Dynamic Aging Population in Germany: A case study about demographic change

by

Aziiz Sutrisno and Oliver Handel

Submitted in Partial Fulfillment of the Requirement of GEO SD304
System Dynamics Modeling Process

University of Bergen
November 2011

Dynamic Aging Population in Germany: A case study about demographic change

Aziiz Sutrisno and Oliver Handel

Recent trends in demographic changes in Germany mainly because of rapid population ageing represented as increasing ratio of older population over total population, have become a major problem for the German government. They are worry if recent trends continues it would cause massive disturbance in Germany socio-economic system, starting from vast amount of pension fund government have to pay to immerse fall of countries GDP. Therefore, by using System Dynamics approach this paper offers systemic point of view on how population structure changed in Germany; it explain why fertility rate in Germany stays low and how economic indicators would trigger changes in population structure. Moreover, it also illustrates feedback effect from population age structure to economic indicators. The result shows that current trends will continue and will not dampen if there is no adequate policy intervention from government. Hence, this paper offers set of policy measures to stabilize increasing ratio of older population. By opening more immigration opportunity for productive age workers, increasing child incentives, increasing pension age, and promoting gender equality as a set of policy measures might exhibit a better result to stabilize the population age structure. This policy measures effect shows desirable result toward expected behavior. As the population structure responds by increasing fertility rate, increasing workers age population and lowering older age population rate thus made population age structure more stable.

Keywords: Population Ageing, System Dynamics, Fertility Rate, Germany

Preface

A high collaboration of both authors makes it difficult to allocate the corresponding work share among the writing team. The following can only give an approximate clue. Aziiz Sutrisno is responsible for modeling the fertility sector and writing the following chapters: Introduction, Dynamic Problem, Policy Design and Implementation, Conclusion, Appendix A and C (and Excel Dashboard). Oliver Handel is accountable for modeling the population, migration and mortality sector plus writing the following parts: Hypothesis for the Dynamic Problem, Model Analysis, Appendix B (and data research).

Introduction

After a dramatic increase of birth rate in 1960's that produced the "baby boomer" generation, Germany now faces a difficult problem on its aging population. This baby boomers' generation form a demographic transition starting to happen in Germany on 1990's that raises big concern for the government. The ratio of young people support the elderly is low and continues over time. This demographic transition can create a massive problem for future generations. Because, if the older population dominate other age group, Germany tax income, public saving and government investment will be decreasing. (Börsch-Supan and Chiappori 1991; Kim and Lee 2008; Van Dalen, Henkens et al. 2010). Production sector also becomes major interest at this point. Germany needs more workers than predicted to support its gigantic production capacity in order to maintain its position as one of the European Union workhorses.

This demographic transition partly happens because of almost constant low birth rate and increasing life expectancy in Germany ((Börsch-Supan and Chiappori 1991; Lee and Mason 2010). Low birth rate in Germany has been continuing from approximately 1975 to now, this has become an unfavorable situation for Germany's government. The government worries over long-term effect of this situation it can drag down government tax income since number of people working is decreasing. Moreover, lower number of people working in the country will also lead to decreasing consumption in the country. While consumption decreases the whole economic activity in Germany, it will trigger another major domino effect as the snowball continues to grow.

On the other hand high retirement rate that occur nowadays because of baby boomer generation maturation enforce Germany to pay high amount of pension program. Yet, high retirement rate would not be a big trouble if Germany has enough young population to support and replace it. Unfortunately, their replacement rate now is lagging behind goal value. It means the elder people will dominate the country and there will be not enough young people to support it as the population pyramid shifting over the years (Statistisches Bundesamt 2011). The reason why such condition happens still be an unsettled discussion in Germany.

However, increasing Germany urbanization rate toward major region has also considered as one big reason why the number of births in Germany is declining. This urbanization means that more and more people in Germany live in big cities. While, housing policy in major big city cannot cope with this increasing rate of urbanization, that fact triggers rise of house prices and a reduction of overall house area. Additionally, this might explain why couples are reluctant to have children. Beside housing policy, economists and demographers for the most part agree that improved living standards, which occur in Germany leading in turn to lower fertility. In addition, the reasons behind German increasing living standards mostly are industrialization, increasing opportunities for non-agrarian employment. Furthermore, one leading factor that might explain German low fertility rate is improvement educational level that changed parental perceptions of the cost and benefits of children(Sinding 2009)

The second main reason of population aging in Germany is its increasing natural life expectancy. Besides the fact of higher living condition, peacetime and better nutritional situation. Germans also gain benefit from their government policy of social health insurance. In 2006 more than 70 million out of 82 million Germans are covered by the social health insurance system (Ulla Schmidt 2006). Therefore, the Germans have more access to better health facility. These facts lead to healthier Germans that live longer and slowing mortality rate which cause increasing number of old population.

Germany government raised pension age from 65 age to 67 in 2007 as a policy measure to counter increasing pensioner population growth. So far, the counter policy measures tend to reduce government spending on pension payment and increase country overall productivity. In the meantime, Germany government also has been working on fertility issue by introducing family policy. Nonetheless, this policy measure does not produce desirable results for German government. Germany birth rate slightly increase in 2007 but then the number plunge again in the following year as the policy resistance behavior shows. Government fears that if this trend continues Germany population will decrease from 82 million people in 2010 to 74 million people in 2050 while it has decreasing already from 2004(David Gordon Smith 2008).

Previous research conducted in Germany and several countries shows that demographic change caused by low birth rate and rapid increasing of retirement rate in the workforce will harm region's economic outlook(Christoph Hendrik Borgmann 2005). In addition, how German government manage to increase fertility rate in order to make the fertility and mortality flows balance enough to support Germany sustainable economic and demographic grow are main issues on EU socio-demographic research. Recent studies in Sweden carried by Granados and Ionides(Tapia Granados and Ionides 2008) and Bengtsson, T. and K. Scott(Bengtsson and Scott 2011) using econometrics shows this issue has become a tricky issue to handle as both papers come out with two different ideas. Moreover, findings from Börsch-Supan and Chiappori explain how the population age structure change using descriptive statistical analysis and An and Jeon that investigates how demographical change can produce different outcome in economic indicators using econometrics provide basic understanding on how the system works.

Dynamic Problem

Decreasing birth rate and aging population over time in Germany could lead to unfavorable conditions. The age structure at working age will shift in favor of older people. At present, the medium age group of the 30 to 49-year-olds accounts for 50% of working-age people, the older age group of 50 to 64 years for 30% and the younger age group of 20 to 29 years for nearly 20% of people at working age. By 2020, the older age group, then accounting for about 40% of working-age people, will be almost as much as the medium age group, which will still grows for a mere 42%. By 2050, the situation will have changed just slightly toward the medium age group(Matthias Eisenmenger, Olga Pötzsch et al. 2006). The consequences of such condition is Germany labor market will need to rely on older people as much as it relies on people at medium age to support current production rate.

Germany government has tried to implement a counter measure policy to tackle birth rate issue. However, the birth rate keeps on a constant low level and the policy measure desirable result has not shown yet. Because of low birth rate and growing maturation rate of big portion of the population, Germany elder age ratio over total population continue to grow. Figure 1 shows the reference mode and behavior over time of the system that indicates increasing elder population ratio in Germany. It shows that Germany elder population ratio keep on increasing from 2000's and the trend continues to 2010. The blue line indicates the business as usual scenario with implementation of family policy in 2007. Government hopes that the policy would be able to increase births rate and make the flow balance (orange dotted line) and stabilize Germany population in 2040 (Matthias Eisenmenger, Olga Pötzsch et al. 2006; Statistisches Bundesamt 2011).

Moreover, prediction from German statistical office shows that with this current trend the increasing rate of older population could become faster. As, they suggest that German total fertility rate is more likely to go down(Matthias Eisenmenger, Olga Pötzsch et al. 2006). Therefore, mean age of German population is increasing even more than linear extrapolation because growing imbalances between young and retired population.

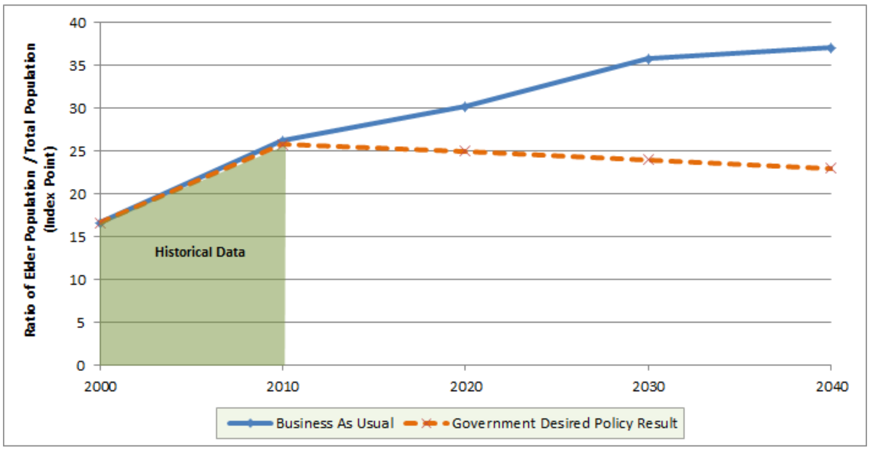


Figure 1 Reference Mode of Population aging of Germany

A growing elder rate ratio over total population would cause a disastrous condition toward all sectors in Germany. Lack of workforce and high dependency ratio cause by the imbalance between birth rate and retirement rate will trigger series of fatal disasters such as increasing pension and health care fund. Such an effect will pull out government resources, decreasing productivity, which in the long term would harm Germany's financial stature. Moreover, as one big workhorse of European Union especially Eurozone, Germany condition would also determine regional development and geopolitical condition (Coleman and Rowthorn 2011). Therefore, a smart strike to knock the root cause of this problem will be critical decision. Thus, the government will gain benefit of long-term investment not only by avoiding such adversity but also achieve long-term benefit from a balance population.

Dynamic Hypothesis

The problematic demographic changes in Germany are caused by the interplay of four different demographic determinates(Weber 2010):

1. Fertility (average number of births per woman in life)
2. Life expectancy (average lifespan from birth to death)
3. Migration (immigration and emigration together)
4. Structure of the population (age distribution)

The first three variables are predominantly mutual independent from each other. The last determinant is influenced by all and describes the distribution of the population in various age categories. Hence, interaction of fertility, life expectancy and migration changes the population structure over time. For this interdependency a model is conceived which generates historical and hypothetical scenarios of the changing population structure since Germany's reunion in the year 1990. The whole model is divided into submodels according to the described determinants. Consequently, four interacting subsystems are arranged as figure 2 shows.

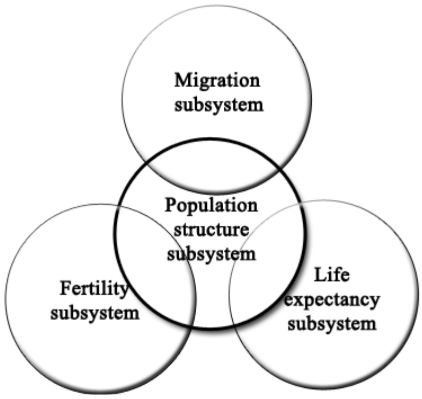


Figure 2. Overlapping subsystems (Source: own figure)

In the following, an overview of the main population subsystem is given first. Afterwards the big picture of the interaction in the whole model is provided. Finally the three peripheral subsystems are discussed sequentially (the SFDs for them are in Appendix A).

The population subsystem

The causal loop diagram (Lecture 4, p. 24ff) in figure 2 shows the basic interdependency of the demographic determinants in the population sector. The population variable is located in the center with three influencing factors around. High fertility increases the number of births. A high number of births lead to a high population and a high population comes to many births. This relationship is a reinforcing one (Lecture 3, p. 25). High life expectancy decreases the amount of deaths. The connection between deaths and the population is the opposite than the other loop, an implicit goal seeking relationship(Sterman 2000). A high population leads to more deaths, more deaths reduces the population. And third, immigration increases, emigration decreases population.

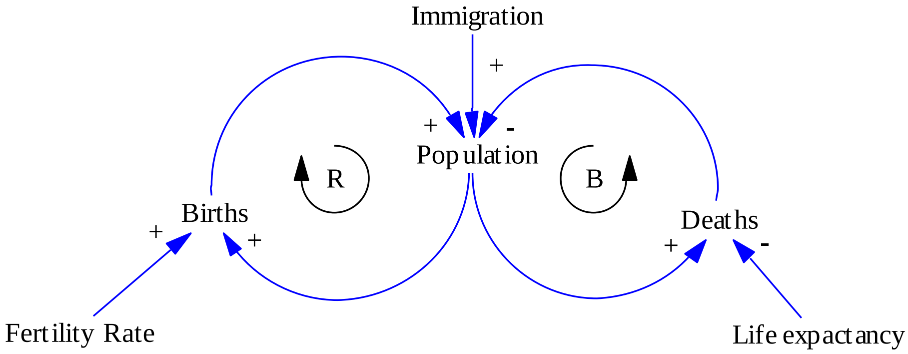
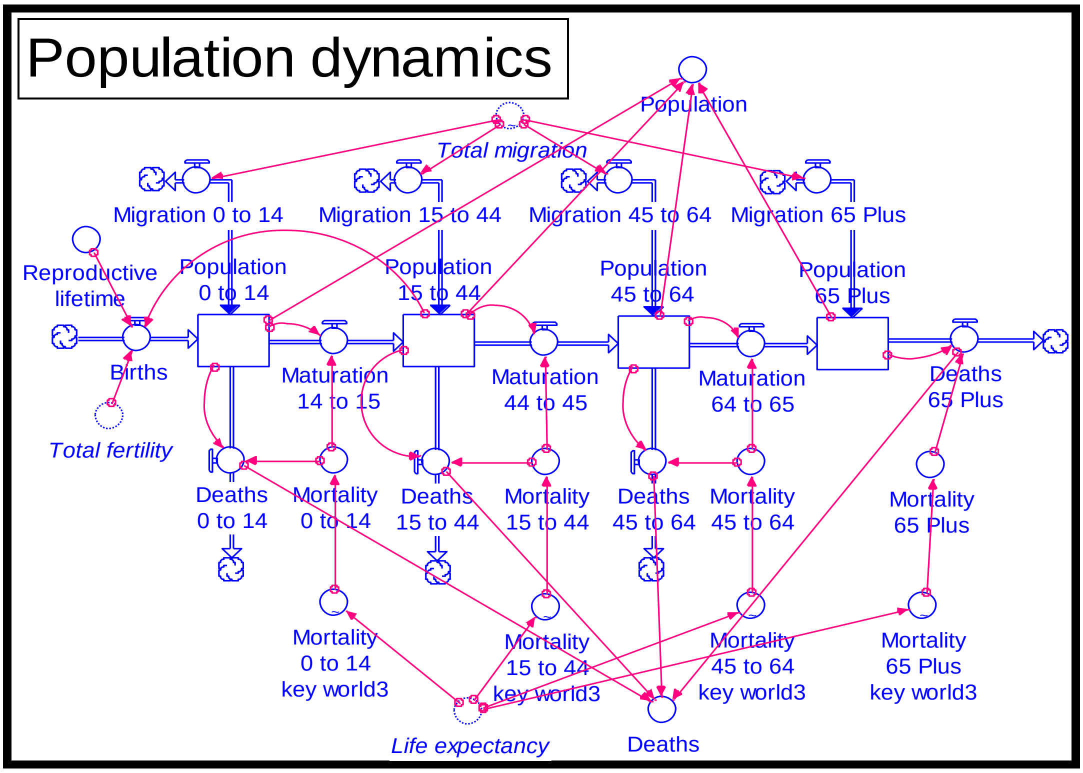


Figure 3. CLD of population structure without different cohorts

The main task of investigation is to focus on the elder population. To do this, the population is split up into four age group specific population stocks. Four stock population models are good manageable and provide accurate results(Bossel 2007). This resulting aging chain is shown in the stock and flow diagram (Lecture 3, p. 18) of figure 4.



Figur 4. SFD of the population structure with different cohorts

The population is divided into four different cohorts: prereproductive cohort (0 to 14 years), reproductive cohort (15 to 44 years), not-reproductive cohort (45 to 64 years) and pensioner cohort (65 years and older). Every cohort stock has one inflow (births or maturation), two outflows (maturation or deaths) and one biflow (immigration), except the pensioner cohort with only one outflow (deaths) and one biflow (immigration). The main inflow births of the first stock is calculated with the total fertility rate, the reproductive cohort stock and the average reproductive lifetime. The inflows of the last three cohort stocks are the respective core outflows of the first three cohort stocks. The transition from cohort to cohort is computed with the average dwell time (=adjustment time) of the particular stock. The population is divided through the associated adjustment time - the interval of the cohort stock. For example population 15 to 44 → adjustment time = 30 years (this interval represents also the mentioned reproductive lifetime). Furthermore all cohort stocks have the outflow deaths. Cohort specific death rates are calculated by two variables: First by the appropriate stock size and second by the cohort specific mortality for the first three population stocks and alternatively by the cohort specific life expectancy for the population stock 65 plus. The second variable is in both cases at the mercy of the actual life expectancy through an empiric relationship. The amounts of all deaths are summarized into the variable deaths. Moreover, cohort specific immigration biflows are depending from the total net immigration and cohort specific distribution fractions of the various immigration flows. Immigration flows can change the population size in both directions, but migration can also lead to redistribution between population stocks when the fractions have different polarities. All population stocks are aggregated in the variable population.

The big picture

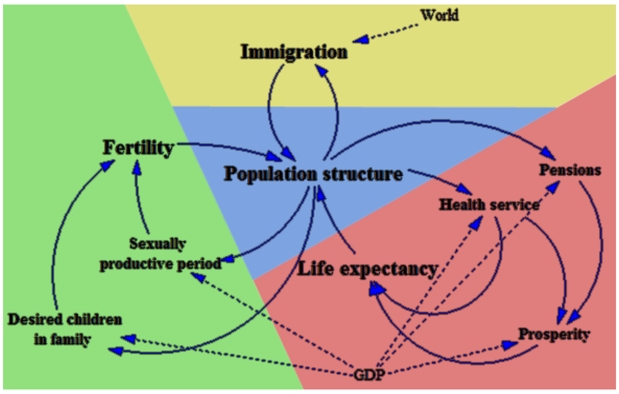


Figure 5. Interdependency between the subsystems

Figure 5 illustrates the big picture of the developed model with associations between important variables. The major feedback loops are visible and minor ones are faded out. Furthermore external variables and parameters are also shielded; only the two important ones *GDP* and *world* are mapped. The four words in bold are the gists of the different subsystems, which are color-coded. The left of the map show the fertility sector. On the one hand is the sexually productive period an important factor, on the other hand the desired children of a family is also important for the fertility average in the population. Both factors have a link to the population structure. On the lower right side, the life expectancy sector is located. In terms of population structure, the amount of monetary measured health service and the amount of pension payments differ. Prosperity is as a function of both latter mentioned variables. Life expectancy is substantial governed by health service and pensions. In the top of the map the importance of the migration aspect is emphasized.

The fertility subsystem

The fertility sector explains two major theories(Weber 2010):

1. Family formation theory, which resembles from Easterlin's hypothesis
2. Postponement effect on women giving first birth is resembled from Gary Becker's hypothesis

The family formation theory might explain on how much children a family eager to have based on their real income compared to their expected cost of carrying babies. This family formation theory follows the Easterlin hypothesis. Increasing income in family is a result of growing economy and this would increase family eagerness on having babies. On the other hand, if economic growth is faster than family income growth then it will decrease eagerness of having babies. The model structure exhibits an increasing economic growth and family income in almost same pace. In addition, the model shows a desired result consistent with the theory. Moreover, the submodel also tries to take postponement effects on women giving first in consideration. If income increases the mean age of women giving first birth also increases. This increase means age will reduce fertility in total. Furthermore, if we combine these two factors, it will produce anticipated behavior similar with historical data.

The life expectancy subsystem

In consideration of discussing the life expectancy subsystem, it is the primary interest to find macro-level trends for the dynamics of life expectancy. Data research shows a remarkable causality between life expectancy and monetary macro-developments, especially health care, prosperity and thus GDP. Many other candidates that can be listed as reasons for the life expectancy increase can be aggregated to those monetary factors: public health, medical care, personal income and poverty but also education and vaccination. Individual decisions that affect life expectancy (e.g. smoking) should not be focused. Moreover the study started from the assumption that a maximum value for life expectancy cannot be stated in general(Oeppen and Vaupel 2002).

Life expectancy is changed by two equivalently basic factors: health and prosperity. The driving forces for those two multipliers are characteristics of the population structure and the real GDP. Real GDP is an exogenous factor based on historical data and the resulting trend equation. Both multipliers rise when the appropriate proportion per capita increases in comparison to the initial 1990-value (normalized change). Furthermore, two adjustment values for the lifetime multipliers are used to make both factors equipollent. Health service capital accumulates investments and decline through depreciation. The stock is initialized with the real GDP adjusted value from Germany's statistical federal agency. The depreciation flow is determined by the average life of health service capital. Health service investment is a fraction of the real GDP. This fraction is depending from the actual and the desired health services capital amount. The desired amount is influenced by an effect of the population structure. The effect variable is normalized with the initial value of the simulation (1990-value). Health care for elder people is much more expensive than for younger people. The indicator population structure summarizes the multiplication of the population cohorts with their age group specific average cost of illness. Data from year 2002 to 2008 is used as average cohort specific costs of illness. To calculate the average cost of illness of the population cohort 65 plus the average age of this stock is used because costs are increasing strongly when average age increases in this stock. The average ages of the other stocks are roughly constant and are lying in the middle of the corresponding interval. Joining the population structure closes the big health care feedback loop. Next, the prosperity part is described in detail. Prosperity capital is the real GDP minus health service capital and pension payments capital. The pension calculation loop is structural similar to the health service loop. Investments increase and depreciation decrease pension payment capital. Pension payments capital is also initialized with the real GDP adjusted 1990-value. As the prosperity capital, the investment of health services is also computed by a fraction from the GDP. Investments rise on a percentage basis as much as the desired pension payments increase. Latter mentioned variable is depending from a normalized effect of the population structure. The decisive influencing factor is the change of the ratio between the 65 plus population and the employed people. The sum of the two middle population stocks determines the potential of employed workers (working age population). From this potential works only a fraction employed. The fork of this partial feedback loop is closed with the connection to the population structure.

The migration subsystem

Migration is a global phenomenon. Reasons for migration are eclectic and complex(Erik Pruyt, Thomas Logtens et al. 2011). In general they can be divided into push and pull factors. Push factors are lying outside the boundary of the national model. Pull factors are significantly influenced by national political decisions. In the past Germany was once already confronted with a big wave of intentional immigrates in the 1960^{th} and 70^{th}. A high need for employers was the reason for this political decision. The structural change in

Germany can lead to a situation where new employees are needed again. In consideration of this trend a tiny immigration subsystem is build.

The migration subsystem works with historical data as far as possible. Up to the year 2010, the immigration flow weakens strongly in Germany, so that the flow is set to zero. What the subsystem does is to calculate the need for migration. Need for migration is depending from two factors, first, by a double weighted need for labor multiplier and second, by a need for population decline compensator. The former compares the unemployed and the employed people and the latter compares births and deaths. The last comparison generates the socket for immigration need. Everything else to this subsystem can be found in the policy part.

Model Analysis

For validation, a rigorous series of tests was made in the modeling process repeatedly. These tests are examined for de-bugging, stress-testing and diagnosing the dynamics of the model (Guidelines for a modeling report, p. 5f). In this chapter, we present a series of tests on the final version of the model.

Unit consistency test

Units are important to validate associations between different variables. Units check if equations are coherent. For all parameters and variables in the model are units defined. Unit consistency (Lecture 5, p. 12) can be tested with the special *Check Units* algorithm in iThink. No inconsistencies can be found for the final model. Mistakes happen often in flow variables, so that we present all flow equations and their units in the population sector here. The full list of equations can be found in appendix A.

1. births = total fertility * population * fraction women / reproductive lifetime
   persons / year = unitless * persons * unitless / year
   persons/ year = persons / year
2. deaths = population / mortality
   persons / year = persons * (1 / year)
   persons / year = persons / year
3. maturation = population / interval
   persons / year = persons / year

Extreme condition test

Extreme condition tests (Lecture 5, p. 16) have two major reasons: On the one hand the procedure proofs if an equation makes sense even if the inputs take on extreme values. On the other hand, the test investigates how the system reacts when extreme policies or real world conditions are used. Two different scenarios are imagined next.

1. Limits of the system structure are demonstrated by the first test. We make the assumption to set births to zero from the beginning. Factored out is also migration. The expectation is that the population stocks will successively get empty. After 15 years the first stock should be depleted, after 45 years the second one and so on. Through the fact that maturation is calculated with an adjustment time the behavior different as figure 6 shows.

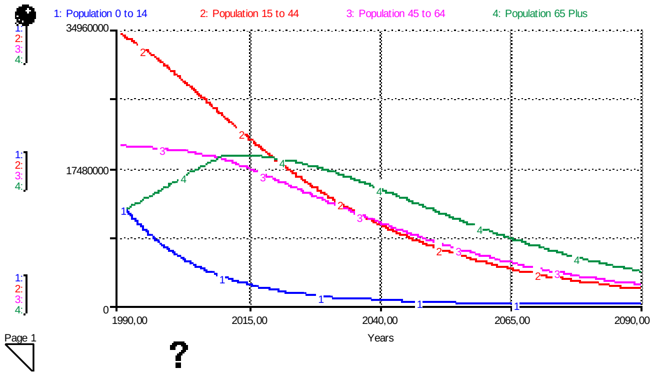


Figure 6. Extreme scenario 1: Births and migration set to zero from simulation start. In the diagram is the behavior for 100 simulated years of different population cohorts represented.

Notwithstanding, four stock aging chains have proved their worth for demographic questions. In many demographic system dynamics models four stock aging chains are used successful to describe realistic population dynamics.

2. Life expectancy is increased by a factor of 1.5 in year 2000. The expectancy is that the amount of deaths decrease dramatically and the population explodes after the change. In figure 7 is the expected behavior produced.

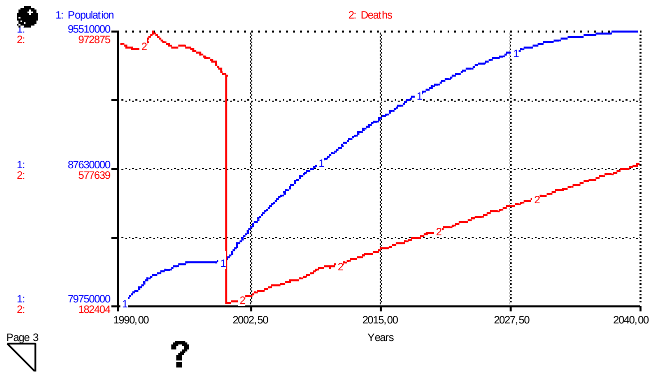


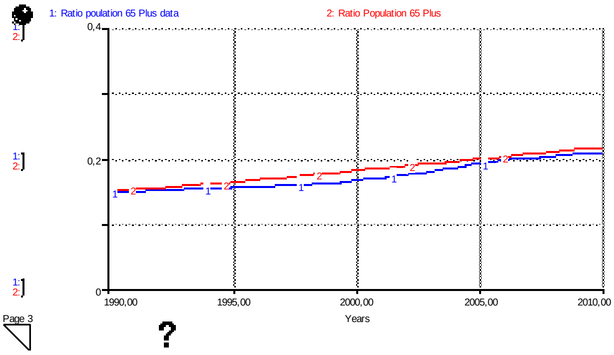
Figure 7. Extreme scenario 2: Increase of life expectancy by 50% in year 2010. The diagram shows the population (blue line; 1) and the amout of deaths (red line; 2) for the simulation interval 1990 to 2010.

Deaths decrease immediately after the increased life expectancy value. That means the outflows of the population stocks drop sharply while the inflows deliver (almost) the same amount. The consequence is the plotted accumulation process of the population variable.

It appears useful to clarify that not every absurd entry produces plausible output. Errors can occur when equations try to divide through zero or table functions are running out of range. But the testing under extreme value conditions helped to optimize the model.

Reference mode comparison test

Introductorily the reference mode was visualized. The reference mode compares elder people with the whole population. Now we want to compare the reference mode with the default behavior of our simulation (Lecture 5, p. 18). To do so the original data was inserted in iThink. Figure 8 shows the result.



Figur 8. Comparision between the reference mode and the appropriate simulation. The diagram shows the elder population ratio for 50 simulated years. The blue line (1) is data of the reference mode, the red line (2) is the simulated behavior of the developed model.

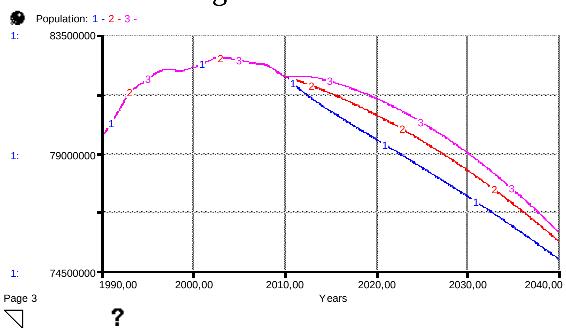
The starting values of both graphs are to the fourth decimal point identical. From the displayed perspective both graphs look very similar. The simulated curve is smoother than the histrorical data. A small gap in the middle can be seen as disfigurement. A more precise answer of sameness gives a statistical comparative meassurement. For this comparrison the coefficient of determination R^2 and the pearson correlation coefficent p is used. The statistical coefficients confirm the high sameness of both graphs. The elder population is computed well ($R^2 = 0.957$, $p = 0.978$)

Structure-behavior tests

In the hypothesis part the major feedback loops were shown in the big picture. Now we want to analyze how strong different loops act. To do so we compare the different loops when they have and when they have not impact. The structure-behavior test results (Lecture 5, p. 19ff) are presented in Appendix B.

Parameter sensitivity tests

GDP is an important factor in our model. The further development is hardly predictable. The default mode of the model is formed by a linear trend function. The parameter sensitivity analysis (Lecture 5, p. 26ff) investigates how the population development changes with different GDP growth fractions under the ceteris paribus assumption. For this GDP is modified by an increase and decrease of 10 % in the future years. The behavior of the aggregated population is shown in figure 9.



Figur 9. Sensitivity analysis: Modification of the GDP future developement. The blue line (1) shows the population behavior of an 10% decreased GDP development after the year 2010, the red line (2) shows the default mode and the pink line (3) shows the development if the GDP development is 10% higher then intended.

As the diagram exhibits changes in the GDP development do not lead to fundamentally different behavior of the aggregated population. The results are only numerically different in the order of 1%.

Policy Design and Implementation

Increasing elder population ratio in Germany has been one major issue for the government. They aware of the long-term consequences they face over this demographic shifting condition. In order to tackle this issue, Germany government introduces several policy measures to reduce increasing rate of elder population ratio. For example, in 2001 government passed series of reformation on pension age pass and child incentives in order to balance increasing elder population with the newly born.

Current condition of Germany demographic outlook shows that policy measures implemented by seem to have good impacts on increasing population fertility rate. However, these impact considered only as a short term impacts(Thyrian, Fendrich et al. 2010) rather than long term impacts. The government seems not to deal with real problems of low fertility rate in Germany as the fertility rate of Germany back to stabilize at small number, which is lower than replacement rate.

One of new government measures on increasing child incentives is a classic government approach on increasing fertility rate. While, previous Germany government has also introduced almost the same policy package in 1976 (in Germany Democratic Republic (GDR)). At that time, this pronatalist policy-package intention was raising family income thus encouraging families to have more children. In addition, several authors report that this family package incentive make immediate boost on fertility rate(Buttner and Lutz 1990). Moreover, Legge and Alford paper suggest that this policy measures taken by GDR government work most sustainably in comparison with other pronatalist measures in Eastern European (measures example: restriction to abortion)(Legge and Alford 1986).

However, government cannot carry out this measure by increasing incentives all year. Not only it is economically un-feasible but also it is impossible to do as budgeting political decision maker in Germany to pass one legislation, could take more than one year. Furthermore, this measure in 1976 was limited in time for two reasons:

- Such measures do accelerate family formation, but they do not have an appreciable effect on completed fertility
- Certain measures in the 1976 package cancelled out the effect of other measures.(Jonathan Grant , Stijn Hoorens et al. 2004)

Instant impact from these policy measures proved that the system would react on such policy package. Therefore, in order to develop more policy that is robust package to tackle on the root cause problem, these policy measures is a good starting point. Set of policy based on family incentives package is aiming on increasing family salary so family income is adequate to support more kids. Two other policies measures that could be incorporated into this policy package is increasing pension age in a short time to lengthen productive period and increasing women participation might increase family income in general. Those policy measures is visualize in system diagram in figure 10.

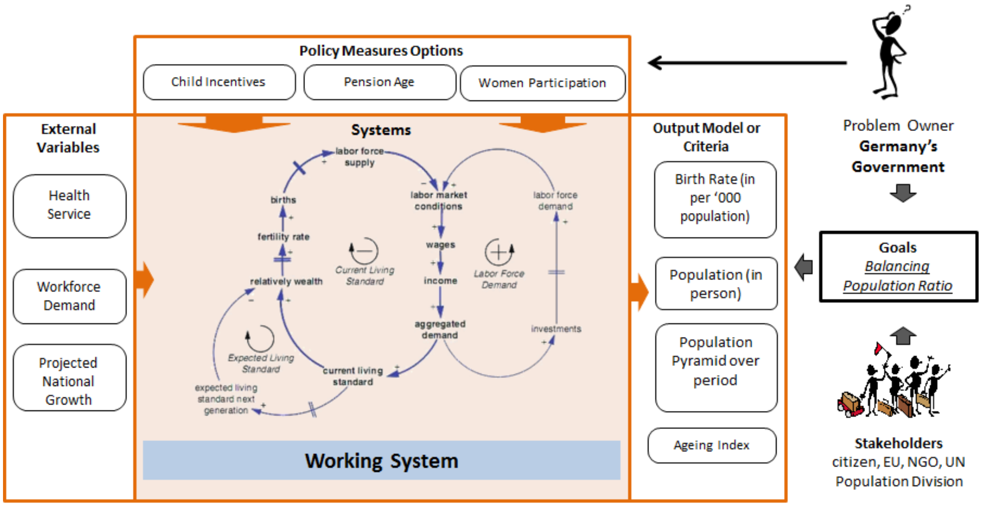


Figure 10 Germany Demography system diagram

Therefore, based on empirical theory and Figure system diagram, we suggest implementing set of policy that consists of:

- increasing child incentives
- Increasing pension age in short term
- Promoting women participation in workforce
- Opening more immigration channel for productive age family

The policy measures in improving child incentives started by developing a wishful thinking link to perceived cost of carrying baby and developing a variable that will decrease that cost. Assumed for every single baby born in Germany, government will provide incentives as much as 10-30% of baby cost by providing direct incentives or prolong maternity leaves with payment. That amount of money will decrease family pressure on having baby. The amount of money then will be adjusted every two years following report on Cost of Living allowance to match growing price of living standard. This policy was extension of previous policy measures of German government, the previous policy itself has stand unchanged since first 1994 and just recently improved in 2007. Our idea is giving more adjusting capabilities for child incentives so the impact is not only for a short period but also in longer period(Thyrian, Fendrich et al. 2010).

Our second policy measures is trying to hold in a short period increasing rate of older population or receiving pension population by increasing pension age. Recently German government implemented this policy measure, by increasing normal pension age from 65 to 67 gradually starting from 2012 to 2023. However, this policy measures is considered as one unpopular policy in the society. Nevertheless, we still think that the entire population system will gain benefit if this policy is implemented. We start building this policy measures by gradually increasing pension age from 65 to 67 in a faster pace. So, instead of having 67 age at 2023 we push program implementation to 2018, making a 5 year differences on higher pension age. This faster changing prolongs breathing space for German government on paying pension bill. As government can use benefit from such policy to fund child incentives for new family.

Our third policy measures focus on increasing women participation in workforce employment. By doing so, average family income will increase and increasing family opportunity of having more kids. Nevertheless, this policy also debatable, many demographers believe women involvement in workforce will also reduce fertility rate, as women tend to focus on their career rather than raising children.

Our fourth policy measure is to open more immigration flow especially for young age family. By introducing desired value of immigration that count gap between working age population and desired ratio of older population over working population In reality the system can described as easiness of issuing immigration certificate and promotion of migrating to Germany. However, this policy also raises long debate. Hence, the effectiveness of migration as a strategy towards preventing population ageing and a decreasing the size of the population depends on the ability of national governments to implement suitable migration policies(Espenshade and Minarik 1987; Coleman 2008). The extent to which immigrants are ready and able to integrate into the receiving population appears to be a crucial factor for the success of immigration strategies(Jonathan Grant , Stijn Hoorens et al. 2004).

On the other hand, in Figure we can see that this particular problem is not only interesting for German government. Broader audiences also interested in this issue, European Union (EU) put big attention on how German government will overcome this problem. Moreover, German government itself consists on different agencies, departments and political parties that have probabilities on having different interest creating a big potential implementation problem for setting the policy.

Respectfully, Table 1 shows six major German political parties multi actor perspectives point of view and how might they react over these set of policies. It might be important realizing that it will become major issue to pass the legislation process.

Table 1 Political parties multi actor perspectives

Actors	Interest	Current Parlimentary Position	Possible Standing
CHRISTIAN DEMOCRATIC UNION	Christian Democracy and Liberal Conservatism	Strong (Ruling party)	Child Incentives : Supporting Pension Age : Indifferent Women Participation : Supporting Immigration Channel: Indifferent
CHRISTIAN SOCIAL UNION	Christian Democracy and Social Conservatism	Weak (Government Coalition party)	Child Incentives : Supporting Pension Age : Indifferent Women Participation : Supporting Immigration Channel: Indifferent
SOCIAL DEMOCRATIC PARTY	Social Democracy	Strong (Opposition party)	Child Incentives : Supporting Pension Age : Oppossing Women Participation : Supporting Immigration Channel: Slight Oppose
THE GREENS	Green Politics	Moderate (Opposition party)	Child Incentives : Supporting Pension Age : Slight Oppos Women Participation : Supporting Immigration Channel: Indifferent
FREE DEMOCRATIC PARTY	Classical Liberalism	Moderate (Government Coalition party)	Child Incentives : Supporting Pension Age : Indifferent Women Participation : Supporting Immigration Channel: Supporting
THE LEFT PARTY	Democratic Socialism	Moderate (Opposition party)	Child Incentives : Supporting Pension Age : Oppossing Women Participation : Indifferent Immigration Channel: Oppossing

Policymaking and analysis especially long-term domain like demographic change always raise a never-ending debate on optimum policy measures and its implementation. However, set of policies that we offer supported by strong ground based theory and proven result in other countries, although there are no single silver bullet to tackle similar problems in different countries but behavior analysis shows that the system reacting toward desired behavior after implementation of these policies. Still, implementation problems in these policies could stop the effect even before it was totally running.

Conclusion

Growing number of elder population in Germany heavily affects country economic performance. This problem emerges into a bigger concern as it will also create social imbalances inside society as the effect of slowing economic performance. This paper investigates how ageing in Germany occur and suggest several policy measures that might useful to reduce the effect of current issue and try to push the system into desired condition.

Major reasons behind growing ratio number of elder population in Germany are low fertility rate and increasing life expectancy. Despite of high complexity between fertility rate, population and life expectancy; this paper result indicates how fertility rate is changing because of economic activities in the society. As family formation theory determines how big fertility rate in the society is. We formularized family formation based on Easterlin hypothesis and Gary Becker’s argument that incorporate income as driving factor of having child. The result of the fertility sector model is coherent with both underlying theory. When income is increasing too fast, women tend to postpone their willingness of having babies. Moreover, if country’s living standard grow too fast the cost of having babies will also go high and many people will reluctant to have babies. Therefore, one policy that we suggest is giving more child incentives and increasing gender equality. So, family income will increase and creates more economic opportunities for family on having more children. Moreover, this paper has well explained connection between economic activities and demographical change. It shows consistencies as two economist papers that previously suggested economic-population structure correlation. On the other hand, the usage of System Dynamics in this paper provides better explanation on feedback effects occur in the real system. Moreover, it also provides policy maker more options on policy testing and analysis rather than parameter changing in the model.

However, this paper is only a starting phase to explain demographical change phenomena in Germany. A deeper data gathering should be conducted to have detailed result on the structure and effect of the issue. For example, one major obstacle is getting enough past data for making arrayed population structure. In addition, future research should also consider feedback effect from increasing women participation rate in workforce because; there are discussions whether increasing women participation will also lower desire on having children.

Appendix A: List of Equations and Documentation

We divide appendix in sectors:

Figure: SFD of the population model subdivided into four age groups

Population Sector

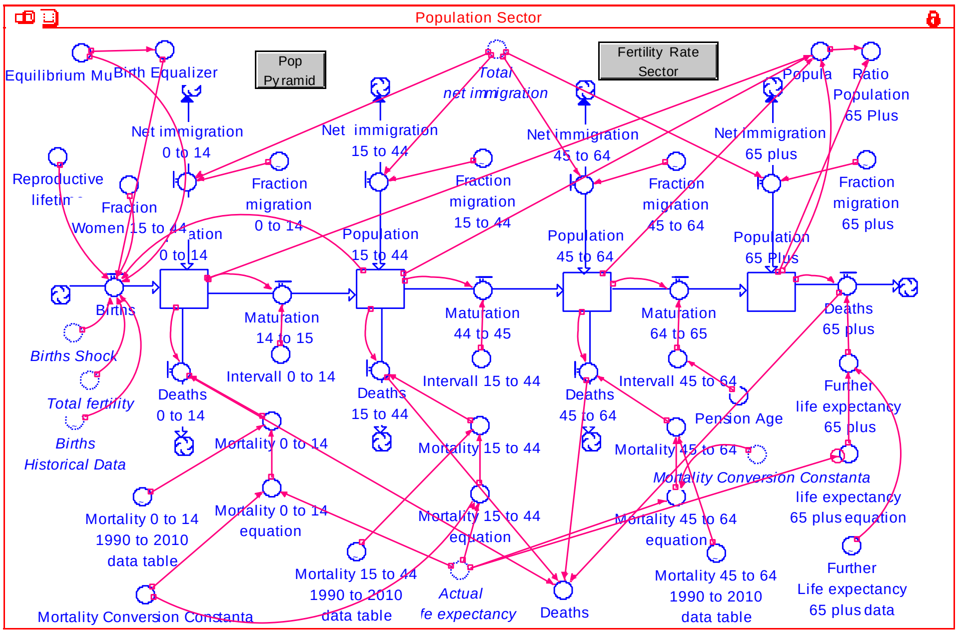


Figure 4 Population sector

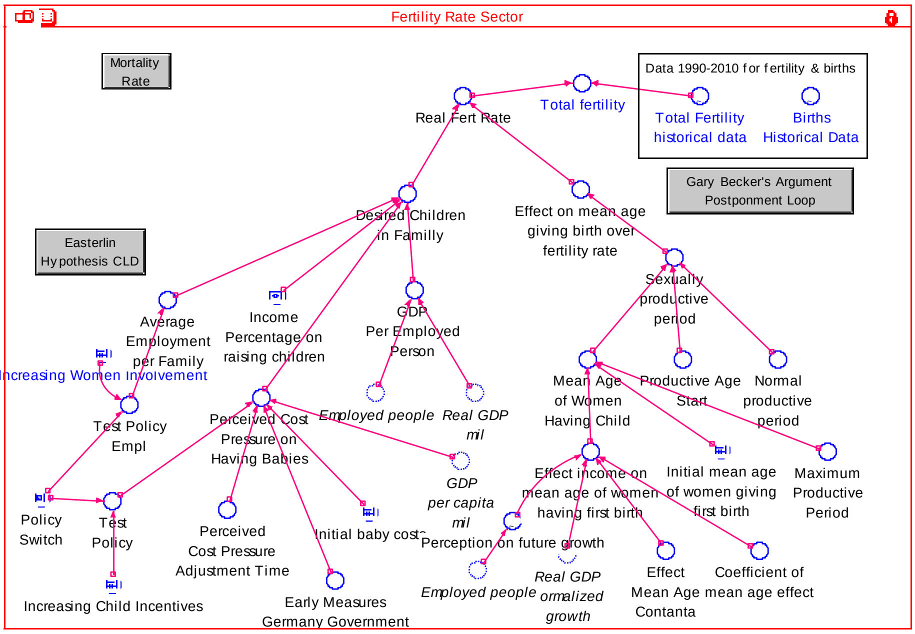


Figure 5 Fertility Sector

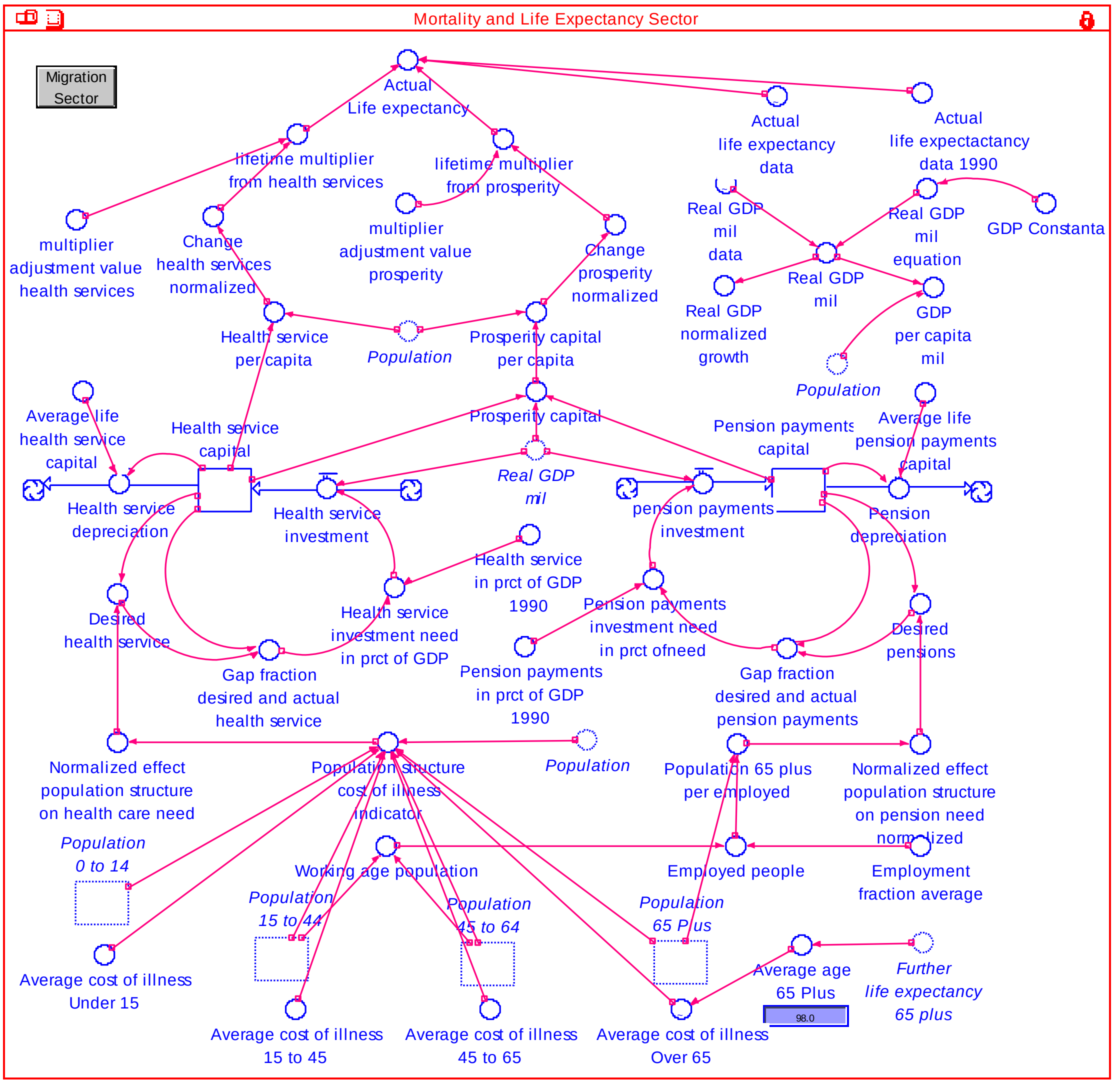


Figure 6 Life Expectancy and Mortality

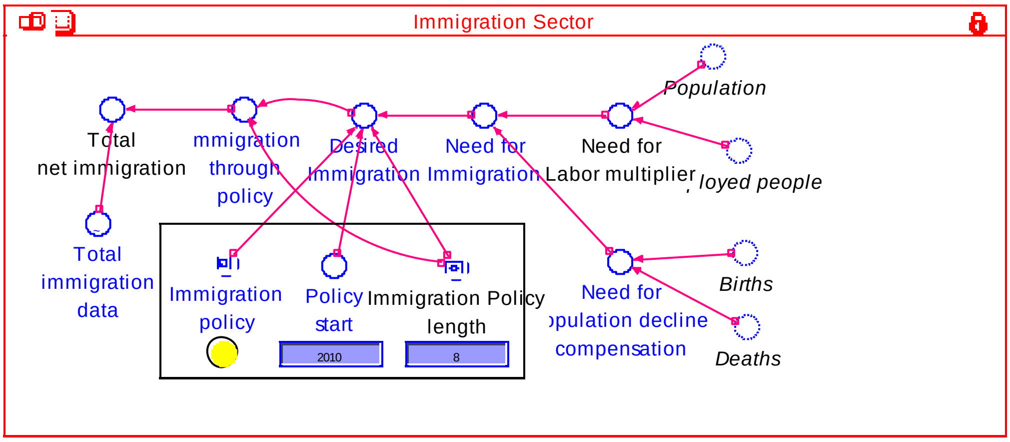


Figure 7 Immigration Sector

List of Equations:

Health_service_capital(t) = Health_service_capital(t - dt) + (Health_service_investment - Health_service_depreciation) * dt
INIT Health_service_capital = 219208

{Euros}
UNITS: Euros (EUR)
INFLOWS:
Health_service_investment =
Real_GDP_mil*Health_service_investment_need_in_prct_of_GDP

{Eur/Years}
UNITS: EUR/YR (EUR/yr)
OUTFLOWS:
Health_service_depreciation = Health_service_capital/Average_life_health_service_capital

{Eur/years}
UNITS: EUR/YR (EUR/yr)
Pension_payments_capital(t) = Pension_payments_capital(t - dt) + (pension_payments_investment - Pension_depreciation) * dt
INIT Pension_payments_capital = 265473

{Euros}
UNITS: Euros (EUR)
INFLOWS:
pension_payments_investment =
Pension_payments_investment_need_in_prct_ofneed*Real_GDP_mil

{EUR/Years}
UNITS: EUR/YR (EUR/yr)
OUTFLOWS:
Pension_depreciation = Pension_payments_capital/Average_life_pension_payments_capital

{Eur/Years}
UNITS: EUR/YR (EUR/yr)
Population_0_to_14(t) = Population_0_to_14(t - dt) + (Births + Net_immigration_0_to_14 - Maturation__14_to_15 - Deaths_0_to_14) * dt
INIT Population_0_to_14 = 12937503*(1-Equilibrium_Multiplier)+14430472.986*Equilibrium_Multiplier

{people}
UNITS: people (person)
DOCUMENT: Germanys population: 0-14 years old
INFLOWS:
Births = (Total_fertility * Population_15_to_44 * Fraction_Women_15_to_44)/Reproductive_lifetime*Birth_Equalizer+

Births_Historical_Data*0
+

((34643682+10000000*Total_fertility*Births_Shock*Fraction_Women_15_to_44)/Reproductive_lifetime)*Equilibrium_Multiplier

{people/years}
UNITS: person/yr
DOCUMENT: Total number of births in Germany.

(Multiplication with 0.5 --> Only women reproduce)
Net_immigration_0_to_14 = Total_net_immigration*Fraction_migration_0_to_14

{people/years}
UNITS: person/yr
OUTFLOWS:
Maturation__14_to_15 = Population_0_to_14 / Intervall_0_to_14*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 0-14 mature into the next age cohort (15-44).
Deaths_0_to_14 = Population_0_to_14 * Mortality_0_to_14

{people/years}
UNITS: person/yr
DOCUMENT: The number of deaths per year among people 0 to 14 years of age.
Population_15_to_44(t) = Population_15_to_44(t - dt) + (Maturation__14_to_15 + Net__immigration_15_to_44 - Maturation_44_to_45 - Deaths_15_to_44) * dt
INIT Population_15_to_44 = 34643682*(1-Equilibrium_Multiplier)+33362872.342*Equilibrium_Multiplier
UNITS: people (person)
DOCUMENT: Germanys population:15-44 years old
INFLOWS:
Maturation__14_to_15 = Population_0_to_14 / Intervall_0_to_14*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 0-14 mature into the next age cohort (15-44).
Net__immigration_15_to_44 = Total_net_immigration*Fraction_migration_15_to_44

{people/years}
UNITS: person/yr
OUTFLOWS:
Maturation_44_to_45 = Population_15_to_44 / Intervall_15_to_44*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 15-44 mature into the next age cohort (45-64).
Deaths_15_to_44 = Population_15_to_44 * Mortality_15_to_44

{people/years}
UNITS: person/yr
DOCUMENT: The number of deaths per year among people 15 to 44 years of age.
Population_45_to_64(t) = Population_45_to_64(t - dt) + (Maturation_44_to_45 + Net_immigration_45_to_64 - Maturation__64_to_65 - Deaths_45_to_64) * dt

INIT Population_45_to_64 = 20259902*(1-Equilibrium_Multiplier)+24545074.133*Equilibrium_Multiplier
UNITS: people (person)
DOCUMENT: Germanys population: 45-64 years old
INFLOWS:
Maturation_44_to_45 = Population_15_to_44 / Intervall_15_to_44*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 15-44 mature into the next age cohort (45-64).
Net_immigration_45_to_64 = Total_net_immigration*Fraction_migration_45_to_64

{people/years}
UNITS: person/yr
OUTFLOWS:
Maturation__64_to_65 = Population_45_to_64 / Intervall_45_to_64*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 45-64 mature into the next age cohort (65 Plus).
Deaths_45_to_64 = Population_45_to_64 * Mortality_45_to_64
{people/years}
UNITS: person/yr
DOCUMENT: The number of deaths per year among people 45 to 64 years of age.
Population_65_Plus(t) = Population_65_Plus(t - dt) + (Maturation__64_to_65 + Net_immigration_65_plus - Deaths_65_plus) * dt
INIT Population_65_Plus = 11912140*(1-Equilibrium_Multiplier)+64831831.257*Equilibrium_Multiplier
UNITS: people (person)
DOCUMENT: Germanys population: 65 years and older
INFLOWS:
Maturation__64_to_65 = Population_45_to_64 / Intervall_45_to_64*1

{people/years}
UNITS: person/yr
DOCUMENT: The fractional rate at which people aged 45-64 mature into the next age cohort (65 Plus).
Net_immigration_65_plus = Total_net_immigration*Fraction_migration_65_plus

{people/years}
UNITS: person/yr
OUTFLOWS:
Deaths_65_plus = Population_65_Plus/Further_life_expectancy__65_plus

{people/years}
UNITS: person/yr
DOCUMENT: The number of deaths per year among people 65 years and older.
Actual_life_expectactancy_data_1990 = 75.2

{years}
UNITS: years (yr)

Actual_life_expectancy_data = GRAPH(time

{years})
(1990, 75.2), (1991, 75.4), (1992, 75.9), (1993, 76.0), (1994, 76.3), (1995, 76.5), (1996, 76.8), (1997, 77.2), (1998, 77.6), (1999, 77.8), (2000, 78.1), (2001, 78.4), (2002, 78.5), (2003, 78.6), (2004, 79.2), (2005, 79.3), (2006, 79.7), (2007, 79.8), (2008, 79.9), (2009, 80.0), (2010, 80.2)
UNITS: years (yr)
DOCUMENT: Source: http://www.lebenserwartung.info/index-Dateien/ledeu.htm

Actual_life_expectancy__65_plus_data = GRAPH(TIME)
(1990, 16.1), (1991, 16.2), (1992, 16.3), (1993, 16.2), (1994, 16.5), (1995, 16.5), (1996, 16.6), (1997, 16.8), (1998, 17.0), (1999, 17.2), (2000, 17.4), (2001, 17.6), (2002, 17.7), (2003, 17.8), (2004, 18.0), (2005, 18.2), (2006, 18.5), (2007, 18.6), (2008, 18.8), (2009, 18.9), (2010, 18.9)
UNITS: Unitless
Actual__Life_expectancy = Actual_life_expectancy_data*0
+
(Actual_life_expectactancy_data_1990*lifetime_multiplier_from_health_services)*0
+
(Actual_life_expectactancy_data_1990*lifetime_multiplier_from_prosperity)*0
+
(Actual_life_expectactancy_data_1990*(lifetime_multiplier_from_health_services+lifetime_multiplier_from_prosperity)*0.5)*1

{years}
UNITS: years (yr)
Average_Employment_per_Family = 1+step(Test_Policy_Empl,2015)

{people}
UNITS: people (person)
DOCUMENT: STATISTISCHES JAHRBUCH 2011
Statistisches Bundesamt (Federal Statistical Office), Wiesbaden
2011
Average_age__65_Plus = 65+(Further_life_expectancy__65_plus)

{years}
UNITS: years (yr)
Average_cost_of_illness_15_to_45 = 1.198

{unitless}
UNITS: Unitless
Average_cost_of_illness_45_to_65 = 2.431

{unitless}
UNITS: Unitless
Average_cost_of_illness_Over_65 = GRAPH(Average_age__65_Plus

{unitless})
(75.0, 4.97), (90.0, 11.8)
UNITS: Unitless
DOCUMENT: Anpassen fŸr eine Sterbetagel mit entsprechenden Daten (2002 - 2008)
Average_cost_of_illness_Under_15 = 1

{unitless}

UNITS: Unitless
Average_life_health_service_capital = 1

{years}
UNITS: years (yr)
Average_life_pension_payments_capital = 1

{years}
UNITS: years (yr)
Births_Historical_Data = GRAPH(TIME

{person/years})
(1990, 905675), (1991, 830019), (1992, 809114), (1993, 798447), (1994, 769603), (1995, 765221), (1996, 796013), (1997, 812173), (1998, 785034), (1999, 770744), (2000, 766999), (2001, 734475), (2002, 719250), (2003, 706721), (2004, 705622), (2005, 685795), (2006, 672724), (2007, 684862), (2008, 682514), (2009, 665126), (2010, 677947)
UNITS: person/yr
Births_Shock = if Shock_Switch and Equilibrium_Switch = 1 then pulse(1.05,5,1) else 0

{unitless}
UNITS: Unitless
Birth_Equalizer = If Equilibrium_Multiplier=1 then 0 else 1

{unitless}
UNITS: Unitless
Change_prosperity_normalized = (Prosperity_capital_per_capita/Init(Prosperity_capital_per_capita))

{unitless}
UNITS: Unitless
Change__health_services_normalized = Health_service_per_capita/Init(Health_service_per_capita)

{unitless}
UNITS: Unitless
Coefficient_of_mean_age_effect = 0.4328

{unitless}
UNITS: Unitless
Data = If Time >2010 then TFR_2050 else Total_Fertility_historical_data
UNITS: baby (baby)
Deaths = Deaths_0_to_14 + Deaths_15_to_44 + Deaths_45_to_64 + Deaths_65_plus

{people/years}
UNITS: person/yr
DOCUMENT: Total number of deaths in Germany.
Desired_health_service = Health_service_capital*Normalized_effect_population_structure_on_health_care_need

{Euros}
UNITS: Euros (EUR)
Desired_Immigration = IF(Immigration_policy=1 AND Time>=Policy_start AND Time<=(Policy_start+Immigration_Policy_length))

THEN Need_for_Immigration
ELSE 0

{person/years}
UNITS: person/yr
Desired_pensions =
Pension_payments_capital*Normalized_effect_population_structure_on_pension_need_normalized

{Euros}
UNITS: Euros (EUR)
Desired_Children_in_Familly =
(Average_Employment_per_Family*GDP__Per_Employed_Person*Income_Percentage_on_raising_children/Perceived_Cost_Pressure_on_Having_Babies)

{baby}
UNITS: baby (baby)
Early_Measures_Germany_Government = 0+step(500,2007)

(Bomb, McCormick et al.)
UNITS: Eur/baby (EUR/baby)
Effect_Mean_Age_Contanta = 0.5671

{unitless}
UNITS: Unitless
Effect_income_on_mean_age_of_women_having_first_birth =
(Coefficient_of_mean_age_effect*Real_GDP_normalized_growth+Effect_Mean_Age_Contanta)*Perception_on_future_growth

{unitless}
UNITS: Unitless
DOCUMENT: Equation derived from a simple linear regression taken from 1985-2006 time series data
all data has been normalized and treated as normal distribution data

GDP Data : Wordl Bank WDI Data
Age on forst child data: UNECE Statistical Division Database, compiled from national and international (Eurostat and UNICEF TransMONEE) official sources.
Effect_on_mean_age_giving_birth_over_fertility_rate =
Init(Sexually_Productive_Period)/Sexually_Productive_Period
UNITS: Unitless
Elder_population_per_employed = Population_65_Plus/Employed_people
UNITS: Unitless
Employed_people = Working_age_population*Employment_fraction_average

{people}
UNITS: people (person)
Employment_fraction_average = 0.718

{unitless}
UNITS: Unitless
EQ = If Equilibrium_Switch = 1 then 0 else 1
UNITS: Unitless

Equilibrium_Switch = IF Equilibrium_Multiplier = 1 then 1 else 0

{unitless}
UNITS: Unitless
Equilibrium_Multiplier = 0
UNITS: people (person)
Fraction_migration_0_to_14 = GRAPH(TIME

{unitless})
(1990, 0.22), (1995, 0.26), (2000, 0.16), (2005, 0.13), (2010, -1.02), (2015, -1.02)
UNITS: Unitless
Fraction_migration_15_to_44 = GRAPH(TIME

{unitless})
(1990, 0.62), (1995, 0.6), (2000, 0.77), (2005, 0.99), (2010, -1.83), (2015, -1.83)
UNITS: Unitless
Fraction_migration_45_to_64 = GRAPH(TIME

{unitless})
(1990, 0.12), (1995, 0.1), (2000, 0.05), (2005, -0.06), (2010, 2.23), (2015, 2.23)
UNITS: Unitless
Fraction_migration_65_plus = GRAPH(TIME

{unitless})
(1990, 0.04), (1995, 0.03), (2000, 0.02), (2005, -0.06), (2010, 1.63), (2015, 0.02)
UNITS: Unitless
Fraction_Women_15_to_44 = 0.487662

{1/baby}
UNITS: 1/baby (1/baby)
DOCUMENT: Units: Women/Baby
Further_life_expectancy_65_plus_equation = ((-0.0037*Actual__Life_expectancy + 0.3375)*0
+
(0.5984*Actual__Life_expectancy - 29.218)*0
+
1.538376*Actual__Life_expectancy - 99.321028)

{years}
UNITS: years (yr)
DOCUMENT: The fractional mortality rate for people aged 65 and older.

Another smoothing equation
(0.063081*Actual__Life_expectancy^2 - 9.216724*Actual__Life_expectancy + 352.419689)*0
Further_life_expectancy__65_plus = IF(TIME> 1010) THEN
Further_life_expectancy_65_plus_equation ELSE Further_Life_expectancy__65_plus_data

{years}
UNITS: years (yr)
Further_Life_expectancy__65_plus_data = GRAPH(TIME)
(1990, 16.6), (1991, 17.0), (1992, 17.8), (1993, 17.7), (1994, 18.2), (1995, 18.4), (1996, 18.5),
(1997, 19.1), (1998, 19.4), (1999, 19.9), (2000, 20.5), (2001, 21.2), (2002, 21.3), (2003, 21.4),
(2004, 23.1), (2005, 23.3), (2006, 24.0), (2007, 24.0), (2008, 23.7), (2009, 23.6), (2010, 23.4)
UNITS: years (yr)

Gap_fraction_desired_and_actual_health_service =
Desired_health_service/Health_service_capital

{unitless}
UNITS: Unitless
Gap_fraction_desired_and_actual__pension_payments =
Desired_pensions/Pension_payments_capital

{unitless}
UNITS: Unitless
GDP_per_capita_mil = Real_GDP_mil/Population

{EUR/People}
UNITS: EUR/Person (EUR/person)
GDP__Per_Employed_Person = Real_GDP_mil*1000000/Employed_people

{EUR/people}
UNITS: EUR/Person (EUR/person)
DOCUMENT: Based on http://www.indexmundi.com/facts/germany/gdp-per-person-employed
on 1990 USD value based
GDP Deflator 1990 based on World Bank WDI 2011 publication is 84.55728

Initial value: 34,481 USD
GDP_Constanta = 1

{Eur/Years}
UNITS: EUR/YR (EUR/yr)
Health_service_investment_need_in_prct_of_GDP =
Health_service_in_prct_of_GDP_1990*Gap_fraction_desired_and_actual_health_service

{Euros}
UNITS: 1/year (1/yr)
Health_service_in_prct_of_GDP_1990 = 0.096605

{unitless}
UNITS: 1/year (1/yr)
Health_service_per_capita = Health_service_capital*1000000/Population

{Euros/people}
UNITS: EUR/Person (EUR/person)
Immigration_policy = 0
UNITS: Unitless
Immigration__through_policy =
SMTH3(Desired_Immigration,MAX(5,Immigration_Policy_length/2))

{person/years}
UNITS: person/yr
Immigration_Policy_length = 7.5
UNITS: years (yr)
Income_Percentage_on_raising_children = 0.315

{unitless}
UNITS: Unitless

DOCUMENT: Assumption made: Author

Based on Businessweek article
http://www.businessweek.com/investor/content/nov2007/pi2007119_694057.htm
Increasing_Child_Incentives = 1000
UNITS: Eur/baby (EUR/baby)
Increasing_Women_Involvement = 0.02
UNITS: people (person)
Initial_baby_costs = 12500

(Bomb, McCormick et al.)
UNITS: Eur/baby (EUR/baby)
Initial_mean_age_of_women_giving_first_birth = 26.28

{years}
UNITS: years (yr)
Intervall_0_to_14 = 15

{years}
UNITS: years (yr)
Intervall_15_to_44 = 30

{years}
UNITS: years (yr)
Intervall_45_to_64 = Pension_Age-(45)

{years}
UNITS: years (yr)
lifetime_multiplier_from_health_services =
(Change__health_services_normalized^multiplier__adjustment_value_health_services)*1

{unitless}
UNITS: Unitless
lifetime_multiplier_from_prosperity =
Change_prosperity_normalized^multiplier_adjustment_value_prosperity

{unitless}
UNITS: Unitless
Maximum_Productive_Period = 40

{years}
UNITS: years (yr)
Mean_Age_of_Women_Having_Child =
Min(Effect_income_on_mean_age_of_women_having_first_birth*Initial_Mean_Age_of_Women_Giving_First_Birth,Maximum_Productive_Period)

{years}
UNITS: years (yr)
Mortality_0_to_14 = IF(TIME>1010) THEN Mortality_0_to_14_equation ELSE
Mortality_0_to_14_1990_to_2010_data_table/1000000

{1/years}
UNITS: 1/year (1/yr)

Mortality_0_to_14_1990_to_2010_data_table = GRAPH(TIME

{1/years})
(1990, 737), (1991, 669), (1992, 586), (1993, 555), (1994, 519), (1995, 490), (1996, 464), (1997, 463), (1998, 438), (1999, 428), (2000, 408), (2001, 401), (2002, 382), (2003, 388), (2004, 366), (2005, 363), (2006, 340), (2007, 350), (2008, 331), (2009, 325), (2010, 319)
UNITS: 1/year (1/yr)
Mortality_0_to_14_equation = (-0.00005930*Actual__Life_expectancy + 0.00505824)/Mortality_Conversion_Constanta

{1/years}
UNITS: 1/year (1/yr)
DOCUMENT: The fractional mortality rate for people aged 0-14.

Formula:
1. Average of year interval aggregated motriliy rates
2. Average of age group interval aggregated mortility rates
3. 2011-11-22 Average cohort mortality distribution function
Mortality_15_to_44 = IF(TIME>1010) THEN Mortality_15_to_44_equation ELSE Mortality_15_to_44_1990_to_2010_data_table/1000000

{1/years}
UNITS: 1/year (1/yr)
Mortality_15_to_44_1990_to_2010_data_table = GRAPH(TIME

{1/years})
(1990, 1078), (1991, 1168), (1992, 1143), (1993, 1126), (1994, 1119), (1995, 1101), (1996, 1066), (1997, 1020), (1998, 962), (1999, 954), (2000, 938), (2001, 889), (2002, 970), (2003, 953), (2004, 804), (2005, 768), (2006, 737), (2007, 711), (2008, 694), (2009, 682), (2010, 668)
UNITS: 1/year (1/yr)
Mortality_15_to_44_equation = (-0.00011023*Actual__Life_expectancy + 0.00951890)/Mortality_Conversion_Constanta

{1/years}
UNITS: 1/year (1/yr)
DOCUMENT: The fractional mortality rate for people aged 15-44.
Mortality_45_to_64 = IF(TIME>1010) THEN Mortality_45_to_64_equation ELSE Mortality_45_to_64_1990_to_2010_data_table/1000000

{1/years}
UNITS: 1/year (1/yr)
Mortality_45_to_64_1990_to_2010_data_table = GRAPH(TIME

{1/years})
(1990, 7518), (1991, 7686), (1992, 7505), (1993, 7478), (1994, 7275), (1995, 7111), (1996, 6970), (1997, 6726), (1998, 6533), (1999, 6402), (2000, 6301), (2001, 6126), (2002, 6033), (2003, 5910), (2004, 5627), (2005, 5485), (2006, 5236), (2007, 5079), (2008, 5018), (2009, 4923), (2010, 4843)
UNITS: 1/year (1/yr)
Mortality_45_to_64_equation = (-0.00060437*Actual__Life_expectancy + 0.05339422)/Mortality_Conversion_Constanta

{1/years}

UNITS: 1/year (1/yr)
DOCUMENT: The fractional mortality rate for people aged 45-64.
Mortality_Conversion_Constanta = 1

{years^2}
UNITS: yr^2 (yr-yr)
multiplier_adjustment_value_prosperity = 0.5
{unitless}
UNITS: Unitless
multiplier__adjustment_value_health_services = 0.13

{unitless}
UNITS: Unitless
Need_for_Immigration =
Need_for_Labor_multiplier*Need_for_population_decline_compensation

{person/years}
UNITS: person/yr
Need_for_Labor_multiplier = (Population/Employed_people)

{unitless}
UNITS: Unitless
Need_for_population_decline_compensation = Births-Deaths

{person/years}
UNITS: person/yr
Normal_productive_period = 35

{years}
UNITS: years (yr)
Normalized_effect_population_structure_on_health_care_need =
Population_structure_cost_of_illness_indicator/Init(Population_structure_cost_of_illness_indic
ator)

{unitless}
UNITS: Unitless
Normalized_effect_population_structure_on_pension_need_normalized =
Population_65_plus_per_employed/Init(Population_65_plus_per_employed)

{unitless}
UNITS: Unitless
Normalized_effect_population_structure_on_pension_need_normalized_2 =
Population_65_plus_per_employed/Init(Population_65_plus_per_employed)
UNITS: Unitless
Normalized_effect_population_structure_on_pension_need_normalized_3 =
Population_65_plus_per_employed/Init(Population_65_plus_per_employed)
UNITS: Unitless
Pension_Age = 65
UNITS: years (yr)
Pension_payments_investment_need_in_prct_ofneed =
Gap_fraction_desired_and_actual__pension_payments*Pension_payments_in_prct_of_GDP_19
90

{Euros}
UNITS: 1/year (1/yr)
Pension_payments_in_prct_of_GDP_1990 = 0.117

{unitless}
UNITS: 1/year (1/yr)
Perceived_Cost_Pressure_Adjustment_Time = 2

{years}
UNITS: years (yr)
Perceived_Cost_Pressure_on_Having_Babies =
SMTH3(Initial_baby_costs*GDP_per_capita_mil/init(GDP_per_capita_mil),Perceived_Cost_Pressure_Adjustment_Time,Initial_baby_costs)-step(Test_Policy,2012)-Early_Measures_Germany_Government

{EUR/Baby}
UNITS: Eur/baby (EUR/baby)
Perception_on_future_growth = GRAPH(Employed_people/Init(Employed_people)

{unitless})
(0.00, 1.00), (1.00, 1.00), (2.00, 1.05)
UNITS: Unitless
Policy_start = 2010
UNITS: years (yr)
Policy_Switch = 0

{unitless}
UNITS: Unitless
Population = Population_0_to_14 + Population_15_to_44 + Population_45_to_64 + Population_65_Plus

{people}
UNITS: people (person)
DOCUMENT: Total population of Germany (all ages)
Population_65_plus_per_employed = Population_65_Plus/Employed_people

{unitless}
UNITS: Unitless
Population_structure_cost_of_illness_indicator =
(Average_cost_of_illness_Under_15*Population_0_to_14+Average_cost_of_illness_15_to_45*Population_15_to_44+Average_cost_of_illness_45_to_65*Population_45_to_64+Average_cost_of_illness_Over_65*Population_65_Plus)/(Population)

{unitless}
UNITS: Unitless
Productive_Age__Start = 15

{years}
UNITS: years (yr)
Prosperity_capital = Real_GDP_mil-Health_service_capital-Pension_payments_capital

{Euros}
UNITS: Euros (EUR)

Prosperity_capital_per_capita = Prosperity_capital/Population

{Eur/People}
UNITS: EUR/Person (EUR/person)
Ratio_Population_65_Plus = Population_65_Plus/Population

{unitless}
UNITS: Unitless
Ratio_poulation_65_Plus_data = GRAPH(time)
(1990, 0.149), (1991, 0.15), (1992, 0.15), (1993, 0.152), (1994, 0.154), (1995, 0.156), (1996, 0.157), (1997, 0.158), (1998, 0.159), (1999, 0.162), (2000, 0.166), (2001, 0.171), (2002, 0.175), (2003, 0.18), (2004, 0.186), (2005, 0.193), (2006, 0.198), (2007, 0.201), (2008, 0.204), (2009, 0.207), (2010, 0.21)
Real_Fert_Rate =
(Desired_Children_in_Familly/Effect_on_mean_age_giving_birth_over_fertility_rate)*1

{baby}
UNITS: baby (baby)
Real_GDP_mil = (Real_GDP_mil_data*0

+

Real_GDP_mil_equation*0

+

(IF (time<=2010) THEN Real_GDP_mil_data ELSE Real_GDP_mil_equation)*1)

(Bomb, McCormick et al.)
UNITS: Euros (EUR)
Real_GDP_mil_data = GRAPH(TIME

{Euros})
(1990, 2.3e+006), (1991, 2.3e+006), (1992, 2.4e+006), (1993, 2.3e+006), (1994, 2.4e+006), (1995, 2.5e+006), (1996, 2.5e+006), (1997, 2.5e+006), (1998, 2.6e+006), (1999, 2.6e+006), (2000, 2.7e+006), (2001, 2.8e+006), (2002, 2.8e+006), (2003, 2.7e+006), (2004, 2.8e+006), (2005, 2.8e+006), (2006, 2.9e+006), (2007, 3e+006), (2008, 3e+006), (2009, 2.8e+006), (2010, 2.9e+006)
UNITS: Euros (EUR)
Real_GDP_mil_equation = (((35.391*(time-1989) + 2255.3)*1000))*GDP_Constanta

{Euros}
UNITS: Euros (EUR)
Real_GDP_normalized_growth = Real_GDP_mil/Init(Real_GDP_mil)

{unitless}
UNITS: Unitless
Reproductive_lifetime = 30

{years}
UNITS: years (yr)
DOCUMENT: The time interval of the reproductive stock in this model: 15 to 44 years --> 30 years

(Number of years people can reproduce)
30 Years according to German statistical database definition

Unit should be year only
Sexually_productive_period = Productive_Age__Start+Normal_productive_period-Mean_Age_of_Women_Having_Child
UNITS: years (yr)
Shock_Switch = 1
UNITS: Unitless
Test_Policy = If Policy_Switch = 1 then Increasing_Child_Incentives else 0

{EUR/baby}
UNITS: Eur/baby (EUR/baby)
Test_Policy_Empl = If Policy_Switch = 1 then Increasing_Women_Involvement else 0
UNITS: people (person)
TFR_2050 = GRAPH(time)
(2010, 1.39), (2040, 1.20)
UNITS: baby (baby)
Total_immigration_data = GRAPH(time

{person/years})
(1990, 681872), (1991, 602523), (1992, 782071), (1993, 462096), (1994, 314998), (1995, 397935), (1996, 282197), (1997, 93664), (1998, 47098), (1999, 201975), (2000, 167120), (2001, 272723), (2002, 219288), (2003, 142645), (2004, 82543), (2005, 78953), (2006, 22791), (2007, 43284), (2008, -55743), (2009, -12782), (2010, 0.00)
UNITS: person/yr
Total_net_immigration = Immigration__through_policy*0
+
Total_immigration_data

{people/years}
UNITS: person/yr
Total_fertility = Total_Fertility_historical_data *0

+ 2.04 *0

+
Real_Fert_Rate*1

{baby}
UNITS: baby (baby)
Total_Fertility_historical_data = GRAPH(time

{baby})
(1990, 1.45), (1991, 1.33), (1992, 1.29), (1993, 1.28), (1994, 1.24), (1995, 1.25), (1996, 1.32), (1997, 1.37), (1998, 1.36), (1999, 1.36), (2000, 1.38), (2001, 1.35), (2002, 1.34), (2003, 1.34), (2004, 1.36), (2005, 1.34), (2006, 1.33), (2007, 1.37), (2008, 1.38), (2009, 1.36), (2010, 1.39)
UNITS: baby (baby)
DOCUMENT: Source: Statistisches Bundesamt

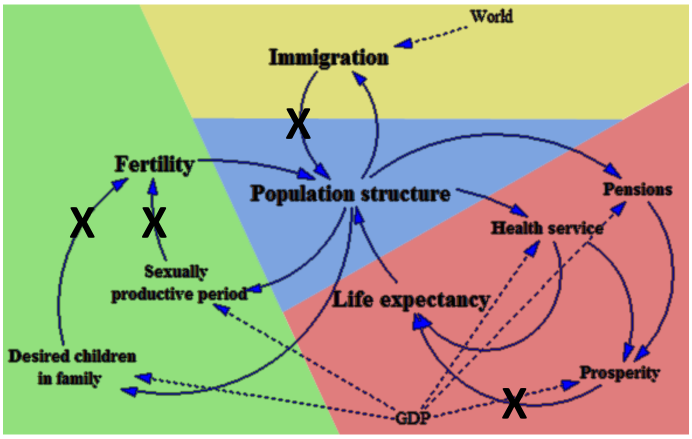
Working_age_population = (Population_15_to_44+Population_45_to_64)
UNITS: people (person)

Zuwachs_0_to_15 = - Deaths_0_to_14 + Births + Net_immigration_0_to_14 - + Maturation__14_to_15
UNITS: person/yr

Appendix B

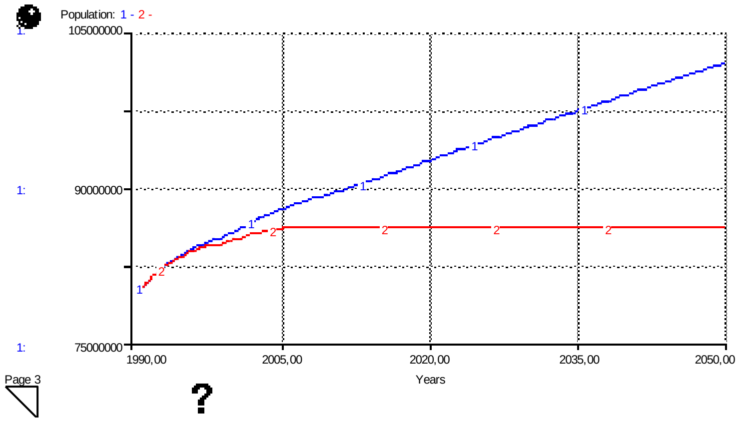
The approach of structure-behavior tests is to cut all loops except one and too examine the remaining behavior of the unseparated loop. Two tests are made for the major feedback loops in the life expectancy subsystem. To extinguish influences of the fertility subsystem the fertility is set to its reproduction level (approximately 2.14) and migration is cut off. The two tests examine how the population behaves if the GDP is on the one hand constant and on the other hand growing.

Test 1: Impact of health service



Figur 11. For the analysis of the health service loop are all other loops cut

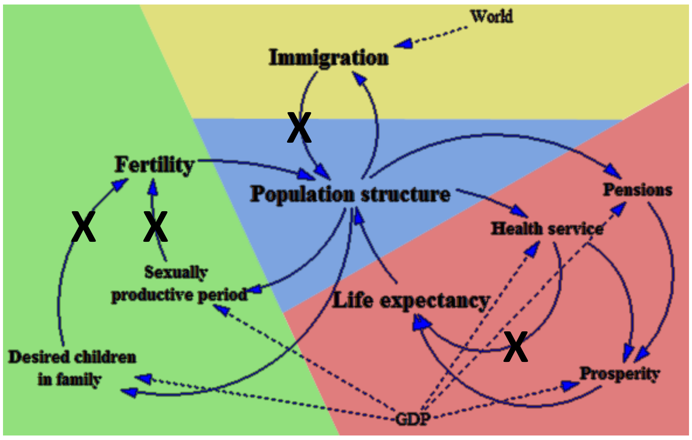
In the first test all loops are cut except the health service loop (figure 11). The effects from the health service variable on prosperity remains also ineffective. In figure 12 the behavior of the population is plotted for dynamic and constant GDP.



Figur 12. Impact of health service: Blue line (1) GDP is growing, red line (2) GDP is constant. Simulation period = 50 years

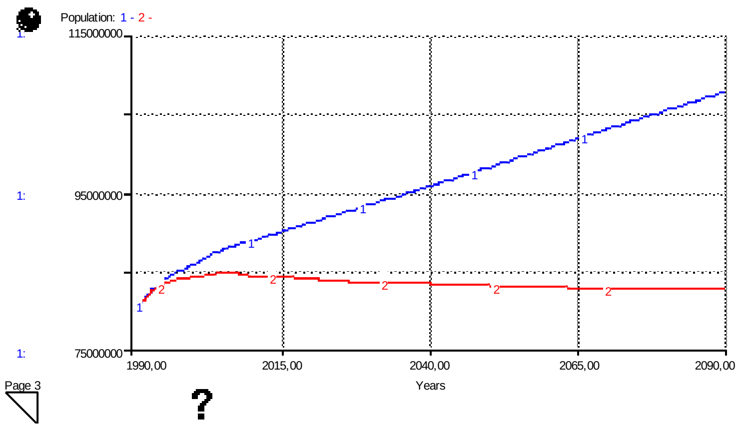
Both curves are as expected. If the GDP is constant, the population amount becomes constant after the asymetric distribution in the population stock has overcome. There is no force which leads to a growth in life expectancy. If the GDP is growing, the population is growing because life expectancy increases as a reason of an improving health care.

Test 2: Impact of prosperity



Figur 13. Proof of the prosperity variable, health service influences prosperity but this variable is not effecting as a multiplier anymore.

Now the effect of the prosperity variable is investigated. The effect from the health service variable on the prosperity is still active. In figure 14 the simulation results are shown.



Figur 14. Impact of prosperity: Blue line (1) GDP is growing, red line (2) GDP is constant. Simulation period = 100 years

The simulated behavior looks similar as the one in figure 12. The explanation is almost the same. The only tiny difference is that the curve with constant GDP shows a small overshoot.

Appendix C: Alternative Methodology Approach

Increasing ratio of elder population over total population especially over working age population attracts many researchers on looking what are its main root cause problems and its consequences. In general, unbalance population age structure because increasing inflow of older population with decreasing inflow of young population over time have bad effects on Germany's economy. Economist and demographers believe that there will be a massive baby boomers retirement in the upcoming year in Germany. Meanwhile, the problem appears when the number of working age population supporting retiree is decreasing. In other words, the Old dependency ratio of Germany is rising, and will continue rising over the year as more and more baby boomers generation reach their pension age. Economist and Demographers call this phenomenon as population ageing reflecting on the condition that average age of Germany population is now increasing because of growing ratio of more older people than young population.

Now this demographic issue becomes more serious when economist and demographers saw potential disastrous effect on economic and social system of Germany. First hit of this demographic structure changing is the pension system, less and less working age population support pension payment for retiree(Coleman and Rowthorn 2011). Economist also believes if the current trend continues they will face even bigger problems like massive reducing of tax income, saving rate, investment rate(Kim and Lee 2008) and causing changing customer behavior.

Two economic papers address similar problem using econometrics, one paper specifically giving detailed descriptive condition on West Germany and United States population ageing(Börsch-Supan and Chiappori 1991). In addition, the second paper gives empirical explanation on how demographic change can cause inverted U-shape growth in economy(An and Jeon 2006).

Börsch-Supan and Chiappori papers explain how the demographical change in Germany and United states occur. This paper investigates Germany and United States system mechanism in labor, financial and housing markets, providing in comparisons between German and US institutions to determine the role of taxes, subsidies and regulations. The results demonstrates that economic policies have powerful effects; some of them are also interact with existing market imperfections, so that a serious consideration of policy options which may moderate the implications of population aging is called for. Author provide statistical table supporting his argument on how important the issue, he also put regression equation in the paper to prove that the correlation between economical and demographical indicators exist. Furthermore, authors engaged discussion in the paper by proposing several policy measures option. He summarized several arguments on the effect of demographical change on economic indicators. The authors put on statistical and mathematical verification on his regression equation. He verified his model by comparing to the historical values and statistical goodness of fit test.

Second Paper delivered by An and Jeon investigates how demographical change can produce different outcome in economic indicators. Authors suggest that economic growth follows Kuznet's hypothesis of age-income profile. They use simple cross-country regression on 25 countries over the period 1960-2000 data.

$$PGDPGR = C + \propto_1 LPGDPINI + \propto_2 INVR + \propto_3 OPEN + \propto_4 EDU + \propto_5 AGESTR$$

where the dependent variable of PGDPGR is log GDP per capita growth rate and the explanatory variables LPGDPINI, INVR, OPEN, EDU, and AGESTR indicate the logarithm of initial GDP per capita, the total investment per GDP, import and export per GDP, average schooling years of the population aged 15 and over, and the variables representing the age structure respectively. Here, LPGDPINI captures conditional convergence and INVR is a measure of physical capital accumulation. Other control variables are meant to detect cross-country differences in the level and rate of growth of technology. In our formulation, we explore the shape of the relationship between demographic change and economic growth in three different functional forms: linear, quadratic and cubic. In addition, authors used statistical goodness of fit test to validate their empirical equation findings.

The empirical findings attempted in this paper show that demographic changes appear to first increase and then decrease economic growth. This can be named as the Demographic U Hypothesis (Curve) — an inverted U-shape relationship between demographic change and economic growth. The economic growth increasing when mean age in population also increasing, but then it start to slow down after certain age and begin to decrease after reaching its peak point. This paper mention Japan as one example how population ageing can harm economic development.

From those two papers mentioned above, we can see how economist and demographers proved there is strong correlation between demographic change and economic development. However, both papers only show one-way relation. In reality, the system works in dynamic feedback mechanism. Therefore, System Dynamics approach would add better understanding on explaining system behavior. Nevertheless, both papers would be a good starting point to develop dynamic hypothesis and providing basis theoretical explanation. Feedback mechanism allows expansion of theoretical explanation from demographic change to economic development to demographic change – economic development – demographic change.

In terms of policy planning, System Dynamics provides broader option rather than parameter changing and sensitivity analysis. Both econometric papers provide policy maker chances on designing policy by changing parameter in the equation. On the other hand, System dynamics approach enhances this parameters changing policy analysis by adding structural new policy structure. This approach provides System Dynamics edge on bringing wishful thinking policy to implementation policy structure. Moreover, white box method that System Dynamics use would present better understanding for actors involved in the decision maker or other interested parties. Therefore, System Dynamics provide better policy analysis instrument to develop robust policy design.

References

An, C.-B. and S.-H. Jeon (2006). "Demographic change and economic growth: An inverted-U shape relationship." Economics Letters **92**(3): 447-454.

Bengtsson, T. and K. Scott (2011). "Population Aging and the Future of the Welfare State: The Example of Sweden." Population and Development Review **37**: 158-170.

Bomb, C., K. McCormick, et al. (2007). "Biofuels for transport in Europe: Lessons from Germany and the UK." Energy Policy **35**: 2256-2267.

Börsch-Supan, A. and P.-A. Chiappori (1991). "Aging Population: Problems and Policy Options in the US and Germany." Economic Policy **6**(12): 104-139.

Bossel, H. (2007). System Zoo 3 Simulation Models: Economy, Society, Development, Books on Demand GmbH.

Buttner, T. and W. Lutz (1990). "Estimating Fertility Responses to Policy Measures in the German Democratic Republic." Population and Development Review **16**(3): 539-555.

Christoph Hendrik Borgmann (2005). Social Security, Demographics, and Risk. Berlin, Springer.

Coleman, D. (2008). "The demographic effects of international migration in Europe." Oxford Review of Economic Policy **24**(3): 452-476.

Coleman, D. and R. Rowthorn (2011). "Who's Afraid of Population Decline? A Critical Examination of Its Consequences." Population and Development Review **37**: 217-248.

David Gordon Smith (2008) "Defusing Germany's Demographic Timebomb." Letter from Berlin.

Erik Pruyt, Thomas Logtens, et al. (2011). Exploring Demographic Shifts: Aging and Migration Exploratory Group Model Specication & Simulation. 29th International Conference of the System Dynamics Society, Washington, DC System Dynamics Societty.

Espenshade, T. J. and J. J. Minarik (1987). "Demographic Implications of the 1986 US Tax Reform." Population and Development Review **13**(1): 115-127.

Jonathan Grant , Stijn Hoorens, et al. (2004). Low Fertility and Population Ageing: Causes, Consequences, and Policy Options. Santa Monica, RAND Corporation**:** 97.

Kim, S. and J.-W. Lee (2008). "Demographic changes, saving, and current account: An analysis based on a panel VAR model." Japan and the World Economy **20**(2): 236-256.

Lee, R. and A. Mason (2010). "Fertility, Human Capital, and Economic Growth over the Demographic Transition." European Journal of Population/Revue européenne de Démographie **26**(2): 159-182.

Legge, J. S., Jr. and J. R. Alford (1986). "Can Government Regulate Fertility? An Assessment of Pronatalist Policy in Eastern Europe." The Western Political Quarterly **39**(4): 709-728.

Matthias Eisenmenger, Olga Pötzsch, et al. (2006). Germany´s population by 2050 (Results of the 11th coordinated population projection). Für die Bundesrepublik Deutschland. Wiesbaden Statistisches Bundesamt.

Oeppen, J. and J. W. Vaupel (2002). "Broken Limits to Life Expectancy." Science **296**(5570): 1029-1031.

Sinding, S. W. (2009). "Population, poverty and economic development." Philosophical Transactions of the Royal Society B: Biological Sciences **364**(1532): 3023-3030.

Statistisches Bundesamt (2011). Statistisches Jahrbuch 2011. Für die Bundesrepublik Deutschland. Silvia Krings u. a. Wiesbaden Statistisches Bundesamt.

Sterman, J. (2000). Business dynamics: systems thinking and modeling for a complex world, Irwin/McGraw-Hill.

Tapia Granados, J. A. and E. L. Ionides (2008). "The reversal of the relation between economic growth and health progress: Sweden in the 19th and 20th centuries." Journal of Health Economics **27**(3): 544-563.

Thyrian, J. R., K. Fendrich, et al. (2010). "Changing maternity leave policy: Short-term effects on fertility rates and demographic variables in Germany." Social Science & Medicine **71**(4): 672-676.

Ulla Schmidt (2006). Health Policy and Health Economics in Germany. G. F. M. o. Health. Minneapolis, Center for German & European Studies, University of Minnesota.

Van Dalen, H. P., K. Henkens, et al. (2010). "Productivity of Older Workers: Perceptions of Employers and Employees." Population and Development Review **36**(2): 309-330.

Weber, L. (2010). Demographic Growth Model

Demographic Change and Economic Growth, Physica-Verlag HD. **0:** 167-213.