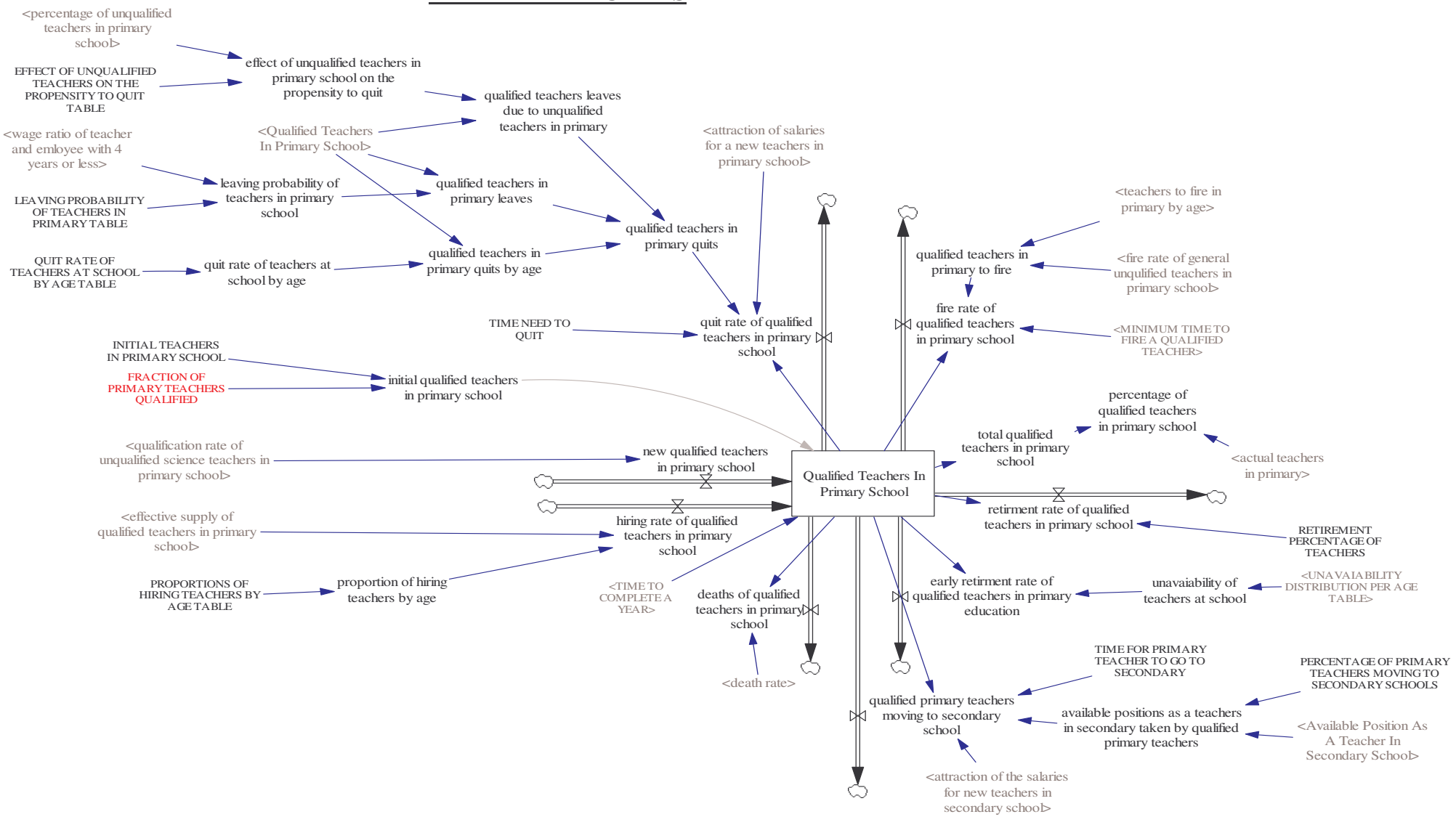


AVAILABLE POSITIONS IN SCIENCE IN PRIMARY

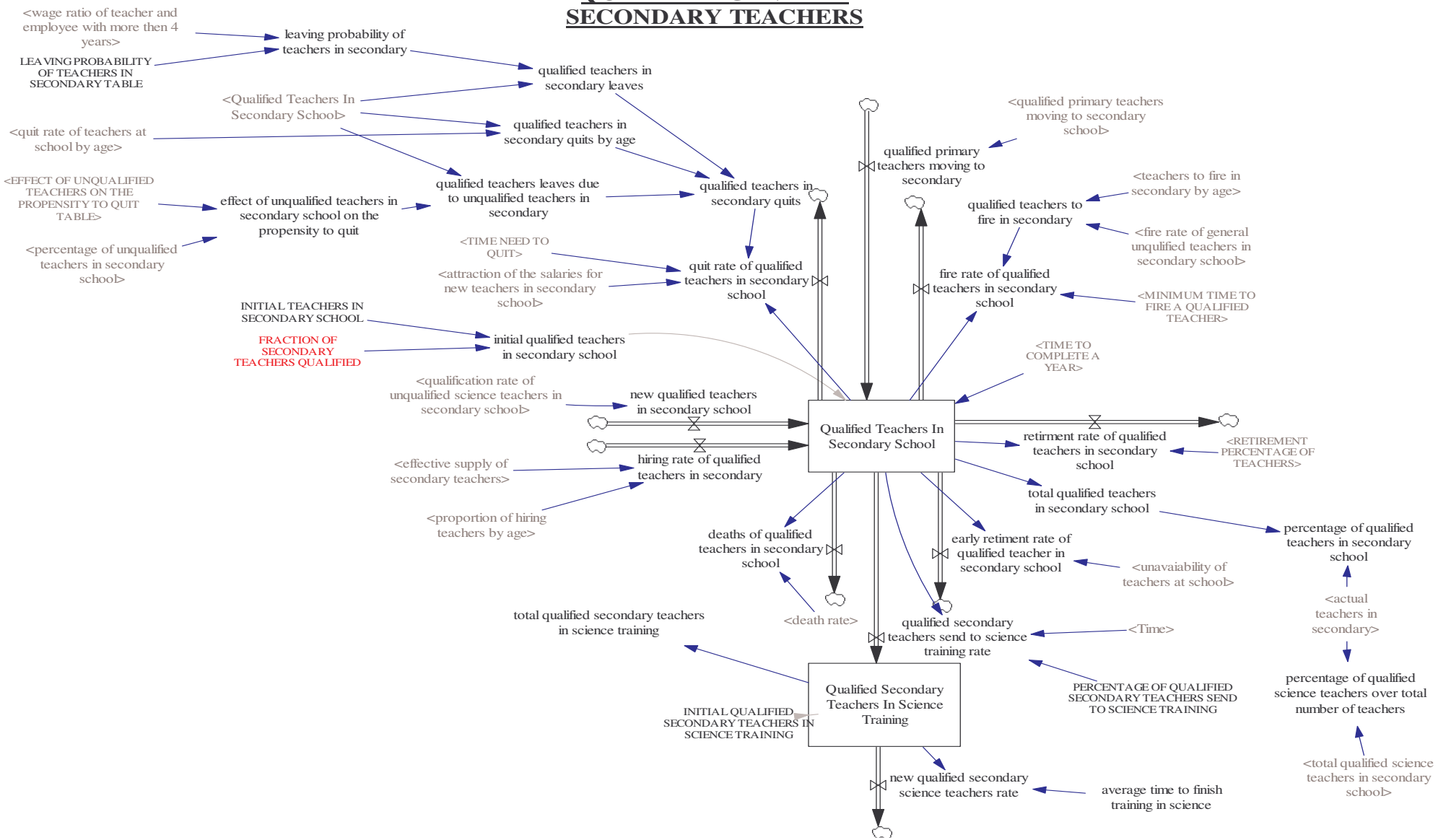


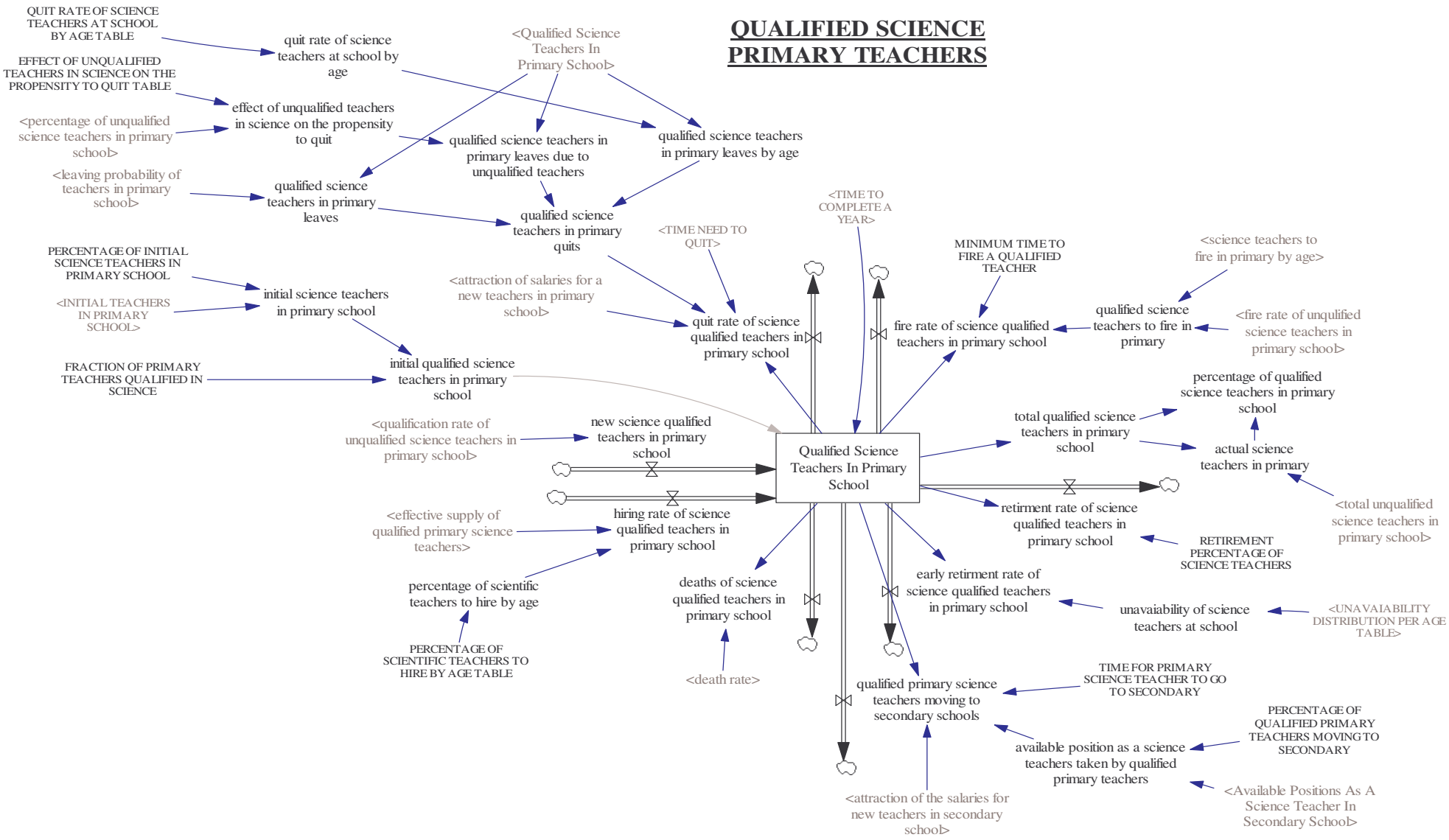

AVAILABLE POSITION IN SCIENCE IN SECONDARY
<deaths of qualified science teachers in secondary school>
<deaths of unqualified science teachers in secondary school>
<fire rate of qualified science teachers in secondary school>
<fire rate of unqualified science teachers in secondary school>
<quit rate of qualified science teachers in secondary school>
<retirment rate of qualified science teachers in secondary school>
<retirment rate of unqualified science teachers in secondary school>
<early retirment rate of unqualified science teachers in secondary school>
<early retiment rate of qualified science teacher in secondary school>
total death rate of science teachers in secondary school
total fire rate of science teachers in secondary
total quit rate of science teachers in secondary school
total retirement rate of science teachers in secondary school
total early retirement of science teachers in secondary school
new available positions as a science teacher in secondary school
change rate in available positions as a science teacher in secondary school
<AVERAGE TIME FOR AN AVAILABLE PLACE TO BE TAKEN>
INITIAL AVAILABLE POSITIONS AS A SCIENCE TEACHER IN SECONDARY SCHOOL
Available Positions As A Science Teacher In Secondary School

QUALIFIED GENERAL PRIMARY TEACHERS

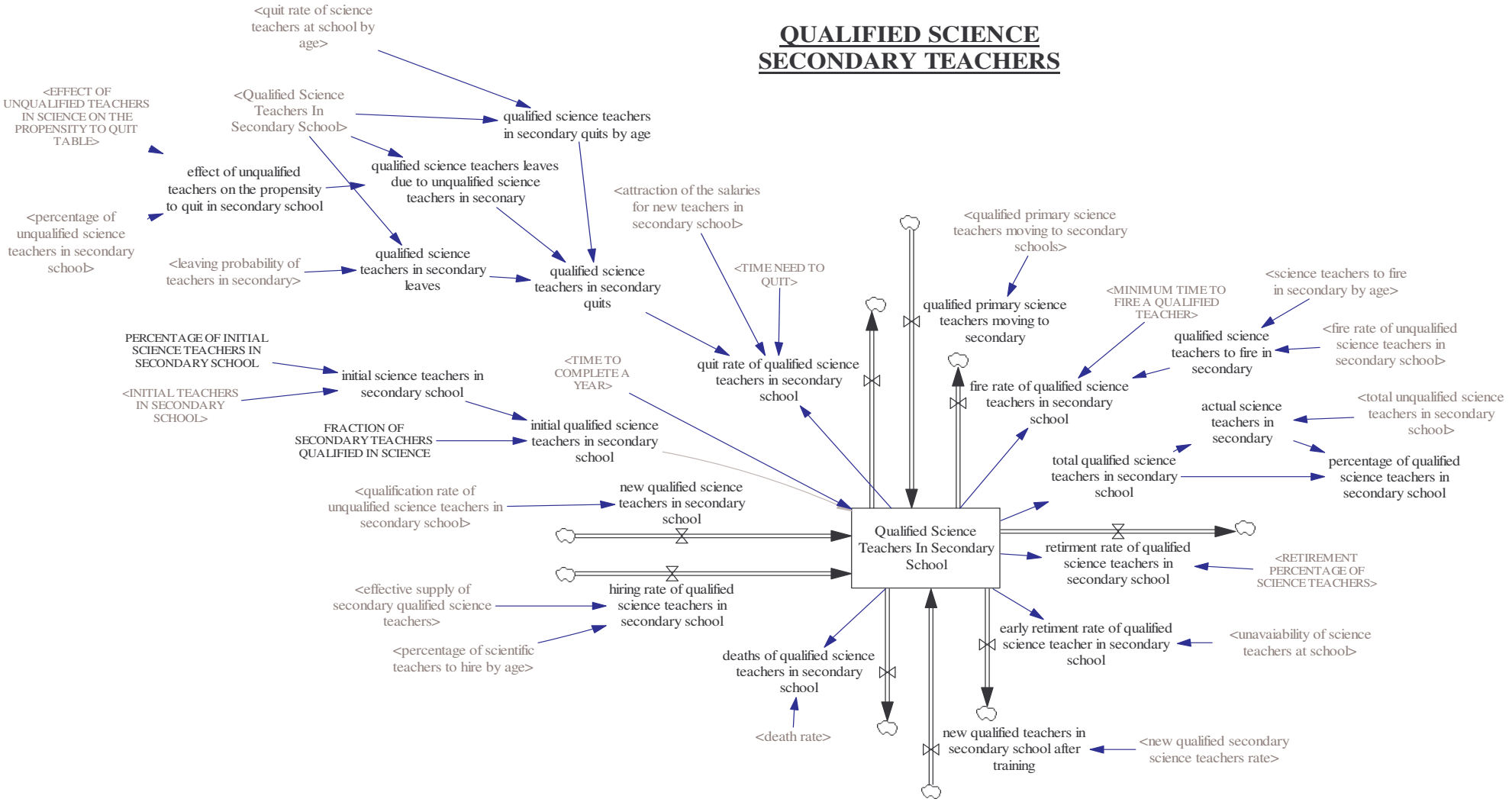


QUALIFIED GENERAL SECONDARY TEACHERS

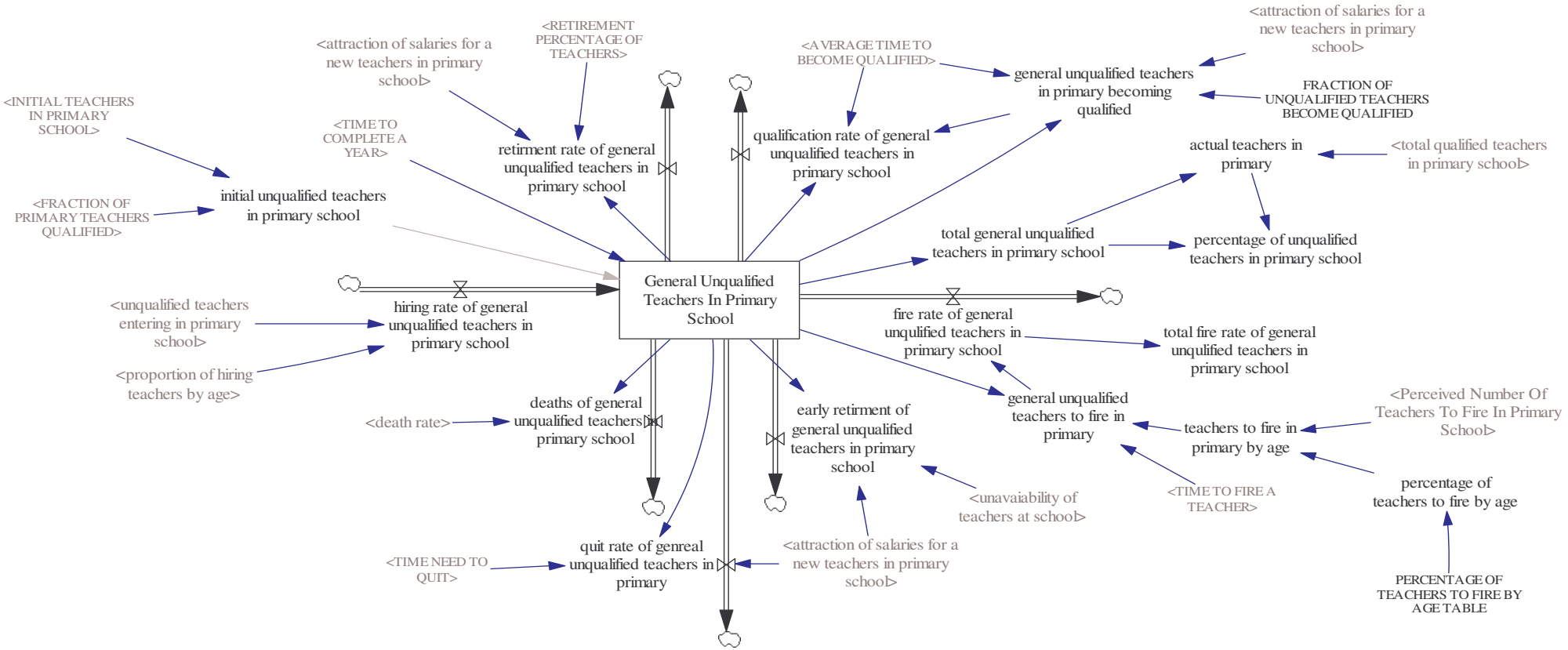



QUALIFIED SCIENCE PRIMARY TEACHERS
QUIT RATE OF SCIENCE TEACHERS AT SCHOOL BY AGE TABLE
quit rate of science teachers at school by age
<Qualified Science Teachers In Primary School>
EFFECT OF UNQUALIFIED TEACHERS IN SCIENCE ON THE PROPENSITY TO QUIT TABLE
effect of unqualified teachers in science on the propensity to quit
<percentage of unqualified science teachers in primary school>
qualified science teachers in primary leaves due to unqualified teachers
qualified science teachers in primary leaves by age
<leaving probability of teachers in primary school>
qualified science teachers in primary leaves
qualified science teachers in primary quits
<TIME TO COMPLETE A YEAR>
<TIME NEED TO QUIT>
MINIMUM TIME TO FIRE A QUALIFIED TEACHER
<science teachers to fire in primary by age>
PERCENTAGE OF INITIAL SCIENCE TEACHERS IN PRIMARY SCHOOL
<attraction of salaries for a new teachers in primary school>
quit rate of science qualified teachers in primary school
fire rate of science qualified teachers in primary school
qualified science teachers to fire in primary
<fire rate of unqulified science teachers in primary school>
<INITIAL TEACHERS IN PRIMARY SCHOOL>
initial science teachers in primary school
FRACTION OF PRIMARY TEACHERS QUALIFIED IN SCIENCE
initial qualified science teachers in primary school
percentage of qualified science teachers in primary school
total qualified science teachers in primary school
actual science teachers in primary
<qualification rate of unqualified science teachers in primary school>
new science qualified teachers in primary school
Qualified Science Teachers In Primary School
<total unqualified science teachers in primary school>
retirment rate of science qualified teachers in primary school
RETIREMENT PERCENTAGE OF SCIENCE TEACHERS
<effective supply of qualified primary science teachers>
hiring rate of science qualified teachers in primary school
percentage of scientific teachers to hire by age
deaths of science qualified teachers in primary school
early retirment rate of science qualified teachers in primary school
unavaiability of science teachers at school
<UNAVAIABILITY DISTRIBUTION PER AGE TABLE>
PERCENTAGE OF SCIENTIFIC TEACHERS TO HIRE BY AGE TABLE
<death rate>
qualified primary science teachers moving to secondary schools
TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY
PERCENTAGE OF QUALIFIED PRIMARY TEACHERS MOVING TO SECONDARY
available position as a science teachers taken by qualified primary teachers
<attraction of the salaries for new teachers in secondary school>
<Available Positions As A Science Teacher In Secondary School>

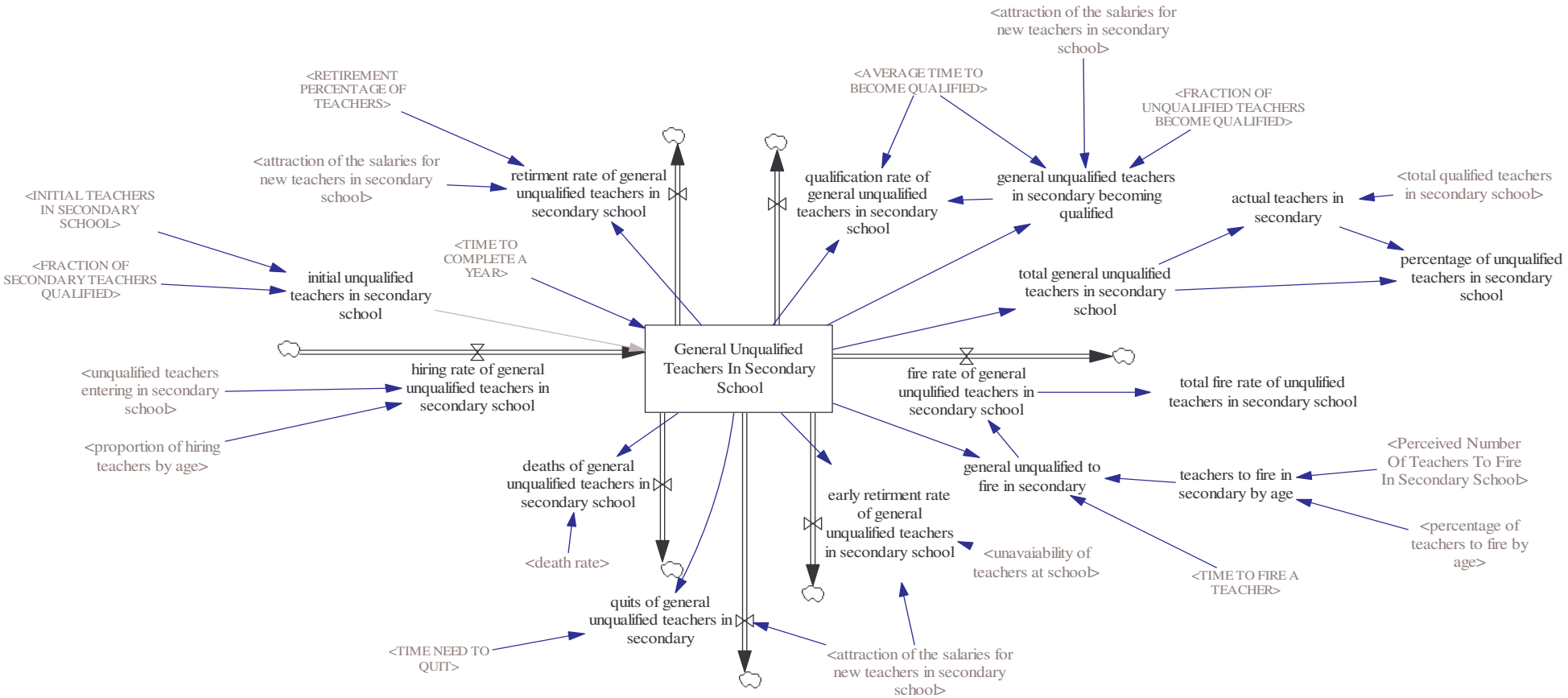
QUALIFIED SCIENCE SECONDARY TEACHERS



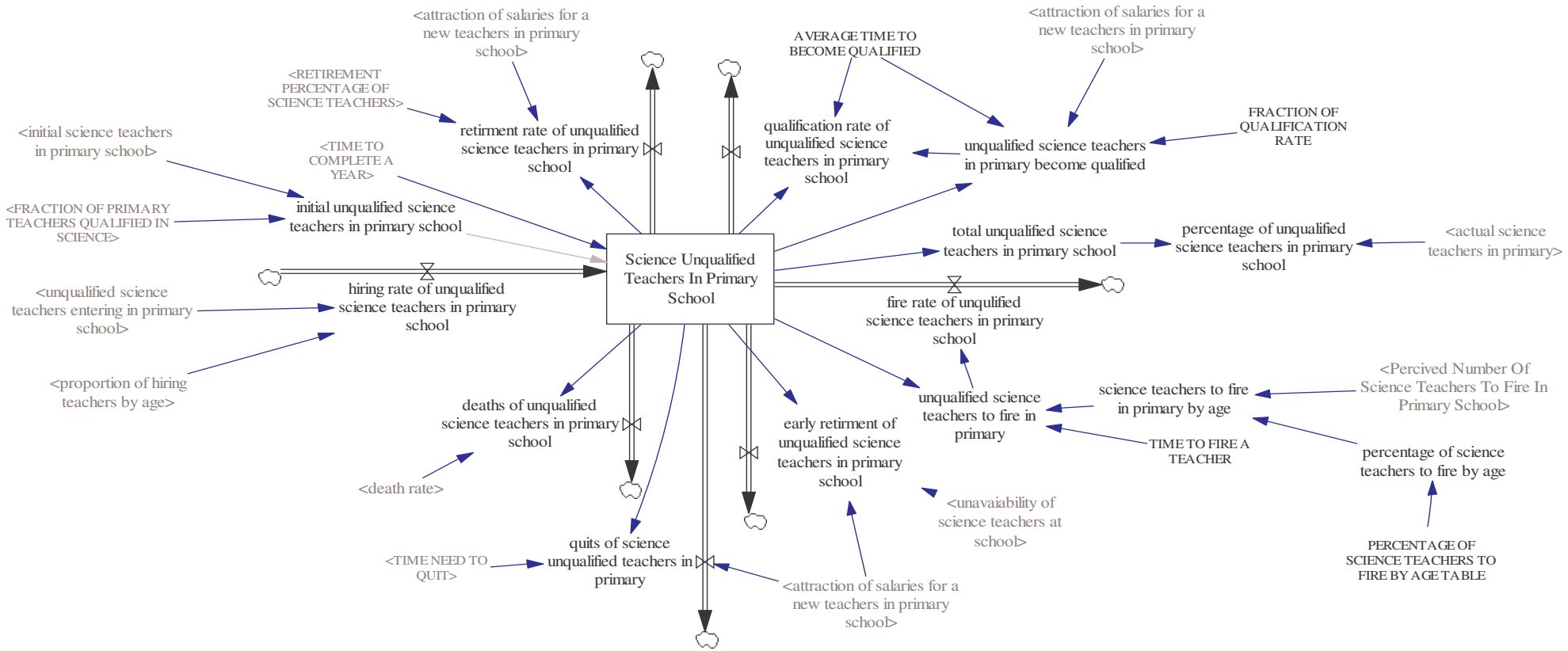
GENERAL UNQUALIFIED PRIMARY TEACHERS



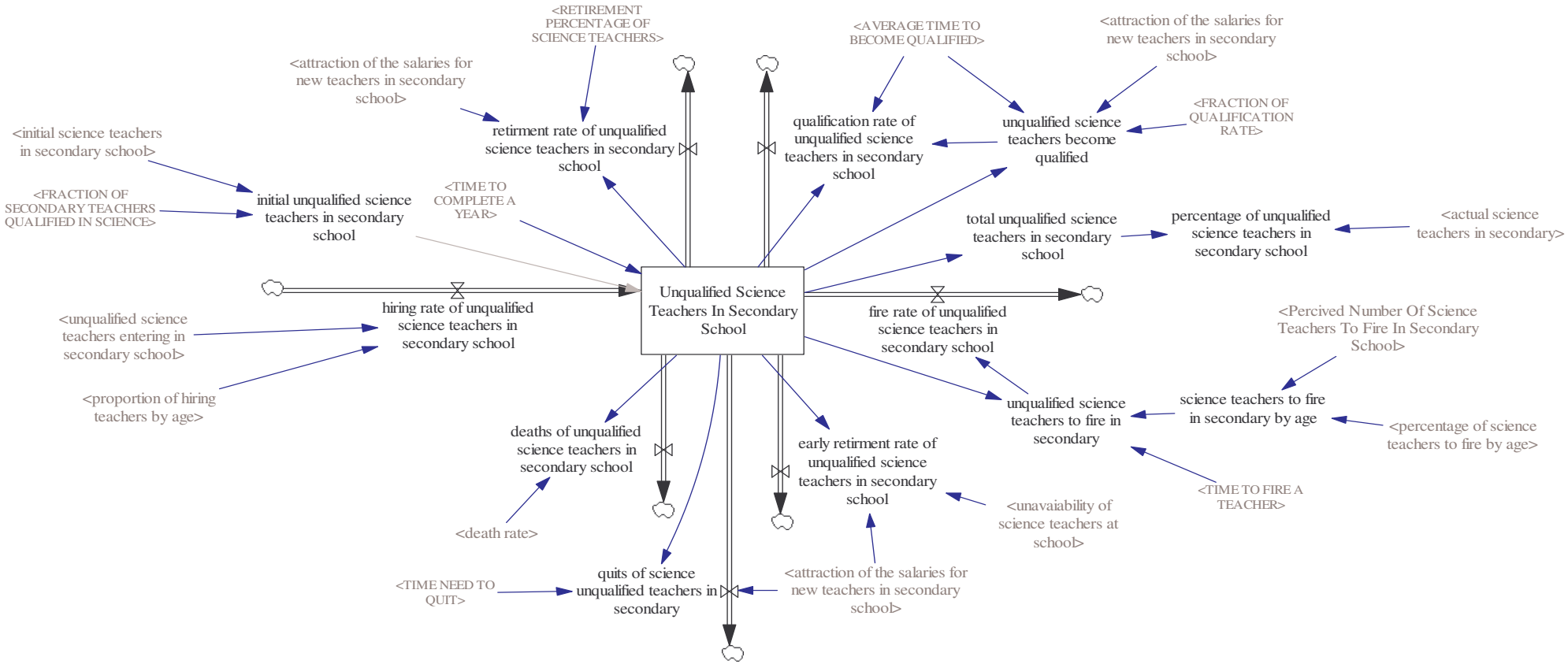
GENERAL UNQUALIFIED SECONDARY TEACHERS

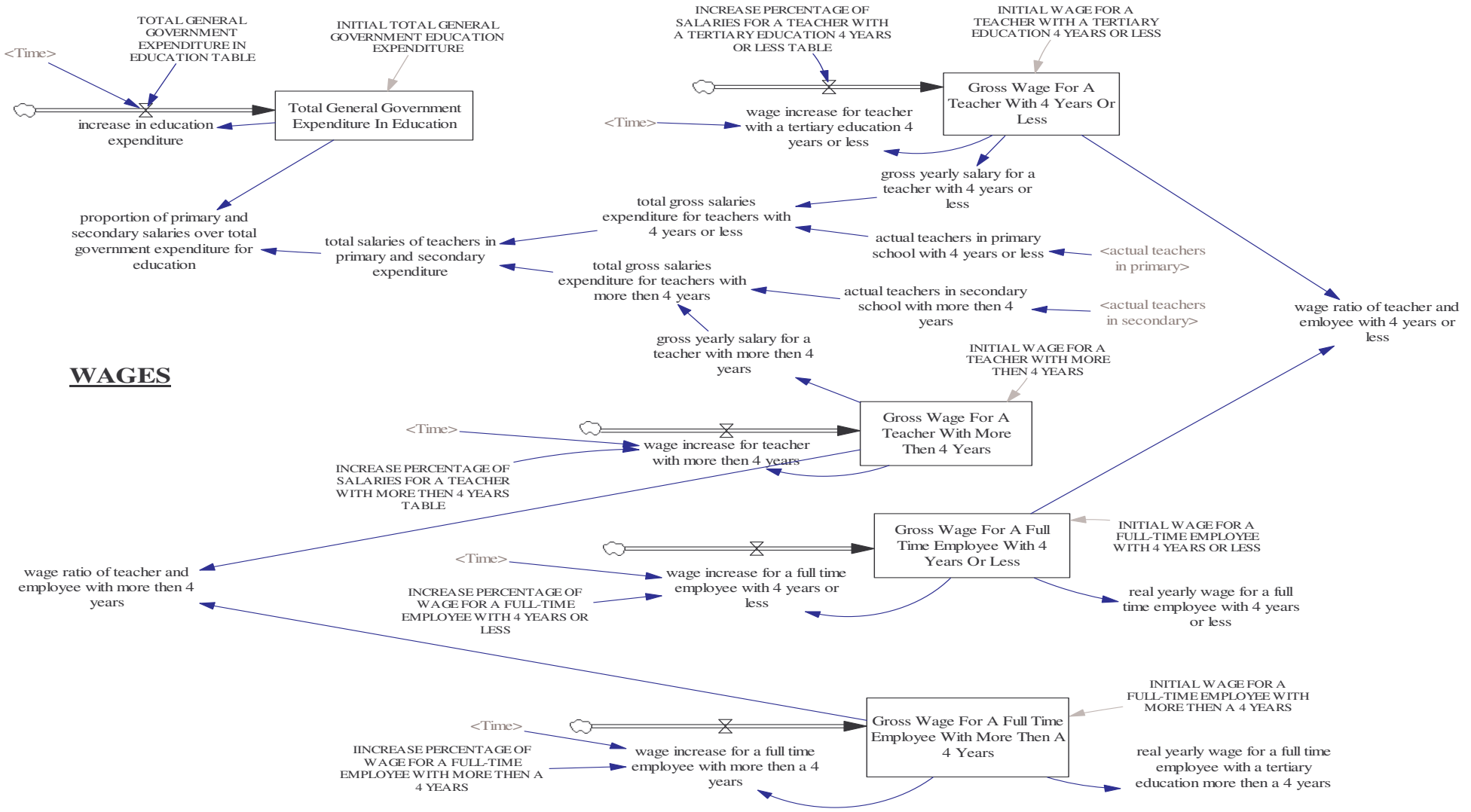


SCIENCE UNQUALIFIED PRIMARY TEACHERS



SCIENCE UNQUALIFIED SECONDARY TEACHERS




WAGES
<Time>
TOTAL GENERAL GOVERNMENT EXPENDITURE IN EDUCATION TABLE
INITIAL TOTAL GENERAL GOVERNMENT EDUCATION EXPENDITURE
increase in education expenditure
Total General Government Expenditure In Education
proportion of primary and secondary salaries over total government expenditure for education
total salaries of teachers in primary and secondary expenditure
INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS TABLE
INITIAL WAGE FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS
wage increase for teacher with a tertiary education 4 years or less
Gross Wage For A Teacher With 4 Years Or Less
gross yearly salary for a teacher with 4 years or less
total gross salaries expenditure for teachers with 4 years or less
actual teachers in primary school with 4 years or less
<actual teachers in primary>
total gross salaries expenditure for teachers with more then 4 years
actual teachers in secondary school with more then 4 years
<actual teachers in secondary>
wage ratio of teacher and emloyee with 4 years or less
gross yearly salary for a teacher with more then 4 years
INITIAL WAGE FOR A TEACHER WITH MORE THEN 4 YEARS
Gross Wage For A Teacher With More Then 4 Years
<Time>
wage increase for teacher with more then 4 years
INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH MORE THEN 4 YEARS TABLE
wage ratio of teacher and employee with more then 4 years
Gross Wage For A Full Time Employee With 4 Years Or Less
INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS
<Time>
wage increase for a full time employee with 4 years or less
INCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS
real yearly wage for a full time employee with 4 years or less
INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS
Gross Wage For A Full Time Employee With More Then A 4 Years
<Time>
wage increase for a full time employee with more then a 4 years
IINCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS
real yearly wage for a full time employee with a tertiary education more then a 4 years

```
********************************
  .Available position in primary
********************************

Available Position As A Teacher In Primary School  =
      INTEG( change rate in available position as teacher in primary school ,
          INITIAL AVAILABLE POSITION AS A TEACHER IN PRIMARY SCHOOL )
            Units: person
            Available positions every year as a teachers in primary school

AVERAGE TIME FOR A POSITION TO BE AVAILABLE  = 1
            Units: Year
            time need to replace a vacant position

change rate in available position as teacher in primary school  =
       new available positions as a teacher in primary school
           - ( Available Position As A Teacher In Primary School
               / AVERAGE TIME FOR A POSITION TO BE AVAILABLE )
            Units: person/Year
            Numbers of positions becoming available in primary schools

INITIAL AVAILABLE POSITION AS A TEACHER IN PRIMARY SCHOOL  = 17808
            Units: person

new available positions as a teacher in primary school  =
       total death rate of teachers in primary school
           + total early retirement rate of teachers in primary school
           + total early retirement rate of teachers in primary school
           + total retirement rate of teachers in primary school
           + total quite rate of teachers in primary school
           + total fire rate in primary
           + total qualified primary teachers moving to secondary
            Units: person/Year
            Total number of teachers leaving the primary schools

total death rate of teachers in primary school  =
       SUM ( deaths of qualified teachers in primary school[sex!,teaching age!] )
           + SUM ( deaths of general unqualified teachers in primary school[sex!,teaching age!] )
            Units: person/Year

total desired teachers  =
       total desired number of primary teachers
           + total desired number of secondary teachers
            Units: person

total early retirement rate of teachers in primary school  =
       SUM ( early retirement rate of qualified teachers in primary education[sex!,teaching age!] )
           + SUM ( early retirement of general unqualified teachers in primary school[sex!,teaching age!] )
            Units: person/Year

total fire rate in primary  =
       SUM ( fire rate of qualified teachers in primary school[sex!,teaching age!] )
           + SUM ( fire rate of general unqualified teachers in primary school[sex!,teaching age!] )
            Units: person/Year

total qualified primary teachers moving to secondary  =
       SUM ( qualified primary teachers moving to secondary school[sex!,teaching agehi 50 to 59!] )
            Units: person/Year

total quite rate of teachers in primary school  =
```

SUM (quit rate of qualified teachers in primary school[sex!,teaching age!])
Units: person/Year

total retirement rate of teachers in primary school =
SUM (retirement rate of qualified teachers in primary school[sex!,TAGE 67])
+ SUM (retirement rate of general unqualified teachers in primary school[sex!,TAGE 67])
Units: person/Year

****
.Available positions in science in primary
****

Available Position As A Science Teacher In Primary School =
INTEG(change rate in available position as a science teacher in primary school ,
INITIAL AVAILABLE POSITION AS A SCIENCE TEACHER IN PRIMARY SCHOOL)
Units: person

change rate in available position as a science teacher in primary school =
new available positions as a science teacher in primary school
- (Available Position As A Science Teacher In Primary School
/ AVERAGE TIME FOR A POSITION TO BE AVAILABLE)
Units: person/Year
numbers of science positions becoming available in primary schools

INITIAL AVAILABLE POSITION AS A SCIENCE TEACHER IN PRIMARY SCHOOL = 4413
Units: person

new available positions as a science teacher in primary school =
total death rate of science teachers in primary school
+ total early retirement rate of science teachers in primary school
+ total early retirement rate of science teachers in primary school
+ total retirement rate of science teachers in primary school
+ total quite rate of science teachers in primary school
+ total fire rate of science teachers in primary school
+ total qualified primary science teachers moving to secondary
Units: person/Year

total death rate of science teachers in primary school =
SUM (deaths of science qualified teachers in primary school[sex!,teaching age!])
+ SUM (deaths of unqualified science teachers in primary school[sex!,teaching age!])
Units: person/Year

total early retirement rate of science teachers in primary school =
SUM (early retirement of unqualified science teachers in primary school[sex!,teaching age!])
+ SUM (early retirement rate of science qualified teachers in primary school[sex!,teaching age!])
Units: person/Year

total fire rate of science teachers in primary school =
SUM (fire rate of science qualified teachers in primary school[sex!,teaching age!])
+ SUM (fire rate of unqualified science teachers in primary school[sex!,teaching age!])
Units: person/Year

total qualified primary science teachers moving to secondary =
SUM (qualified primary science teachers moving to secondary schools[sex!,teaching agehi 50 to 59!])
Units: person/Year

total quite rate of science teachers in primary school =
SUM (quit rate of science qualified teachers in primary school[sex!,teaching age!])
Units: person/Year

```
total retirement rate of science teachers in primary school  =
        SUM ( retirement rate of science qualified teachers in primary school[sex!,TAGE 67] )
            + SUM ( retirement rate of unqualified science teachers in primary school[sex!,TAGE 67] )
             Units: person/Year

*******************************
  .Available positions in science in secondary
*******************************

Available Positions As A Science Teacher In Secondary School  =
       INTEG( change rate in available positions as a science teacher in secondary school ,
           INITIAL AVAILABLE POSITIONS AS A SCIENCE TEACHER IN SECONDARY SCHOOL )
             Units: person

change rate in available positions as a science teacher in secondary school  =
        new available positions as a science teacher in secondary school
            - ( Available Positions As A Science Teacher In Secondary School
                / AVERAGE TIME FOR A POSITION TO BE AVAILABLE )
             Units: person/Year
             numbers of science positions becoming available in secondary schools

INITIAL AVAILABLE POSITIONS AS A SCIENCE TEACHER IN SECONDARY SCHOOL  = 1718
             Units: person

new available positions as a science teacher in secondary school  =
        total death rate of science teachers in secondary school
            + total early retirement of science teachers in secondary school
            + total quit rate of science teachers in secondary school
            + total retirement rate of science teachers in secondary school
            + total fire rate of science teachers in secondary
             Units: person/Year

total death rate of science teachers in secondary school  =
        SUM ( deaths of qualified science teachers in secondary school[sex!,teaching age!] )
            + SUM ( deaths of unqualified science teachers in secondary school[sex!,teaching age!] )
             Units: person/Year

total desired teachers in science  =
        total desired number of science teachers in primary school
            + desired number of secondary science teachers
             Units: person

total early retirement of science teachers in secondary school  =
        SUM ( early retirement rate of qualified science teacher in secondary school[sex!,teaching age!] )
            + SUM ( early retirement rate of unqualified science teachers in secondary school[sex!,teaching age!] )
             Units: person/Year

total fire rate of science teachers in secondary  =
        SUM ( fire rate of qualified science teachers in secondary school[sex!,teaching age!] )
            + SUM ( fire rate of unqualified science teachers in secondary school[sex!,teaching age!] )
             Units: person/Year

total quit rate of science teachers in secondary school  =
        SUM ( quit rate of qualified science teachers in secondary school[sex!,teaching age!] )
             Units: person/Year

total retirement rate of science teachers in secondary school  =
        SUM ( retirement rate of qualified science teachers in secondary school[sex!,TAGE 67] )
            + SUM ( retirement rate of unqualified science teachers in secondary school[sex!,TAGE 67] )
             Units: person/Year
```

```
*******************************
  .Available positions in secondary
*******************************

Available Position As A Teacher In Secondary School  =
      INTEG( change rate in available position as a teacher in secondary school ,
         INITIAL AVAILABLE POSITION AS A TEACHER IN SECONDARY SCHOOL )
           Units: person

change rate in available position as a teacher in secondary school  =
       new available positions as a teacher in secondary school
           - ( Available Position As A Teacher In Secondary School
              / AVERAGE TIME FOR A POSITION TO BE AVAILABLE )
           Units: person/Year
           numbers of positions becoming available in secondary schools

INITIAL AVAILABLE POSITION AS A TEACHER IN SECONDARY SCHOOL  = 8880
           Units: person

new available positions as a teacher in secondary school  =
       total death rate of teachers in secondary school
           + total early retirement of teachers in secondary school
           + total quit rate of teachers in secondary school
           + total retirement rate of teachers in secondary school
           + total fire rate in secondary
           + total fire rate of unqualified teachers in secondary school
           Units: person/Year
           Total number of teachers leaving the secondary schools

total death rate of teachers in secondary school  =
       SUM ( deaths of qualified teachers in secondary school[sex!,teaching age!] )
           + SUM ( deaths of general unqualified teachers in secondary school[sex!,teaching age!] )
           Units: person/Year

total early retirement of teachers in secondary school  =
       SUM ( early retirement rate of qualified teacher in secondary school[sex!,teaching age!] )
           + SUM ( early retirement rate of general unqualified teachers in secondary school[sex!,teaching age!] )
           Units: person/Year

total fire rate in secondary  =
       SUM ( fire rate of qualified teachers in secondary school[sex!,teaching age!] )
           + SUM ( fire rate of general unqualified teachers in secondary school[sex!,teaching age!] )
           Units: person/Year

total quit rate of teachers in secondary school  =
       SUM ( quit rate of qualified teachers in secondary school[sex!,teaching age!] )
           Units: person/Year

total retirement rate of teachers in secondary school  =
       SUM ( retirement rate of qualified teachers in secondary school[sex!,TAGE 67] )
           + SUM ( retirement rate of general unqualified teachers in primary school[sex!,TAGE 67] )
           Units: person/Year

*******************************
  .College sector
*******************************

AVERAGE PERCENTAGE OF STUDENTS ENTERING IN TEACHERS COLLEGE EDUCATION  =
0.0660257
```

Units: Dmnl
Data source DBH .Percentage of students entering in college education which choose the teacher education. The percentage has been calculated considering the entering students in teacher education over the students entering in college education. Data table can be found in excel file "Statistic Data"

AVERAGE PERCENTAGE OF STUDENTS FINISHING COLLEGE FOR TEACHERS = 0.196706
Units: Dmnl
Data source DBH. Percentage of students which finish the course of study. The data has been calculated with the historical data found. Data table can be found in excel file "Statistic Data"

Bachelors Graduates At Colleges For General Teachers Education[sex,AGE 23] =
INTEG(profession's BACHELOR graduation rate for teachers education[sex,AGE 23]
- Bachelors Graduates At Colleges For General Teachers Education[sex,AGE 23]
/ TIME TO COMPLETE A YEAR
- deaths of bachelors graduates at college for teachers education[sex,AGE 23]
- unavaiability rate of bachelors graduates at colleges for teachers education[sex,AGE 23] ,
INITIAL BACHELORS GRADUATES AT COLLEGES FOR GENERAL TEACHERS EDUCATION[sex,AGE 23])
Bachelors Graduates At Colleges For General Teachers Education[sex,age c gradhi] =
INTEG(Bachelors Graduates At Colleges For General Teachers Education[sex,age c gradlow]
/ TIME TO COMPLETE A YEAR
+ profession's BACHELOR graduation rate for teachers education[sex,age c gradhi]
- Bachelors Graduates At Colleges For General Teachers Education[sex,age c gradhi]
/ TIME TO COMPLETE A YEAR
- deaths of bachelors graduates at college for teachers education[sex,age c gradhi]
- unavaiability rate of bachelors graduates at colleges for teachers education[sex,age c gradhi] ,
INITIAL BACHELORS GRADUATES AT COLLEGES FOR GENERAL TEACHERS EDUCATION[sex,age c gradhi])
Units: person

Bachelors Students At Colleges For General Teachers Education[sex,AGE 19] =
INTEG(college entering rate for general teachers education[sex,AGE 19]
- Bachelors Students At Colleges For General Teachers Education[sex,AGE 19]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- drop out rate from colleges for general teachers education[sex,AGE 19]
- deaths of students at colleges for general teachers education[sex,AGE 19] ,
INITIAL BACHELORS STUDENTS AT COLLEGES FOR GENERAL TEACHER EDUCATION[sex,AGE 19])
Bachelors Students At Colleges For General Teachers Education[sex,age unihi] =
INTEG(Bachelors Students At Colleges For General Teachers Education[sex,age unilow]
/ TIME TO COMPLETE AN ACADEMIC YEAR
+ college entering rate for general teachers education[sex,age unihi]
- Bachelors Students At Colleges For General Teachers Education[sex,age unihi]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- deaths of students at colleges for general teachers education[sex,age unihi]
- drop out rate from colleges for general teachers education[sex,age unihi]
- profession's BACHELOR graduation rate for teachers education[sex,age unihi] ,
INITIAL BACHELORS STUDENTS AT COLLEGES FOR GENERAL TEACHER EDUCATION[sex,age unihi])
Units: person

college entering rate for general teachers education[sex,age uni] =
college entering rate[sex,age uni]
* AVERAGE PERCENTAGE OF STUDENTS ENTERING IN TEACHERS COLLEGE EDUCATION
Units: person/Year

deaths of bachelors graduates at college for teachers education[sex,age c grad] =
Bachelors Graduates At Colleges For General Teachers Education[sex,age c grad]
* death rate[sex,age over 22]
Units: person/Year

deaths of students at colleges for general teachers education[sex,age uni] =
Bachelors Students At Colleges For General Teachers Education[sex,age uni]
* death rate[sex,university age]
Units: person/Year

drop out pct at colleges for general teachers education[sex,age uni] =
IF THEN ELSE (age uni
<= 49,
0.035,
0)
Units: 1/Year
Value assumed by calibration to the historical data

drop out rate from colleges for general teachers education[sex,age uni] =
Bachelors Students At Colleges For General Teachers Education[sex,age uni]
* drop out pct at colleges for general teachers education[sex,age uni]
Units: person/Year

INITIAL BACHELORS GRADUATES AT COLLEGES FOR GENERAL TEACHERS EDUCATION[MALE,age c grad] = 3.04672, 15.3182, 30.4672, 47.1395, 57.9722, 51.9634, 48.8321, 34.1909, 25.7278, 17.0955, 13.4563, 10.4096, 8.12458, 8.12458, 8.4631, 8.29384, 4.48544, 5.83954, 5.07786, 3.63913, 4.48544, 2.96209, 3.04672, 3.89303
, 2.4543, 2.53893, 2.53893, 2.11578, 0.84631, 1.18483, 1.26947, 1.26947, 0.338524, 0.169262, 0.169262, 0.169262, 0, 0, 0, 0, 0, 0, 0, 0, 0
INITIAL BACHELORS GRADUATES AT COLLEGES FOR GENERAL TEACHERS EDUCATION[FEMALE,age c grad] = 18.5342, 65.7583, 105.535, 126.947, 116.875, 94.7867, 68.7204, 53.0636, 44.3466, 31.652, 29.4516, 28.7745, 25.6432, 22.935, 23.8659, 20.7346, 23.6121, 22.3426, 19.1266, 15.0643, 16.8416, 15.4875, 13.6256, 10.9174
, 8.88626, 9.39404, 6.43196, 4.9086, 5.07786, 3.63913, 2.87745, 2.03114, 1.60799, 1.18483, 0.507786, 0.677048, 0.169262, 0.423155, 0.338524, 0, 0.084631, 0, 0, 0, 0
Units: person
Initial number of graduates at colleges for teacher is an assumed value. the only data available are from 1999. It is assumed that the number of graduates in this particular course of college is 1500 at the starting year

INITIAL BACHELORS STUDENTS AT COLLEGES FOR GENERAL TEACHER EDUCATION[MALE,age uni] = 32.9289, 165.559, 329.289, 509.483, 626.564, 561.621, 527.777, 369.536, 278.066, 184.768, 145.436, 112.507, 87.8104, 87.8104, 91.4692, 89.6398, 48.4787, 63.1137, 54.8815, 39.3318, 48.4787, 32.0142, 32.9289, 42.0758
, 26.5261, 27.4408, 27.4408, 22.8673, 9.14692, 12.8057, 13.7204, 13.7204, 3.65877, 1.82938, 1.82938, 1.82938, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
INITIAL BACHELORS STUDENTS AT COLLEGES FOR GENERAL TEACHER EDUCATION[FEMALE,age uni] = 200.318, 710.716, 1140.62, 1372.04, 1263.19, 1024.45, 742.73, 573.512, 479.299, 342.095, 318.313, 310.995, 277.152, 247.882, 257.943, 224.1, 255.199, 241.479, 206.72, 162.815, 182.024, 167.389, 147.265, 117.995,
96.0427, 101.531, 69.5166, 53.0521, 54.8815, 39.3318, 31.0995, 21.9526, 17.3791, 12.8057, 5.48815, 7.31754, 1.82938, 4.57346, 3.65877, 0, 0.914692, 0, 0, 0, 0, 0, 0, 0, 0
Units: person
Number of students in colleges' education during the year 1990. Data source DBH. The initial value it has been assumed since the data available were only from the year 1998. Using the historical data found and calculating the trend we assume that at the year 1990 the number of students were around 16000

profession's BACHELOR graduation rate for teachers education[sex,AGE 20] =
((Bachelors Students At Colleges For General Teachers Education[sex,AGE 20]
* AVERAGE PERCENTAGE OF STUDENTS FINISHING COLLEGE FOR TEACHERS)
/ time for finish the general teachers education BACHELOR at college)
* 0
profession's BACHELOR graduation rate for teachers education[sex,AGE 21] =
((Bachelors Students At Colleges For General Teachers Education[sex,AGE 21]
* AVERAGE PERCENTAGE OF STUDENTS FINISHING COLLEGE FOR TEACHERS)

```
        / time for finish the general teachers education BACHELOR at college )
        * 0
profession's BACHELOR graduation rate for teachers education[sex,AGE 22]  =
    ( ( Bachelors Students At Colleges For General Teachers Education[sex,AGE 22]
        * AVERAGE PERCENTAGE OF STUDENTS FINISHING COLLEGE FOR TEACHERS )
        / time for finish the general teachers education BACHELOR at college )
        * 0
profession's BACHELOR graduation rate for teachers education[sex,age c grad]  =
    ( Bachelors Students At Colleges For General Teachers Education[sex,age c grad]
        * AVERAGE PERCENTAGE OF STUDENTS FINISHING COLLEGE FOR TEACHERS )
        / time for finish the general teachers education BACHELOR at college
          Units: person/Year
          Number of students finishing the bachelors at college.

time for finish the general teachers education BACHELOR at college  =
     time to finish a year at college
         * YEARS NEEDED TO FINISH THE BACHELOR IN GENERAL TEACHERS EDUCATION
          Units: Year
          Time need to finish the college course of study

TIME NEED TO BECOME UNAVAILABLE  = 1
          Units: Year

time to finish a year at college  =
     ( 1
        / 12)
        * 9
          Units: Dmnl
          (1/12)*9 one year time in university is not equivalent to a solar year. The university year is
comprehensive of nine months

total bachelors students at colleges for general teacher education  =
     SUM ( Bachelors Students At Colleges For General Teachers Education[sex!,age uni!] )
          Units: person

unavaiability distribution per age[age over 22]  =
     UNAVAIABILITY DISTRIBUTION PER AGE TABLE ( age over 22)
          Units: 1/Year

UNAVAIABILITY DISTRIBUTION PER AGE TABLE  (
        [(22,0)-(67,1)],(22,0),(60,0),(63,0),(64,0.36),(65,0),(67,0) )
          Units: 1/Year
          Unavailability of finished graduates by age. It was assumed that at age 64 the 36% will retire and will
not be available, the availability depends also on the outside market conditions, but no information was found.

unavaiability rate of bachelors graduates at colleges for teachers education[sex,age c grad]  =
     IF THEN ELSE ( ( Bachelors Graduates At Colleges For General Teachers Education[sex,age c grad]
          / TIME NEED TO BECOME UNAVAILABLE )
          <= 0,
        0,
        ( Bachelors Graduates At Colleges For General Teachers Education[sex,age c grad]
          * unavaiability distribution per age[age over 22] )
          + ( total bachelors graduates in general teachers education qualified in science applying for primary
school
              * proportion of hiring teachers by age[sex,age over 22] )
          + ( total bachelors graduates in general teacher education qualified in science APPLY for secondary
school
              * proportion of hiring teachers by age[sex,age over 22] ) )
          Units: person/Year
```

Unavailability of bachelor graduates at college, if one age cohort of the students is <=0 then the outflow is equal to 0 for the specific age cohort. Otherwise the flow is equal to the sum of college teachers hired into the teaching work force and the bachelors graduates unavailable for
age reasons

YEARS NEEDED TO FINISH THE BACHELOR IN GENERAL TEACHERS EDUCATION = 5.3
Units: Year

****
.Control
****

Simulation Control Parameters

FINAL TIME = 2050
Units: Year
The final time for the simulation.

INITIAL TIME = 1990
Units: Year
The initial time for the simulation.

SAVEPER = 1
Units: Year [0,?]
The frequency with which output is stored.

TIME STEP = 0.0625
Units: Year [0,?]
The time step for the simulation.

****
.Desired general primary teachers
****

AVERAGE TEACHERS PER CLASS = 1.60641
Units: person/class
Data source SSB. The average has been calculated with the historical data found. Data table can be found in excel file "Statistic Data"

FIXED TEACHING HOURS PER TEACHER IN PRIMARY EDUCATION = 640
Units: hours/person
Number of teaching hours per teacher every year

number of classes in high primary school =
teachers desired per pupils in high primary
/ AVERAGE TEACHERS PER CLASS
Units: class

number of classes in low primary school =
teachers desired per pupils in low primary
/ AVERAGE TEACHERS PER CLASS
Units: class

number of classes in low secondary school =
teachers desired per pupils in low secondary
/ AVERAGE TEACHERS PER CLASS
Units: class

PUPILS PER PRIMARY TEACHERS TABLE (

[(1990,0)-
(2025,15)],(1992,10.0462),(1993,10.0086),(1994,9.90143),(1995,9.80651),(1996,9.6635),(1997,9.80258),(1998,
9.57014),(1999,9.5884),(2000,9.63108),(2001,9.6894),(2002,9.92835),(2003,10.2188))
Units: Dmnl
Source data SSB. Average percentage of pupils over total teachers. Data table can be found in excell file
"Statistical Data"

teachers desired per pupils in high primary =
total pupils in high primary education
/ PUPILS PER PRIMARY TEACHERS TABLE (Time)
Units: person
number of teachers desired for high primary education

teachers desired per pupils in low primary =
total pupils in low primary education
/ PUPILS PER PRIMARY TEACHERS TABLE (Time)
Units: person
Number of teachers desired for low primiary education

teachers desired per pupils in low secondary =
total pupils in low secondary education
/ PUPILS PER PRIMARY TEACHERS TABLE (Time)
Units: person
number of teachers desired for low secondary education

total desired number of primary teachers =
(total hours to cover for class in high primary education
+ total hours to cover for class in low primary education
+ total hours to cover for class in low secondary education)
/ FIXED TEACHING HOURS PER TEACHER IN PRIMARY EDUCATION
Units: person
Number of desired teachers in primary. The value is calculated by the number of hours that a teachers
has to work every school year

TOTAL HOURS PER HIGH PRIMARY CLASS PER YEAR = 1026
Units: hours/class
Data from Euroscene 2004

TOTAL HOURS PER LOW PRIMARY CLASS PER YEAR = 836
Units: hours/class
Data from Euroscene 2004 report

TOTAL HOURS PER LOW SECONDARY CLASS PER YEAR = 1140
Units: hours/class
Data from Euroscene 2004

total hours to cover for class in high primary education =
number of classes in high primary school
* TOTAL HOURS PER HIGH PRIMARY CLASS PER YEAR
Units: hours

total hours to cover for class in low primary education =
number of classes in low primary school
* TOTAL HOURS PER LOW PRIMARY CLASS PER YEAR
Units: hours

total hours to cover for class in low secondary education =
number of classes in low secondary school
* TOTAL HOURS PER LOW SECONDARY CLASS PER YEAR
Units: hours

```
********************************
  .Desired primary science teachers
********************************

difference of primary science teachers to cover  =
      IF THEN ELSE ( net difference of science teachers in primary
            < 0,
          0,
          net difference of science teachers in primary
              + Available Position As A Science Teacher In Primary School )
           Units: person

Need Of Primary Science Teachers To Cover  =
      DELAY N ( difference of primary science teachers to cover ,
          3,700,
          1)
           Units: person

net difference of science teachers in primary  =
      total desired number of science teachers in primary school
          - actual science teachers in primary
           Units: person

number of science teachers to fire in primary school  =
      IF THEN ELSE ( actual science teachers in primary
              > total desired number of science teachers in primary school ,
          actual science teachers in primary
              - total desired number of science teachers in primary school ,
          0)
           Units: person

Percived Number Of Science Teachers To Fire In Primary School  =
      DELAY N ( number of science teachers to fire in primary school ,
          ( 1
              / 12)
              * 4.5,number of science teachers to fire in primary school ,
          1)
           Units: person

total desired number of science teachers in primary school  =
      ( total hours of science to cover for class in high primary education
          + total hours of science to cover for class in low primary education
          + total hours of science to cover for class in low secondary education )
          / FIXED TEACHING HOURS PER TEACHER IN PRIMARY EDUCATION
           Units: person

TOTAL HOURS OF SCIENCE PER HIGH PRIMARY CLASS PER YEAR  = 227.33
           Units: hours/class
           145 hour per class per year (mathematic) + 82,33 hour per class per year (science and environment)

TOTAL HOURS OF SCIENCE PER LOW PRIMARY CLASS PER YEAR  = 190
           Units: hours/class
           152 Hours per class per year (mathematic) + 38 hours per class per year (science and environment)

TOTAL HOURS OF SCIENCE PER LOW SECONDARY CLASS PER YEAR  = 253.3
           Units: hours/class
           139.3 hour per class per year (mathematic) + 114 hour per class per year (science and environment)

total hours of science to cover for class in high primary education  =
```

number of classes in high primary school
* TOTAL HOURS OF SCIENCE PER HIGH PRIMARY CLASS PER YEAR
Units: hours

total hours of science to cover for class in low primary education =
number of classes in low primary school
* TOTAL HOURS OF SCIENCE PER LOW PRIMARY CLASS PER YEAR
Units: hours

total hours of science to cover for class in low secondary education =
number of classes in low secondary school
* TOTAL HOURS OF SCIENCE PER LOW SECONDARY CLASS PER YEAR
Units: hours

****
.Desired secondary science teachers
****

available positions as science teachers in secondary left to new applicants =
Available Positions As A Science Teacher In Secondary School
- available position as a science teachers taken by qualified primary teachers
Units: person

AVERAGE OF PUPILS PER SECONDARY TEACHER = 8.87432
Units: Dmnl

AVERAGE PERCENTAGE OF PUPILS IN SCIENCE IN SECONDARY SCHOOL = 0.427099
Units: Dmnl

desired number of secondary science teachers =
desired secondary teachers at first year
+ desired secondary science teachers in second and third year of secondary education
Units: person

desired secondary science teachers in second and third year of secondary education =
pupils in science in secondary school
/ AVERAGE OF PUPILS PER SECONDARY TEACHER
Units: person

desired secondary teachers at first year =
total pupils in first year of secondary education
/ AVERAGE OF PUPILS PER SECONDARY TEACHER
Units: person

difference of secondary science teachers in secondary school =
IF THEN ELSE (net difference of science teachers in secondary school
< 0,
0,
net difference of science teachers in secondary school
+ available positions as science teachers in secondary left to new applicants)
Units: person

Needed Of Secondary Science Teachers To Hire =
DELAY N (difference of secondary science teachers in secondary school ,
3,0,
1)
Units: person

net difference of science teachers in secondary school =
desired number of secondary science teachers

```
        - actual science teachers in secondary
        Units: person

number of science teachers to fire in secondary school  =
      IF THEN ELSE ( actual science teachers in secondary
            > desired number of secondary science teachers ,
          actual science teachers in secondary
            - desired number of secondary science teachers ,
          0)
        Units: person

Percived Number Of Science Teachers To Fire In Secondary School  =
      DELAY N ( number of science teachers to fire in secondary school ,
          ( 1
            / 12)
            * 4.5,number of science teachers to fire in secondary school ,
          1)
        Units: person

pupils in science in secondary school  =
      total pupils in second and third year of secondary education
          * AVERAGE PERCENTAGE OF PUPILS IN SCIENCE IN SECONDARY SCHOOL
        Units: person

********************************
  .General teachers to hire and fire
********************************

available positions as a teacher in secondary left to new applicants  =
     Available Position As A Teacher In Secondary School
        - available positions as a teachers in secondary taken by qualified primary teachers
        Units: person

difference of primary teachers to hire  =
      IF THEN ELSE ( net difference of teachers in primary
            < 0,
          0,
          net difference of teachers in primary
            + Available Position As A Teacher In Primary School )
        Units: person
        Number of available positions to cover

difference of secondary teachers to hire  =
      IF THEN ELSE ( net difference of secondary teachers
            < 0,
          0,
          net difference of secondary teachers
            + available positions as a teacher in secondary left to new applicants )
        Units: person

net difference of secondary teachers  =
      total desired number of secondary teachers
          - actual teachers in secondary
        Units: person

net difference of teachers in primary  =
      total desired number of primary teachers
          - actual teachers in primary
        Units: person
```

number of teachers to fire in primary school =
IF THEN ELSE (actual teachers in primary
> total desired number of primary teachers ,
actual teachers in primary
- total desired number of primary teachers ,
0)
Units: person
The variable is calculating the number of teachers that must be fired if the number of teachers in primary school is higher than the desired number of teacher then some of the teachers in primary school will be fired.

number of teachers to fire in secondary school =
IF THEN ELSE (actual teachers in secondary
> total desired number of secondary teachers ,
actual teachers in secondary
- total desired number of secondary teachers ,
0)
Units: person
The variable is calculating the number of teachers that must be fired if the number of teachers in secondary school is higher than the desired number of teacher then some of the teachers in secondary school will be fired.

Perceived Difference Of Primary Teachers To Hire =
DELAY N (difference of primary teachers to hire ,
3,5500,
1)
Units: person
Available positions to cover, we assume that this value is percived with a delay of 2 years and it is not adjusted immediatly

Perceived Difference Of Secondary Teachers To Hire =
DELAY N (difference of secondary teachers to hire ,
3,0,
1)
Units: person
Available positions to cover, we assume that this value is percived with a delay of 2 years and it is not adjusted immediatly

Perceived Number Of Teachers To Fire In Primary School =
DELAY N (number of teachers to fire in primary school ,
(1
/ 12)
* 4,number of teachers to fire in primary school ,
1)
Units: person
the number of teachers to fire is percived not immidiatly but with a time delay. It was assumed that to fire a teachers there should be at least a semester of time before firing him/her

Perceived Number Of Teachers To Fire In Secondary School =
DELAY N (number of teachers to fire in secondary school ,
(1
/ 12)
* 4,number of teachers to fire in secondary school ,
1)
Units: person
the number of teachers to fire is percived not immidiatly but with a time delay. It was assumed that to fire a teachers there should be at least a semester of time before firing him/her

pupils per secondary teachers =
PUPILS PER SECONDARY TEACHERS TABLE (Time)

Units: Dmnl

PUPILS PER SECONDARY TEACHERS TABLE (
[(1992,0)-
(2003,10)],(1992,6.69911),(1993,6.41461),(1994,6.19199),(1995,5.91653),(1996,5.68286),(1997,5.67959),(1998,5.74215),(1999,5.74411),(2000,5.77262),(2001,5.77191),(2002,5.75969),(2003,5.79633))
Units: Dmnl

total desired number of secondary teachers =
total pupils in secondary education
/ pupils per secondary teachers
Units: person
Number of desired teachers in primary. The value is calculated by the variable "pupils per secondary teachers". The desired number of teachers in secondary school could not be calculated by teaching hours per teacher since the some of the subjects in secondary are not compulsory

****
.General unqualified primary teachers
****

actual teachers in primary =
total qualified teachers in primary school
+ total general unqualified teachers in primary school
Units: person

deaths of general unqualified teachers in primary school[sex,teaching age] =
General Unqualified Teachers In Primary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement of general unqualified teachers in primary school[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
General Unqualified Teachers In Primary School[sex,teaching age]
* unavaiability of teachers at school[sex,work age])
Units: person/Year

fire rate of general unqualified teachers in primary school[sex,teaching age] =
general unqualified teachers to fire in primary[sex,teaching age]
Units: person/Year

FRACTION OF UNQUALIFIED TEACHERS BECOME QUALIFIED = 0.35
Units: Dmnl
Percentage of unqualified teachers that decied to get formal qualification to became a teacher and join the work force in school. The value has been taken from the report "Attracting, developing and retaining effective teachers" Pag 32 Point 111 (35%)

general unqualified teachers in primary becoming qualified[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
(General Unqualified Teachers In Primary School[sex,teaching age]
* FRACTION OF UNQUALIFIED TEACHERS BECOME QUALIFIED)
/ AVERAGE TIME TO BECOME QUALIFIED)
Units: person/Year
If the attraction of salaries is 0 then we assume there are no motivation for an unqualified to become qualified

General Unqualified Teachers In Primary School[sex,TAGE 22] =

INTEG(hiring rate of general unqualified teachers in primary school[sex,TAGE 22]
- General Unqualified Teachers In Primary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- deaths of general unqualified teachers in primary school[sex,TAGE 22]
- fire rate of general unqualified teachers in primary school[sex,TAGE 22]
- qualification rate of general unqualified teachers in primary school[sex,TAGE 22]
- quit rate of genreal unqualified teachers in primary[sex,TAGE 22] ,
initial unqualified teachers in primary school[sex,TAGE 22])

General Unqualified Teachers In Primary School[sex,teaching agehi] =
INTEG(General Unqualified Teachers In Primary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ hiring rate of general unqualified teachers in primary school[sex,teaching agehi]
- General Unqualified Teachers In Primary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- deaths of general unqualified teachers in primary school[sex,teaching agehi]
- early retirement of general unqualified teachers in primary school[sex,teaching agehi]
- fire rate of general unqualified teachers in primary school[sex,teaching agehi]
- qualification rate of general unqualified teachers in primary school[sex,teaching agehi]
- retirement rate of general unqualified teachers in primary school[sex,teaching agehi]
- quit rate of genreal unqualified teachers in primary[sex,teaching agehi] ,
initial unqualified teachers in primary school[sex,teaching agehi])
Units: person
The stock present the following flows: INFLOW is the hiring rate, OUTFLOWS are DEATHS, FIRE RATE EARLY RETIREMENTS, RETIREMENTS and QUALIFICATION RATE. The last outflow count the number of unqualified teachers that get the forlam qualifiaction to teach after a certain period of time, and get qualified in the subject that they teach.

general unqualified teachers to fire in primary[sex,teaching age] =
IF THEN ELSE (teachers to fire in primary by age[sex,work age]
= 0,
0,
IF THEN ELSE (General Unqualified Teachers In Primary School[sex,teaching age]
/ TIME TO FIRE A TEACHER
> teachers to fire in primary by age[sex,work age] ,
teachers to fire in primary by age[sex,work age] ,
General Unqualified Teachers In Primary School[sex,teaching age]
/ TIME TO FIRE A TEACHER))
Units: person/Year
If there are not teachers to fire then 0 is the value of the variable. Otherwise if the number of teachers to fire is higher than the stock it will be emptied. Otherwise the number of teachers to fire will be subtracted by the stock

hiring rate of general unqualified teachers in primary school[sex,teaching age] =
unqualified teachers entering in primary school
* proportion of hiring teachers by age[sex,work age]
Units: person/Year

initial unqualified teachers in primary school[sex,teaching age] =
INITIAL TEACHERS IN PRIMARY SCHOOL[sex,teaching age]
* (1
- FRACTION OF PRIMARY TEACHERS QUALIFIED)
Units: person

percentage of teachers to fire by age[sex,work age] =
PERCENTAGE OF TEACHERS TO FIRE BY AGE TABLE (work age
- 2)
Units: 1/Year

PERCENTAGE OF TEACHERS TO FIRE BY AGE TABLE (

[(22,0)-
(67,0.1)],(22,0.0322901),(23,0.0322901),(24,0.0316507),(25,0.031024),(26,0.0304097),(27,0.0298075),(28,0.02
92173),(29,0.0286388),(30,0.0280717),(31,0.0275158),(32,0.026971),(33,0.0264369),(34,0.0259134),(35,0.025
4003),(36,0.0248974),(37,0.0244044),(38,0.0239211),(39,0.0234474),(40,0.0229832)
,(41,0.0225281),(42,0.022082),(43,0.0216447),(44,0.0212161),(45,0.020796),(46,0.0203842),(47,0.0199
806),(48,0.019585),(49,0.0191971),(50,0.018817),(51,0.0184444),(52,0.0180792),(53,0.0177212),(54,0.017370
3),(55,0.0170263),(56,0.0166892),(57,0.0163587),(58,0.0160348),(59,0.0157173),(60,0.0154061)
,(61,0.015101),(62,0.014802),(63,0.0145089),(64,0.0142216),(65,0.01394),(66,0.013664),(67,0.0133934
))
Units: 1/Year

percentage of unqualified teachers in primary school =
total general unqualified teachers in primary school
/ actual teachers in primary
Units: Dmnl

qualification rate of general unqualified teachers in primary school[sex,teaching age] =
IF THEN ELSE (general unqualified teachers in primary becoming qualified[sex,teaching age]
= 0,
0,
IF THEN ELSE (General Unqualified Teachers In Primary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED
> general unqualified teachers in primary becoming qualified[sex,teaching age] ,
general unqualified teachers in primary becoming qualified[sex,teaching age] ,
General Unqualified Teachers In Primary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED))
Units: person/Year
If there are no unqualified teachers becoming qualified the flow is 0, Otherwise if the number of teacher becoming qualified is > of the stock then it will be emptied. Otherwise the number of unqualified becoming unqualified will be subtracted by the stock

quit rate of genreal unqualified teachers in primary[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
General Unqualified Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT ,
0)
Units: person/Year
If the attraction of salaries is equal to zero then all the unqualified will leave the positions

retirement rate of general unqualified teachers in primary school[sex,TAGE 67] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
General Unqualified Teachers In Primary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF TEACHERS)
retirement rate of general unqualified teachers in primary school[sex,teaching agelow] = 0
Units: person/Year

teachers to fire in primary by age[sex,work age] =
Perceived Number Of Teachers To Fire In Primary School
* percentage of teachers to fire by age[sex,work age]
Units: person/Year

total fire rate of general unqualified teachers in primary school =
SUM (fire rate of general unqualified teachers in primary school[sex!,teaching age!])
Units: person/Year

total general unqualified teachers in primary school =
SUM (General Unqualified Teachers In Primary School[sex!,teaching age!])

Units: person

****
.General unqualified secondary teachers
****

actual teachers in secondary =
total qualified teachers in secondary school
+ total general unqualified teachers in secondary school
Units: person

deaths of general unqualified teachers in secondary school[sex,teaching age] =
General Unqualified Teachers In Secondary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement rate of general unqualified teachers in secondary school[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
General Unqualified Teachers In Secondary School[sex,teaching age]
* unavaiability of teachers at school[sex,work age])
Units: person/Year

fire rate of general unqualified teachers in secondary school[sex,teaching age] =
general unqualified to fire in secondary[sex,teaching age]
Units: person/Year

general unqualified teachers in secondary becoming qualified[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
(General Unqualified Teachers In Secondary School[sex,teaching age]
* FRACTION OF UNQUALIFIED TEACHERS BECOME QUALIFIED)
/ AVERAGE TIME TO BECOME QUALIFIED)
Units: person/Year
If the attraction of salaries is 0 then we assume there are no motivation for an unqualified to become qualified

General Unqualified Teachers In Secondary School[sex,TAGE 22] =
INTEG(hiring rate of general unqualified teachers in secondary school[sex,TAGE 22]
- General Unqualified Teachers In Secondary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- deaths of general unqualified teachers in secondary school[sex,TAGE 22]
- fire rate of general unqualified teachers in secondary school[sex,TAGE 22]
- qualification rate of general unqualified teachers in secondary school[sex,TAGE 22]
- quits of general unqualified teachers in secondary[sex,TAGE 22] ,
initial unqualified teachers in secondary school[sex,TAGE 22])
General Unqualified Teachers In Secondary School[sex,teaching agehi] =
INTEG(General Unqualified Teachers In Secondary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ hiring rate of general unqualified teachers in secondary school[sex,teaching agehi]
- General Unqualified Teachers In Secondary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- deaths of general unqualified teachers in secondary school[sex,teaching agehi]
- early retirement rate of general unqualified teachers in secondary school[sex,teaching agehi]
- fire rate of general unqualified teachers in secondary school[sex,teaching agehi]
- qualification rate of general unqualified teachers in secondary school[sex,teaching agehi]
- retirement rate of general unqualified teachers in secondary school[sex,teaching agehi]
- quits of general unqualified teachers in secondary[sex,teaching agehi] ,

initial unqualified teachers in secondary school[sex,teaching agehi])
Units: person
The stock present the following flows: INFLOW is the hiring rate; OUTFLOWS are DEATHS, FIRE RATE EARLY RETIREMENTS, RETIREMENTS and QUALIFICATION RATE. The last outflow counts the number of unqualified teachers that get the formal qualification to teach after a certain period of time, and get qualified in the subject that they teach.

general unqualified to fire in secondary[sex,teaching age] =
IF THEN ELSE (teachers to fire in secondary by age[sex,teaching age]
= 0,
0,
IF THEN ELSE (General Unqualified Teachers In Secondary School[sex,teaching age]
/ TIME TO FIRE A TEACHER
> teachers to fire in secondary by age[sex,teaching age] ,
teachers to fire in secondary by age[sex,teaching age] ,
General Unqualified Teachers In Secondary School[sex,teaching age]
/ TIME TO FIRE A TEACHER))
Units: person/Year
If there are not teachers to fire then 0 is the value of the variable. Otherwise if the number of teachers to fire is higher than the stock it will be emptied. Otherwise the number of teachers to fire will be subtracted by the stock

hiring rate of general unqualified teachers in secondary school[sex,teaching age] =
unqualified teachers entering in secondary school
* proportion of hiring teachers by age[sex,work age]
Units: person/Year

initial unqualified teachers in secondary school[sex,teaching age] =
INITIAL TEACHERS IN SECONDARY SCHOOL[sex,teaching age]
* (1
- FRACTION OF SECONDARY TEACHERS QUALIFIED)
Units: person

percentage of unqualified teachers in secondary school =
total general unqualified teachers in secondary school
/ actual teachers in secondary
Units: Dmnl

qualification rate of general unqualified teachers in secondary school[sex,teaching age] =
IF THEN ELSE (general unqualified teachers in secondary becoming qualified[sex,teaching age]
= 0,
0,
IF THEN ELSE (General Unqualified Teachers In Secondary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED
> general unqualified teachers in secondary becoming qualified[sex,teaching age] ,
general unqualified teachers in secondary becoming qualified[sex,teaching age] ,
General Unqualified Teachers In Secondary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED))
Units: person/Year
If there are no unqualified teachers becoming qualified the flow is 0, Otherwise if the number of teacher becoming qualified is > of the stock then it will be emptied. Otherwise the number of unqualified becoming unqualified will be subtracted by the stock

quits of general unqualified teachers in secondary[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
General Unqualified Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT ,
0)
Units: person/Year

retirement rate of general unqualified teachers in secondary school[sex,TAGE 67] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
General Unqualified Teachers In Secondary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF TEACHERS)
retirement rate of general unqualified teachers in secondary school[sex,teaching agelow] = 0
Units: person/Year

teachers to fire in secondary by age[sex,teaching age] =
Perceived Number Of Teachers To Fire In Secondary School
* percentage of teachers to fire by age[sex,work age]
Units: person/Year

total fire rate of unqualified teachers in secondary school =
SUM (fire rate of general unqualified teachers in secondary school[sex!,teaching age!])
Units: person/Year

total general unqualified teachers in secondary school =
SUM (General Unqualified Teachers In Secondary School[sex!,teaching age!])
Units: person

****
.Population
****

AGE EMIGRATION DISTRIBUTION[sex,NEW BORN] = 0
AGE EMIGRATION DISTRIBUTION[sex,age0 to age4] = 0.0663319
AGE EMIGRATION DISTRIBUTION[sex,age5 to age9] = 0.0506242
AGE EMIGRATION DISTRIBUTION[sex,age10 to age14] = 0.0338109
AGE EMIGRATION DISTRIBUTION[sex,age15 to age19] = 0.0567967
AGE EMIGRATION DISTRIBUTION[sex,age20 to age24] = 0.172555
AGE EMIGRATION DISTRIBUTION[sex,age25 to age29] = 0.17578
AGE EMIGRATION DISTRIBUTION[sex,age30 to age34] = 0.126399
AGE EMIGRATION DISTRIBUTION[sex,age35 to age39] = 0.085172
AGE EMIGRATION DISTRIBUTION[sex,age40 to age44] = 0.0608964
AGE EMIGRATION DISTRIBUTION[sex,age45 to age49] = 0.046202
AGE EMIGRATION DISTRIBUTION[sex,age50 to age54] = 0.0338569
AGE EMIGRATION DISTRIBUTION[sex,age55 to age59] = 0.0334884
AGE EMIGRATION DISTRIBUTION[sex,age60 to age64] = 0.0264867
AGE EMIGRATION DISTRIBUTION[sex,age65 to age69] = 0.0166751
AGE EMIGRATION DISTRIBUTION[sex,age70 to age74] = 0.00884426
AGE EMIGRATION DISTRIBUTION[sex,age75 to age79] = 0.00336266
AGE EMIGRATION DISTRIBUTION[sex,age80 to age84] = 0.00271777
Units: Dmnl

AGE IMMIGRATION DISTRIBUTION[sex,NEW BORN] = 0
AGE IMMIGRATION DISTRIBUTION[sex,age0 to age4] = 0.0866295
AGE IMMIGRATION DISTRIBUTION[sex,age5 to age9] = 0.0602521
AGE IMMIGRATION DISTRIBUTION[sex,age10 to age14] = 0.0491432
AGE IMMIGRATION DISTRIBUTION[sex,age15 to age19] = 0.0684966
AGE IMMIGRATION DISTRIBUTION[sex,age20 to age24] = 0.157218
AGE IMMIGRATION DISTRIBUTION[sex,age25 to age29] = 0.186659
AGE IMMIGRATION DISTRIBUTION[sex,age30 to age34] = 0.136346
AGE IMMIGRATION DISTRIBUTION[sex,age35 to age39] = 0.088373
AGE IMMIGRATION DISTRIBUTION[sex,age40 to age44] = 0.0597041
AGE IMMIGRATION DISTRIBUTION[sex,age45 to age49] = 0.0386072
AGE IMMIGRATION DISTRIBUTION[sex,age50 to age54] = 0.0240361
AGE IMMIGRATION DISTRIBUTION[sex,age55 to age59] = 0.0163146

AGE IMMIGRATION DISTRIBUTION[sex,age60 to age64] = 0.0108847
AGE IMMIGRATION DISTRIBUTION[sex,age65 to age69] = 0.00754708
AGE IMMIGRATION DISTRIBUTION[sex,age70 to age74] = 0.00493175
AGE IMMIGRATION DISTRIBUTION[sex,age75 to age79] = 0.00261532
AGE IMMIGRATION DISTRIBUTION[sex,age80 to age84] = 0.00224171
	Units: Dmnl

age specific fertility distribution[childbearing] =
	FERTILITY DISTRIBUTION TABLE (FERTILIY AGE[childbearing])
	Units: 1/Year

births[sex] =
	norwegian birth rate[sex]
	Units: person/Year

death rate[sex,age] =
	DEATH RATE TABLE[sex,age] (Time)
	Units: 1/Year
	number of deaths of person per year

DEATH RATE TABLE[FEMALE,age0 to age4] (
	[(1990,0)-(2045,0.01)],(1990,0.0012),(1995,0.00088),(2000,0.000745),(2005,0.000669),(2010,0.000637),(2015,0.000634),(2020,0.000635),(2025,0.000616),(2030,0.000576),(2035,0.000533),(2040,0.000501),(2045,0.000481))
DEATH RATE TABLE[FEMALE,age5 to age9] (
	[(1990,0)-(2045,0.001)],(1990,0.00016),(1995,0.00011),(2000,5.6e-005),(2005,4.4e-005),(2010,3.7e-005),(2015,3.1e-005),(2020,2.8e-005),(2025,2.6e-005),(2030,2.4e-005),(2035,2.2e-005),(2040,1.9e-005),(2045,1.7e-005))
DEATH RATE TABLE[FEMALE,age10 to age14] (
	[(1990,0)-(2025,0.001)],(1990,0.00011),(1995,0.00012),(2000,7.4e-005),(2005,6.4e-005),(2010,5.6e-005),(2015,4.7e-005),(2020,4.1e-005),(2025,3.7e-005),(2030,3.5e-005),(2035,3.4e-005),(2040,3.1e-005),(2045,2.8e-005))
DEATH RATE TABLE[FEMALE,age15 to age19] (
	[(1990,0)-(2025,0.001)],(1990,0.00028),(1995,0.00031),(2000,0.000128),(2005,0.000117),(2010,0.000109),(2015,9.4e-005),(2020,7.8e-005),(2025,6.7e-005),(2030,6.1e-005),(2035,5.7e-005),(2040,5.3e-005),(2045,4.8e-005))
DEATH RATE TABLE[FEMALE,age20 to age24] (
	[(1990,0)-(2025,0.001)],(1990,0.0003),(1995,0.00029),(2000,0.000162),(2005,0.000147),(2010,0.000148),(2015,0.000139),(2020,0.000121),(2025,0.000103),(2030,9.1e-005),(2035,8.5e-005),(2040,8.1e-005),(2045,7.6e-005))
DEATH RATE TABLE[FEMALE,age25 to age29] (
	[(1990,0)-(2045,0.0004)],(1990,0.00033),(1995,0.00036),(2000,0.00022),(2005,0.000177),(2010,0.000172),(2015,0.000175),(2020,0.000166),(2025,0.000146),(2030,0.000127),(2035,0.000113),(2040,0.000106),(2045,0.000101))
DEATH RATE TABLE[FEMALE,age30 to age34] (
	[(1990,0)-(2045,0.0006)],(1990,0.00053),(1995,0.00048),(2000,0.000335),(2005,0.000268),(2010,0.000227),(2015,0.000219),(2020,0.00022),(2025,0.000208),(2030,0.000184),(2035,0.00016),(2040,0.000142),(2045,0.000132))
DEATH RATE TABLE[FEMALE,age35 to age39] (
	[(1990,0)-(2045,0.0008)],(1990,0.00071),(1995,0.00073),(2000,0.000508),(2005,0.000453),(2010,0.00038),(2015,0.000318),(2020,0.000304),(2025,0.000305),(2030,0.000289),(2035,0.000255),(2040,0.00022),(2045,0.000194))
DEATH RATE TABLE[FEMALE,age40 to age44] (
	[(1990,0)-(2045,0.002)],(1990,0.0012),(1995,0.00114),(2000,0.000795),(2005,0.000737),(2010,0.000691),(2015,0.000578),(2020,0.000482),(2025,0.000459),(2030,0.000462),(2035,0.000438),(2040,0.000385),(2045,0.000331))
DEATH RATE TABLE[FEMALE,age45 to age49] (
	[(1990,0)-(2045,0.004)],(1990,0.00196),(1995,0.00182),(2000,0.00119),(2005,0.001111),(2010,0.001088),(2015,0.001024),(2020,0.00086),(2025,0.000722),(2030,0.000695),(2035,0.000705),(2040,0.000671),(2045,0.000593))

DEATH RATE TABLE[FEMALE,age50 to age54] (
[(1990,0)-
(2045,0.004)],(1990,0.00299),(1995,0.0031),(2000,0.001877),(2005,0.001731),(2010,0.001698),(2015,0.001672
),(2020,0.001583),(2025,0.00134),(2030,0.001134),(2035,0.001099),(2040,0.00112),(2045,0.001073))
DEATH RATE TABLE[FEMALE,age55 to age59] (
[(1990,0)-
(2045,0.006)],(1990,0.00479),(1995,0.00454),(2000,0.002796),(2005,0.002864),(2010,0.002756),(2015,0.00271
5),(2020,0.002684),(2025,0.002554),(2030,0.002177),(2035,0.001854),(2040,0.001803),(2045,0.001845))
DEATH RATE TABLE[FEMALE,age60 to age64] (
[(1990,0)-
(2045,0.01)],(1990,0.00535088),(1994.71,0.00447368),(2000,0.003699),(2005,0.004256),(2010,0.004531),(201
5,0.004379),(2020,0.004331),(2025,0.0043),(2030,0.00411),(2035,0.00352),(2040,0.00301),(2045,0.00294))
DEATH RATE TABLE[FEMALE,age65 to age69] (
[(1990,0)-
(2045,0.02)],(1990,0.00877193),(1994.88,0.00666667),(2000,0.005088),(2005,0.005384),(2010,0.006439),(201
5,0.006885),(2020,0.006703),(2025,0.006672),(2030,0.006669),(2035,0.006409),(2040,0.005521),(2045,0.0047
53))
DEATH RATE TABLE[FEMALE,age70 to age74] (
[(1990,0)-
(2045,0.04)],(1990,0.0129825),(1994.88,0.0110526),(2000,0.008403),(2005,0.007609),(2010,0.008308),(2015,0
.009971),(2020,0.010731),(2025,0.010487),(2030,0.01048),(2035,0.010511),(2040,0.010141),(2045,0.00877))
DEATH RATE TABLE[FEMALE,age75 to age79] (
[(1990,0)-
(2045,0.06)],(1990,0.0252632),(1994.71,0.0202632),(2000,0.015022),(2005,0.012495),(2010,0.011683),(2015,0
.0128),(2020,0.015395),(2025,0.016593),(2030,0.016257),(2035,0.016275),(2040,0.016353),(2045,0.015797))
DEATH RATE TABLE[FEMALE,age80 to age84] (
[(1990,0)-
(2045,0.08)],(1989.83,0.0364912),(1994.71,0.0277193),(2000,0.021761),(2005,0.019638),(2010,0.017023),(201
5,0.016093),(2020,0.017818),(2025,0.021595),(2030,0.023367),(2035,0.023066),(2040,0.023242),(2045,0.0235
12))
DEATH RATE TABLE[MALE,age0 to age4] (
[(1990,0)-
(2045,0.004)],(1990,0.00147),(1995,0.001032),(2000,0.00092),(2005,0.00081),(2010,0.000761),(2015,0.00075),
(2020,0.000743),(2025,0.000713),(2030,0.000654),(2035,0.000593),(2040,0.000551),(2045,0.000523))
DEATH RATE TABLE[MALE,age5 to age9] (
[(1990,0)-(2045,0.0004)],(1990,0.00016),(1995,0.0001),(2000,8.9e-005),(2005,7e-005),(2010,5.8e-
005),(2015,5e-005),(2020,4.5e-005),(2025,4.1e-005),(2030,3.8e-005),(2035,3.4e-005),(2040,3e-
005),(2045,2.7e-005))
DEATH RATE TABLE[MALE,age10 to age14] (
[(1990,0)-
(2045,0.0004)],(1990,0.00022),(1995,0.000159),(2000,0.000148),(2005,0.000128),(2010,0.000108),(2015,9.2e-
005),(2020,7.9e-005),(2025,7.1e-005),(2030,6.4e-005),(2035,5.8e-005),(2040,5.2e-005),(2045,4.5e-005))
DEATH RATE TABLE[MALE,age15 to age19] (
[(1990,0)-
(2045,0.001)],(1990,0.00074),(1995,0.000388),(2000,0.000332),(2005,0.00029),(2010,0.000259),(2015,0.00021
9),(2020,0.000181),(2025,0.000149),(2030,0.000126),(2035,0.000113),(2040,0.000103),(2045,8.9e-005))
DEATH RATE TABLE[MALE,age20 to age24] (
[(1990,0)-
(2045,0.002)],(1990,0.00091),(1995,0.000565),(2000,0.000439),(2005,0.000378),(2010,0.000365),(2015,0.0003
37),(2020,0.000285),(2025,0.000235),(2030,0.000195),(2035,0.000172),(2040,0.00016),(2045,0.000145))
DEATH RATE TABLE[MALE,age25 to age29] (
[(1990,0)-
(2045,0.002)],(1990,0.00093),(1995,0.000683),(2000,0.000535),(2005,0.000417),(2010,0.000393),(2015,0.0003
92),(2020,0.000365),(2025,0.000312),(2030,0.000258),(2035,0.000223),(2040,0.000203),(2045,0.00019))
DEATH RATE TABLE[MALE,age30 to age34] (
[(1990,0)-
(2045,0.002)],(1990,0.00113),(1995,0.000881),(2000,0.000769),(2005,0.000595),(2010,0.000493),(2015,0.0004
7),(2020,0.000468),(2025,0.000434),(2030,0.000369),(2035,0.000311),(2040,0.000272),(2045,0.000247))
DEATH RATE TABLE[MALE,age35 to age39] (

[(1990,0)-
(2045,0.002)],(1990,0.00144),(1995,0.001132),(2000,0.001049),(2005,0.000916),(2010,0.000756),(2015,0.0006
35),(2020,0.000606),(2025,0.000603),(2030,0.000562),(2035,0.000487),(2040,0.000417),(2045,0.000364))
DEATH RATE TABLE[MALE,age40 to age44] (
[(1990,0)-
(2045,0.004)],(1990,0.00205),(1995,0.001578),(2000,0.001478),(2005,0.001387),(2010,0.00129),(2015,0.00108
2),(2020,0.000915),(2025,0.000879),(2030,0.000886),(2035,0.000843),(2040,0.000743),(2045,0.000641))
DEATH RATE TABLE[MALE,age45 to age49] (
[(1990,0)-
(2045,0.004)],(1990,0.00337),(1995,0.002411),(2000,0.002211),(2005,0.00209),(2010,0.002059),(2015,0.00193
),(2020,0.001627),(2025,0.001385),(2030,0.001341),(2035,0.001365),(2040,0.001308),(2045,0.001158))
DEATH RATE TABLE[MALE,age50 to age54] (
[(1990,0)-
(2045,0.008)],(1990,0.00523),(1995,0.003343),(2000,0.003437),(2005,0.003183),(2010,0.003141),(2015,0.0031
14),(2020,0.002936),(2025,0.002491),(2030,0.002137),(2035,0.002086),(2040,0.00214),(2045,0.002064))
DEATH RATE TABLE[MALE,age55 to age59] (
[(1990,0)-
(2045,0.02)],(1990,0.00909),(1995,0.004457),(2000,0.005287),(2005,0.005521),(2010,0.005308),(2015,0.00526
6),(2020,0.00525),(2025,0.004993),(2030,0.004275),(2035,0.003686),(2040,0.003614),(2045,0.003732))
DEATH RATE TABLE[MALE,age60 to age64] (
[(1990,0)-
(2045,0.02)],(1990,0.00798246),(1995,0.006555),(2000,0.007093),(2005,0.008465),(2010,0.0091),(2015,0.0087
75),(2020,0.008736),(2025,0.00874),(2030,0.008331),(2035,0.007147),(2040,0.006191),(2045,0.006095))
DEATH RATE TABLE[MALE,age65 to age69] (
[(1990,0)-
(2045,0.04)],(1990,0.0129825),(1995,0.01034),(2000,0.009488),(2005,0.010393),(2010,0.012808),(2015,0.0138
),(2020,0.013401),(2025,0.013422),(2030,0.013512),(2035,0.012935),(2040,0.011152),(2045,0.009726))
DEATH RATE TABLE[MALE,age70 to age74] (
[(1990,0)-
(2045,0.06)],(1990,0.0202632),(1995,0.016343),(2000,0.013976),(2005,0.013057),(2010,0.014823),(2015,0.018
376),(2020,0.019959),(2025,0.019556),(2030,0.019753),(2035,0.020013),(2040,0.019279),(2045,0.016761))
DEATH RATE TABLE[MALE,age75 to age79] (
[(1990,0)-
(2045,0.08)],(1990.17,0.0252632),(1995,0.020907),(2000,0.019426),(2005,0.016955),(2010,0.016455),(2015,0.
0189),(2020,0.023682),(2025,0.025889),(2030,0.025685),(2035,0.026169),(2040,0.026757),(2045,0.026001))
DEATH RATE TABLE[MALE,age80 to age84] (
[(1990,0)-
(2045,0.2)],(1990,0.0298246),(1995,0.019953),(2000,0.020594),(2005,0.019592),(2010,0.017823),(2015,0.0175
85),(2020,0.020611),(2025,0.026226),(2030,0.029006),(2035,0.029198),(2040,0.030148),(2045,0.031307))
DEATH RATE TABLE[FEMALE,NEW BORN] (
[(1900,0.01)-(2100,0.04)],(1990,0),(1997,0),(2004,0),(2011,0),(2018,0),(2025,0))
DEATH RATE TABLE[MALE,NEW BORN] (
[(1900,0.01)-(2100,0.04)],(1990,0),(1997,0),(2004,0),(2011,0),(2018,0),(2025,0))
Units: 1/Year
death rate tables are coming from the UN database, the data were available only from 2000 until 2045. Since the starting year in the model is 1990, and since the data were grouped in 5 years groups projection and obtained data, for the year 1990 and 1995 for the cohorts over 60 we assumed the value of the death rate looking at the trend in the death rate for the future. The value has been assumed because the historical data found in the SSB for those cohorts did not match the future projection.\!\!

deaths[sex,age] =
National Population[sex,age]
* death rate[sex,age]
Units: person/Year
The number of people of each age dying.

emigration =
EMIGRATION TABLE (Time)
Units: person/Year

```
emigration rate[sex,age]  =
      ( emigration
          / 1000)
          * AGE EMIGRATION DISTRIBUTION[sex,age]
          * sex emigration distribution[sex]
           Units: person/Year

EMIGRATION TABLE  (
          [(0,0)-
(10,10)],(1990,23784),(1991,18238),(1992,16801),(1993,18903),(1994,19475),(1995,19312),(1996,20590),(199
7,21257),(1998,22881),(1999,22842),(2000,26854),(2001,26309),(2002,22948),(2003,24672),(2004,23271),(200
5,21709) )
           Units: person/Year

FERTILITY DISTRIBUTION TABLE  (
          [(0,0)-(60,0.2)],(15,0.0171),(17.5,0.0934),(20,0.144),(30,0.0952),(35,0.0322),(40,0.0047),(50,0.0003) )
           Units: 1/Year
           number of children born per 1000 women alive\!\!\!

FERTILIY AGE[childbearing]  = 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50
           Units: Dmnl
           Ages in which the women are fertile and in which they can procreate. Data from SSB.

immigration  =
      IMMIGRATION TABLE ( Time )
           Units: person/Year

immigration rate[sex,age]  =
      ( immigration
          / 1000)
          * sex immigration distribution[sex]
          * AGE IMMIGRATION DISTRIBUTION[sex,age]
           Units: person/Year

IMMIGRATION TABLE  (
          [(0,0)-
(10,10)],(1990,25494),(1991,26283),(1992,26743),(1993,31711),(1994,26911),(1995,25678),(1996,26407),(199
7,31957),(1998,36704),(1999,41841),(2000,36542),(2001,34264),(2002,40122),(2003,35957),(2004,36482),(200
5,40148) )
           Units: person/Year

INITIAL POPULATION[FEMALE,age]  = 0, 28733, 27988, 26670, 25714, 25175, 24912, 24573, 25238, 25463,
25234, 25552, 25562, 25256, 26485, 27968, 29851, 30166, 31819, 32391, 31853, 33373, 33189, 32863, 32833,
32506, 32246, 31625, 30791, 30803, 30608, 30898, 31020, 30818, 31372, 30786, 30416, 30422, 29800
      , 28531, 29360, 29518, 30166, 31288, 32570, 29279, 28056, 25180, 23273, 20571, 21179, 20861, 20184,
19336, 18594, 18201, 18085, 18028, 19406, 19642, 20006, 19709, 20272, 20146, 21275, 21051, 22027, 22788,
22884, 23135, 24463, 20121, 21142, 20847, 19531, 18884, 18183, 17505, 16968, 15875, 14857
      , 14208, 12667, 11710, 10523, 9380
INITIAL POPULATION[MALE,age]  = 0, 30325, 29434, 27599, 27295, 26520, 26086, 26145, 26742, 26325,
26781, 26825, 26978, 26489, 27724, 29121, 30746, 31921, 33269, 33717, 33324, 35107, 34974, 34256, 34855,
34573, 34465, 33024, 32705, 32634, 32349, 32922, 32577, 32328, 32647, 32421, 31704, 31784, 31648,
     30731, 31331, 31554, 32495, 33146, 34541, 30854, 29937, 26411, 24145, 21115, 21842, 21042, 20322,
19356, 18736, 17695, 18045, 18073, 19008, 18867, 19473, 19108, 19129, 18958, 19792, 19443, 20079, 20422,
19796, 19424, 20509, 16759, 16672, 16222, 14600, 13796, 13249, 12393, 11600, 10528, 9351,
     8607, 7324, 6395, 5574, 4626
           Units: person
           Norwegian population per age and sex, registered in the year 1990. Data source SSB (StatBank)

National Population[sex,NEW BORN]  =
```

INTEG(births[sex] ,
INITIAL POPULATION[sex,NEW BORN])
National Population[sex,age over 0] =
INTEG(immigration rate[sex,age over 0]
- deaths[sex,age over 0]
- emigration rate[sex,age over 0] ,
INITIAL POPULATION[sex,age over 0])
Units: person
Population broken down into one year cohorts. Note that the cohorts are shifted annually to prevent dispersion of population trends. This is why there is no inflow to anything other than the first cohort.

norwegian active females[childbearing] =
National Population[FEMALE,childbearing]
Units: person

norwegian birth rate[sex] =
SUM (norwegian active females[childbearing!]
* age specific fertility distribution[childbearing!])
* sex ratio at birth[sex]
Units: person/Year

norwegian population cohort shift[sex] =
SHIFT IF TRUE (National Population[sex,NEW BORN] ,
MODULO (Time ,
1)
< TIME STEP
/ 2,
AGE84,
1,
0)
Units: person
Variable that make possible to shift the population each year

sex emigration distribution[sex] =
SEX EMIGRATION DISTRIBUTION TABLE[sex] (Time)
Units: Dmnl

SEX EMIGRATION DISTRIBUTION TABLE[MALE] (
[(1990,0)-
(2005,1)],(1990,0.541541),(1991,0.523029),(1992,0.525504),(1993,0.535735),(1994,0.516662),(1995,0.50756),(1996,0.50476),(1997,0.495084),(1998,0.503737),(1999,0.496541),(2000,0.51132),(2001,0.517466),(2002,0.516428),(2003,0.527967),(2004,0.514847),(2005,0.511309))
SEX EMIGRATION DISTRIBUTION TABLE[FEMALE] (
[(1990,0)-
(2005,1)],(1990,0.458459),(1991,0.476971),(1992,0.474496),(1993,0.464265),(1994,0.483338),(1995,0.49244),(1996,0.49524),(1997,0.504916),(1998,0.496263),(1999,0.503459),(2000,0.48868),(2001,0.482534),(2002,0.483572),(2003,0.472033),(2004,0.485153),(2005,0.488691))
Units: Dmnl

sex immigration distribution[sex] =
SEX IMMIGRATION DISTRIBUTION TABLE[sex] (Time)
Units: Dmnl

SEX IMMIGRATION DISTRIBUTION TABLE[MALE] (
[(1990,0)-
(2005,1)],(1990,0.516631),(1991,0.526386),(1992,0.513667),(1993,0.49352),(1994,0.48326),(1995,0.477763),(1996,0.471504),(1997,0.487843),(1998,0.49891),(1999,0.49865),(2000,0.523781),(2001,0.492704),(2002,0.482055),(2003,0.488695),(2004,0.488707),(2005,0.501818))
SEX IMMIGRATION DISTRIBUTION TABLE[FEMALE] (

[(1990,0)-
(2005,1)],(1990,0.483369),(1991,0.473614),(1992,0.486333),(1993,0.50648),(1994,0.51674),(1995,0.522237),(1996,0.528496),(1997,0.512157),(1998,0.50109),(1999,0.50135),(2000,0.476219),(2001,0.507296),(2002,0.517945),(2003,0.511305),(2004,0.511293),(2005,0.498182))
Units: Dmnl

sex ratio at birth[FEMALE] = 0.485
sex ratio at birth[MALE] =
1
- sex ratio at birth[FEMALE]
Units: Dmnl

total national population =
SUM (National Population[sex!,age!])
Units: person

****
.Primary and secondary education
****

pct of pupils remaining in secondary education[sex,AGE17] =
1
- QUIT PCT OF PUPILS IN SECONDARY SCHOOL
pct of pupils remaining in secondary education[sex,AGE18] =
pct of pupils remaining in secondary education[sex,AGE17]
* (1
- QUIT PCT OF PUPILS IN SECONDARY SCHOOL)
pct of pupils remaining in secondary education[sex,AGE19] =
pct of pupils remaining in secondary education[sex,AGE18]
* (1
- QUIT PCT OF PUPILS IN SECONDARY SCHOOL)
Units: Dmnl
Percentage of students that doesn't leave the upper secondary education

pupils in primary education[sex,compulsory school age] =
National Population[sex,compulsory school age]
Units: person
Pupils who attend the first tenth grade of school

pupils in secondary education[sex,upper secondary school age] =
National Population[sex,upper secondary school age]
Units: person
Pupils attending the last three grades of the school system

QUIT PCT OF PUPILS IN SECONDARY SCHOOL = 0.02
Units: Dmnl
Percentage of students who leave the upper secondary education

real pupils in secondary education[sex,upper secondary school age] =
pupils in secondary education[sex,upper secondary school age]
* pct of pupils remaining in secondary education[sex,upper secondary school age]
Units: person
Number of pupils by age which actually stay in the last three grades of school education

total pupils in first year of secondary education =
SUM (real pupils in secondary education[sex!,AGE17])
Units: person
Number of pupils in the first year of three of secondary school

total pupils in high primary education =

SUM (pupils in primary education[sex!,AGE10])
+ SUM (pupils in primary education[sex!,AGE11])
+ SUM (pupils in primary education[sex!,AGE12])
+ SUM (pupils in primary education[sex!,AGE13])
Units: person
Total number of pupils from grade 5 to 9. This part of primary education is also called "high primary education"

total pupils in low primary education =
SUM (pupils in primary education[sex!,AGE6])
+ SUM (pupils in primary education[sex!,AGE7])
+ SUM (pupils in primary education[sex!,AGE8])
+ SUM (pupils in primary education[sex!,AGE9])
Units: person
Total number of pupils in the first four grades in primary school. This part of the education is called also "low primary education"

total pupils in low secondary education =
SUM (pupils in primary education[sex!,AGE14])
+ SUM (pupils in primary education[sex!,AGE15])
+ SUM (pupils in primary education[sex!,AGE16])
Units: person
Total number of pupils from grade 10 to 12. this part of primary education is also called "low secondary education"

total pupils in primary education =
SUM (pupils in primary education[sex!,compulsory school age!])
Units: person

total pupils in second and third year of secondary education =
SUM (real pupils in secondary education[sex!,AGE18])
+ SUM (real pupils in secondary education[sex!,AGE19])
Units: person
Number of pupils in the last two of three grades in secondary school

total pupils in secondary education =
SUM (real pupils in secondary education[sex!,upper secondary school age!])
Units: person
Total number of pupils which attend the last three grade of school education

****
.Qualified general primary teachers
****

available positions as a teachers in secondary taken by qualified primary teachers =
Available Position As A Teacher In Secondary School
* PERCENTAGE OF PRIMARY TEACHERS MOVING TO SECONDARY SCHOOLS
Units: person
Available positions taken in secondary by primary teachers. They move into secondary education because the salary is higher.

deaths of qualified teachers in primary school[sex,teaching age] =
Qualified Teachers In Primary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement rate of qualified teachers in primary education[sex,teaching age] =
Qualified Teachers In Primary School[sex,teaching age]
* unavaiability of teachers at school[sex,work age]
Units: person/Year

effect of unqualified teachers in primary school on the propensity to quit =
EFFECT OF UNQUALIFIED TEACHERS ON THE PROPENSITY TO QUIT TABLE (percentage of unqualified teachers in primary school)
Units: Dmnl/Year
percentage of teachers leaving due to the presence of unqualified collegues

EFFECT OF UNQUALIFIED TEACHERS ON THE PROPENSITY TO QUIT TABLE (
[(0,0)-(1,0.2)],(0,0),(1,0.1041))
Units: 1/Year
Non linear relationship taken from the paper "Teacher turnover and non pecuniary factors" , with no unqualified teacher hired in schools the effect is zero when the percentage of unqualified the highest effect is around 10,4%.\!\!\!

fire rate of qualified teachers in primary school[sex,teaching age] =
IF THEN ELSE (Qualified Teachers In Primary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER
> qualified teachers in primary to fire[sex,teaching age] ,
qualified teachers in primary to fire[sex,teaching age] ,
Qualified Teachers In Primary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER)
Units: person/Year
If the stock is higher than the number of teacher to fire then the number of teachers to fire will be subtracted to the stock. Otherwise the stock will be emptied

FRACTION OF PRIMARY TEACHERS QUALIFIED = 0.95
Units: Dmnl
percentage of teachers in primary education with a specialization in scientific subjects

hiring rate of qualified teachers in primary school[sex,teaching age] =
effective supply of qualified teachers in primary school
* proportion of hiring teachers by age[sex,work age]
Units: person/Year

initial qualified teachers in primary school[sex,teaching age] =
INITIAL TEACHERS IN PRIMARY SCHOOL[sex,teaching age]
* FRACTION OF PRIMARY TEACHERS QUALIFIED
Units: person

INITIAL TEACHERS IN PRIMARY SCHOOL[MALE,teaching age] = 103.421, 122.599, 141.777, 160.954, 182.871, 202.049, 224.457, 246.864, 267.989, 286.146, 304.303, 322.459, 340.616, 366.789, 392.963, 419.136, 445.309, 471.482, 598.959, 630.46, 661.961, 693.462, 724.963, 689.101, 653.238, 617.375, 581.512, 545.649
, 443.089, 411.918, 380.747, 349.576, 318.406, 300.844, 283.283, 265.721, 248.159, 230.598, 195.187, 169.81, 144.434, 119.057, 104.175, 89.2926, 74.4105, 59.5284
INITIAL TEACHERS IN PRIMARY SCHOOL[FEMALE,teaching age] = 241.317, 286.064, 330.812, 375.56, 426.7, 471.447, 523.732, 576.017, 625.309, 667.674, 710.04, 752.405, 794.771, 855.842, 916.913, 977.984, 1039.05, 1100.13, 1397.57, 1471.07, 1544.58, 1618.08, 1691.58, 1607.9, 1524.22, 1440.54, 1356.86, 1273.18
, 1033.87, 961.142, 888.41, 815.678, 742.947, 701.97, 660.993, 620.016, 579.039, 538.062, 455.437, 396.224, 337.012, 277.799, 243.074, 208.349, 173.624, 138.9
Units: person
qualified teachers in primary age 30 - 39 MALE (267.989, 286.146, 304.303, 322.459, 340.616, 366.789, 392.963, 419.136, 445.309, 471.482,) FEMALE (625.309, 667.674, 710.04, 752.405, 794.771, 855.842, 916.913, 977.984, 1039.05, 1100.13,)

leaving probability of teachers in primary school =
MAX (0,
LEAVING PROBABILITY OF TEACHERS IN PRIMARY TABLE (wage ratio of teacher and emloyee with 4 years or less))
Units: 1/Year

The variable is calculating the leaving probability of teachers in primary school based on the wages ration for teachers with education required to teach in secondary and the national average salaries of employee with the same level of education. The variable also applied a function of maximum. In case the leaving probability goes below zero then the variable will assume the value 0

LEAVING PROBABILITY OF TEACHERS IN PRIMARY TABLE (
[(-0.5,0)-(1.9,0.1)],(-0.5,0.06685),(-0.45,0.065925),(-0.4,0.065),(-0.35,0.064075),(-0.3,0.06315),(-0.25,0.062225),(-0.2,0.0613),(-0.15,0.060375),(-0.1,0.05945),(-0.05,0.058525),(7.45058e-009,0.0576),(0.05,0.056675),(0.1,0.05575),(0.15,0.054825),(0.2,0.0539),(0.25,0.052975),(0.3,0.05205)
,(0.35,0.051125),(0.4,0.0502),(0.45,0.049275),(0.5,0.04835),(0.55,0.047425),(0.6,0.0465),(0.65,0.045575),(0.7,0.04465),(0.75,0.043725),(0.8,0.0428),(0.85,0.041875),(0.9,0.04095),(0.95,0.040025),(1,0.0391),(1.05,0.038175),(1.1,0.03725),(1.15,0.036325),(1.2,0.0354),(1.25,0.034475),(1.3,0.03355)
,(1.35,0.032625),(1.4,0.0317),(1.45,0.030775),(1.5,0.02985),(1.55,0.028925),(1.6,0.028),(1.65,0.027075),(1.7,0.02615),(1.75,0.025225),(1.8,0.0243),(1.85,0.023375),(1.9,0.02245))
Units: 1/Year
The values in the table are expressed in the report "Avgang og rekruttering i undervisningssektoren - hva betyr lønn?" by Pål Schøne. The leaving probability of a teacher in this case has been measured in correlation with the wages ratio comparing the wage of teachers with the national average wages for teachers and employee with the same level of education

new qualified teachers in primary school[sex,teaching age] =
qualification rate of unqualified science teachers in primary school[sex,teaching age]
Units: person/Year

PERCENTAGE OF PRIMARY TEACHERS MOVING TO SECONDARY SCHOOLS = 0.08
Units: Dmnl

percentage of qualified teachers in primary school =
total qualified teachers in primary school
/ actual teachers in primary
Units: Dmnl

proportion of hiring teachers by age[sex,work age] =
PROPORTIONS OF HIRING TEACHERS BY AGE TABLE (work age
- 2)
Units: 1/Year
Age proportion of hiring new teachers

PROPORTIONS OF HIRING TEACHERS BY AGE TABLE (
[(22,0)-(67,0.1)],(22,0.0659731),(23,0.0659731),(24,0.0615129),(25,0.0573542),(26,0.0534767),(27,0.0498614),(28,0.0464904),(29,0.0433474),(30,0.0404168),(31,0.0376844),(32,0.0351367),(33,0.0327613),(34,0.0305464),(35,0.0284813),(36,0.0265558),(37,0.0247604),(38,0.0230865),(39,0.0215257),

(40,0.0200704),(41,0.0187135),(42,0.0174484),(43,0.0162688),(44,0.0151689),(45,0.0141434),(46,0.0131872),(47,0.0122957),(48,0.0114644),(49,0.0106893),(50,0.00996667),(51,0.00929286),(52,0.00866461),(53,0.00807883),(54,0.00753265),(55,0.0070234),(56,0.00654857),(57,0.00610585),(58,0.00569305)
,(59,0.00530817),(60,0.0049493),(61,0.0046147),(62,0.00430272),(63,0.00401183),(64,0.0037406),(65,0.00348772),(66,0.00325192),(67,0.00303207))
Units: 1/Year

qualified primary teachers moving to secondary school[sex,teaching agehi 50 to 59] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
IF THEN ELSE (Qualified Teachers In Primary School[sex,teaching agehi 50 to 59]
/ TIME FOR PRIMARY TEACHER TO GO TO SECONDARY
> available positions as a teachers in secondary taken by qualified primary teachers
/ TIME FOR PRIMARY TEACHER TO GO TO SECONDARY ,
available positions as a teachers in secondary taken by qualified primary teachers

/ TIME FOR PRIMARY TEACHER TO GO TO SECONDARY ,
Qualified Teachers In Primary School[sex,teaching agehi 50 to 59]
/ TIME FOR PRIMARY TEACHER TO GO TO SECONDARY))
qualified primary teachers moving to secondary school[sex,teaching agehi non 50 to 59] = 0
Units: person/Year

qualified teachers in primary leaves[sex,teaching age] =
Qualified Teachers In Primary School[sex,teaching age]
* leaving probability of teachers in primary school
Units: person/Year

qualified teachers in primary quits[sex,teaching age] =
qualified teachers in primary leaves[sex,teaching age]
+ qualified teachers leaves due to unqualified teachers in primary[sex,teaching age]
+ qualified teachers in primary quits by age[sex,teaching age]
Units: person/Year

qualified teachers in primary quits by age[sex,teaching age] =
Qualified Teachers In Primary School[sex,teaching age]
* quit rate of teachers at school by age[sex,work age]
Units: person/Year

Qualified Teachers In Primary School[sex,TAGE 22] =
INTEG(hiring rate of qualified teachers in primary school[sex,TAGE 22]
+ new qualified teachers in primary school[sex,TAGE 22]
- Qualified Teachers In Primary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- quit rate of qualified teachers in primary school[sex,TAGE 22]
- fire rate of qualified teachers in primary school[sex,TAGE 22]
- deaths of qualified teachers in primary school[sex,TAGE 22] ,
initial qualified teachers in primary school[sex,TAGE 22])
Qualified Teachers In Primary School[sex,teaching agehi] =
INTEG(Qualified Teachers In Primary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ new qualified teachers in primary school[sex,teaching agehi]
+ hiring rate of qualified teachers in primary school[sex,teaching agehi]
- qualified primary teachers moving to secondary school[sex,teaching agehi]
- Qualified Teachers In Primary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- quit rate of qualified teachers in primary school[sex,teaching agehi]
- fire rate of qualified teachers in primary school[sex,teaching agehi]
- deaths of qualified teachers in primary school[sex,teaching agehi]
- early retirement rate of qualified teachers in primary education[sex,teaching agehi]
- retirement rate of qualified teachers in primary school[sex,teaching agehi] ,
initial qualified teachers in primary school[sex,teaching agehi])
Units: person
The stock of QUALIFIED TEACHERS present the following flows: INFLOWS new qualified teachers and hiring rate of qualified teachers; OUTFLOWS deaths, early retirement, retirement fire rate and quit rate. The last outflow is present only in the stock of qualified teachers, the reason is that we assumed that a qualified teacher could been attracted by different opportunities out side the teaching work, while an unqualified teachers which has been hired to do not create a shortage of staff is not attracted to other profession, usually unqualified teachers are the first one to get replaced if an higher supply of qualified is enrolled

qualified teachers in primary to fire[sex,teaching age] =
teachers to fire in primary by age[sex,work age]
- fire rate of general unqualified teachers in primary school[sex,teaching age]
Units: person/Year

qualified teachers leaves due to unqualified teachers in primary[sex,teaching age] =
Qualified Teachers In Primary School[sex,teaching age]

* effect of unqualified teachers in primary school on the propensity to quit
Units: person/Year

quit rate of qualified teachers in primary school[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
Qualified Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT ,
IF THEN ELSE (Qualified Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT
> qualified teachers in primary quits[sex,teaching age] ,
qualified teachers in primary quits[sex,teaching age] ,
Qualified Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT))
Units: person/Year
If the attraction of the salaries is equal to 0 then all the teachers will quit the positions. Otherwise if the number of teacher that want to leave is higher than the stock of teacher, the stock will be 0. Otherwise only the number of teachers that want to leave will be subtracted by the stock

quit rate of teachers at school by age[sex,work age] =
QUIT RATE OF TEACHERS AT SCHOOL BY AGE TABLE (work age
- 2)
Units: 1/Year
Number teachers that quite based on the elderly age

QUIT RATE OF TEACHERS AT SCHOOL BY AGE TABLE (
[(22,0)-(67,1)],(22,0.251),(24,0.254),(30,0.16),(40,0.1),(50,0.07),(55,0.06),(60,0.07),(67,0.08))
Units: 1/Year
Relation between age of teachers and quit rate of school. Data to define the relation have been inspired by the article "Teachers turn-over and non-pecuniary factors" Pag. 14 by Torberg Falch and Bjarne Strøm\!\!\!

RETIREMENT PERCENTAGE OF TEACHERS = 0.1
Units: 1/Year

retirement rate of qualified teachers in primary school[sex,TAGE 67] =
Qualified Teachers In Primary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF TEACHERS
retirement rate of qualified teachers in primary school[sex,teaching agelow] = 0
Units: person/Year

TIME FOR PRIMARY TEACHER TO GO TO SECONDARY = 1
Units: Year

TIME NEED TO QUIT = 1
Units: Year

total qualified teachers in primary school =
SUM (Qualified Teachers In Primary School[sex!,teaching age!])
Units: person

unavaiability of teachers at school[sex,work age] =
UNAVAIABILITY DISTRIBUTION PER AGE TABLE (work age
- 2)
Units: 1/Year
number of teachers who become unavailable because early retirement or normal retirement

****
.Qualified general secondary teachers
****

average time to finish training in science =
(1
/ 12)
* 9
Units: Year

deaths of qualified teachers in secondary school[sex,teaching age] =
Qualified Teachers In Secondary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement rate of qualified teacher in secondary school[sex,teaching age] =
Qualified Teachers In Secondary School[sex,teaching age]
* unavaiability of teachers at school[sex,work age]
Units: person/Year

effect of unqualified teachers in secondary school on the propensity to quit =
EFFECT OF UNQUALIFIED TEACHERS ON THE PROPENSITY TO QUIT TABLE (percentage of unqualified teachers in secondary school)
Units: Dmnl/Year
percentage of teachers leaving due to the presence of unqualified collegues

fire rate of qualified teachers in secondary school[sex,teaching age] =
IF THEN ELSE (Qualified Teachers In Secondary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER
> qualified teachers to fire in secondary[sex,teaching age] ,
qualified teachers to fire in secondary[sex,teaching age] ,
Qualified Teachers In Secondary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER)
Units: person/Year
If the stock is higher than the number of teacher to fire then the number of teachers to fire will be subtracted to the stock. Otherwise the stock will be emptied

FRACTION OF SECONDARY TEACHERS QUALIFIED = 0.6
Units: Dmnl
Percentage of teachers hired in school with a specialization in science subjects

hiring rate of qualified teachers in secondary[sex,teaching age] =
effective supply of secondary teachers
* proportion of hiring teachers by age[sex,work age]
Units: person/Year

INITIAL QUALIFIED SECONDARY TEACHERS IN SCIENCE TRAINING[MALE,teaching agehi] = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
INITIAL QUALIFIED SECONDARY TEACHERS IN SCIENCE TRAINING[FEMALE,teaching agehi] = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
Units: person
Initial number of secondary qualified teachers in training, the value is assumed to be 0 persons in training at the starting year. The data have been assumed due to lack of historical data

initial qualified teachers in secondary school[sex,teaching age] =
INITIAL TEACHERS IN SECONDARY SCHOOL[sex,teaching age]
* FRACTION OF SECONDARY TEACHERS QUALIFIED
Units: person

INITIAL TEACHERS IN SECONDARY SCHOOL[MALE,teaching age] = 45.4773, 74.6786, 103.88, 133.081, 162.282, 191.484, 220.685, 249.886, 263.596, 283.956, 304.316, 324.676, 345.036, 368.768, 392.5, 416.232, 439.964, 463.696, 574.584, 602.56, 630.535, 658.51, 686.486, 652.861, 619.237, 585.612, 551.988, 518.364
, 424.831, 395.362, 365.893, 336.424, 306.955, 289.497, 272.038, 254.579, 237.12, 219.661, 206.69, 183.89, 161.09, 138.29, 121.004, 103.718, 86.4314, 69.1451

INITIAL TEACHERS IN SECONDARY SCHOOL[FEMALE,teaching age] = 37.2087, 61.1006, 84.9926, 108.885, 132.777, 156.669, 180.56, 204.452, 215.669, 232.328, 248.986, 265.644, 282.302, 301.719, 321.136, 340.553, 359.97, 379.387, 470.114, 493.003, 515.892, 538.781, 561.67, 534.159, 506.648, 479.137, 451.627, 424.116, 347.589, 323.478, 299.367, 275.256, 251.145, 236.861, 222.576, 208.292, 194.007, 179.723, 169.11, 150.456, 131.801, 113.147, 99.0032, 84.8599, 70.7166, 56.5733

Units: person

Total number fo teachers. data for the number of science teachers are not available. Qualified teachers in secondary age 40 - 49 MALE (574.584, 602.56, 630.535, 658.51, 686.486, 652.861, 619.237, 585.612, 551.988, 518.364,) FEMALE (470.114, 493.003, 515.892, 538.781, 561.67, 534.159, 506.648, 479.137, 451.627, 424.116,)

leaving probability of teachers in secondary =
MAX (0,
LEAVING PROBABILITY OF TEACHERS IN SECONDARY TABLE (wage ratio of teacher and employee with more then 4 years))

Units: Dmnl/Year

The variable is calculating the leaving probability of teachers in secondary school based on the wages ration for teachers with education required to teach in secondary and the national average salaries of employee with the same level of education. The variable also applied a function of maximum. In case the leaving probability goes below zero then the variable will assume the value 0

LEAVING PROBABILITY OF TEACHERS IN SECONDARY TABLE (
[(-0.5,0)-(1.9,0.1)],(-0.5,0.06685),(-0.45,0.065925),(-0.4,0.065),(-0.35,0.064075),(-0.3,0.06315),(-0.25,0.062225),(-0.2,0.0613),(-0.15,0.060375),(-0.1,0.05945),(-0.05,0.058525),(7.45058e-009,0.0576),(0.05,0.056675),(0.1,0.05575),(0.15,0.054825),(0.2,0.0539),(0.25,0.052975),(0.3,0.05205)
,(0.35,0.051125),(0.4,0.0502),(0.45,0.049275),(0.5,0.04835),(0.55,0.047425),(0.6,0.0465),(0.65,0.045575),(0.7,0.04465),(0.75,0.043725),(0.8,0.0428),(0.85,0.041875),(0.9,0.04095),(0.95,0.040025),(1,0.0391),(1.05,0.038175),(1.1,0.03725),(1.15,0.036325),(1.2,0.0354),(1.25,0.034475),(1.3,0.03355)
,(1.35,0.032625),(1.4,0.0317),(1.45,0.030775),(1.5,0.02985),(1.55,0.028925),(1.6,0.028),(1.65,0.027075),(1.7,0.02615),(1.75,0.025225),(1.8,0.0243),(1.85,0.023375),(1.9,0.02245))

Units: 1/Year

The values in the table are expressed in the report "Avgang og rekruttering i undervisningssektoren - hva betyr lønn?" by Pål Schøne. The leaving probabilility of a teacher in this case has been mesured in correlation with the wages ratio comparing the wage of teachers with the national average wages for teachers and empoloyee with the same level of education\!\!

new qualified secondary science teachers rate[sex,teaching agehi 30 to 39] =
Qualified Secondary Teachers In Science Training[sex,teaching agehi 30 to 39]
/ average time to finish training in science
new qualified secondary science teachers rate[sex,teaching agehi non 30 to 39] = 0

Units: person/Year

number of teachers finishing the training in science every year

new qualified teachers in secondary school[sex,teaching age] =
qualification rate of unqualified science teachers in secondary school[sex,teaching age]

Units: person/Year

percentage of qualified science teachers over total number of teachers =
total qualified science teachers in secondary school
/ actual teachers in secondary

Units: Dmnl

PERCENTAGE OF QUALIFIED SECONDARY TEACHERS SEND TO SCIENCE TRAINING = 0

Units: 1/Year

percentage of qualified teachers which are requested to take training (the value can be set to test different policy)

percentage of qualified teachers in secondary school =
total qualified teachers in secondary school
/ actual teachers in secondary

Units: Dmnl

qualified primary teachers moving to secondary[sex,teaching agehi 50 to 59] =
qualified primary teachers moving to secondary school[sex,teaching agehi 50 to 59]
qualified primary teachers moving to secondary[sex,teaching agehi non 50 to 59] = 0
Units: person/Year

Qualified Secondary Teachers In Science Training[sex,teaching agehi] =
INTEG(qualified secondary teachers send to science training rate[sex,teaching agehi]
- new qualified secondary science teachers rate[sex,teaching agehi] ,
INITIAL QUALIFIED SECONDARY TEACHERS IN SCIENCE TRAINING[sex,teaching agehi])
Units: person
number of secondary qualified teachers currently under training in science

qualified secondary teachers send to science training rate[sex,teaching agehi 30 to 39] =
IF THEN ELSE (Time
>= 2006,
Qualified Teachers In Secondary School[sex,teaching agehi 30 to 39]
* PERCENTAGE OF QUALIFIED SECONDARY TEACHERS SEND TO SCIENCE TRAINING ,
0)
qualified secondary teachers send to science training rate[sex,teaching agehi non 30 to 39] = 0
Units: person/Year
number of qualified secondary teachers within age 30 to 39 send to training every year

qualified teachers in secondary leaves[sex,teaching age] =
Qualified Teachers In Secondary School[sex,teaching age]
* leaving probability of teachers in secondary
Units: person/Year
Number of teachers leaving due to the nonlinear relationship of salaries. If the salaries outside the education are higher a percentage of teachers will be attracted by other job positions

qualified teachers in secondary quits[sex,teaching age] =
qualified teachers in secondary leaves[sex,teaching age]
+ qualified teachers in secondary quits by age[sex,teaching age]
+ qualified teachers leaves due to unqualified teachers in secondary[sex,teaching age]
Units: person/Year

qualified teachers in secondary quits by age[sex,teaching age] =
Qualified Teachers In Secondary School[sex,teaching age]
* quit rate of teachers at school by age[sex,work age]
Units: person/Year
Number of teachers leaving following the non linear relationship of the age

Qualified Teachers In Secondary School[sex,TAGE 22] =
INTEG(new qualified teachers in secondary school[sex,TAGE 22]
+ hiring rate of qualified teachers in secondary[sex,TAGE 22]
+ qualified primary teachers moving to secondary[sex,TAGE 22]
- Qualified Teachers In Secondary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- quit rate of qualified teachers in secondary school[sex,TAGE 22]
- fire rate of qualified teachers in secondary school[sex,TAGE 22]
- qualified secondary teachers send to science training rate[sex,TAGE 22]
- deaths of qualified teachers in secondary school[sex,TAGE 22] ,
initial qualified teachers in secondary school[sex,TAGE 22])
Qualified Teachers In Secondary School[sex,teaching agehi] =
INTEG(Qualified Teachers In Secondary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ new qualified teachers in secondary school[sex,teaching agehi]
+ hiring rate of qualified teachers in secondary[sex,teaching agehi]
+ qualified primary teachers moving to secondary[sex,teaching agehi]

- Qualified Teachers In Secondary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- quit rate of qualified teachers in secondary school[sex,teaching agehi]
- early retirement rate of qualified teacher in secondary school[sex,teaching agehi]
- fire rate of qualified teachers in secondary school[sex,teaching agehi]
- qualified secondary teachers send to science training rate[sex,teaching agehi]
- deaths of qualified teachers in secondary school[sex,teaching agehi]
- retirement rate of qualified teachers in secondary school[sex,teaching agehi] ,
initial qualified teachers in secondary school[sex,teaching agehi])
Units: person
The stock of QUALIFIED TEACHERS present the following flows: INFLOWS new qualified teachers and hiring rate of qualified teachers; OUTFLOWS deaths, early retirement, retirement fire rate and quit rate. The last outflow is present only in the stock of qualified teachers, the reason is that we assumed that a qualified teacher could been attracted by different opportunities out side the teaching work, while an unqualified teachers which has been hired to do not create a shortage of staff is not attracted to other profession, usually unqualified teachers are the first one to get replaced if an higher supply of qualified is enrolled

qualified teachers leaves due to unqualified teachers in secondary[sex,teaching age] =
Qualified Teachers In Secondary School[sex,teaching age]
* effect of unqualified teachers in secondary school on the propensity to quit
Units: person/Year
Number of teachers leaving due to the presence of unqualified collegues

qualified teachers to fire in secondary[sex,teaching age] =
teachers to fire in secondary by age[sex,teaching age]
- fire rate of general unqualified teachers in secondary school[sex,teaching age]
Units: person/Year

quit rate of qualified teachers in secondary school[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
Qualified Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT ,
IF THEN ELSE (Qualified Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT
> qualified teachers in secondary quits[sex,teaching age] ,
qualified teachers in secondary quits[sex,teaching age] ,
Qualified Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT))
Units: person/Year
If the attraction of the salaries is equal to 0 then all the teachers will quit the positions. Otherwise if the number of teacher that want to leave is higher than the stock of teacher, the stock will be 0. Otherwise only the number of teachers that want to leave will be subtracted by the stock

retirement rate of qualified teachers in secondary school[sex,TAGE 67] =
Qualified Teachers In Secondary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF TEACHERS
retirement rate of qualified teachers in secondary school[sex,teaching agelow] = 0
Units: person/Year

total qualified secondary teachers in science training =
SUM (Qualified Secondary Teachers In Science Training[sex!,teaching agehi!])
Units: person
Total number of new qualified secondary teachers

total qualified teachers in secondary school =
SUM (Qualified Teachers In Secondary School[sex!,teaching age!])
Units: person

****

```
  .Qualified science primary teachers
********************************

actual science teachers in primary  =
      total qualified science teachers in primary school
         + total unqualified science teachers in primary school
          Units: person

available position as a science teachers taken by qualified primary teachers  =
       Available Positions As A Science Teacher In Secondary School
          * PERCENTAGE OF QUALIFIED PRIMARY TEACHERS MOVING TO SECONDARY
          Units: person

deaths of science qualified teachers in primary school[sex,teaching age]  =
       Qualified Science Teachers In Primary School[sex,teaching age]
          * death rate[sex,work age]
          Units: person/Year

early retirement rate of science qualified teachers in primary school[sex,teaching age]  =
       Qualified Science Teachers In Primary School[sex,teaching age]
          * unavaiability of science teachers at school[sex,work age]
          Units: person/Year

effect of unqualified teachers in science on the propensity to quit  =
       EFFECT OF UNQUALIFIED TEACHERS IN SCIENCE ON THE PROPENSITY TO QUIT TABLE
( percentage of unqualified science teachers in primary school )
          Units: Dmnl/Year
          percentage of teachers leaving due to the presence of unqualified collegues

EFFECT OF UNQUALIFIED TEACHERS IN SCIENCE ON THE PROPENSITY TO QUIT TABLE  (
         [(0,0)-(1,0.2)],(0,0),(1,0.1041) )
          Units: 1/Year
          data take from the paper (teacehr turnover and non pecuniary factors. PAG 15. we adapt the assumption
as follow, in case of no hiring of unqualified teachers then the 8,7% of teachers will leave in any case for reason
linked to the environment, otherwise in case of an employing rate of unqualified teachers equal to 100% the
propensity to leave will rise to 10,4%. The case studied in the paper take in consideration a dummy variable
equal to 0 or 1 to divide those schools who hire unqualified teachers to qualified one.\!\!

fire rate of science qualified teachers in primary school[sex,teaching age]  =
       IF THEN ELSE ( qualified science teachers to fire in primary[sex,teaching age]
             = 0,
          0,
          IF THEN ELSE ( Qualified Science Teachers In Primary School[sex,teaching age]
                / MINIMUM TIME TO FIRE A QUALIFIED TEACHER
                > qualified science teachers to fire in primary[sex,teaching age] ,
             qualified science teachers to fire in primary[sex,teaching age] ,
             Qualified Science Teachers In Primary School[sex,teaching age]
                / MINIMUM TIME TO FIRE A QUALIFIED TEACHER ) )
          Units: person/Year
          If the stock is higher than the number of teacher to fire then the number of teachers to fire will be
subtracted to the stock. Otherwise the stock will be emptied

FRACTION OF PRIMARY TEACHERS QUALIFIED IN SCIENCE  = 0.7
          Units: Dmnl

hiring rate of science qualified teachers in primary school[sex,teaching age]  =
       effective supply of qualified primary science teachers
          * percentage of scientific teachers to hire by age[sex,work age]
          Units: person/Year
```

```
initial qualified science teachers in primary school[sex,teaching age]  =
        initial science teachers in primary school[sex,teaching age]
            * FRACTION OF PRIMARY TEACHERS QUALIFIED IN SCIENCE
            Units: person

initial science teachers in primary school[sex,teaching age]  =
        INITIAL TEACHERS IN PRIMARY SCHOOL[sex,teaching age]
            * PERCENTAGE OF INITIAL SCIENCE TEACHERS IN PRIMARY SCHOOL
            Units: person

MINIMUM TIME TO FIRE A QUALIFIED TEACHER  = 2
            Units: Year

new science qualified teachers in primary school[sex,teaching age]  =
        qualification rate of unqualified science teachers in primary school[sex,teaching age]
            Units: person/Year

PERCENTAGE OF INITIAL SCIENCE TEACHERS IN PRIMARY SCHOOL  = 0.24
            Units: Dmnl

PERCENTAGE OF QUALIFIED PRIMARY TEACHERS MOVING TO SECONDARY  = 0.02
            Units: Dmnl

percentage of qualified science teachers in primary school  =
        total qualified science teachers in primary school
            / actual science teachers in primary
            Units: Dmnl

percentage of scientific teachers to hire by age[sex,work age]  =
        PERCENTAGE OF SCIENTIFIC TEACHERS TO HIRE BY AGE TABLE ( work age
                - 2)
            Units: 1/Year

PERCENTAGE OF SCIENTIFIC TEACHERS TO HIRE BY AGE TABLE  (
            [(22,0)-
(67,0.1)],(22,0.0659731),(23,0.0659731),(24,0.0615129),(25,0.0573542),(26,0.0534767),(27,0.0498614),(28,0.0
464904),(29,0.0433474),(30,0.0404168),(31,0.0376844),(32,0.0351367),(33,0.0327613),(34,0.0305464),(35,0.0
284813),(36,0.0265558),(37,0.0247604),(38,0.0230865),(39,0.0215257),

(40,0.0200704),(41,0.0187135),(42,0.0174484),(43,0.0162688),(44,0.0151689),(45,0.0141434),(46,0.0131872),(
47,0.0122957),(48,0.0114644),(49,0.0106893),(50,0.00996667),(51,0.00929286),(52,0.00866461),(53,0.008078
83),(54,0.00753265),(55,0.0070234),(56,0.00654857),(57,0.00610585),(58,0.00569305)
            ,(59,0.00530817),(60,0.0049493),(61,0.0046147),(62,0.00430272),(63,0.00401183),(64,0.0037406),(65,0
.00348772),(66,0.00325192),(67,0.00303207) )
            Units: 1/Year

qualified primary science teachers moving to secondary schools[sex,teaching agehi 50 to 59]  =
        IF THEN ELSE ( attraction of the salaries for new teachers in secondary school
                = 0,
            0,
            IF THEN ELSE ( Qualified Science Teachers In Primary School[sex,teaching agehi 50 to 59]
                    / TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY
                    > available position as a science teachers taken by qualified primary teachers
                        / TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY ,
                available position as a science teachers taken by qualified primary teachers
                    / TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY ,
                Qualified Science Teachers In Primary School[sex,teaching agehi 50 to 59]
                    / TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY ) )
qualified primary science teachers moving to secondary schools[sex,teaching agehi non 50 to 59]  = 0
            Units: person/Year
```

Number of teachers moving from primary schools to secondary school. if the number of teachers moving is higher than the number of teacher in the stock of primary then only those in the stock are taken

```
qualified science teachers in primary leaves[sex,teaching age]  =
        Qualified Science Teachers In Primary School[sex,teaching age]
            * leaving probability of teachers in primary school
            Units: person/Year

qualified science teachers in primary leaves by age[sex,teaching age]  =
        Qualified Science Teachers In Primary School[sex,teaching age]
            * quit rate of science teachers at school by age[sex,work age]
            Units: person/Year

qualified science teachers in primary leaves due to unqualified teachers[sex,teaching age]  =
        ( Qualified Science Teachers In Primary School[sex,teaching age]
            * effect of unqualified teachers in science on the propensity to quit )
            Units: person/Year

qualified science teachers in primary quits[sex,teaching age]  =
        qualified science teachers in primary leaves[sex,teaching age]
            + qualified science teachers in primary leaves by age[sex,teaching age]
            + qualified science teachers in primary leaves due to unqualified teachers[sex,teaching age]
            Units: person/Year

Qualified Science Teachers In Primary School[sex,TAGE 22]  =
        INTEG( hiring rate of science qualified teachers in primary school[sex,TAGE 22]
                + new science qualified teachers in primary school[sex,TAGE 22]
                - qualified primary science teachers moving to secondary schools[sex,TAGE 22]
                - Qualified Science Teachers In Primary School[sex,TAGE 22]
                    / TIME TO COMPLETE A YEAR
                - deaths of science qualified teachers in primary school[sex,TAGE 22]
                - fire rate of science qualified teachers in primary school[sex,TAGE 22]
                - quit rate of science qualified teachers in primary school[sex,TAGE 22] ,
            initial qualified science teachers in primary school[sex,TAGE 22] )
Qualified Science Teachers In Primary School[sex,teaching agehi]  =
        INTEG( Qualified Science Teachers In Primary School[sex,teaching agelow]
                / TIME TO COMPLETE A YEAR
                + hiring rate of science qualified teachers in primary school[sex,teaching agehi]
                + new science qualified teachers in primary school[sex,teaching agehi]
                - qualified primary science teachers moving to secondary schools[sex,teaching agehi]
                - Qualified Science Teachers In Primary School[sex,teaching agehi]
                    / TIME TO COMPLETE A YEAR
                - deaths of science qualified teachers in primary school[sex,teaching agehi]
                - fire rate of science qualified teachers in primary school[sex,teaching agehi]
                - quit rate of science qualified teachers in primary school[sex,teaching agehi]
                - early retirement rate of science qualified teachers in primary school[sex,teaching agehi]
                - retirement rate of science qualified teachers in primary school[sex,teaching agehi] ,
            initial qualified science teachers in primary school[sex,teaching agehi] )
            Units: person
```

The stock of unqualified teachers has only one out flow which regards the fire rate. The unqualified or uncertified teachers could not have a long term contract and of course they are the first to get fired. So it's really impossible for them to get at the end of the career and go to retirement has a unqualified teachers

```
qualified science teachers to fire in primary[sex,teaching age]  =
        science teachers to fire in primary by age[sex,teaching age]
            - fire rate of unqualified science teachers in primary school[sex,teaching age]
            Units: person/Year

quit rate of science qualified teachers in primary school[sex,teaching age]  =
        IF THEN ELSE ( attraction of salaries for a new teachers in primary school
```

= 0,
Qualified Science Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT ,
IF THEN ELSE (Qualified Science Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT
> qualified science teachers in primary quits[sex,teaching age] ,
qualified science teachers in primary quits[sex,teaching age] ,
Qualified Science Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT))
Units: person/Year
If the attraction of the salaries is equal to 0 then all the teachers will quit the positions. otherwise if the number of teacher that want to leave is higher than the stock of teacher, the stock will left to 0. Otherwise only the number of teachers that want to leave will be subtracted by the stock

quit rate of science teachers at school by age[sex,work age] =
QUIT RATE OF SCIENCE TEACHERS AT SCHOOL BY AGE TABLE (work age
- 2)
Units: 1/Year
Number teachers that quite based on the elderly age

QUIT RATE OF SCIENCE TEACHERS AT SCHOOL BY AGE TABLE (
[(22,0)-(67,1)],(22,0.251),(24,0.254),(30,0.16),(40,0.1),(50,0.07),(55,0.06),(60,0.07),(67,0.08))
Units: 1/Year
Realtion between age of teachers and quit rate of school. Data to define the relation have been inspired by the article "Teachers turn-over and non-pecuniary factors"\!\!\!

RETIREMENT PERCENTAGE OF SCIENCE TEACHERS = 0.1
Units: 1/Year

retirement rate of science qualified teachers in primary school[sex,TAGE 67] =
Qualified Science Teachers In Primary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF SCIENCE TEACHERS
retirement rate of science qualified teachers in primary school[sex,teaching agelow] = 0
Units: person/Year

TIME FOR PRIMARY SCIENCE TEACHER TO GO TO SECONDARY = 1
Units: Year

total qualified science teachers in primary school =
SUM (Qualified Science Teachers In Primary School[sex!,teaching age!])
Units: person

unavaiability of science teachers at school[sex,work age] =
UNAVAIABILITY DISTRIBUTION PER AGE TABLE (work age)
Units: 1/Year
Number of teachers who become unavailable because early retirement or normal retirement

****
.Qualified science secondary teachers
****

actual science teachers in secondary =
total qualified science teachers in secondary school
+ total unqualified science teachers in secondary school
Units: person

deaths of qualified science teachers in secondary school[sex,teaching age] =
Qualified Science Teachers In Secondary School[sex,teaching age]

* death rate[sex,work age]
Units: person/Year

early retirement rate of qualified science teacher in secondary school[sex,teaching age] =
Qualified Science Teachers In Secondary School[sex,teaching age]
* unavaiability of science teachers at school[sex,work age]
Units: person/Year

effect of unqualified teachers on the propensity to quit in secondary school =
EFFECT OF UNQUALIFIED TEACHERS IN SCIENCE ON THE PROPENSITY TO QUIT TABLE
(percentage of unqualified science teachers in secondary school)
Units: Dmnl/Year

fire rate of qualified science teachers in secondary school[sex,teaching age] =
IF THEN ELSE (qualified science teachers to fire in secondary[sex,teaching age]
= 0,
0,
IF THEN ELSE (Qualified Science Teachers In Secondary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER
> qualified science teachers to fire in secondary[sex,teaching age] ,
qualified science teachers to fire in secondary[sex,teaching age] ,
Qualified Science Teachers In Secondary School[sex,teaching age]
/ MINIMUM TIME TO FIRE A QUALIFIED TEACHER))
Units: person/Year
If the stock is higher than the number of teacher to fire then the number of teachers to fire will be subtracted to the stock. Otherwise the stock will be emptied

FRACTION OF SECONDARY TEACHERS QUALIFIED IN SCIENCE = 0.4
Units: Dmnl

hiring rate of qualified science teachers in secondary school[sex,teaching age] =
effective supply of secondary qualified science teachers
* percentage of scientific teachers to hire by age[sex,work age]
Units: person/Year

initial qualified science teachers in secondary school[sex,teaching age] =
initial science teachers in secondary school[sex,teaching age]
* FRACTION OF SECONDARY TEACHERS QUALIFIED IN SCIENCE
Units: person

initial science teachers in secondary school[sex,teaching age] =
INITIAL TEACHERS IN SECONDARY SCHOOL[sex,teaching age]
* PERCENTAGE OF INITIAL SCIENCE TEACHERS IN SECONDARY SCHOOL
Units: person

new qualified science teachers in secondary school[sex,teaching age] =
qualification rate of unqualified science teachers in secondary school[sex,teaching age]
Units: person/Year

new qualified teachers in secondary school after training[sex,teaching agehi] =
new qualified secondary science teachers rate[sex,teaching agehi]
Units: person/Year

PERCENTAGE OF INITIAL SCIENCE TEACHERS IN SECONDARY SCHOOL = 0.49
Units: Dmnl

percentage of qualified science teachers in secondary school =
total qualified science teachers in secondary school
/ actual science teachers in secondary
Units: Dmnl

qualified primary science teachers moving to secondary[sex,teaching agehi 50 to 59] =
qualified primary science teachers moving to secondary schools[sex,teaching agehi 50 to 59]
qualified primary science teachers moving to secondary[sex,teaching agehi non 50 to 59] = 0
Units: person/Year

qualified science teachers in secondary leaves[sex,teaching age] =
Qualified Science Teachers In Secondary School[sex,teaching age]
* leaving probability of teachers in secondary
Units: person/Year

qualified science teachers in secondary quits[sex,teaching age] =
qualified science teachers in secondary leaves[sex,teaching age]
+ qualified science teachers in secondary quits by age[sex,teaching age]
+ qualified science teachers leaves due to unqualified science teachers in seconary[sex,teaching age]
Units: person/Year

qualified science teachers in secondary quits by age[sex,teaching age] =
Qualified Science Teachers In Secondary School[sex,teaching age]
* quit rate of science teachers at school by age[sex,work age]
Units: person/Year

Qualified Science Teachers In Secondary School[sex,TAGE 22] =
INTEG(hiring rate of qualified science teachers in secondary school[sex,TAGE 22]
+ new qualified science teachers in secondary school[sex,TAGE 22]
+ qualified primary science teachers moving to secondary[sex,TAGE 22]
- Qualified Science Teachers In Secondary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- deaths of qualified science teachers in secondary school[sex,TAGE 22]
- fire rate of qualified science teachers in secondary school[sex,TAGE 22]
- quit rate of qualified science teachers in secondary school[sex,TAGE 22] ,
initial qualified science teachers in secondary school[sex,TAGE 22])
Qualified Science Teachers In Secondary School[sex,teaching agehi] =
INTEG(Qualified Science Teachers In Secondary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ new qualified science teachers in secondary school[sex,teaching agehi]
+ new qualified teachers in secondary school after training[sex,teaching agehi]
+ hiring rate of qualified science teachers in secondary school[sex,teaching agehi]
+ qualified primary science teachers moving to secondary[sex,teaching agehi]
- Qualified Science Teachers In Secondary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- deaths of qualified science teachers in secondary school[sex,teaching agehi]
- early retirement rate of qualified science teacher in secondary school[sex,teaching agehi]
- fire rate of qualified science teachers in secondary school[sex,teaching agehi]
- quit rate of qualified science teachers in secondary school[sex,teaching agehi]
- retirement rate of qualified science teachers in secondary school[sex,teaching agehi] ,
initial qualified science teachers in secondary school[sex,teaching agehi])
Units: person
The stock of unqualified teachers has only one out flow which regards the fire rate. The unqualified or uncertified teachers could not have a long term contract and of course they are the first to get fired. So it's really impossible for them to get at the end of the career and go to retirement has a unqualified teachers

qualified science teachers leaves due to unqualified science teachers in seconary[sex,teaching age] =
Qualified Science Teachers In Secondary School[sex,teaching age]
* effect of unqualified teachers on the propensity to quit in secondary school
Units: person/Year
Percentage of teachers leaving due to the presence of unqualified colleagues

qualified science teachers to fire in secondary[sex,teaching age] =
science teachers to fire in secondary by age[sex,teaching age]

- fire rate of unqualified science teachers in secondary school[sex,teaching age]
Units: person/Year

quit rate of qualified science teachers in secondary school[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
Qualified Science Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT ,
IF THEN ELSE (Qualified Science Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT
> qualified science teachers in secondary quits[sex,teaching age] ,
qualified science teachers in secondary quits[sex,teaching age] ,
Qualified Science Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT))
Units: person/Year
If the attraction of the salaries is equal to 0 then all the teachers will quit the positions. Otherwise if the number of teacher that wants to leave is higher than the stock of teacher, the stock will be 0. Otherwise only the number of teachers that want to leave will be subtracted by the stock

retirement rate of qualified science teachers in secondary school[sex,TAGE 67] =
Qualified Science Teachers In Secondary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF SCIENCE TEACHERS
retirement rate of qualified science teachers in secondary school[sex,teaching agelow] = 0
Units: person/Year

total qualified science teachers in secondary school =
SUM (Qualified Science Teachers In Secondary School[sex!,teaching age!])
Units: person

****
.Qualified science teachers
****

****
.Qualified teachers
****

****
.Qualified workforce entering teaching
****

FRACTION OF BACHELORS GRADUATES IN SCIENCE AT THE UNIVERSITY WHO APPLY FOR THE PCT = 0.1
Units: Dmnl
Assumed percentage of bachelor graduates which apply to qualified as a teacher. No data were available.

FRACTION OF UNIVERSITY MASTERS GRADUATES FOR THE PTC (
[(1990,0)-(2025,0.1)],(1990,0.073),(1994,0.064))
Units: Dmnl
Data used from the research "Realfagslærere i skolen" 2002 T.Næse pag 40\!\!\!

PERCENTAGE OF GRADUATES IN GENERAL TEACHER EDUCATION ENTERING TEACHING = 0.75
Units: Dmnl
Percentage used is relative to the year 2001. Attrating,developing and retaining effective teachers, Pag. 34 point num 118

PERCENTAGE OF STUDENTS CHOOSING SCIENTIFIC SUBJECTS IN GENERAL TEACHER EDUCATION = 0.4
Units: Dmnl

PCT of students that during the college education decide to carry on specific subjects like math, physic, biology or chemistry. Data from NOKUT

total bachelor graduates from general teacher education =
SUM (Bachelors Graduates At Colleges For General Teachers Education[sex!,age c grad!])
Units: person

total bachelors graduates at university in science =
SUM (Bachelors Graduates At The University In Science[sex!,age b grad!])
Units: person

total bachelors graduates in general teacher education at colleges entering teaching =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
SUM (Bachelors Graduates At Colleges For General Teachers Education[sex!,age c grad!])
* PERCENTAGE OF GRADUATES IN GENERAL TEACHER EDUCATION ENTERING TEACHING)
Units: person

"total bachelors graduates at the university in science & certified as a teacher" =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
total bachelors graduates at university in science
* FRACTION OF BACHELORS GRADUATES IN SCIENCE AT THE UNIVERSITY WHO APPLY FOR THE PCT)
Units: person

total bachelors graduates in general teacher education qualified in science =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
total bachelors graduates in general teacher education at colleges entering teaching
* PERCENTAGE OF STUDENTS CHOOSING SCIENTIFIC SUBJECTS IN GENERAL TEACHER EDUCATION)
Units: person
Number of students qualified for teaching scientific subjects

total potential qualified teachers workforce in science =
total bachelor graduates from general teacher education
+ total bachelors graduates at university in science
+ total university masters graduates in science
Units: person

total university masters graduates in science =
SUM (University Masters Graduates In Science[sex!,age m grad!])
Units: person

University Masters Graduates Certified As Teachers =
DELAY N ((SUM (University Masters Graduates[sex!,age m grad!])
* FRACTION OF UNIVERSITY MASTERS GRADUATES FOR THE PTC (Time)) ,
4,0,
1)
Units: person
university masters candidates certified as a teachers the data are delayed of 4 year as it was found in one of the report (Næss, 2002)

university masters graduates certified attracted by salaries =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school

= 0,
0,
University Masters Graduates Certified As Teachers)
Units: person

University Masters Graduates In Science Certified As Teachers =
DELAY N ((SUM (University Masters Graduates In Science[sex!,age m grad!])
* FRACTION OF UNIVERSITY MASTERS GRADUATES FOR THE PTC (Time)) ,
4,0,
1)
Units: person
Number of master students which qualified to become teachers, the delay time seemed to be four years as it was reported in the work "Realfagslærer i skolen"

university masters graduates in science certified attracted by salaries =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
University Masters Graduates In Science Certified As Teachers)
Units: person

****
.Salaries
****

actual teachers in primary school with 4 years or less =
actual teachers in primary
* 0.7
Units: person
in primary schools the 0.3 percent of the teachers have a higher education qualification. in our case we consider them as masters graduates from university

actual teachers in secondary school with more then 4 years =
actual teachers in secondary
* 0.45
Units: person
In secondary schools the percentage of teachers with a tertiary education of 4 year or less are respectively: Bachelors from university 0.3 percentage, and profession's bachelors from colleges 0.25 percentage. The remaining are university masters with a high education more than 4 years.

Gross Wage For A Full Time Employee With 4 Years Or Less =
INTEG(wage increase for a full time employee with 4 years or less ,
"INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS")
Units: Nok/person

Gross Wage For A Full Time Employee With More Then A 4 Years =
INTEG(wage increase for a full time employee with more then a 4 years ,
"INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS")
Units: Nok/person

Gross Wage For A Teacher With 4 Years Or Less =
INTEG(wage increase for teacher with a tertiary education 4 years or less ,
INITIAL WAGE FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS)
Units: Nok/person

Gross Wage For A Teacher With More Then 4 Years =
INTEG(wage increase for teacher with more then 4 years ,
INITIAL WAGE FOR A TEACHER WITH MORE THEN 4 YEARS)
Units: Nok/person

gross yearly salary for a teacher with 4 years or less =
Gross Wage For A Teacher With 4 Years Or Less
* 12
Units: Nok/person
Gross yearly salary for a teacher with less than four years of tertiary education

gross yearly salary for a teacher with more then 4 years =
Gross Wage For A Teacher With More Then 4 Years
* 12
Units: Nok/person
Gross yearly salary for a teacher with more than four years of tertiary education

"IINCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS" (
[(1990,0)-(2025,0.1)],(1990,0.0549874),(1991,0.0549874),(1992,0.0549874),(1993,0.0549874),(1994,0.0549874),(1995,0.0549874),(1996,0.0549874),(1997,0.076643),(1998,0.0405203),(1999,0.0549444),(2000,0.058482),(2001,0.0714006),(2002,0.0315578),(2003,0.0313014),(2004,0.0521213))
Units: 1/Year
Data source SSB. The percentage of increase for the salaries for employee outside educational sector has been calculated with the historical data found and reported here in the table. The last value is the average percentage of increase. Data table can be found in excell file "Statistical Data"

increase in education expenditure =
TOTAL GENERAL GOVERNMENT EXPENDITURE IN EDUCATION TABLE (Time)
* Total General Government Expenditure In Education
Units: Nok/Year
Yearly increase of government expenditure in education. The increase is calculated as a percentage of the expenditure

INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS TABLE (
[(1990,0)-(2006,0.2)],(1990,0.047647),(1991,0.047647),(1992,0.0217044),(1993,0.0169387),(1994,0.021879),(1995,0.0416375),(1996,0.0327945),(1997,0.0869587),(1998,0.04053),(1999,0.047838),(2000,0.0878903),(2001,0.105108),(2002,0.024041),(2003,0.0359517),(2004,0.0209746),(2005,0.0525475),(2006,0.045)
)
Units: 1/Year
Data source SSB. The percentage has been calculated with the statistical data obtained and then reported here in the table. The last value is equivalent to the average percentage of increase. Data table can be found in the excel file "Statistic Data"\!\!\!

INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH MORE THEN 4 YEARS TABLE (
[(1990,0)-(2006,0.2)],(1990,0.0453909),(1991,0.0453909),(1992,0.00988962),(1993,0.00514368),(1994,0.0193869),(1995,-0.00579234),(1996,0.0622906),(1997,0.0900823),(1998,0.0880466),(1999,0.0764518),(2000,0.0558081),(2001,0.0975453),(2002,0.0189676),(2003,0.0310141),(2004,0.00705716),(2005,0.0521213)
,(2006,0.0429487))
Units: 1/Year
Data source SSB. The percentage has been calculated with the statistical data obtained and then reported here in the table. The last value is equivalent to the average percentage of increase. Data table can be found in the excel file "Statistic Data"\!\!\!

"INCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS" (
[(1990,0)-(2025,0.1)],(1990,0.0554619),(1991,0.0554619),(1992,0.0554619),(1993,0.0554619),(1994,0.0554619),(1995,0.0554619),(1996,0.0554619),(1997,0.0825483),(1998,0.0399482),(1999,0.0577178),(2000,0.0555617),(2001,0.0709729),(2002,0.027276),(2003,0.0338075),(2004,0.0525475))

Units: 1/Year
Data source SSB. The percentage of increase for the salaries for employee outside educational sector has been calculated with the historical data found and reported here in the table. The last value is the average percentage of increase. Data table can be found in excel file "Statistic Data"

INITIAL TOTAL GENERAL GOVERNMENT EDUCATION EXPENDITURE = 32516
Units: Nok
Million of Nok

"INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS" = 15641.4
Units: Nok/person
Assumed value considering the historical data set found in the SSB 15641.4

"INITIAL WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS" = 19635.5
Units: Nok/person
Assumed value considering the historical data set found in the SSB 19635.5

INITIAL WAGE FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS = 15951.7
Units: Nok/person
15951.7

INITIAL WAGE FOR A TEACHER WITH MORE THEN 4 YEARS = 18320.1
Units: Nok/person
18320.1

proportion of primary and secondary salaries over government exp for edu =
total salaries of teachers in primary and secondary expenditure
/ (Total General Government Expenditure In Education
* 1e+006)
Units: Dmnl
Percentage of total salaries for teachers in primary and secondary weight upon total government expenditure in education

real yearly wage for a full time employee with 4 years or less =
Gross Wage For A Full Time Employee With 4 Years Or Less
* 12
Units: Nok/person

real yearly wage for a full time employee with a tertiary education more then a 4 years =
Gross Wage For A Full Time Employee With More Then A 4 Years
* 12
Units: Nok/person

Total General Government Expenditure In Education =
INTEG(increase in education expenditure ,
INITIAL TOTAL GENERAL GOVERNMENT EDUCATION EXPENDITURE)
Units: Nok
Total government expenditure for education (including colleges and universities). The expenditure considered is on a national level and they are calculated in Million NOK.

TOTAL GENERAL GOVERNMENT EXPENDITURE IN EDUCATION TABLE (
[(1991,0)-(2004,1)],(1991,0.0634991),(1992,0.0383737),(1993,0.0539827),(1994,0.0829793),(1995,0.0355347),(1996,0.116979),(1997,0.0445369),(1998,0.0273391),(1999,0.0569339),(2000,0.0817858),(2001,0.0572766),(2002,0.110148),(2003,0.0137803),(2004,0.0343693),(2005,0.0570245),(2006,0.0583029)
)
Units: 1/Year

Data source SSB. The percentage of increase has been calculated using the historical data found. Data in 2004 is the average percentage of increase in the previous years. Data table can be found in the excel file "Statistic Data"\!\!\!

total gross salaries expenditure for teachers with 4 years or less =
gross yearly salary for a teacher with 4 years or less
* actual teachers in primary school with 4 years or less
Units: Nok
total salaries for teachers with less than four years of tertiary education effectively enrolled in primary education

total gross salaries expenditure for teachers with more then 4 years =
gross yearly salary for a teacher with more then 4 years
* actual teachers in secondary school with more then 4 years
Units: Nok
total salaries for teachers with more than four years of tertiary education effectively enrolled in secondary education

total salaries of teachers in primary and secondary expenditure =
total gross salaries expenditure for teachers with 4 years or less
+ total gross salaries expenditure for teachers with more then 4 years
Units: Nok

wage increase for a full time employee with 4 years or less =
"INCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH 4 YEARS OR LESS" (Time)
* Gross Wage For A Full Time Employee With 4 Years Or Less
Units: Nok/(person*Year)

wage increase for a full time employee with more then a 4 years =
"INCREASE PERCENTAGE OF WAGE FOR A FULL-TIME EMPLOYEE WITH MORE THEN A 4 YEARS" (Time)
* Gross Wage For A Full Time Employee With More Then A 4 Years
Units: Nok/(person*Year)

wage increase for teacher with a tertiary education 4 years or less =
(INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH A TERTIARY EDUCATION 4 YEARS OR LESS TABLE (Time)
* Gross Wage For A Teacher With 4 Years Or Less)
Units: Nok/(person*Year)

wage increase for teacher with more then 4 years =
(INCREASE PERCENTAGE OF SALARIES FOR A TEACHER WITH MORE THEN 4 YEARS TABLE (Time)
* Gross Wage For A Teacher With More Then 4 Years)
Units: Nok/(person*Year)

wage ratio of teacher and emloyee with 4 years or less =
(Gross Wage For A Teacher With 4 Years Or Less
/ Gross Wage For A Full Time Employee With 4 Years Or Less)
- 1
Units: Dmnl
Wage ratio between teachers wage and national average employee wage with less than four years of tertiary education

wage ratio of teacher and employee with more then 4 years =
(Gross Wage For A Teacher With More Then 4 Years
/ Gross Wage For A Full Time Employee With More Then A 4 Years)
- 1
Units: Dmnl

Wage ratio between teachers wage and national average employee wage with more than four years of tertiary education

```
********************************
  .Science unqualified primary teachers
********************************
```

AVERAGE TIME TO BECOME QUALIFIED = 4
Units: Year
The value is an assumption, it indicates an average time that an unqualified teacher has to spend in the school before he or she can be considerate qualified. The parameter has been set to 5 years since so in our assumption we consider that spending one year in school as a teacher is
equivalent to spend one year at the university or at college in form of qualification and education. In this case the formal qualification they recive can be considered "on field"

deaths of unqualified science teachers in primary school[sex,teaching age] =
Science Unqualified Teachers In Primary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement of unqualified science teachers in primary school[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
Science Unqualified Teachers In Primary School[sex,teaching age]
* unavaiability of science teachers at school[sex,work age])
Units: person/Year

fire rate of unqualified science teachers in primary school[sex,teaching age] =
unqualified science teachers to fire in primary[sex,teaching age]
Units: person/Year

FRACTION OF QUALIFICATION RATE = 0.35
Units: Dmnl

hiring rate of unqualified science teachers in primary school[sex,teaching age] =
IF THEN ELSE (unqualified science teachers entering in primary school
> 0,
unqualified science teachers entering in primary school
* proportion of hiring teachers by age[sex,work age] ,
0)
Units: person/Year

initial unqualified science teachers in primary school[sex,teaching age] =
initial science teachers in primary school[sex,teaching age]
* (1
- FRACTION OF PRIMARY TEACHERS QUALIFIED IN SCIENCE)
Units: person

percentage of science teachers to fire by age[sex,work age] =
PERCENTAGE OF SCIENCE TEACHERS TO FIRE BY AGE TABLE (work age
- 2)
Units: 1/Year

PERCENTAGE OF SCIENCE TEACHERS TO FIRE BY AGE TABLE (
[(22,0)-
(67,0.15)],(22,0.0294387),(23,0.0294387),(24,0.0290004),(25,0.0285686),(26,0.0281433),(27,0.0277243),(28,0.0273115),(29,0.0269049),(30,0.0265043),(31,0.0261097),(32,0.025721),(33,0.0253381),(34,0.0249609),(35,0.0245892),(36,0.0242231),(37,0.0238625),(38,0.0235072),(39,0.0231573),

(40,0.0228125),(41,0.0224729),(42,0.0221383),(43,0.0218087),(44,0.021484),(45,0.0211641),(46,0.0208491),(47,0.0205387),(48,0.0202329),(49,0.0199316),(50,0.0196349),(51,0.0193426),(52,0.0190546),(53,0.0187709),(54,0.0184915),(55,0.0182162),(56,0.0179449),(57,0.0176778),(58,0.0174146),(59,0.0171553)
,(60,0.0168999),(61,0.0166483),(62,0.0164004),(63,0.0161563),(64,0.0159157),(65,0.0156788),(66,0.0154454),(67,0.0152154))
Units: 1/Year

percentage of unqualified science teachers in primary school =
total unqualified science teachers in primary school
/ actual science teachers in primary
Units: Dmnl

qualification rate of unqualified science teachers in primary school[sex,teaching age] =
IF THEN ELSE (unqualified science teachers in primary become qualified[sex,teaching age]
= 0,
0,
IF THEN ELSE (Science Unqualified Teachers In Primary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED
> unqualified science teachers in primary become qualified[sex,teaching age] ,
unqualified science teachers in primary become qualified[sex,teaching age] ,
Science Unqualified Teachers In Primary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED))
Units: person/Year
If there are no unqualified teachers becoming qualified the flow is 0, Otherwise if the number of teacher becoming qualified is > of the stock then it will be emptied. Otherwise the number of unqualified becoming unqualified will be subtracted by the stock

quits of science unqualified teachers in primary[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
Science Unqualified Teachers In Primary School[sex,teaching age]
/ TIME NEED TO QUIT ,
0)
Units: person/Year

retirement rate of unqualified science teachers in primary school[sex,TAGE 67] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
Science Unqualified Teachers In Primary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF SCIENCE TEACHERS)
retirement rate of unqualified science teachers in primary school[sex,teaching agelow] = 0
Units: person/Year

science teachers to fire in primary by age[sex,teaching age] =
Percived Number Of Science Teachers To Fire In Primary School
* percentage of science teachers to fire by age[sex,work age]
Units: person/Year

Science Unqualified Teachers In Primary School[sex,TAGE 22] =
INTEG(hiring rate of unqualified science teachers in primary school[sex,TAGE 22]
- Science Unqualified Teachers In Primary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- deaths of unqualified science teachers in primary school[sex,TAGE 22]
- fire rate of unqualified science teachers in primary school[sex,TAGE 22]
- qualification rate of unqualified science teachers in primary school[sex,TAGE 22]
- quits of science unqualified teachers in primary[sex,TAGE 22] ,
initial unqualified science teachers in primary school[sex,TAGE 22])
Science Unqualified Teachers In Primary School[sex,teaching agehi] =

INTEG(Science Unqualified Teachers In Primary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ hiring rate of unqualified science teachers in primary school[sex,teaching agehi]
- Science Unqualified Teachers In Primary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- deaths of unqualified science teachers in primary school[sex,teaching agehi]
- early retirement of unqualified science teachers in primary school[sex,teaching agehi]
- fire rate of unqualified science teachers in primary school[sex,teaching agehi]
- qualification rate of unqualified science teachers in primary school[sex,teaching agehi]
- retirement rate of unqualified science teachers in primary school[sex,teaching agehi]
- quits of science unqualified teachers in primary[sex,teaching agehi] ,
initial unqualified science teachers in primary school[sex,teaching agehi])
Units: person
The stock of unqualified teachers has only one out flow which regards the fire rate. The unqualified or uncertified teachers could not have a long term contract and of course they are the first to get fired. So it's really impossible for them to get at the end of the career and go to retirement has a unqualified teachers

TIME TO FIRE A TEACHER = 2
Units: Year

total unqualified science teachers in primary school =
SUM (Science Unqualified Teachers In Primary School[sex!,teaching age!])
Units: person

unqualified science teachers in primary become qualified[sex,teaching age] =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
(Science Unqualified Teachers In Primary School[sex,teaching age]
* FRACTION OF QUALIFICATION RATE)
/ AVERAGE TIME TO BECOME QUALIFIED)
Units: person/Year
If the attraction of salaries is 0 then we assume there are no motivations for an unqualified to become qualified

unqualified science teachers to fire in primary[sex,teaching age] =
IF THEN ELSE (science teachers to fire in primary by age[sex,teaching age]
= 0,
0,
IF THEN ELSE (Science Unqualified Teachers In Primary School[sex,teaching age]
/ TIME TO FIRE A TEACHER
> science teachers to fire in primary by age[sex,teaching age] ,
science teachers to fire in primary by age[sex,teaching age] ,
Science Unqualified Teachers In Primary School[sex,teaching age]
/ TIME TO FIRE A TEACHER))
Units: person/Year
If there are not teachers to fire then 0 is the value of the variable. Otherwise if the number of teachers to fire is higher, than the stock it will empty. Otherwise the number of teachers to fire will be subtracted by the stock

****
.Science unqualified secondary teachers
****

deaths of unqualified science teachers in secondary school[sex,teaching age] =
Unqualified Science Teachers In Secondary School[sex,teaching age]
* death rate[sex,work age]
Units: person/Year

early retirement rate of unqualified science teachers in secondary school[sex,teaching age] =

IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
Unqualified Science Teachers In Secondary School[sex,teaching age]
* unavaiability of science teachers at school[sex,work age])
Units: person/Year

fire rate of unqualified science teachers in secondary school[sex,teaching age] =
unqualified science teachers to fire in secondary[sex,teaching age]
Units: person/Year

hiring rate of unqualified science teachers in secondary school[sex,teaching age] =
IF THEN ELSE (unqualified science teachers entering in secondary school
> 0,
unqualified science teachers entering in secondary school
* proportion of hiring teachers by age[sex,work age] ,
0)
Units: person/Year

initial unqualified science teachers in secondary school[sex,teaching age] =
initial science teachers in secondary school[sex,teaching age]
* (1
- FRACTION OF SECONDARY TEACHERS QUALIFIED IN SCIENCE)
Units: person

percentage of unqualified science teachers in secondary school =
total unqualified science teachers in secondary school
/ actual science teachers in secondary
Units: Dmnl

qualification rate of unqualified science teachers in secondary school[sex,teaching age] =
IF THEN ELSE (unqualified science teachers become qualified[sex,teaching age]
= 0,
0,
IF THEN ELSE (Unqualified Science Teachers In Secondary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED
> unqualified science teachers become qualified[sex,teaching age] ,
unqualified science teachers become qualified[sex,teaching age] ,
Unqualified Science Teachers In Secondary School[sex,teaching age]
/ AVERAGE TIME TO BECOME QUALIFIED))
Units: person/Year
If there are no unqualified teachers becoming qualified the flow is 0, Otherwise if the number of teacher becoming qualified is > of the stock then it will be emptied. Otherwise the number of unqualified becoming unqualified will be subtracted by the stock

quits of science unqualified teachers in secondary[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
Unqualified Science Teachers In Secondary School[sex,teaching age]
/ TIME NEED TO QUIT ,
0)
Units: person/Year

retirement rate of unqualified science teachers in secondary school[sex,TAGE 67] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
Unqualified Science Teachers In Secondary School[sex,TAGE 67]
* RETIREMENT PERCENTAGE OF SCIENCE TEACHERS)
retirement rate of unqualified science teachers in secondary school[sex,teaching agelow] = 0

Units: person/Year

science teachers to fire in secondary by age[sex,teaching age] =
Percived Number Of Science Teachers To Fire In Secondary School
* percentage of science teachers to fire by age[sex,work age]
Units: person/Year

total unqualified science teachers in secondary school =
SUM (Unqualified Science Teachers In Secondary School[sex!,teaching age!])
Units: person

unqualified science teachers become qualified[sex,teaching age] =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
(Unqualified Science Teachers In Secondary School[sex,teaching age]
* FRACTION OF QUALIFICATION RATE)
/ AVERAGE TIME TO BECOME QUALIFIED)
Units: person/Year
If the attraction of salaries is 0 then we assume there are no motivation for an unqualified to become qualified

Unqualified Science Teachers In Secondary School[sex,TAGE 22] =
INTEG(hiring rate of unqualified science teachers in secondary school[sex,TAGE 22]
- Unqualified Science Teachers In Secondary School[sex,TAGE 22]
/ TIME TO COMPLETE A YEAR
- deaths of unqualified science teachers in secondary school[sex,TAGE 22]
- fire rate of unqualified science teachers in secondary school[sex,TAGE 22]
- qualification rate of unqualified science teachers in secondary school[sex,TAGE 22]
- quits of science unqualified teachers in secondary[sex,TAGE 22] ,
initial unqualified science teachers in secondary school[sex,TAGE 22])
Unqualified Science Teachers In Secondary School[sex,teaching agehi] =
INTEG(Unqualified Science Teachers In Secondary School[sex,teaching agelow]
/ TIME TO COMPLETE A YEAR
+ hiring rate of unqualified science teachers in secondary school[sex,teaching agehi]
- Unqualified Science Teachers In Secondary School[sex,teaching agehi]
/ TIME TO COMPLETE A YEAR
- deaths of unqualified science teachers in secondary school[sex,teaching agehi]
- early retirement rate of unqualified science teachers in secondary school[sex,teaching agehi]
- fire rate of unqualified science teachers in secondary school[sex,teaching agehi]
- qualification rate of unqualified science teachers in secondary school[sex,teaching agehi]
- retirement rate of unqualified science teachers in secondary school[sex,teaching agehi]
- quits of science unqualified teachers in secondary[sex,teaching agehi] ,
initial unqualified science teachers in secondary school[sex,teaching agehi])
Units: person
The stock of unqualified teachers has only one out flow which regards the fire rate. The unqualified or uncertified teachers could not have a long term contract and of course they are the first to get fired. so it's really impossible for them to get at the end of the career and go to retirement has a unqualified teachers

unqualified science teachers to fire in secondary[sex,teaching age] =
IF THEN ELSE (science teachers to fire in secondary by age[sex,teaching age]
= 0,
0,
IF THEN ELSE (Unqualified Science Teachers In Secondary School[sex,teaching age]
/ TIME TO FIRE A TEACHER
> science teachers to fire in secondary by age[sex,teaching age] ,
science teachers to fire in secondary by age[sex,teaching age] ,
Unqualified Science Teachers In Secondary School[sex,teaching age]
/ TIME TO FIRE A TEACHER))
Units: person/Year

If there are not teachers to fire then 0 is the value of the variable. Otherwise if the number of teachers to fire is higher than the stock it will be emptied. Otherwise the number of teachers to fire will be subtracted by the stock

****
.Subscripts
****

age : NEW BORN,(AGE0-AGE84)

age b grad : (AGE 22-AGE 67)
-> age over 21

age b gradhi : (AGE 23-AGE 67)

age b gradlow : (AGE 22-AGE 66)
-> age b gradhi

age c grad : (AGE 23-AGE 67)
-> age over 22

age c gradhi : (AGE 24-AGE 67)

age c gradlow : (AGE 23-AGE 66)
-> age c gradhi

age m grad : (AGE 24-AGE 67)
-> age over 23

age m gradhi : (AGE 25-AGE 67)

age m gradlow : (AGE 24-AGE 66)
-> age m gradhi

age over 0 : (AGE0-AGE84)

age over 19 : (AGE20-AGE67)

age over 21 : (AGE22-AGE67)
-> age b grad
age from which one could get his BACHELOR at university

age over 22 : (AGE23-AGE67)
-> age c grad
age from which one could get his BACHELOR at college

age over 23 : (AGE24-AGE67)
-> age m grad

age over 24 : (AGE25-AGE67)

age over 25 : (AGE26-AGE67)

age uni : (AGE 19-AGE 67)
-> university age

age unihi : (AGE 20-AGE 67)

age unilow : (AGE 19-AGE 66)
-> age unihi

age0 to age4 : (AGE0-AGE4)

age10 to age14 : (AGE10-AGE14)

age15 to age19 : (AGE15-AGE19)

age20 to age24 : (AGE20-AGE24)

age25 to age29 : (AGE25-AGE29)

age30 to age34 : (AGE30-AGE34)

age35 to age39 : (AGE35-AGE39)

age40 to age44 : (AGE40-AGE44)

age45 to age49 : (AGE45-AGE49)

age5 to age9 : (AGE5-AGE9)

age50 to age54 : (AGE50-AGE54)

age55 to age59 : (AGE55-AGE59)

age60 to age64 : (AGE60-AGE64)

age65 to age69 : (AGE65-AGE69)

age70 to age74 : (AGE70-AGE74)

age75 to age79 : (AGE75-AGE79)

age80 to age84 : (AGE80-AGE84)

childbearing : (AGE15-AGE50)
Age of procreation for women

compulsory school age : (AGE6-AGE16)
Compulsory school age for pupils

high primary education age : (AGE14-AGE16)
School age for pupils attending the middle school, also called high primary education

primary low education age : (AGE6-AGE13)
School age for pupil attending the first seventh grades

sex : FEMALE,MALE

teaching age : (TAGE 22-TAGE 67)
-> work age

teaching agehi : (TAGE 23-TAGE 67)

teaching agehi 30 to 39 : (TAGE 30-TAGE 39)

teaching agehi 50 to 59 : (TAGE 50-TAGE 59)

teaching agehi non 30 to 39 : (TAGE 22-TAGE 29),(TAGE 40-TAGE 67)

teaching agehi non 50 to 59 : (TAGE 22-TAGE 49),(TAGE 60-TAGE 67)

teaching agelow : (TAGE 22-TAGE 66)
-> teaching agehi

university age : (AGE19-AGE67)
-> age uni
Age for students who attend university

upper secondary school age : (AGE17-AGE19)
Age for pupils in low secondary school

work age : (AGE22-AGE67)
-> teaching age
Working age, in which one is supposed to work

****
.Supply of general qualified teachers
****

attraction of salaries for a new teachers in primary school =
MAX (0,
ATTRACTION OF SALARIES FOR A NEW TEACHERS IN PRIMARY SCHOOL TABLE (wage ratio of teacher and emloyee with 4 years or less))
Units: Dmnl
Percentage of applicants for teacher positions in primary attracted by salaries

ATTRACTION OF SALARIES FOR A NEW TEACHERS IN PRIMARY SCHOOL TABLE (
[(-0.5,0)-(1.9,0.4)],(-0.5,-0.00365),(-0.45,0.003515),(-0.4,0.01068),(-0.35,0.017845),(-0.3,0.02501),(-0.25,0.032175),(-0.2,0.03934),(-0.15,0.046505),(-0.1,0.05367),(-0.05,0.060835),(7.45058e-009,0.068),(0.05,0.075165),(0.1,0.08233),(0.15,0.089495),(0.2,0.09666),(0.25,0.103825),(0.3,0.11099)
,(0.35,0.118155),(0.4,0.12532),(0.45,0.132485),(0.5,0.13965),(0.55,0.146815),(0.6,0.15398),(0.65,0.161145),(0.7,0.16831),(0.75,0.175475),(0.8,0.18264),(0.85,0.189805),(0.9,0.19697),(0.95,0.204135),(1,0.2113),(1.05,0.218465),(1.1,0.22563),(1.15,0.232795),(1.2,0.23996),(1.25,0.247125),(1.3,0.25429)
,(1.35,0.261455),(1.4,0.26862),(1.45,0.275785),(1.5,0.28295),(1.55,0.290115),(1.6,0.29728),(1.65,0.304445),(1.7,0.31161),(1.75,0.318775),(1.8,0.32594),(1.85,0.333105),(1.9,0.34027))
Units: Dmnl
Calculate probability to attract teacher based on the wage ration. the function here presented has been calculated using a linear extrapolation from the original function. The original function of this non linear relationship can be found in the report "Avgang og rekruttering i undervisningssektoren - hva betyr lønn?" Pag. 78

attraction of the salaries for new teachers in secondary school =
MAX (0,
ATTRACTION OF THE SALARIES FOR NEW TEACHERS IN SECONDARY SCHOOL TABLE (wage ratio of teacher and employee with more then 4 years))
Units: Dmnl
Percentage of applicants for teacher positions in secondary attracted by salaries

ATTRACTION OF THE SALARIES FOR NEW TEACHERS IN SECONDARY SCHOOL TABLE (
[(-0.5,-0.004)-(1.9,0.4)],(-0.5,-0.00365),(-0.45,0.003515),(-0.4,0.01068),(-0.35,0.017845),(-0.3,0.02501),(-0.25,0.032175),(-0.2,0.03934),(-0.15,0.046505),(-0.1,0.05367),(-0.05,0.060835),(7.45058e-009,0.068),(0.05,0.075165),(0.1,0.08233),(0.15,0.089495),(0.2,0.09666),(0.25,0.103825),(0.3,0.11099)
,(0.35,0.118155),(0.4,0.12532),(0.45,0.132485),(0.5,0.13965),(0.55,0.146815),(0.6,0.15398),(0.65,0.161145),(0.7,0.16831),(0.75,0.175475),(0.8,0.18264),(0.85,0.189805),(0.9,0.19697),(0.95,0.204135),(1,0.2113),(1.05,0.218465),(1.1,0.22563),(1.15,0.232795),(1.2,0.23996),(1.25,0.247125),(1.3,0.25429)
,(1.35,0.261455),(1.4,0.26862),(1.45,0.275785),(1.5,0.28295),(1.55,0.290115),(1.6,0.29728),(1.65,0.304445),(1.7,0.31161),(1.75,0.318775),(1.8,0.32594),(1.85,0.333105),(1.9,0.34027))
Units: Dmnl

Calculate probability to attract teacher based on the wage ration. the function here presented has been calculated using a linear extrapolation from the original function. The original function of this non linear relationship can be found in the report "Avgang og rekruttering i undervisningssektoren - hva betyr lønn?" Pag. 78

bachelor not choosing teaching as first choice =
total bachelors graduates at university
- university bachelors certified as teachers
Units: person
Number of bachelors which do not choose to enter in education as first choice.

college bachelors in teacher education not choosing teaching as first choice =
total bachelor graduates from general teacher education
- total bachelors graduates in general teacher education at colleges entering teaching
Units: person

effective supply of qualified teachers in primary school =
MIN (Perceived Difference Of Primary Teachers To Hire ,
total applicants as a teachers in primary)
Units: person
The variable is taking the minimum value between applicants in primary and the available positions to cover

effective supply of secondary teachers =
MIN (Perceived Difference Of Secondary Teachers To Hire ,
total applicants as teachers in secondary)
Units: person

need of unqualified teachers in primary school =
IF THEN ELSE (effective supply of qualified teachers in primary school
< Perceived Difference Of Primary Teachers To Hire ,
Perceived Difference Of Primary Teachers To Hire
- effective supply of qualified teachers in primary school ,
0)
Units: person
If the value of effective supply of qualified teachers is lower than the available positions to cover then there is a need of unqualified teachers

need of unqualified teachers in secondary school =
IF THEN ELSE (effective supply of secondary teachers
< Perceived Difference Of Secondary Teachers To Hire ,
Perceived Difference Of Secondary Teachers To Hire
- effective supply of secondary teachers ,
0)
Units: person
If the value of effective supply of qualified teachers is lower than the available positions to cover then there is a need of unqualified teachers

total applicants as a teachers in primary =
total university masters graduates certified as teachers applying for primary
+ total bachelors graduates in general teacher education at colleges applying for primary
+ university bachelors certified as teachers applying for primary
+ total profession's bachelors graduates at colleges applying for primary school
+ total university bachelors attracted by salaries
Units: person
Number of applicants in primary for the available positions as teacher

total applicants as teachers in secondary =
total university bachelors certified as teachers applying for secondary school
+ total bachelors graduates in general teacher education at colleges applying for secondary

+ total university masters graduates attracted by salaries
+ university masters graduates certified attracted by salaries
Units: person
Number of applicants in secondary for the available positions as teacher

total bachelors graduates in general teacher education at colleges applying for primary =
total bachelors graduates in general teacher education at colleges entering teaching
- total bachelors graduates in general teacher education at colleges applying for secondary
Units: person

total bachelors graduates in general teacher education at colleges applying for secondary =
total bachelors graduates in general teacher education at colleges entering teaching
* attraction of the salaries for new teachers in secondary school
Units: person

total profession's bachelors graduates at colleges applying for primary school =
college bachelors in teacher education not choosing teaching as first choice
* attraction of salaries for a new teachers in primary school
Units: person
Number of college bachelors from teaching education, which did not choose teaching as first choice, which are attracted to teaching by the salaries

total university bachelors attracted by salaries =
bachelor not choosing teaching as first choice
* attraction of salaries for a new teachers in primary school
Units: person
University bachelors attracted to teaching by salaries

total university bachelors certified as teachers applying for secondary school =
university bachelors certified as teachers
* attraction of the salaries for new teachers in secondary school
Units: person
Number of bachelor graduates and certified as teacher attracted into secondary by the salary

total university masters graduates attracted by salaries =
total university masters graduates not choosing teaching as first choice
* attraction of the salaries for new teachers in secondary school
Units: person
Total master graduates at university attracted to teaching in secondary by the salaries

total university masters graduates certified as teachers applying for primary =
(total university masters graduates
- total university masters graduates attracted by salaries
- university masters graduates certified attracted by salaries)
* attraction of salaries for a new teachers in primary school
Units: person
There is percentage of students qualified for secondary school employed in primary. Therefore the number of master graduates applying for primary will be the difference between the total number of master graduate and those who are applying for secondary multiply by the attraction of the salary for primary teachers

total university masters graduates not choosing teaching as first choice =
total university masters graduates
- university masters graduates certified attracted by salaries
Units: person
Number of master graduates not choosing teacher as first choice

university bachelors certified as teachers applying for primary =
university bachelors certified as teachers
- total university bachelors certified as teachers applying for secondary school

Units: person

unqualified teachers entering in primary school =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,
need of unqualified teachers in primary school)
Units: person
If the attraction of salaries is 0 then no unqualified will enter the workforce. Otherwise the need number of unqualified will enter the workforce

unqualified teachers entering in secondary school =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
need of unqualified teachers in secondary school)
Units: person
Effective number of unqualified teacher entering schools. If the attraction of the salaries is 0 then we assumed there are not reasons for an unqualified to enter the teaching profession

****
.Supply of qualified science teachers
****

effective supply of qualified primary science teachers =
MIN (Need Of Primary Science Teachers To Cover ,
total applicants as a teachers in science)
Units: person
The variable is taking the minimum value between applicants in primary and the available positions to cover

effective supply of secondary qualified science teachers =
MIN (Needed Of Secondary Science Teachers To Hire ,
total applicants qualified APPLYing for secondary school)
Units: person
The variable is taking the minimum value between applicants in primary and the available positions to cover

need of unqualified science teachers in primary school =
IF THEN ELSE (effective supply of qualified primary science teachers
< Need Of Primary Science Teachers To Cover ,
Need Of Primary Science Teachers To Cover
- effective supply of qualified primary science teachers ,
0)
Units: person
If the value of effective supply of qualified teachers is lower than the available positions to cover then there is a need of unqualified teachers IF THEN ELSE(effective supply of qualified primary science teachers<Need Of Primary Science Teachers To Cover ,Need Of Primary Science
Teachers To Cover -effective supply of qualified primary science teachers ,0)

need of unqualified science teachers in secondary school =
IF THEN ELSE (effective supply of secondary qualified science teachers
< Needed Of Secondary Science Teachers To Hire ,
Needed Of Secondary Science Teachers To Hire
- effective supply of secondary qualified science teachers ,
0)
Units: person
If the value of effective supply of qualified teachers is lower than the available positions to cover then there is a need of unqualified teachers

total applicants as a teachers in science =
total bachelors graduates in general teachers education qualified in science applying for primary school
+ "total bachelors graduates at the university in science & certified as teachers applying for primary school"
+ university masters graduates in science certified as teachers applying for primary
Units: person

total applicants qualified APPLYing for secondary school =
total master graduates in science attracted by salaries
+ university masters graduates in science certified attracted by salaries
+ "total bachelors graduates at university in science & certified as teachers applying for secondary school"
+ total bachelors graduates in general teacher education qualified in science APPLY for secondary school
Units: person

"total bachelors graduates at the university in science & certified as teachers applying for primary school" =
"total bachelors graduates at the university in science & certified as a teacher"
- "total bachelors graduates at university in science & certified as teachers applying for secondary school"
Units: person

"total bachelors graduates at university in science & certified as teachers applying for secondary school" =
"total bachelors graduates at the university in science & certified as a teacher"
* attraction of the salaries for new teachers in secondary school
Units: person
It is unknown how many bachelor student qualified to teach are employee in secondary school

total bachelors graduates in general teacher education qualified in science APPLY for secondary school =
total bachelors graduates in general teacher education qualified in science
* attraction of the salaries for new teachers in secondary school
Units: person

total bachelors graduates in general teachers education qualified in science applying for primary school =
total bachelors graduates in general teacher education qualified in science
- total bachelors graduates in general teacher education qualified in science APPLY for secondary school
Units: person
number of college bachelor qualified in science applying for becoming a teacher

total master graduates in science attracted by salaries =
total master graduates in science not choosing teaching
* attraction of the salaries for new teachers in secondary school
Units: person

total master graduates in science not choosing teaching =
total university masters graduates in science
- university masters graduates in science certified attracted by salaries
Units: person

university masters graduates in science certified as teachers applying for primary =
(total university masters graduates in science
- total master graduates in science attracted by salaries
- university masters graduates in science certified attracted by salaries)
* attraction of salaries for a new teachers in primary school
Units: person

unqualified science teachers entering in primary school =
IF THEN ELSE (attraction of salaries for a new teachers in primary school
= 0,
0,

need of unqualified science teachers in primary school)
Units: person
If the attraction of salaries is 0 then no unqualified will enter the workforce. Otherwise the need number of unqualified will enter the workforce

unqualified science teachers entering in secondary school =
IF THEN ELSE (attraction of the salaries for new teachers in secondary school
= 0,
0,
need of unqualified science teachers in secondary school)
Units: person
If the attraction of salaries is 0 then no unqualified will enter the workforce. Otherwise the need number of unqualified will enter the workforce IF THEN ELSE(attraction of the salaries for new teachers in secondary school=0,0,need of unqualified science teachers in secondary school)

****
.University
****

AVERAGE OF GRADUATES AT UNIVERSITY = 0.221072
Units: Dmnl
Euroscene report, data obtained using the historical data found in the reports at page 26

AVERAGE PERCENTAGE OF NEW ENTRANS IN COLLEGE EDUCATION = 0.0486231
Units: 1/Year
average percentage of graduates from high school entering in college education. Data has been calculate using the data provided by the DBH regarding the new entrans in college education. Table data are included in excell file "Statistic Data"

AVERAGE PERCENTAGE OF NEW ENTRANTS AT UNIVERSITY = 0.0584536
Units: 1/Year
Eruoscene reports data. Percentage calculated using the historical data obtained by the report page 26. The percentage in this case has been calculated using the total number of new entrants in university over the total number of high school graduates obtained by the model

AVERAGE TIME TO FINISH A BACHELOR = 4
Units: Year
time needed to finsh a BACHELOR program in Norway

AVERAGE TIME TO FINISH A MASTER = 2.7
Units: Year

Bachelors Graduates At University[sex,AGE 22] =
INTEG(BACHELOR graduation rate[sex,AGE 22]
- unavailability rate of graduates from university[sex,AGE 22]
- Bachelors Graduates At University[sex,AGE 22]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- master's recruitment rate[sex,AGE 22] ,
INITIAL BACHELORS GRADUATES[sex,AGE 22])
Bachelors Graduates At University[sex,age b gradhi] =
INTEG(Bachelors Graduates At University[sex,age b gradlow]
/ TIME TO COMPLETE AN ACADEMIC YEAR
+ BACHELOR graduation rate[sex,age b gradhi]
- Bachelors Graduates At University[sex,age b gradhi]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- deaths of graduates at the university[sex,age b gradhi]
- master's recruitment rate[sex,age b gradhi]
- unavailability rate of graduates from university[sex,age b gradhi] ,
INITIAL BACHELORS GRADUATES[sex,age b gradhi])
Units: person

number of students that finish the BACHELOR program

BACHELOR graduation rate[sex,age b grad] =
(Students At University For A Bachelor[sex,age b grad]
* AVERAGE OF GRADUATES AT UNIVERSITY)
/ time to finish a bachelor
BACHELOR graduation rate[sex,AGE 20] =
(Students At University For A Bachelor[sex,AGE 20]
/ time to finish a bachelor)
* 0
BACHELOR graduation rate[sex,AGE 21] =
(Students At University For A Bachelor[sex,AGE 21]
/ time to finish a bachelor)
* 0
Units: person/Year
number of students that every year finsh the BACHELOR at university

college entering rate[sex,age uni] =
(High School Graduates[sex,age uni]
* AVERAGE PERCENTAGE OF NEW ENTRANS IN COLLEGE EDUCATION)
Units: person/Year

death rate of graduates[sex,age uni] =
High School Graduates[sex,age uni]
* death rate[sex,university age]
Units: person/Year
number of graduates who die every year

deaths of graduates at the university[sex,age b grad] =
Bachelors Graduates At University[sex,age b grad]
* death rate[sex,age over 21]
Units: person/Year
number of deaths of bachelors graduates from the university

deaths of students at university for a bachelor[sex,age uni] =
Students At University For A Bachelor[sex,age uni]
* death rate[sex,university age]
Units: person/Year
deaths of students at university that are attending the courses for a BACHELOR

deaths of university masters graduates[sex,age m grad] =
University Masters Graduates[sex,age m grad]
* death rate[sex,age over 23]
Units: person/Year

deaths of university masters students[sex,age b grad] =
University Masters Students[sex,age b grad]
* death rate[sex,age over 21]
Units: person/Year

drop out pct of masters students[sex,age b grad] =
IF THEN ELSE (age b grad
<= 46,
0.04,
0)
Units: 1/Year
The drop out average has been calculated for the masters students at university as it was calculated for the bachelors students.

drop out percentage for bachelors students[sex,age uni] =

IF THEN ELSE (age uni
<= 49,
0.185,
0)
Units: 1/Year
Assumed drop out rate, there are not available statistic regarding the drop out of students at university in general. The percentage of drop out is assumed by "calibration". If all the other outflows of the stock have been set with parameter found in statistical data base then to match the historic data the out flow must be equal to the value that we calibrate

drop out rate of university masters[sex,age b grad] =
University Masters Students[sex,age b grad]
* drop out pct of masters students[sex,age b grad]
Units: person/Year
number of students that leave the university master's program every year

drop out rate of university's students[sex,age uni] =
Students At University For A Bachelor[sex,age uni]
* drop out percentage for bachelors students[sex,age uni]
Units: person/Year
Number of students that leave the universities

FRACTION OF UNIVERSITY BACHELORS GRADUATES FOR THE PTC = 0.15
Units: Dmnl
Value assumed, there are no statistic about Bachelors graduates attending the PTC (Post Certificate of Education)

High School Graduates[sex,AGE 19] =
INTEG(new high school graduates[sex,AGE 19]
- High School Graduates[sex,AGE 19]
/ TIME TO COMPLETE A YEAR
- college entering rate[sex,AGE 19]
- death rate of graduates[sex,AGE 19]
- university entering rate[sex,AGE 19] ,
INITIAL GRADUATES[sex,AGE 19])
High School Graduates[sex,age unihi] =
INTEG(High School Graduates[sex,age unilow]
/ TIME TO COMPLETE A YEAR
- High School Graduates[sex,age unihi]
/ TIME TO COMPLETE A YEAR
- death rate of graduates[sex,age unihi]
- college entering rate[sex,age unihi]
- university entering rate[sex,age unihi] ,
INITIAL GRADUATES[sex,age unihi])
Units: person
The stock presents 2 subscripts, SEX and AGE. Every stock that represents a part of a population (such students or teachers) includes 2 equations. The two equations are working together to produce the ageing of the population. The first equation is assembling the cohorts from the first until the second to last; the second equation is assembling the cohorts from the second until the last one. Every year the population of the stock is decrease by the out flows and the population which do not leave is moved one age cohort forward

INITIAL BACHELORS GRADUATES[MALE,age b grad] = 81.4246, 89.7013, 97.2158, 87.1965, 76.4875, 65.1251, 48.7894, 40.2948, 31.7276, 25.4474, 19.0221, 16.6261, 13.9761, 11.6891, 9.51103, 9.40212, 8.16787, 7.87745, 6.6069, 6.53429, 4.64661, 4.31989, 3.84797, 2.65002, 2.94043, 3.48496, 2.57742, 2.57742, 2.83153
, 1.56097, 0.943842, 1.16165, 0.726033, 0.834938, 0.726033, 0.617128, 0.471921, 0.254111, 0.21781, 0.21781, 0.145207, 0.290413, 0.326715, 0.0726033, 0.0181508, 0.0726033
INITIAL BACHELORS GRADUATES[FEMALE,age b grad] = 104.403, 104.621, 99.3576, 80.7711, 64.871, 55.5415, 43.0537, 31.1831, 26.2098, 21.0186, 17.0255, 14.6659, 12.1247, 10.3823, 11.5076, 10.9268, 8.67609, 9.40212, 8.9302, 8.16787, 8.42198, 7.95006, 7.69595, 6.38909, 7.51444, 6.02607, 5.98977, 6.31648,

5.77196, 3.66646, 2.68632, 2.2144, 2.65002, 2.06919, 1.70618, 1.37946, 0.798636, 0.871239, 0.871239, 0.943842, 0.653429, 0.471921, 0.471921, 0.0544524, 0.199659, 0.0181508

Units: person

Data are from the DBH from the year 1990. 1618 are the students which are registered has "ferdig kandidater", candidate which have finished their studies

INITIAL GRADUATES[MALE,age uni] = 10631, 11289.1, 13826.4, 16363.7, 15705.2, 15046.7, 12821, 12234.2, 11647.5, 10880.9, 10114.4, 9141.98, 8767.17, 8392.35, 8017.53, 7642.72, 7459.36, 7276.01, 7092.65, 6909.29, 6725.94, 6863.75, 6671.4, 6479.04, 6286.68, 6094.32, 5826.54, 5558.75, 5290.96, 5023.17, 4755.39, 4107.04, 3861.96, 3616.88, 3371.8, 3126.72, 3078.25, 3029.79, 2981.32, 2932.85, 2884.39, 2670.88, 2605.98, 2541.09, 2476.2, 2721.51, 2690.83, 2660.16, 3136.7
INITIAL GRADUATES[FEMALE,age uni] = 9294.03, 11314.5, 13566.5, 15818.6, 14676.7, 13534.7, 10739.8, 9750.18, 8760.57, 7849.34, 6938.12, 5803.47, 5364.75, 4926.02, 4487.3, 4048.57, 3875.04, 3701.51, 3527.98, 3354.44, 3180.91, 3167.57, 2984.79, 2802.02, 2619.24, 2436.47, 2300.44, 2164.41, 2028.38, 1892.36, 1756.33, 1405.56, 1287.56, 1169.57, 1051.57, 933.566, 943.722, 953.878, 964.035, 974.191, 984.347, 1146.77, 1163.55, 1180.33, 1197.11, 1197.26, 1197.41, 1197.56, 1392.27

Units: person

Data take from the SSB data base, the registered population which complete the final year in the high school. The data has been disaggregated into each cohorts of age from 19 to 67

INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR[MALE,age uni] = 76.1658, 3179.92, 4879.37, 5338.75, 5881.43, 6374.13, 5717.2, 5015.04, 4270.05, 3198.96, 2642, 2080.28, 1668.51, 1247.22, 1090.12, 916.37, 766.419, 623.608, 616.467, 535.541, 516.499, 433.193, 428.433, 304.663, 283.242, 252.299, 173.753, 192.795, 228.497, 168.993, 168.993, 185.654, 102.348, 61.8847, 76.1658, 47.6036, 54.7442, 47.6036, 40.4631, 30.9424, 16.6613, 14.2811, 14.2811, 9.52073, 19.0415, 21.4216, 4.76036, 1.19009, 4.76036
INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR[FEMALE,age uni] = 180.894, 4032.03, 6593.1, 6845.4, 6859.68, 6514.56, 5295.9, 4253.38, 3641.68, 2822.9, 2044.58, 1718.49, 1378.13, 1116.31, 961.593, 794.981, 680.732, 754.518, 716.435, 568.863, 616.467, 585.525, 535.541, 552.202, 521.26, 504.599, 418.912, 492.698, 395.11, 392.73, 414.152, 378.449, 240.398, 176.133, 145.191, 173.753, 135.67, 111.869, 90.4469, 52.364, 57.1244, 57.1244, 61.8847, 42.8433, 30.9424, 30.9424, 3.57027, 13.091, 1.19009

Units: person

Data source DBH. The data base had only data reliable starting from 1991, since the model starts in 1990 we assumed the initial value but we used the age distribution of students which were registered in 1991 from the DBH. The initial value is set to 125000 students registered at Universities

INITIAL UNIVERSITY MASTERS GRADUATES[MALE,age m grad] = 78.536, 70.4419, 61.7907, 52.6115, 39.4146, 32.5523, 25.6313, 20.5578, 15.367, 13.4315, 11.2907, 9.44309, 7.68351, 7.59553, 6.59843, 6.36382, 5.3374, 5.27875, 3.75378, 3.48984, 3.1086, 2.14083, 2.37544, 2.81533, 2.08217, 2.08217, 2.28746, 1.26103, 0.762486, 0.938444, 0.586527, 0.674507, 0.586527, 0.498548, 0.381243, 0.205285, 0.175958, 0.175958, 0.117305, 0.234611, 0.263937, 0.0586527, 0.0146632, 0.0586527
INITIAL UNIVERSITY MASTERS GRADUATES[FEMALE,age m grad] = 80.2663, 65.2512, 52.4062, 44.8694, 34.7811, 25.1914, 21.1736, 16.98, 13.7541, 11.8479, 9.79501, 8.38734, 9.29646, 8.82724, 7.009, 7.59553, 7.21429, 6.59843, 6.80372, 6.42248, 6.21719, 5.16144, 6.07056, 4.86818, 4.83885, 5.10279, 4.66289, 2.96196, 2.17015, 1.78891, 2.14083, 1.6716, 1.37834, 1.1144, 0.64518, 0.703833, 0.703833, 0.762486, 0.527875, 0.381243, 0.381243, 0.0439896, 0.161295, 0.0146632

Units: person

Initial data assumed by the historical statistic found on the DBH database. We assumed the initial value of the stock is around 800

INITIAL UNIVERSITY MASTERS STUDENTS[MALE,age b grad] = 211.362, 232.846, 252.352, 226.344, 198.546, 169.052, 126.647, 104.597, 82.3585, 66.0564, 49.3774, 43.1581, 36.2792, 30.3426, 24.6887, 24.406, 21.2021, 20.4483, 17.1502, 16.9617, 12.0617, 11.2136, 9.98856, 6.87891, 7.63277, 9.04624, 6.69045, 6.69045, 7.35007, 4.05196, 2.45002, 3.01541, 1.88463, 2.16733, 1.88463, 1.60194, 1.22501, 0.659622, 0.56539, 0.56539, 0.376927, 0.753853, 0.848085, 0.188463, 0.0471158, 0.188463
INITIAL UNIVERSITY MASTERS STUDENTS[FEMALE,age b grad] = 271.01, 271.576, 257.912, 209.665, 168.392, 144.174, 111.759, 80.945, 68.0353, 54.5601, 44.1947, 38.0696, 31.4734, 26.9503, 29.8714, 28.3637, 22.5214, 24.406, 23.181, 21.2021, 21.8617, 20.6367, 19.9771, 16.5848, 19.506, 15.6425, 15.5482, 16.3963, 14.9828, 9.5174, 6.97314, 5.74813, 6.87891, 5.37121, 4.42889, 3.5808, 2.0731, 2.26156, 2.26156, 2.45002, 1.69617, 1.22501, 1.22501, 0.141348, 0.518274, 0.0471158

Units: person
Initial value assumed by historical data found in the DBH database. we assume that the intial value is around 4200 students

master graduation rate[sex,age m grad] =
(University Masters Students[sex,age m grad]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master
master graduation rate[sex,AGE 22] =
((University Masters Students[sex,AGE 22]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master)
* 0
master graduation rate[sex,AGE 23] =
((University Masters Students[sex,AGE 23]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master)
* 0
Units: person/Year

master's recruitment rate[sex,age b grad] =
(Bachelors Graduates At University[sex,age b grad]
* PERCENTAGE OF STUDENTS ENTERING THE MASTER)
Units: person/Year
Number of students graduates from BACHELOR that take the master at the university

MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES TO BE UNAVAILABLE = 1
Units: Year

new high school graduates[sex,AGE 19] =
real pupils in secondary education[sex,AGE19]
/ TIME TO COMPLETE A YEAR
Units: person/Year

PCT OF FINISH MASTER GRADUATES = 0.035
Units: Dmnl
prima c'era 0,17. 0,035 equivale al 60% di quelli che proseguono nel master ovvero il 16,9%

PERCENTAGE OF STUDENTS ENTERING THE MASTER = 0.17
Units: 1/Year
16.9% percentage of bachelors graduates that follow a master course after the bachelor. Data obtained by the SSB. (http://www.ssb.no/english/subjects/04/02/40/hugjen_en/tab-2006-10-12-03-en.html) the data have been calculated by the author

Students At University For A Bachelor[sex,AGE 19] =
INTEG(university entering rate[sex,AGE 19]
- Students At University For A Bachelor[sex,AGE 19]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- deaths of students at university for a bachelor[sex,AGE 19]
- drop out rate of university's students[sex,AGE 19] ,
INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR[sex,AGE 19])
Students At University For A Bachelor[sex,age unihi] =
INTEG(Students At University For A Bachelor[sex,age unilow]
/ TIME TO COMPLETE AN ACADEMIC YEAR
+ university entering rate[sex,age unihi]
- Students At University For A Bachelor[sex,age unihi]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- drop out rate of university's students[sex,age unihi]
- deaths of students at university for a bachelor[sex,age unihi]
- BACHELOR graduation rate[sex,age unihi] ,

INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR[sex,age unihi])
Units: person
Students at the four main universities in Norway (Oslo, Bergen, Tromsø and Trondheim) that are attending the BACHELOR program in science (math, biology, chemistry and physic)

TIME TO COMPLETE A YEAR = 1
Units: Year
one year time

TIME TO COMPLETE AN ACADEMIC YEAR = 1
Units: Year

time to finish a bachelor =
AVERAGE TIME TO FINISH A BACHELOR
* time to finish a year at university
Units: Year
average time to finish a bachelor*time to finish a year at university

time to finish a master =
time to finish a year at university
* AVERAGE TIME TO FINISH A MASTER
Units: Year

time to finish a year at university =
(1
/ 12)
* 9
Units: Dmnl
(1/12)*9 one year time in university is not equivalent to a solar year. The university year is comprehensive of nine months

total bachelors graduates at university =
SUM (Bachelors Graduates At University[sex!,age b grad!])
Units: person

total graduates =
SUM (High School Graduates[sex!,age uni!])
Units: person

total students for a bachelor at universities =
SUM (Students At University For A Bachelor[sex!,age uni!])
Units: person
total number of students at universities for a BACHELOR

total university masters graduates =
SUM (University Masters Graduates[sex!,age m grad!])
Units: person

total university masters students =
SUM (University Masters Students[sex!,age b grad!])
Units: person

unavaiability distribution per age of graduates from university[sex,age over 21] =
UNAVAIABILITY DISTRIBUTION PER AGE TABLE (age over 21)
Units: 1/Year
number of person that every year become unavailable for different reason. Data to verify

unavailability rate of graduates from university[sex,age b grad] =
(Bachelors Graduates At University[sex,age b grad]
* unavaiability distribution per age of graduates from university[sex,age over 21])

```
        + ( total university bachelors attracted by salaries
            * proportion of hiring teachers by age[sex,age over 21] )
        + ( total university bachelors certified as teachers applying for secondary school
            * proportion of hiring teachers by age[sex,age over 21] )
         Units: person/Year
         (if then else(Bachelors Graduates At University[sex,AGE B GRAD]<=0,0,Bachelors Graduates At
University[sex,AGE B GRAD ]*unavaiability distribution per age of graduates from university[sex,age over
21])+(total university bachelors certified as teachers applying for primary school
                              *proportion of hiring teachers by age [sex,age over 21])+(total university bachelors
certified as teachers applying for secondary school*proportion of hiring teachers by age [sex,age over 21]))

unavailability distribution per age of master graduates at university[sex,age over 23]  =
      UNAVAIABILITY DISTRIBUTION PER AGE TABLE ( age over 23
            - 2)
         Units: 1/Year

unavailability of master graduates from university[sex,age m grad]  =
      IF THEN ELSE ( University Masters Graduates[sex,age m grad]
            / MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES TO BE UNAVAILABLE
            <= 0,
         0,
         University Masters Graduates[sex,age m grad]
            * unavailability distribution per age of master graduates at university[sex,age over 23]
            + ( total university masters graduates certified as teachers applying for primary
                * proportion of hiring teachers by age[sex,age over 23] )
            + ( total university masters graduates attracted by salaries
                * proportion of hiring teachers by age[sex,age over 23] ) )
         Units: person/Year
         Unavailability of master graduates, if one age cohort of the students is <=0 then the outflow is equal to
0 for the specific age cohort. Otherwise the flow is equal to the sum of master teachers hired into the teaching
work force and the master graduates unavailable for age reasons

university bachelors certified as teachers  =
      IF THEN ELSE ( attraction of salaries for a new teachers in primary school
            = 0,
         0,
         SUM ( Bachelors Graduates At University[sex!,age b grad!] )
            * FRACTION OF UNIVERSITY BACHELORS GRADUATES FOR THE PTC )
         Units: person

university entering rate[sex,age uni]  =
      ( ( High School Graduates[sex,age uni]
         * AVERAGE PERCENTAGE OF NEW ENTRANTS AT UNIVERSITY ) )
         Units: person/Year

University Masters Graduates[sex,AGE 24]  =
      INTEG( master graduation rate[sex,AGE 24]
            - University Masters Graduates[sex,AGE 24]
               / TIME TO COMPLETE AN ACADEMIC YEAR
            - deaths of university masters graduates[sex,AGE 24]
            - unavailability of master graduates from university[sex,AGE 24] ,
         INITIAL UNIVERSITY MASTERS GRADUATES[sex,AGE 24] )
University Masters Graduates[sex,age m gradhi]  =
      INTEG( University Masters Graduates[sex,age m gradlow]
            / TIME TO COMPLETE AN ACADEMIC YEAR
            + master graduation rate[sex,age m gradhi]
            - University Masters Graduates[sex,age m gradhi]
               / TIME TO COMPLETE AN ACADEMIC YEAR
            - deaths of university masters graduates[sex,age m gradhi]
            - unavailability of master graduates from university[sex,age m gradhi] ,
```

```
        INITIAL UNIVERSITY MASTERS GRADUATES[sex,age m gradhi] )
          Units: person

University Masters Students[sex,AGE 22]  =
      INTEG( master's recruitment rate[sex,AGE 22]
               - deaths of university masters students[sex,AGE 22]
               - drop out rate of university masters[sex,AGE 22]
               - University Masters Students[sex,AGE 22]
                  / TIME TO COMPLETE AN ACADEMIC YEAR ,
           INITIAL UNIVERSITY MASTERS STUDENTS[sex,AGE 22] )
University Masters Students[sex,age b gradhi]  =
     INTEG( University Masters Students[sex,age b gradlow]
              / TIME TO COMPLETE AN ACADEMIC YEAR
              + master's recruitment rate[sex,age b gradhi]
              - University Masters Students[sex,age b gradhi]
                 / TIME TO COMPLETE AN ACADEMIC YEAR
              - deaths of university masters students[sex,age b gradhi]
              - drop out rate of university masters[sex,age b gradhi]
              - master graduation rate[sex,age b gradhi] ,
          INITIAL UNIVERSITY MASTERS STUDENTS[sex,age b gradhi] )
          Units: person

********************************
  .University faculties of science
********************************

AVERAGE OF GRADUATES IN SCIENCE  = 0.0669309
          Units: Dmnl
          Euroscene report, data obtained using the historical data found in the report at page 26

AVERAGE TIME TO FINISH A BACHELOR IN SCIENCE  = 4
          Units: Year

AVERAGE TIME TO FINISH A MASTER IN SCIENCE  = 2.6
          Units: Year

bachelor graduation in science[sex,AGE 20]  =
      ( ( Students At University For A Bachelor In Science[sex,AGE 20]
          * AVERAGE OF GRADUATES IN SCIENCE )
         / time need for finish a BACHELOR in science )
         * 0
bachelor graduation in science[sex,AGE 21]  =
     ( ( Students At University For A Bachelor In Science[sex,AGE 21]
         * AVERAGE OF GRADUATES IN SCIENCE )
         / time need for finish a BACHELOR in science )
         * 0
bachelor graduation in science[sex,age b grad]  =
     ( Students At University For A Bachelor In Science[sex,age b grad]
         * AVERAGE OF GRADUATES IN SCIENCE )
         / time need for finish a BACHELOR in science
          Units: person/Year

Bachelors Graduates At The University In Science[sex,AGE 22]  =
      INTEG( bachelor graduation in science[sex,AGE 22]
               - Bachelors Graduates At The University In Science[sex,AGE 22]
                  / TIME TO COMPLETE AN ACADEMIC YEAR
               - deaths of graduates at the university in science[sex,AGE 22]
               - unavaiability of graduates at the university in science[sex,AGE 22]
               - master's recruitment rate in science[sex,AGE 22] ,
          INITIAL BACHELORS GRADUATES AT THE UNIVERSITY IN SCIENCE[sex,AGE 22] )
```

```
Bachelors Graduates At The University In Science[sex,age b gradhi]  =
      INTEG( Bachelors Graduates At The University In Science[sex,age b gradlow]
               / TIME TO COMPLETE AN ACADEMIC YEAR
               + bachelor graduation in science[sex,age b gradhi]
               - Bachelors Graduates At The University In Science[sex,age b gradhi]
                  / TIME TO COMPLETE AN ACADEMIC YEAR
               - deaths of graduates at the university in science[sex,age b gradhi]
               - unavaiability of graduates at the university in science[sex,age b gradhi] ,
            INITIAL BACHELORS GRADUATES AT THE UNIVERSITY IN SCIENCE[sex,age b gradhi] )
             Units: person

deaths of graduates at the university in science[sex,age b grad]  =
      Bachelors Graduates At The University In Science[sex,age b grad]
            * death rate[sex,age over 21]
             Units: person/Year

deaths of students at university for a BACHELOR in science[sex,age uni]  =
      Students At University For A Bachelor In Science[sex,age uni]
            * death rate[sex,university age]
             Units: person/Year

deaths of university masters graduates in science[sex,age m grad]  =
      University Masters Graduates In Science[sex,age m grad]
            * death rate[sex,age over 23]
             Units: person/Year

deaths of university masters students in science[sex,age b grad]  =
      University Masters Students In Science[sex,age b grad]
            * death rate[sex,age over 21]
             Units: person/Year

drop out of students at university for a bachelor in science[sex,age uni]  =
      Students At University For A Bachelor In Science[sex,age uni]
            * drop out pct of students from university in science[sex,age uni]
             Units: person/Year

drop out pct of masters students in science[sex,age b grad]  =
      IF THEN ELSE ( age b grad
                <= 46,
            0.07,
            0)
             Units: 1/Year

drop out pct of students from university in science[sex,age uni]  =
      IF THEN ELSE ( age uni
                <= 24,
            0.14,
            0)
             Units: 1/Year

drop out university masters students in science[sex,age b grad]  =
      University Masters Students In Science[sex,age b grad]
            * drop out pct of masters students in science[sex,age b grad]
             Units: person/Year

INITIAL BACHELORS GRADUATES AT THE UNIVERSITY IN SCIENCE[MALE,age b grad]  = 9.95938,
9.03618, 9.0455, 8.9709, 7.74929, 7.14315, 5.76301, 4.73723, 4.09379, 3.18924, 2.41524, 1.79045, 1.55732,
1.66922, 1.04443, 0.699394, 0.811297, 0.512889, 0.559516, 0.456938, 0.53154, 0.317059, 0.251782, 0.214481,
0.233131
```

, 0.317059, 0.17718, 0.0279758, 0.111903, 0.279758, 0.0839273, 0.102578, 0.0186505, 0.0186505, 0.0746021, 0.037301, 0, 0, 0, 0.00932526, 0, 0, 0.0186505, 0, 0, 0
INITIAL BACHELORS GRADUATES AT THE UNIVERSITY IN SCIENCE[FEMALE,age b grad] = 7.96377, 6.60228, 6.89137, 5.51123, 3.86066, 3.28249, 2.89083, 1.57597, 1.61327, 1.22161, 1.14701, 0.801972, 0.72737, 0.410311, 0.624792, 0.428962, 0.410311, 0.326384, 0.17718, 0.121228, 0.205156, 0.214481, 0.139879, 0.0466263
, 0.130554, 0.130554, 0.0559516, 0.0746021, 0.139879, 0.0652768, 0.0186505, 0.0466263, 0.037301, 0.00932526, 0, 0, 0, 0.0186505, 0, 0, 0, 0, 0, 0, 0, 0
Units: person

INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR IN SCIENCE[MALE,age uni] = 429.714, 896.708, 1018.36, 1047.8, 950.668, 951.649, 943.8, 815.279, 751.508, 606.308, 498.389, 430.695, 335.53, 254.1, 188.368, 163.841, 175.614, 109.881, 73.5811, 85.3541, 53.9595, 58.8649, 48.073, 55.9216, 33.3568, 26.4892,
22.5649, 24.527, 33.3568, 18.6405, 2.94324, 11.773, 29.4324, 8.82973, 10.7919, 1.96216, 1.96216, 7.84865, 3.92433, 0, 0, 0, 0.981082, 0, 0, 1.96216, 0, 0, 0
INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR IN SCIENCE[FEMALE,age uni] = 365.943, 845.692, 867.276, 837.844, 694.606, 725.019, 579.819, 406.168, 345.341, 304.135, 165.803, 169.727, 128.522, 120.673, 84.373, 76.5244, 43.1676, 65.7325, 45.1297, 43.1676, 34.3379, 18.6405, 12.7541, 21.5838, 22.5649,
14.7162, 4.90541, 13.7351, 13.7351, 5.88649, 7.84865, 14.7162, 6.86757, 1.96216, 4.90541, 3.92433, 0.981082, 0, 0, 0, 1.96216, 0, 0, 0, 0, 0, 0, 0, 0
Units: person
20000 initial value of bachelor in science

INITIAL UNIVERSITY MASTERS GRADUATES IN SCIENCE[MALE,age m grad] = 41.3705, 41.0293, 35.4421, 32.6699, 26.3577, 21.6662, 18.7233, 14.5863, 11.0463, 8.1888, 7.12255, 7.63435, 4.7768, 3.19875, 3.71055, 2.34575, 2.559, 2.08985, 2.43105, 1.4501, 1.15155, 0.98095, 1.06625, 1.4501, 0.81035, 0.12795, 0.5118
, 1.2795, 0.38385, 0.46915, 0.0853, 0.0853, 0.3412, 0.1706, 0, 0, 0, 0.04265, 0, 0, 0.0853, 0, 0, 0
INITIAL UNIVERSITY MASTERS GRADUATES IN SCIENCE[FEMALE,age m grad] = 31.5183, 25.2061, 17.6571, 15.0128, 13.2215, 7.20785, 7.37845, 5.58715, 5.24595, 3.6679, 3.3267, 1.8766, 2.85755, 1.9619, 1.8766, 1.49275, 0.81035, 0.55445, 0.9383, 0.98095, 0.63975, 0.21325, 0.5971, 0.5971, 0.2559, 0.3412, 0.63975
, 0.29855, 0.0853, 0.21325, 0.1706, 0.04265, 0, 0, 0, 0.0853, 0, 0, 0, 0, 0, 0, 0, 0
Units: person
Assumed value by the historical data found in the DBH database. We assume the initial value of master graduates is around 450

INITIAL UNIVERSITY MASTERS STUDENTS IN SCIENCE[MALE,age b grad] = 264.17, 239.682, 239.929, 237.951, 205.548, 189.47, 152.862, 125.654, 108.587, 84.5936, 64.0636, 47.4912, 41.3074, 44.2756, 27.7032, 18.5512, 21.5194, 13.6042, 14.841, 12.1201, 14.0989, 8.40989, 6.67845, 5.68905, 6.18375, 8.40989, 4.69965
, 0.742049, 2.9682, 7.42049, 2.22615, 2.72085, 0.4947, 0.4947, 1.9788, 0.989399, 0, 0, 0, 0.24735, 0, 0, 0.4947, 0, 0, 0
INITIAL UNIVERSITY MASTERS STUDENTS IN SCIENCE[FEMALE,age b grad] = 211.237, 175.124, 182.792, 146.184, 102.403, 87.0671, 76.6784, 41.8021, 42.7915, 32.4028, 30.424, 21.2721, 19.2933, 10.8834, 16.5724, 11.3781, 10.8834, 8.65724, 4.69965, 3.21555, 5.4417, 5.68905, 3.71025, 1.23675, 3.4629, 3.4629, 1.4841
, 1.9788, 3.71025, 1.73145, 0.4947, 1.23675, 0.989399, 0.24735, 0, 0, 0, 0.4947, 0, 0, 0, 0, 0, 0, 0, 0
Units: person
Initial value for master students in science has been assumed, since the available data started from 1998. Considering the trend of the historical value we assume the intial value around 3500

master graduation rate in science[sex,age m grad] =
(University Masters Students In Science[sex,age m grad]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master in science
master graduation rate in science[sex,AGE 22] =
((University Masters Students In Science[sex,AGE 22]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master in science)
* 0
master graduation rate in science[sex,AGE 23] =

((University Masters Students In Science[sex,AGE 23]
* PCT OF FINISH MASTER GRADUATES)
/ time to finish a master in science)
* 0
Units: person/Year

master's recruitment rate in science[sex,age b grad] =
(Bachelors Graduates At The University In Science[sex,age b grad]
* PERCENTAGE OF STUDENTS ENTERING THE MASTER IN SCIENCE)
Units: person/Year

MINIMUM TIME FOR A UNIVERSITY BACHELOR GRADUATE IN SCIENCE TO BE UNAVAILABLE = 1
Units: Year

MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES IN SCIENCE TO BE UNAVAILABLE = 1
Units: Year

PERCENTAGE OF STUDENTS ENTERING EVERY YEAR IN THE SCIENCE FACULTY TABLE = 0.053239
Units: Dmnl
Euroscene report. Data obtained by the reports and the table of historical data. Page 26. The data has been calculated in the excel file "Data for the Thesis" (university new entrants-graduates sheet) the number of students entering in Science faculty are a percentage of Students entering
in general University

PERCENTAGE OF STUDENTS ENTERING THE MASTER IN SCIENCE = 0.169
Units: 1/Year

Students At University For A Bachelor In Science[sex,AGE 19] =
INTEG(university entering rate in science[sex,AGE 19]
- Students At University For A Bachelor In Science[sex,AGE 19]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- deaths of students at university for a BACHELOR in science[sex,AGE 19]
- drop out of students at university for a bachelor in science[sex,AGE 19] ,
INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR IN SCIENCE[sex,AGE 19])
Students At University For A Bachelor In Science[sex,age unihi] =
INTEG(Students At University For A Bachelor In Science[sex,age unilow]
/ TIME TO COMPLETE AN ACADEMIC YEAR
+ university entering rate in science[sex,age unihi]
- Students At University For A Bachelor In Science[sex,age unihi]
/ TIME TO COMPLETE AN ACADEMIC YEAR
- deaths of students at university for a BACHELOR in science[sex,age unihi]
- drop out of students at university for a bachelor in science[sex,age unihi]
- bachelor graduation in science[sex,age unihi] ,
INITIAL STUDENTS AT UNIVERSITY FOR A BACHELOR IN SCIENCE[sex,age unihi])
Units: person

time need for finish a BACHELOR in science =
AVERAGE TIME TO FINISH A BACHELOR IN SCIENCE
* time to finish a year at university
Units: Year

time to finish a master in science =
AVERAGE TIME TO FINISH A MASTER IN SCIENCE
* time to finish a year at university
Units: Year

total students at university for a bachelor in science =

```
    SUM ( Students At University For A Bachelor In Science[sex!,age uni!] )
        Units: person

total university masters students in science  =
    SUM ( University Masters Students In Science[sex!,age b grad!] )
        Units: person

unavaiability of graduates at the university in science[sex,age b grad]  =
    MIN ( Bachelors Graduates At The University In Science[sex,age b grad]
            / MINIMUM TIME FOR A UNIVERSITY BACHELOR GRADUATE IN SCIENCE TO BE
UNAVAILABLE ,
        IF THEN ELSE ( Bachelors Graduates At The University In Science[sex,AGE 62]
            <= 0,
            0,
            Bachelors Graduates At The University In Science[sex,age b grad]
                * unavaiability per age of graduates at the university in science[sex,age over 21]
                + ( "total bachelors graduates at the university in science & certified as teachers applying for
primary school"
                    * proportion of hiring teachers by age[sex,age over 21] )
                + ( "total bachelors graduates at university in science & certified as teachers applying for
secondary school"
                    * proportion of hiring teachers by age[sex,age over 21] ) ) )
        Units: person/Year

unavaiability per age of graduates at the university in science[sex,age over 21]  =
    UNAVAIABILITY DISTRIBUTION PER AGE TABLE ( age over 21)
        Units: 1/Year

unavailability of university masters graduates in science[sex,age m grad]  =
    IF THEN ELSE ( University Masters Graduates In Science[sex,age m grad]
            / MINIMUM TIME FOR A UNIVERSITY MASTER GRADUATES IN SCIENCE TO BE
UNAVAILABLE
            <= 0,
        0,
        University Masters Graduates In Science[sex,age m grad]
            * unavailability per age of university masters graduates in science[sex,age over 23]
            + total master graduates in science attracted by salaries
                * proportion of hiring teachers by age[sex,age over 23]
            + university masters graduates in science certified attracted by salaries
                * proportion of hiring teachers by age[sex,age over 23] )
        Units: person/Year
        Unavailability of master graduates in science, if one age cohort of the students is <=0 then the outflow
is equal to 0 for the specific age cohort. Otherwise the flow is equal to the sum of master teachers hired into the
teaching work force and the master graduates unavailable for age
                                reasons

unavailability per age of university masters graduates in science[sex,age over 23]  =
    UNAVAIABILITY DISTRIBUTION PER AGE TABLE ( age over 23)
        Units: 1/Year

university entering rate in science[sex,age uni]  =
    university entering rate[sex,age uni]
        * PERCENTAGE OF STUDENTS ENTERING EVERY YEAR IN THE SCIENCE FACULTY
TABLE
        Units: person/Year

University Masters Graduates In Science[sex,AGE 24]  =
    INTEG( master graduation rate in science[sex,AGE 24]
            - University Masters Graduates In Science[sex,AGE 24]
                / TIME TO COMPLETE AN ACADEMIC YEAR
```

```
            - deaths of university masters graduates in science[sex,AGE 24]
            - unavailability of university masters graduates in science[sex,AGE 24] ,
          INITIAL UNIVERSITY MASTERS GRADUATES IN SCIENCE[sex,AGE 24] )
University Masters Graduates In Science[sex,age m gradhi]  =
      INTEG( University Masters Graduates In Science[sex,age m gradlow]
            / TIME TO COMPLETE AN ACADEMIC YEAR
            + master graduation rate in science[sex,age m gradhi]
            - University Masters Graduates In Science[sex,age m gradhi]
               / TIME TO COMPLETE AN ACADEMIC YEAR
            - deaths of university masters graduates in science[sex,age m gradhi]
            - unavailability of university masters graduates in science[sex,age m gradhi] ,
          INITIAL UNIVERSITY MASTERS GRADUATES IN SCIENCE[sex,age m gradhi] )
           Units: person

University Masters Students In Science[sex,AGE 22]  =
       INTEG( master's recruitment rate in science[sex,AGE 22]
            - University Masters Students In Science[sex,AGE 22]
               / TIME TO COMPLETE AN ACADEMIC YEAR
            - deaths of university masters students in science[sex,AGE 22]
            - drop out university masters students in science[sex,AGE 22] ,
          INITIAL UNIVERSITY MASTERS STUDENTS IN SCIENCE[sex,AGE 22] )
University Masters Students In Science[sex,age b gradhi]  =
      INTEG( University Masters Students In Science[sex,age b gradlow]
            / TIME TO COMPLETE AN ACADEMIC YEAR
            + master's recruitment rate in science[sex,age b gradhi]
            - University Masters Students In Science[sex,age b gradhi]
               / TIME TO COMPLETE AN ACADEMIC YEAR
            - deaths of university masters students in science[sex,age b gradhi]
            - drop out university masters students in science[sex,age b gradhi]
            - master graduation rate in science[sex,age b gradhi] ,
          INITIAL UNIVERSITY MASTERS STUDENTS IN SCIENCE[sex,age b gradhi] )
           Units: person
```

APPENDIX III – Reports

1 STATISTICAL DATA BASE: SSB AND DBH

The two offices of statistical analysis and storage, have been working together for the collection of particular data where the field of analysis is crossed, in this case, regarding the collection of tertiary education data. The SSB is the central statistical office which collects almost every type of data from demographic to economic issues, including historical data. This has been essential for the initialization of the stocks in all model and for a first look at the system behaviour. The office collects base data yearly, relative to the main social, economical and environmental sectors of Norwegian society.

Similar to the SSB, the DBH collects data on a yearly basis; however the DBH's main priority is the collection of data relevant to tertiary education. This data is provided to the DBH by the colleges and universities around Norway. The decision to include the DBH in our sources has been made due to the deep importance of the university and college sectors on the model and the explanation of the problem and also because it is the largest database for this type of data. DBH has been incredibly helpful for data such the "drop out" rate for students and the age distribution of students.

The DBH source due to its very detailed nature has been used carefully and the data obtained are disaggregated and selected to improve the level of accuracy. Despite the DBH holding a good level of data, in some case we found missing data for certain years. This is generally due to events at the college or university institutions, for example in 1997 the data from Trondheim University is missing, due to the fact that in that year the NTNU was formed unifying three different institution.

In our research we focus on the population of teachers in science subjects, including mathematics and the population of students, attending higher education to become a teacher, during the entire process of education. Particular attention is paid to those that choose the university system and that proceed after a first degree to a higher level of education.

Thus far we have described how the two main data base sources have been helpful for collecting demographic data. However in the model other sectors are relevant. The SSB has been essential by providing data regarding the salaries of teachers and salaries of general employee. Salaries have played a key role in policies implemented and the potential future

policies described in this research. A deeper description of the role of salaries and the consequences related to them were illustrated in chapter 6, paragraph 2.
In addition to the SSB and DBH databases, reported statistical data from the literature has been used.

2 "PISA" REPORT

The PISA (2000) and the PISA (2003) are the main reports on a European level concerning the quality and knowledge of students in mathematics and science. The results of PISA 2006 are only partially available at the current time and therefore are not considered as a source of statistical data.
A PISA report is a survey conducted by the OECD every three years and is issued in different countries. The first results of each survey are commented on in two other reports:

- Learning for tomorrow's world. First results from PISA 2000 and 2003;
- Problem solving for tomorrow's world. First measurement of cross-curricular competencies from PISA 2000 and 2003;

The report covers 41 countries, 30 belonging to the OECD community plus 11 partner countries, with over a quarter of a million students involved in the survey. It tests the students' skills in:

- Reading literacy;
- Mathematical literacy;
- Science literacy;
- Problem solving capacity.

The first survey conducted in 2000 generally focused on all of the above topics with the exception of problem solving, which has been introduced in the latest reports. In 2003 the report was more focused on mathematical issues, while in 2006 the main topic is science literacy. The full results of the latest report are not available and only one paper with the first results has been published.
The PISA reports classify and grade the performances of students in six different levels. Level six is the highest one and it indicates that the students are fully able to solve a problem of a certain complexity and that they are capable of overcoming difficulties in the subjects by their own accord. Level one indicates those students who can sufficiently solve the simplest

problems, but they do not have the skills to manage complexity. Below level one are those students that lack the knowledge and skills to solve the basic problems and questions proposed in the subjects. The report ranks the countries by knowledge of students, see Table 1 in Chapter 1.

Of the 30 countries in the OECD, Norway is ranked 25th for mathematical literacy of students which could be considered a bad result, and indicates that there may be issues in the teaching of this subject in schools.

The 2003 results for science literacy in 2003 show a similarly worrisome situation. Norway is among the worst performing countries, in terms of a decrease in position from the previous survey, with only Austria obtaining a worse result.

3 "ATTRACTING, DEVELOPING AND RETAINING EFFECTIVE TEACHERS" REPORT

The above report was published in 2003 by the OECD giving a general background of the Norwegian education system. It is a paper which is included in a series of reports for various nations conducted by the OECD in the education field.

The report addresses a generalized situation of teachers' composition, evaluating first the national context and then going deeper in describing the school system and the teaching work force.

The central chapters of the report are focused on policies used to attract able people to the teaching profession and educate, train and develop or certify teachers for a specific purpose. In these chapters the major concerns about the situation are described and in this chapter few lines are dedicated to the lack of qualified science teachers. The problems are supported with data trends, but those are mainly in reference to an aggregated context. The condition of the teaching staff is described and evaluated, salaries are considered as a potential tool to attract new teachers and options for educating and developing teachers are suggested as measures of recruitment other then pecuniary ones.

In general this report does not characterize a specific problem but demonstrates how the system is developing and outlines the latest major reforms regarding the teaching working force in primary and secondary education. It has been helpful for having a first view on the structure of the education system in Norway, and also to choose a topic for the thesis.

4 “THE DEVELOPMENT OF EDUCATION IN NORWAY 2000 – 2004” REPORT

This report was made by the Norwegian Ministry of Education and Research for the international conference on education in Geneva 2004. It presents a picture of the national educational system over the last decade, describing the reforms that have occurred.

The main topic is a general overview on how the system was before the changes and how it is after; it describes the premises for the development of education, it reports how the main reforms have influenced the system, and it describes the main achievements reached by the reforms.

At the end the report describes the future challenges for the Norwegian education system, listing a long number of points and goals ahead that should be achieved in the near future to sustain an education capable of competing with changes in society.

This report has been useful for its description of the education system reforms. It assists a better comprehension of the structure and how it could be represented in a System Dynamics model. Not all of the reforms described have been taken into consideration during the construction of the model structure as some of them do not closely influence the part of the education system that we are investigating.

5 “MATH, SCIENCE, AND TECHNOLOGY, NATURALLY…” REPORT

The report edited by the Norwegian Ministry of Education and Research, has been made after the first results of the PISA project were published and it is a strategic plan to improve the situation in Norwegians schools.

This report describes a strategy plan which is presented to parliament, and updated every year. The PISA results define the situation of crisis that Norway is dealing with and the plan is to take several measures to increase the quality of teaching.

It presents the superior goals of the strategic plan and a list of “hot topics” inside the educational system that must be improved. For each of these points they provide goals and initiatives to reach them. It is the first report which focuses on the lack of quality in subjects like mathematics and science. It drew the first assets for the future national curriculum, which are now applied, and it describes clearly the difficulties with the previous assets to reach the wanted quality of knowledge for students.

The report was helpful in this research due to its deep content regarding the definition of the problem and the description of the assets in schools, such as the hours of teaching, courses adopted, required knowledge and number of courses for the admission to the university.

6 "EUROSCENE 2003" REPORT

This report has been compiled by the Norwegian science centre of education in collaboration with the University of Oslo and the Norwegian Ministry of Education and Research has participated as third party in the construction of the paper.
This paper, as with the one published by the OECD, gives an overview at the situation of the education system in Norway, but the topic of the report is more related to the potential crisis in quality of teaching in science and mathematics subjects.
The structure of the school system is given with a prospective that addresses particularly the aspects of those two subjects. It focus on the number of hours of science and mathematic that the pupils receive during compulsory education as for the secondary school, the number of students that choose to attend natural science at the university and the teachers' recruitment qualifications.
All the data collected in the report has been helpful for the calibration of the model, especially the data relative to the students in the tertiary education following a scientific path to a bachelor or a master.
The paper in the end does not suggest any policies or possible measure of contingency to the problem it just shows the strategy plan for MST studies (Mathematic, Science and Technology) create by the different institutions involved in solving the situation.

7 "NOKUT – EVALUERING AV ALLMENNLÆRERUTDANNING I NORGE 2006" REPORT

The NOKUT, the Norwegian agency for quality assurance in education, is an institution created in 2002 by the Norwegian parliament. The aim of this new foundation is to assure the quality of education on a tertiary level in Norway, to evaluate the vocational training and to recognize and acknowledge the qualifications obtained abroad. The board as the institution itself has been made independent while is performing its tasks. This means that the studies carried by the NOKUT are not dependent by the Ministry of education and research neither

by the education institutions like colleges and universities. The work is conduct and regulated in conformity by laws, regulations and guidelines which informs the NOKUT's decisions so the accreditation of the institution cannot be overturned by anyone.
Their work started officially the first of January 2003, and in 2006 they published the report relative to the results of quality referred to the "allmennlærerutdanning" which is the college education for general teacher.
The report is unluckily only provided in Norwegian as other reports used for this work, nevertheless we could have a look to the conclusions of the study.

8 "REALFAGSLÆRERE I SKOLEN. REKRUTTERING, BEHOLDING OG AVGANG" REPORT

This report titled in English "Science teachers at school. Recruiting, retaining and retiring", written by Næss T., is the most important research conduct on the problem of future shortage of science teachers in Norway. It is a report edited by the NIFU institution which is the responsible for the studies in innovation, research and education. This paper has been cited in all the other report has one of the main studies for establishing the teachers' science situation in the education system.
Unluckily the paper exists only in a Norwegian version and there are not translations of the work in English. The work is investigating the situation of science teachers in school and how to recruit them into the work force, how to keep them into the work force and it also take in consideration the future retirement of teachers qualified in this category. The topic of the research is matching almost perfectly with the aim of this report, so even if the reading of the paper was not possible, we take a closer look to the data presented as figures and tables.
The results of the study shows and evidence the lack of students applying for science faculties and the damage that this trend is causing to the supply of teachers qualified.
It is needless to say that, even if the body of the research was not "available", the importance of the data collected and the results showed were essential to the construction of the model and for creating an idea of what the problem will be. This research has a fundamental importance not only for this thesis but also for all the reports officially published by the ministry and the organization involved into the education in the country.

9 "TEACHER TURNOVER AND NON PECUNIARY FACTORS" PAPER

This paper is part of a project funded by the Norwegian Research Council; the authors are Torberg Falch and Bjarne Strøm at the Norwegian University of Science and Technology in Trondehim. The topic of the paper is the relation between the leaving or simply moving out of some school by teachers and the factors who caused this turnover of staff.

The results founded are that personnel of schools are motivated to leave the profession or the institution to other positions due to cause not only related to the salaries.

The research characterizes different cause who leads to a teachers' turnover, such as a high presence of immigrant students or a high percentage of pupils with special needs. In addiction they found that some condition of the working environment influence this decision, the presence of non qualified teachers as the proportion of the class size or the schools size.

The results of the paper were used to calculate the drop out of teachers in schools in regard to the presence of non qualified colleagues. It has been mentioned before that lately to re-fill the absence of qualified teachers in science subjects, the qualification for entering the profession were lowered. This research helped us to calculate the flow of teachers' leaving the profession due to this reason.

10 "AVGANG OG REKRUTTERING I UNDERVISNINGSSEKTOREN – HVA BETYR LØNN?" REPORT

This report has been edited by the NIFU[71] and it is a first work which studies the relation between salaries increase/decrease and recruitment in the education sector made by Pål Schøne. The study, as like as "Realfagslærere i skolen. Rekruttering, beholding og avgang" report, is an essential work for the projection of possible future policy; For this reason it has been cited in different national papers investigating the national situation of the education.

Due to the Norwegian language in which the report has been written the access to the research and informations was partially limited, nevertheless some really important parts of the results helped the construction of the model.

The study is not focused only on a specific type of employees in education, but it is a general research conducted in 1999 to describe the influence of increasing or decreasing wages on the

[71] NIFU is the center for Studies Innovation, Research and Education. http://english.nifustep.no

recruitment and leaving of the teachers. The percentage of increasing or decreasing of the salaries is calculated respectively of teachers with a certain qualification and the salaries of a general employee with the same level of education.

The importance of the study for the thesis came from the statistic data obtained in the results which describe the non linear relations between salaries/recruiting and the salaries/retaining which are used in the model to recreate the system behaviour (Figure 82 and Figure 83).

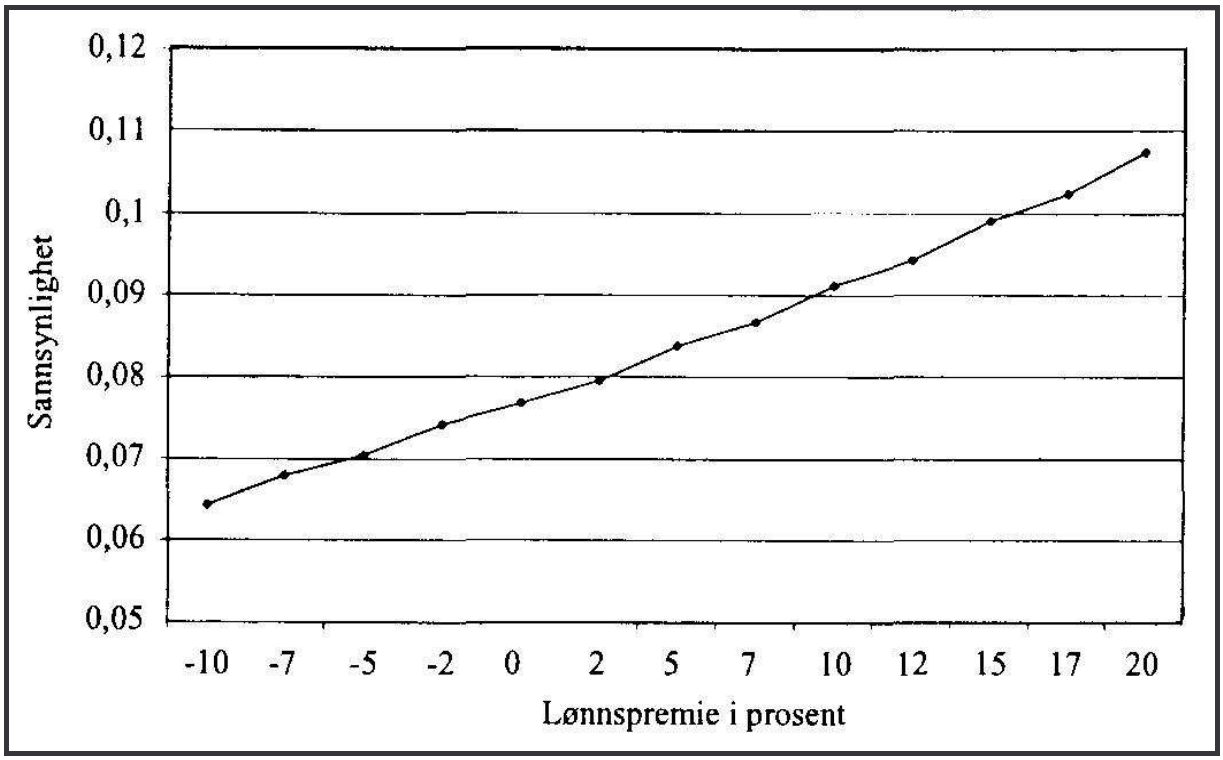


Figure 82: Attraction to the teaching profession function. Calculate probability for recruitment of teacher in education based on the wages ratio of the salaries for teachers and for national general employee in norway with the same level of education

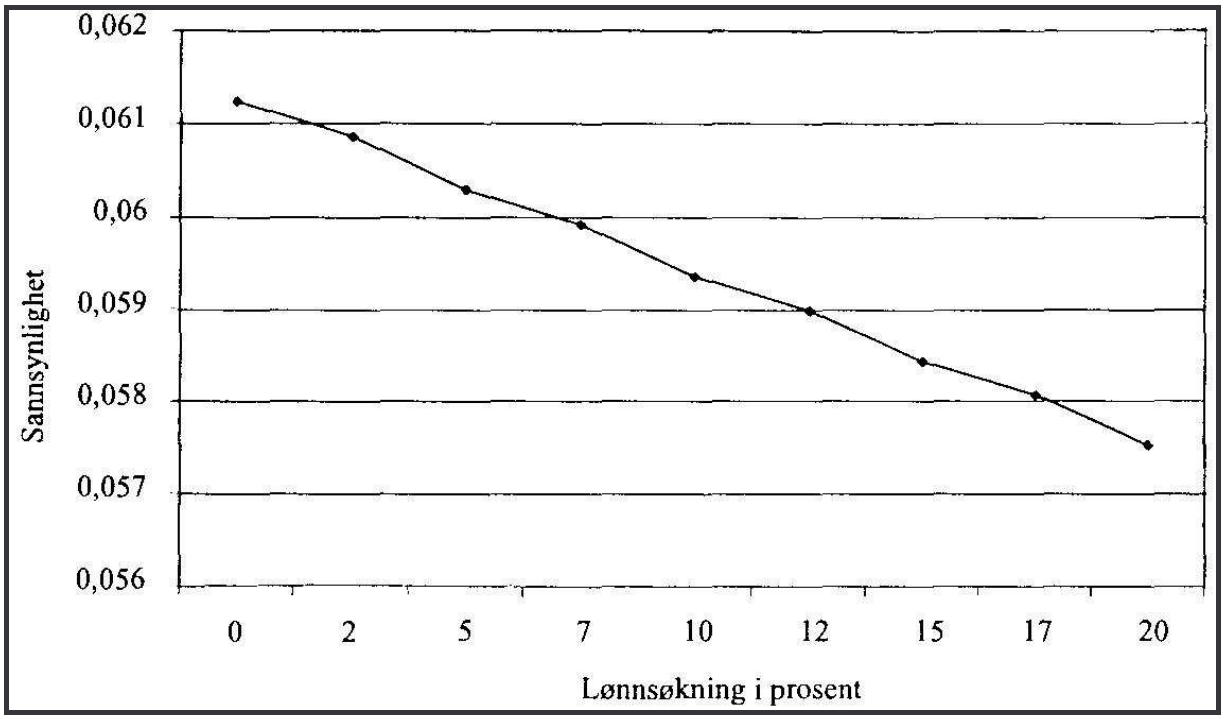


Figure 83: Leaving of the teaching profession function. Calculate leaving probability for teachers based on the wages ratio for teachers and national general employee in Norway with the same level of education

LIST OF FIGURES

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WEB RESOURCES LIST

Main websites used during the research:

Statistik Sentralbyrå (*www.ssb.no/english/*) main page of available statistic data base on a national level, from this page the historical data have been found and used for the research.

The main source used during the collection of statistical data were the StatBank which is the official data base of the web site and provide all type of data in the different sector which the website is divided.
(*http://statbank.ssb.no/statistikkbanken/Default_FR.asp?Maintable=LevendefodteNR&PLanguage=1&nvl=true&PXSid=0&tilside=selectvarval/define.asp&direkte=1*)
This part of the website has been used for different data: immigration and emigration, general government expenditure for education, number of graduates from high school.

Immigration and emigration data can be found at the web page (*http://www.ssb.no/innvandring_en/*).
Historical data on immigration and emigration can be found at the web page (*http://www.ssb.no/english/subjects/02/02/20/innvutv_en/tab-2007-05-03-01-en.html*). As of (12/09/2006)

Data relative to age distribution of immigrants and emigrants can be found at the web page (*http://www.ssb.no/english/subjects/02/02/20/innvutv_en/arkiv/tab-2006-03-30-06-en.html*). As of (4/10/2006)

Main page on statistic on education (*http://www.ssb.no/utdanning_en/*) from this page data relative to pupils, teachers and number of classes were taken

Main page statistic on population (*http://www.ssb.no/befolkning_en/*) from this page the data for the population sector of the model were taken

Main page statistic on wage (*http://www.ssb.no/lonn_en/*) from this page it is possible to have access to the statistic regarding the wages for workers in Norway. In our case we searched for the teachers wage and the data in the archive can be found at the following web address (*http://www.ssb.no/english/subjects/06/05/lonnskole_en/arkiv/*). As of (29/04/2007)

PISA data source have been taken from the web page of the project (*http://www.oecd.org/pages/0,2966,en_32252351_32235731_1_1_1_1_1,00.html*). As of 13/12/2006

Database for statistikk om Høgre utdanning (*http://dbh.nsd.uib.no/dbhvev/*)

NIFU Studies in Innovation, Research and Education (*http://english.nifustep.no/*)