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POLICY CREDIBILITY IN NUMERICAL OVERLAPPING GENERATIONS MODELS

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ABSTRACT: Numerical overlapping generations models contain inherent tools for analyzing the credibility of policy measures. We demonstrate this by studying the credibility of reducing pension benefits and raising the retirement age. Standard policy analysis requires that future paths of policy variables are known with certainty. This is implausible as regards a reduction in pensions, since in most periods a majority of adults would gain by increasing the benefit level. As regards raising the retirement age this presumption is much more credible. The results are sensitive to, for example, the initial wealth distribution and demographic factors. We then search for an equilibrium level of pension benefits which the majority wants neither to increase nor to decrease. This benefit level can be very sensitive to the openness of the economy and the rules of the pension system. The analysis may shed light not only on credibility questions but also on the weaknesses of numerical OLG models and be used in calibration.

KEY WORDS: Majority voting, pension policies, numerical overlapping generations model

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TIIVISTELMÄ: Numeerisia limittäisten sukupolvien simulointimalleja voidaan käyttää apuna tutkittaessa, kuinka suuri osa äänestäjäkunnasta kannattaa tai vastustaa eri toimenpiteitä. Tutkimuksessa asiaa havainnollistetaan analysoimalla eläkejärjestelmän muutosten vaikutuksia. Verrattaessa eri politiikkavaihtoehtoja rationaalisten odotusten malleilla oletetaan yleensä, että politiikkamuuttujien urat tulevaisuudessa ovat eksogeenisesti annettuja. Oletus ei vaikuta uskottavalta esimerkiksi eläketason alentamisen suhteen, koska useimpina periodeina tulevaisuudessa kulloisenkin äänestäjäkunnan enemmistö hyötyisi eläketason korottamisesta. Eläkkeellejäämisiän korottamisen suhteen asia on toinen: enemmistö kannattaa korottamista lähes kaikkina tulevinakin periodeina. Kahden kiinteän vaihtoehdon tarkastelun jälkeen tutkimuksessa haetaan sellainen eläketason tasapaino, jota enemmistö ei halua korottaa eikä alentaa. Tällaisen eläketason korkeus on herkkä talouden avoimuutta kuvaaville piirteille ja eläkejärjestelmän säännöille. Politiikan uskottavuuskysymysten lisäksi tämäntyyppinen analyysi voi paljastaa mallien puutteellisuuksia ja auttaa kalibroinnissa.

ASIASANAT: Enemmistöpäätökset, eläkepolitiikka, numeerinen limittäisten sukupolvien simulointimalli

SUMMARY

Dissatisfaction of the constituents regarding any proposed or actually made policy change may well have far-reaching consequences on the domestic political scene. Thus it may be important to estimate the number of winners and losers, and perhaps also the magnitudes of the wins and losses, among the current voting-age population. Some policy changes cannot be made because of their consequences; some can. The policies are actually endogenous, although in standard analysis they are regarded as exogenous.

Numerical OLG simulation models can be applied in a straightforward manner to public choice issues. The models contain sufficient ingredients, as they are normally used to analyze changes in intergenerational distribution. It is to be expected that using these models to endogenize policy decisions will have impacts on the model development also.

We analyse the effects of a reduction in the pension benefit level and an increase in the retirement age using a Finnish overlapping generations numerical simulation model. When the pension system is changed, the utility of an individual may change because of four effects. First, nominal pension incomes change. Second, compensation from work changes, both because payroll taxes change and because the effects of working on future pensions may change. Third, consumption prices change. And fourth, the initial wealth changes because the value of firms is re-evalued in the asset market. The total effect determines each voter's attitude towards the change in the pension system. Our analysis shows that increasing the retirement age is more popular than reducing the benefit level if different methods of lowering the contribution rate are compared.

The economy described by the model has a voting equilibrium pension level, which the majority wants neither to increase nor decrease. The responsiveness of the interest rate to the current account is extremely crucial. The voting equilibrium pension level is the higher the more inelastic the interest rate is. A small open economy with free capital movements may have a very high voting equilibrium. The aggregating period of the pension system is also important. The voting equilibrium pension level rises significantly the longer the aggregation period. Wealth effects are important and may even dominate the decisions of the median voter over a wide range of initial pension levels.

Numerical simulation models can study the credibility, from a future voting point of view, of any given policy path compared to a set of specified alternatives. The analysis requires a dynamic model, because the important voters are those living when the policy change is made or proposed, and by definition this situation is not a steady state.

With some parameter values only very high pension benefit levels would be credible. As the levels are higher than those observed in reality, one might conclude that the model is not well specified or calibrated. Adding altruistic features into the households´ utility functions would perhaps produce more sensible results. It probably would also change all standard policy analysis results. Indeed it is hard to imagine a feature of the model that would systematically affect the voting results without affecting policy analysis results. Thus credibility simulations should become a standard part of policy analysis in overlapping generations models.

YHTEENVETO

Enemmistön etu on usein tärkeä tekijä talouspolitiikkaa suunniteltaessa ja siitä päätettäessä. On useita talouspoliittisia toimenpiteitä jotka pitkällä tähtäimellä ovat hyödyllisiä mutta joita on vaikea panna toimeen koska lyhyellä tähtäimellä äänestäjäkunnan enemmistö vastustaa niitä. Monet julkisen talouden säästötoimet kuuluvat tähän ryhmään.

Numeerisia limittäisten sukupolvien simulointimalleja käytetään yleisesti selvitettäessä eri toimenpiteiden vaikutuksia sukupolvien väliseen tulonjakoon ja hyvinvointiin. Mistä tahansa politiikkatoimenpiteestä voidaan suoraan sanoa mitkä ikäryhmät hyötyvät ja mitkä ikäryhmät kärsivät. Jos mallissa eri ikäryhmät ovat edustettuina väestöosuuksiensa mukaisin painoin, voidaan mallilla arvioida enemmistön äänestyskäyttäytymistä, kun oletetaan jokaisen äänestävän oman etunsa mukaisesti. Täten mallilla voidaan arvioida sekä eri politiikkatoimenpiteiden suosiota että muuttaa talouspolitiikka endogeeniseksi, enemmistöpolitiikalla päätettäväksi. Tällaiseen politiikka-analyysiin liittyy kuitenkin suuria vaikeuksia.

Tutkimuksessa havainnollistetaan tämäntyyppistä talouspolitiikan analyysia. Esimerkkinä käytetään eläkepolitiikkaa. Suomen taloutta kuvaava numeerinen simulointimalli on kehitetty ETLAssa, yhteistyössä sosiaali- ja terveysministeriön kanssa. Eläkejärjestelmä kuvaa suomalaista TEL-järjestelmää.

Kun eläkejärjestelmää muutetaan, vaikutukset yksilön hyvinvointiin tulevat useaa kautta. Ensinnäkin eläketulot muuttuvat. Toiseksi työstä saatava kompensaatio muuttuu, sekä eläkemaksujen muuttumisen vuoksi että kertyvässä eläketurvassa tapahtuvien muutosten vuoksi. Kolmas vaikutuskanava on kuluttajahinnat, jotka reagoivat mm. työvoimakustannusten muutoksiin. Neljäs vaikutustapa tulee varallisuuden arvonmuutosten kautta: hintojen ja kustannusten muutokset näkyvät osakemarkkinoilla tuotto-odostusten muutoksina ja siten osakkeiden hintojen muutoksina, ja osakkeiden omistajien varallisuus muuttuu. Eri ikäryhmissä näistä tekijöistä tuleva kokonaisvaikutus on erilainen, ja suhtautuminen muutoksen aiheuttaneeseen toimenpiteeseen on siten erilainen. Analyysi osoittaa, että tulevaa eläkerasitusta pienentävistä vaihtoehdoista eläkkeellejäämisiän korottaminen on äänestäjäkunnan enemmistöä hyödyttävää politiikkaa ja siten suositumpi toimenpide kuin eläketason laskeminen, josta enemmistö kärsisi.

Tutkimuksessa etsitään sellainen eläketason tasapaino, jota enemmistö ei halua korottaa eikä alentaa. Tällaisen eläketason suuruus on herkkä talouden avoimuutta kuvaaville piirteille. Erityisesti kotimaisen korkotason riippuvuus vaihtotaseesta on tärkeä. Pienessä avotaloudessa joka voi ilman kohoavaa korkotasoa lainata pääomia ulkomailta on eläkkeiden äänestystasapaino hyvin korkea. Myös eläkejärjestelmän säännöt ovat merkittävä tekijä: eläkkeiden määräytymisperiodin pidentäminen mm. nostaa eläkkeiden äänestystasapainoa.

Politiikka-analyysi vaatii dynaamista mallia, koska toimenpiteitten vaikutukset ovat erilaisia tekohetkellä eläville kansalaisille ja tuleville sukupolville. Politiikan uskottavuuskysymysten lisäksi tämäntyyppinen analyysi voi paljastaa limittäisten sukupolvien mallien puutteellisuuksia ja auttaa kalibroinnissa.

1. Introduction

We concern ourselves here with changes in policy, changes in intergenerational distribution, and political pressures. The first link is between changes in policy and intergenerational distribution. This is a standard issue addressed in most studies of policy effects using overlapping generations models. Any policy change affects different age groups differently, changes their lifetime utilities and thus changes the intergenerational distribution.

The second link between changes in intergenerational distribution and political pressures expresses the fact that the dissatisfaction of the constituents regarding any proposed or actually made policy change may well have far-reaching consequences on the domestic political scene. Thus it may be important to estimate the number of winners and losers, and perhaps also the magnitudes of the wins and losses, among the current voting-age population. Some policy changes cannot be made because of their consequences; some can. The policies are actually endogenous, although in standard analysis they were regarded as exogenous. A recent example coming from the Netherlands is a case in point: The Social Democrats proposed cuts in pensions, two political parties were formed in a matter of weeks to oppose the cuts, pensioners deserted some old parties in droves, and the proposed cuts became infeasible.

There is a well-established pattern in using numerical OLG models in economic policy analysis, starting from Auerbach and Kotlikoff (1987). For pension policy analysis, which we shall use as an example, see Bovenberg, Broer and Westerhout (1992), Jensen and Nielsen (1992), and Chaveau and Loufir (1994). The characteristic feature of all numerical OLG model solutions is a rational expectations, perfect foresight equilibrium. Intergenerational distribution is one of the key points of view in OLG models. As explicit utility functions are formulated for the households, it is straightforward to calculate which generations win and which lose. But there the analysis usually ends. Questions such as whether the policy decision will be made if there are many losers are not studied.

These questions are studied theoretically in the public choice literature, a short review of which is included in the next section. The questions can, however, be brought to numerical OLG models in a straightforward manner, as the sufficient ingredients are already in the model. Essentially it requires summarizing the winner-loser balance of the current working-age population.

We combine the two strands of research by bringing voting decisions to numerical simulation models. Pension policy is especially suitable for this kind of analysis. The alternatives, though perhaps not the consequences, are clear and concrete even to the layman. The results show that numerical models are indeed inspiring tools for studying these difficult questions.

The structure of the paper is as follows. Section 2 contains a brief survey of the public choice literature. Section 3 covers the analysis between two fixed policy alternatives, using the reduction of pension levels and an increase in retirement age as examples. In Section 4 we define and analyze the voting equilibrium level of pensions. Concluding remarks are presented in Section 5. A description of the simulation model is included in the Appendix.

2. Social security in the public choice literature

Verbon (1993) notes that voting power helps explaining public pension schemes in most contributions in the literature of public choice. Those contributions rely mainly on simple theoretical overlapping generations models. He finds also three other factors that determine the existence and scale of pension systems.

The first of them is that the young generations perceive a positive relationship between their contributions to the system and the benefits they expect to get themselves when they are old. In many studies this relationship have just been assumed to exist without further analysis. Browning (1975) and Boadway and Wildasin (1989a,b) assume that the young voters support the existence of a pension system, because they believe the voted system to remain unchanged indefinitely. The assumption is explained by infrequent voting or noting that the analyses applies only to steady states. Another possibility is to rely on a social contract or on a constitutional arrangement that ties the hands of the next voting majority. Verbon (1987) and van Dalen and van Praag (1993) relate the future levels of social security positively to the current level with declining weights. Also in Hu's (1982) analysis the link between the current and future level of social security is positive, but uncertain.

The second factor explaining public pensions is intergenerational altruism. Barro's (1974) classic model is based on an extreme assumption that the child's marginal utility is included in the parent's utility function. The other extreme is a pure life cycle model without bequests to descendants or gifts to parents. Cuckierman and Meltzer (1989) show how the extent of intergenerational distribution in a political equilibrium depends on the strength of the voter's bequest motive and on the general equilibrium effects of the policy. If an older voter wants to, and is prevented to leave negative private bequests, he is in favour of public transfers from young to old.

The third factor is heterogeneity of voters within generations. The majority of pension systems lead to intragenerational redistribution if individuals in the same generation have different abilities or wealth. In Tabellini's (1990) model poor altruistic young people are in favour of the public pension system because it helps them to support their parents.

The focus of Verbon and Verhoeven's (1992) analysis is similar to ours. They claim that the effects of future shocks, like demographic changes, to the existence of the pension system can be studied in a way which is consistent with the assumption of perfect foresight. The agents in the two-period OLG model anticipate the future majorities in favour or against the pension system and react accordingly.

The problem with the earlier studies seems to be that intergenerational transfers include complicated general equilibrium effects, which cannot be studied with theoretical models in a satisfying way. The utility changes and therefore also the supporting majorities of a policy reform depend essentially on the structure and dynamics of the economy. Also the use of very simple two-period simulation models, as Holz-Eakin (1993), cannot give enough information.

The novelties and limitations of our analysis can be reflected to the above mentioned earlier contributions. Our twelve-period numerical OLG model is loosely calibrated to imitate the Finnish economy. Parents get utility from giving bequests, but the amount of bequests is not linked to the descendant's utility. We have in this model version just one type of household, so the focus is on intergenerational aspects.

We do not solve the whole path of voting decisions. Instead we analyse firstly if an exogenously given pension policy change is likely in some period assuming that it is permanent. Secondly we try to find out if there is a pension level that will not be changed by majority voting, and we do find one. Thirdly we study how this equilibrium level depends on the features of the economy.

Our simulations with a full scale dynamic CGE model show that, for example, different assumptions on the openness of the economy lead to a totally different amount of support for various pension policy measures. We see therefore that this kind of analysis can shed light on many important questions which have been either impossible to solve or totally neglected in the traditional public choice literature.

3. Comparisons between two alternatives

3.1. Main features of the model

We analyse the effects of a reduction in the pension benefit level and an increase in the retirement age using a Finnish OLG model. The analysis is presented more closely in Lassila, Palm and Valkonen (1995). The model is described in more detail in the Appendix, but its main features are as follows.

- overlapping generations of households, each maximising lifetime utility with respect to consumption and labour supply,

- forward-looking value-maximizing firm sector, choosing the optimal path of investment, use of labour and intermediate goods and producing a domestic good which can be exported and which is an imperfect substitute for the imported good,

- government sector, collecting taxes and producing public services, which are provided free of charge and are not taken into account in individual utility considerations,

- a pension fund, paying the pensions and collecting contributions from both workers and employers. The latters' rate is endogenous and balances the fund's budget each period,

- the rest of the world, with which goods can be traded and capital moved. The price elasticity of the foreign demand for the domestic good and the sensitivity of the domestic interest rate to differences in aggregate saving and investment can be changed by parameter adjustment.

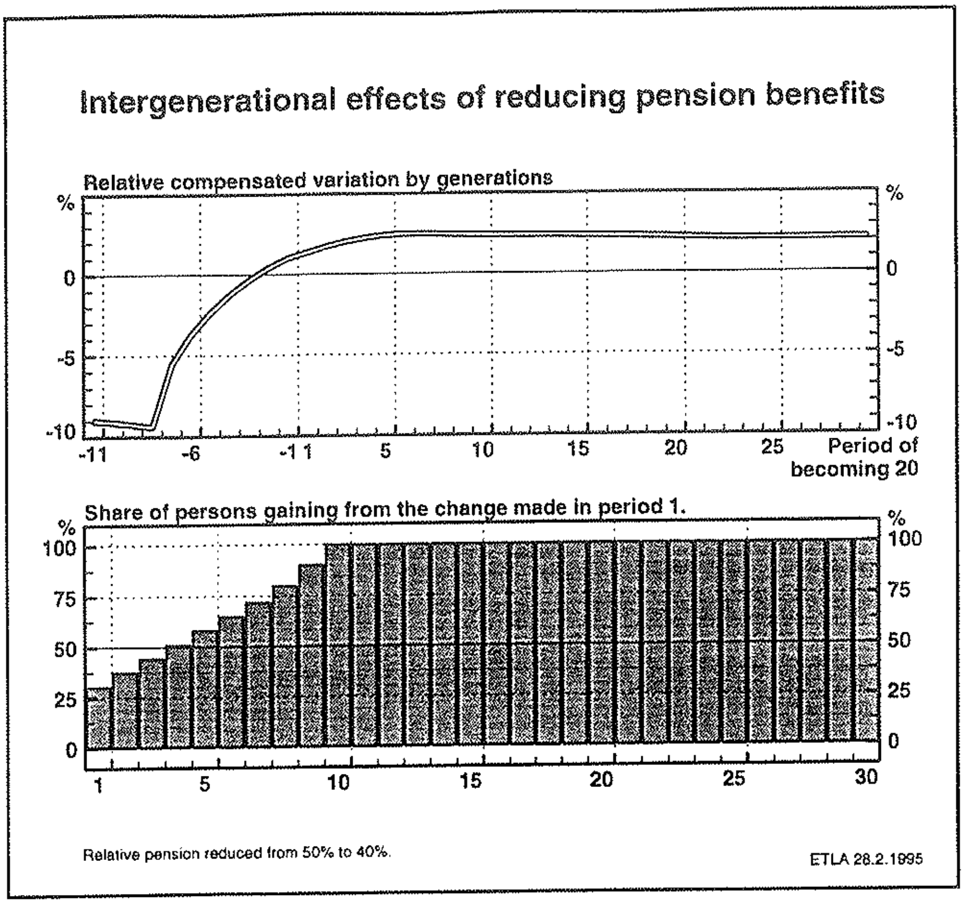
- equilibrium in labour, goods and financial markets in each period, with all expectations fulfilled.

3.2. Example 1: Credibility of reduction in pension benefit level

The average earnings-related pension is nowadays about 50 % of the reference wage, which is based on earnings during the work-years and partially indexed to current wages. We simulated the effects of a pension benefit level reduction from 50 to 40 per cent of the reference wage.

The welfare loss of the retired generations is not as large as could be expected. This is because of the reverse wage and wealth effects. The wage effect is generated by lower firms' pension contributions, which induce a higher wage level and therefore also a higher pension level. The wealth effect is caused by the increase in the labour supply, which generates lower unit labour costs, higher profitability and thereby higher value of the firms, which are owned largely by the older generations. In spite of these positive general equilibrium effects, also some middle-aged generations suffer a welfare loss because of the cut in their future pensions.

The welfare gain of the young and future generations are due to at least three reasons. Firstly, the link between individual's labour supply and pension level is weak in the model, and down-sizing the pension system reduces the distortion in the labour supply and increases welfare. Secondly, downsizing the pension system reduces also the intergenerational transfer to older generations due to unfavourable demographic trends. Thirdly, the temporary increase in the savings of retired and middle-aged generations induces a current account surplus, lowers the net foreign debt and thereby generates a permanent improvement in the terms of trade of the country. This change in the terms of trade increases the domestic future generations' welfare at the expense of their foreign trading partners.



The accompanying chart sums up the intergenerational aspects. The upper part of the chart shows relative compensated variations by generations, measured as $100(\ln E_s - \ln E_c)$, where E denotes discounted lifetime consumption expenditure, s refers to the simulation run and c is consumption necessary to achieve the baseline utility at simulation prices. Many current generations lose, especially current pensioners. Future generations would gain.

The lower part of the chart shows that the majority of the current population, about 70 per cent, would suffer from the reform, whereas in the future everybody would gain. If the adults living for instance in period 10, fifty years from now, look back at the present time and evaluate whether they have won or lost from the pension reduction made at period 1, they will all be glad that the reduction was made. But they will not create any political pressure during period 1. From the point of view of political pressures, only the first period value of the indicator is important, as it sums up the winners and losers in the current period, and no other voters are present in period 1. The current majority would probably prevent the reform.

We assume that voting is possible each period. That means that any policy measure or change can be implemented if a majority finds it advantageous. As for the individual choices, we assume that lifetime utility is the basic factor. That may well include elements like the welfare of future generations, bequests and so on, but regardless of the utility functions, the decision concerning any possible measure depends on whether it increases or decreases lifetime utility.

Assume that we opt for the path that is preferred by the current households. 'Preferred' refers to lifetime utility calculations between the two alternatives, where in both cases the future path of policy variables is believed with certainty. We may now ask whether the chosen path will still be chosen in the next period, against the alternative of choosing the other possible value of policy variable in the next period and staying on that path thereafter. Then we can move on to the following period, and repeat the exercise. By calculating the share of winners we get a series of numbers, one for each period. Call this the ***voting indicator***. It is only defined against an alternative which consists of a set of future paths, each starting from the preferred path but at different points in time.[1]

The following chart presents how large a share of households would gain in each period from a reduction in benefits. The reduction is made in the corresponding period presuming that the history up to that period is the unreduced 50 % benefit level, while a reduced 40 % benefit level would (be believed to) prevail from that period on. The chart is based on a sixty period baseline run with a 50 % benefit level, and 20 simulation runs (with a 40 % benefit level) around the baseline, each starting from a different period.

In most periods a minority would gain from leaving the 50 % level permanently. There are nevertheless exceptions in periods 2, 3 and 4. They are the results of both the initial wealth distribution and the varying sizes of age cohorts.

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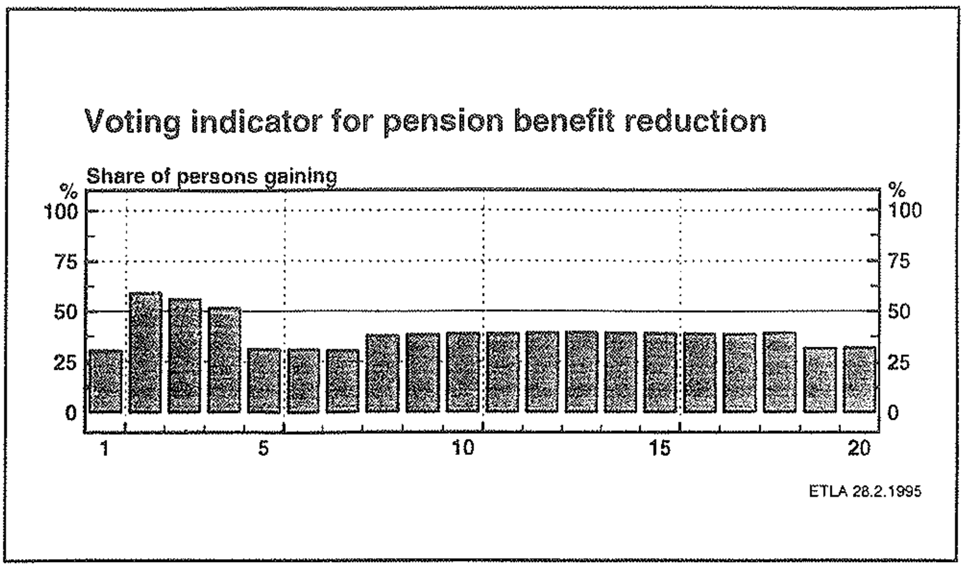
1 Again, there is no shortage of possible alternatives even in this simple setup. Besides studying whether it will be worthwhile to move from policy A to policy B at time t, one could also study whether it is good to decide at time t that a move from A to B will be made at t+s, where s = 1,2,... .

If initially, at the start of period one, some cohort has a large amount of wealth, it may be that the price effects are more important to lifetime utility than wage and pension effects. A cut in pensions leaves room for higher wages as pension contributions decline. Labour costs may still decline and prices fall. Although pensions fall, the real value of initial wealth may make it advantageous even to those already on a pension. In this analysis all pensioners suffer but some cohorts near the retirement age benefit, as reflected in the chart.



The results concerning periods after period 4 are unanimous: the majority would suffer. Indeed in the steady state 2/3 of the households would suffer, and reversing the analysis a vast majority would gain from increasing the benefit level to a very high level. This issue is dealt with in the next section.

The results in the chart indicate that at time period 2 a reversion of the policy is likely. Then we must come back to period one (the current period) and formulate the policy path 1 differently: it consists of benefit variable level of 50 % until period 2, and from then on it consists of a benefit level of 40 %. Then we start from the beginning and compare policy path 1 to a path where the benefit is kept at 50 %, and go through all the phases as before. It is likely that there is a further reversal of policy, perhaps in period 5, and benefits are raised to 50 % and kept there. Iterating this schema we hopefully end up with a politically robust path 1 with respect to some alternative paths.

If path A is preferred to path B and will thus be voted for, the calculations made at the present time concerning path B are based on erroneous expectations. This is inconsistent with the perfect foresight, rational expectations notion of the model. In practise we have at least two possibilities. Firstly, the analysis is valid but people have erroneous expectations. This is not desirable in an otherwise rational expectations, perfect foresight setup. Secondly, people in fact do form some sort of credible policy paths in their minds. In this case the standard analysis gives incorrect and perhaps misleading results, and it would be better to compare two paths that are different from each other only for a limited period, not permanently. This may have practical relevance. Effects of policy measures may of course be quite different when the policy is permanent than when it is reversed at some time in the future.

There is a close analogy to the time inconsistency problem. Standard solutions for this problem are commitment and reputation building. Commitment can be interpreted as minority power, that is, some changes need, for example, a two-thirds majority. This may in some cases restore the possibility that an inferior alternative can be believed with certainty, because a sufficient majority is not found to implement the better alternative. Reputation building perhaps reflects the strength of the implicit social contract. One government cannot, however, build a reputation for pension questions. A third option would be that the policies considered, at least the one which the standard analysis shows to be 'best', would be optimal in the sense that the model could not produce better alternatives for any majority in any period. Policy variables perhaps could be optimized, using e.g. the median voter approach. This line is attempted in the next section. It may well be that no optimum could be found, because a majority can prefer A to B, B to C and C to A.

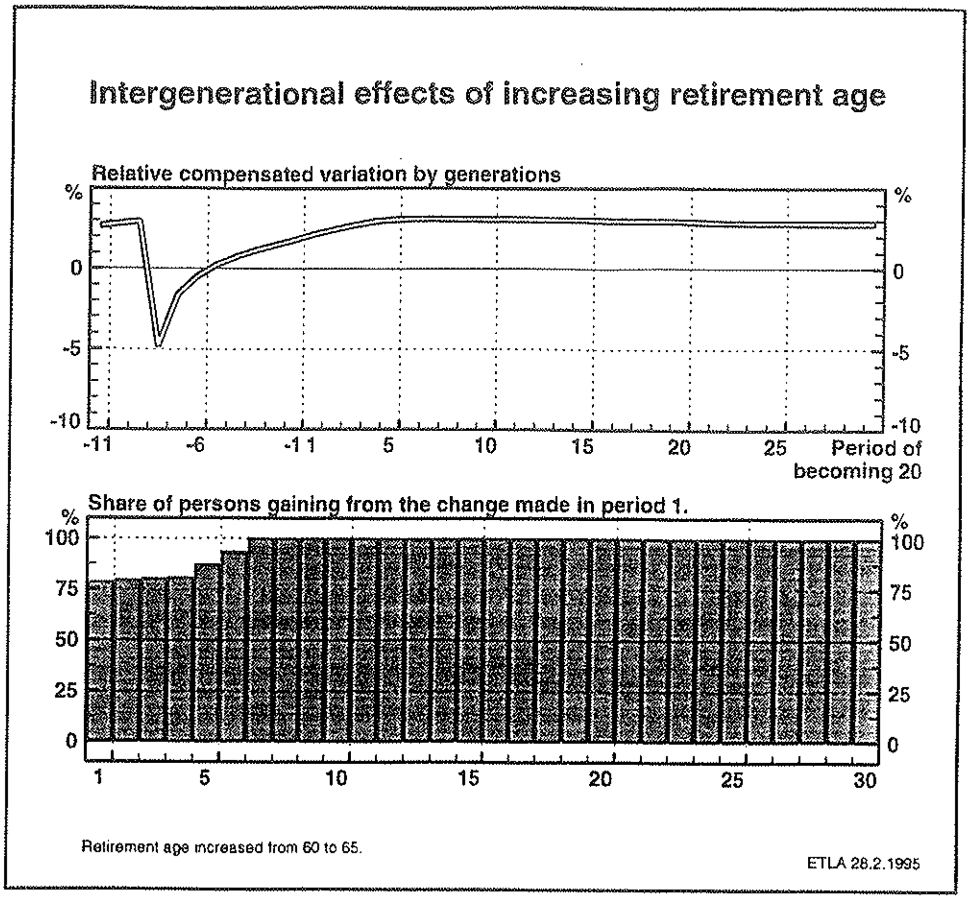
The reduction in pensions in the analysis above was implemented very crudely, namely as a surprise and effective at once. There are other possible policies, such as **preannounced benefit reduction**. Consider a reduction in pension benefits implemented in some future period, although the decision is made now. This may be stated as the reduction in the accrual of pension benefits. Now a majority of current households will probably benefit from the reform. Young generations will benefit as before, and old generations due to the advantageous effects that come from the anticipated future change. Some generations still suffer, namely those whose retirement is not far away. This kind of reform is much more likely to be actually made than the immediate reform considered earlier.

A possible time inconsistency arises when we analyze preannounced policy effects. We should compare this policy option to one where the actual lowering is postponed further. It may be that no policy path is credible, when compared to the alternative of further postponing: further postponing is not credible beacause of the possibility of still further postponing etc., so no postponing is credible. But then they should not be used as if they are believed with certainty, which seems to make the analysis self-contradictory. Where would this lead us? One interpretation is that nobody believes that the change will ever be made, so there are no expectational effects, and as the actual change is never made, the baseline path is really the only possible path. An analogous reasoning led Boadway and Wildasin (1989 b) to conclude that the existence of positive pension levels cannot be explained by a majority approach, because in each period a postponement of the creation of pensions could be preferred to the immediate establishment of the system.

3.2. Example 2: change in the retirement age

The ageing of the population in western countries has forced politicians to search for measures to lengthen the working age. In Finland the problem is most urgent. The demographic trends here are extremely unfavourable and the average actual retirement age is only 59 years.

In this example we try to find out if people would vote for the higher or lower retirement age if they knew all the consequences of the measure. Let us first look at the possibility of raising the official retirement age from 60 to 65 years. The chart below shows that this policy change is credible. A majority would support the reform.

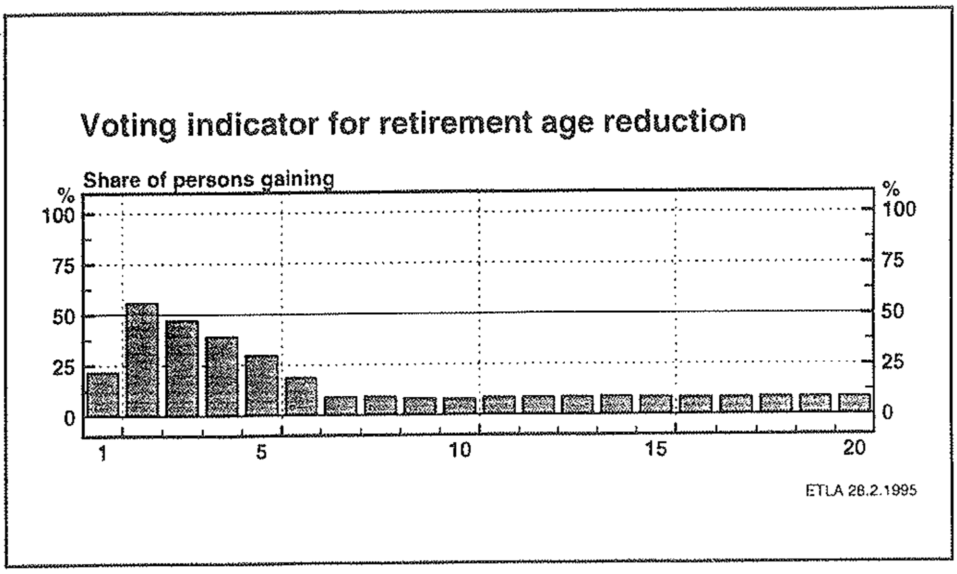


The reason for the support is that raising the retirement age has favourable economic consequences. The retirement age is crucial to the contribution level, as it affects the worker - pensioner ratio in two ways. The reform both increases the number of workers and decreases the number of pensioners. If the pensions are paid and contributions collected on the basis of a balanced pay-as-you-go system, the contribution rate can be lowered markedly. Firms react to this by raising wages, which leads to a higher labour supply and consumption of the wage-earners. Also the pensioners gain, because their pension is indexed to wages. Higher total consumption weakens the current account balance, but in this simulation it has no effects on interest rates.

The reform changes the intergenerational income distribution considerably. All existing pensioners win, as described above. The only generation that is likely to lose is the one that would otherwise retire in the next period, namely workers aged 60-64. They have to work an extra period even though their productivity has already declined and they lose one period's pension. The loss of utility from that outweighs the benefit that comes through higher pensions.

The youngest generations are in favour, because they can benefit the longest time from the positive economic consequences of the higher retirement age. For the generations between, it is more likely that they support the reform as time passes. One reason for this is that the age group of 60-64 becomes rapidly larger as the population ages, and it benefits the economy more to carry out the shift. In the steady state everyone gains.

If it is likely that the retirement age will be lifted in period one, how likely is it that it will be lowered again in the next period? The answer can be seen in the voting indicator chart below and in the table on the next page. The only period when a majority of citizens would vote for an immediate reduction in the retirement age is period two. The reason for the mild support is, of course, the unfavourable economic consequences. The age structure effects are now reversed, so that it becomes more unlikely for the decision to come true when time passes. In the steady state only those aged 60-64 would support the measure. It seems that if the decision to lower the retirement age is not made soon, it will never be carried out.



Demographic trends and lowering the retirement age

The table below describes the shares of cumulative age groups. The first group from the left is those who most certainly win in the reform, namely 60-65 year old citizens. The underlying age structure is a stylized version of a Finnish population forecast in the sense that people die at the age of 80 and the birth rate is stabilised after 50 years.

The shadowed numbers show the percentage of the people who gain from lowering the retirement age by five years. In the five years period starting from the year 1993 those who are between 50 and 64 years would vote for lowering the retirement age. The only period where a majority of citizens would vote for the reform is the second one. It is interesting to note that this age group is not the largest until the next period. The population is in a steady state after the year 2128. Then less than ten per cent of the population supports the measure.

The share of the people gaining from the lower retirement age

year	AGE60-64	AGE54-64	AGE50-64	AGE45-64	AGE40-64	AGE35-64	AGE30-64	AGE25-64
1993	0.068398	0.138287	0.216855	0.314122	0.433879	0.54606	0.652829	0.75769
1998	0.06706	0.142447	0.235776	0.350685	0.458324	0.56077	0.661386	0.750332
2003	0.072188	0.161556	0.271589	0.37466	0.472759	0.569105	0.654276	0.734188
2008	0.086958	0.194023	0.294315	0.389768	0.483516	0.56639	0.644147	0.725476
2013	0.105115	0.20358	0.297294	0.389335	0.470699	0.54704	0.626888	0.706071
2018	0.096704	0.188742	0.279136	0.359045	0.434021	0.512441	0.590207	0.667058
2023	0.091506	0.181377	0.260824	0.335365	0.413332	0.490648	0.567054	0.644734
2028	0.091052	0.171543	0.247065	0.326056	0.404388	0.481798	0.560499	0.634581
2033	0.083256	0.161371	0.243075	0.324099	0.404168	0.485572	0.562199	0.635964
2038	0.080341	0.164372	0.247704	0.330054	0.413777	0.492587	0.568453	0.643748
2043	0.086073	0.17143	0.25578	0.341538	0.422262	0.499972	0.577096	0.654059
2048	0.087433	0.173835	0.261679	0.344367	0.423968	0.502968	0.581803	0.660393
2053	0.087715	0.176894	0.260838	0.341648	0.421848	0.501882	0.581665	0.660144
2058	0.090231	0.175166	0.256929	0.338076	0.419054	0.499779	0.579183	0.656093
2063	0.086393	0.169561	0.252101	0.334468	0.41658	0.497347	0.575578	0.651646
2068	0.084588	0.168538	0.252313	0.335827	0.417975	0.497542	0.57491	0.65114
2073	0.085317	0.170457	0.255331	0.338816	0.419679	0.498307	0.575779	0.65284
2078	0.086686	0.173102	0.258104	0.340436	0.420492	0.499371	0.577832	0.656257
2083	0.08751	0.173587	0.256961	0.33803	0.417908	0.497362	0.57678	0.656198
2088	0.086879	0.171028	0.252851	0.333472	0.413665	0.493822	0.573978	0.654135
2093	0.084882	0.167417	0.248739	0.329631	0.410485	0.491339	0.572193	0.653048
2098	0.083245	0.165265	0.246851	0.3284	0.409949	0.491498	0.573047	0.654595
2103	0.082708	0.164977	0.247209	0.329442	0.411674	0.493906	0.576138	0.65837
2108	0.082841	0.165644	0.248447	0.33125	0.414053	0.496856	0.579659	0.662462
2113	0.083146	0.166292	0.249438	0.332584	0.41573	0.498876	0.582022	0.665168
2118	0.08329	0.16658	0.24987	0.33316	0.41645	0.49974	0.58303	0.66632
2123	0.08333	0.16666	0.24999	0.333321	0.416651	0.499981	0.583311	0.666641
2128	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667
2133	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667
2138	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667
2143	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667
2148	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667
2153	0.083333	0.166667	0.25	0.333333	0.416667	0.5	0.583333	0.666667

4. Voting equilibrium pension level

4.1. Defining and finding the voting equilibrium

In the previous section we noticed that when comparing two policy alternatives, one is usually preferred to the other by the current generations. A natural question then is whether there is a value for the policy variable in question that is preferred to all other values. We are looking for a pension level which the majority of voters wants neither to increase nor to decrease. In each voting situation there are again only two exogenously given alternatives. So there are no complications of the effects of voting order or a third alternative.

The basis of the voting is, as mentioned above, an individual's lifetime utility. There is, however, no guarantee that the preferences of the voter are single-peaked when the general equilibrium effects of the pension reform are taken into account. This means that we cannot restrict the analysis to the behaviour of the median voter. In all the simulations we have done, however, the deciding group of voters is always the same: those aged 45 - 50, which is the median age group. Our results also show that the median voter can be surprisingly indifferent between the alternatives, even though the reform can induce large changes in other generations' welfare.

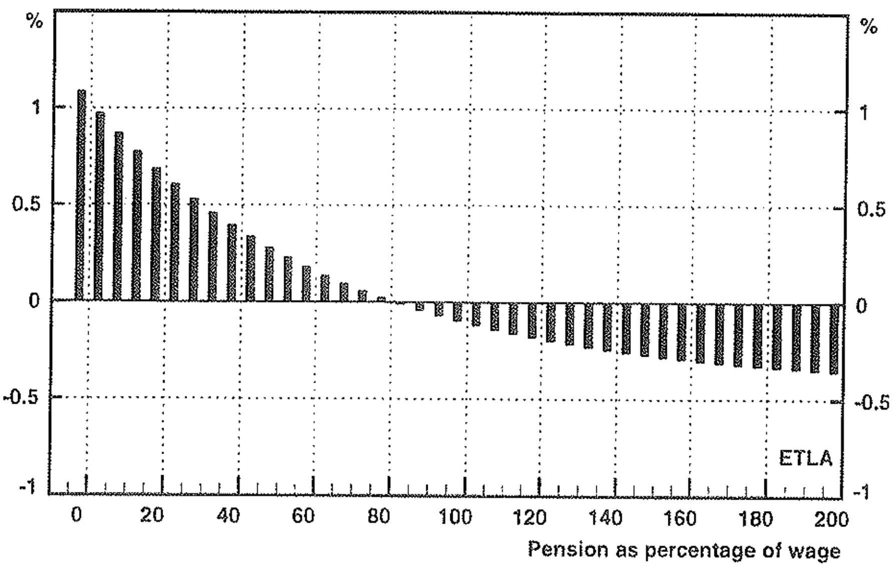
An alternative to voting is representative decision making. Here we could imitate it by stating that the amount of wins and losses are important, not just the sign. Those who lose a lot put pressure through their representative organisations, whereas those who gain little may be indifferent. If we weigh the wins and losses, the picture might change. These questions are left for future studies.

We concentrate on permanent changes in pensions. The starting point is always a steady state. From each steady state we calculate the intergenerational effects from an increase in the pension benefit level. The intergenerational effects are again summarized by relative compensated variations by age, but we take into account only those effects that concern generations that are alive (and adult) at the time of the pension increase. If a majority of these gain from the reform, we consider the increase accepted. We then calculate a new steady state with the higher pension level and repeat the analysis. When the majority no longer gains from a further increase, we check that the majority does not want to decrease the pension level permanently. When both of these conditions are met, we have found a voting equilibrium pension level.

Two things are important in this definition of the voting equilibrium. First, we have ruled out the possibility of both preannounced changes and temporary changes in pensions. It is very likely that there exist policies of these kind which the majority would support even in the voting equilibrium, on the grounds discussed in section 3. Second, we are looking only for a steady state equilibrium. The dynamics around the equilibrium can be hard to analyze. The reason is that the level of the pensions affects the steady state of the economy, for instance the capital stock. If we are below the voting equilibrium, there may be a maximum increase in pensions that the majority wants to be done during the first period, which is not sufficient to reach the voting equilibrium level. This is because the decision depends on the capital stock which is different from its voting equilibrium steady-state value and can be changed substantially in the short run only with great costs. Pensions may be further increased during the second period, and expectations of this affect also the first period. Ideally, we should find an optimal path which the majority would like to follow to the voting equilibrium. This is not pursued here. But although we are searching a steady-state voting equilibrium, we must use a dynamic model and dynamic simulations to find it.

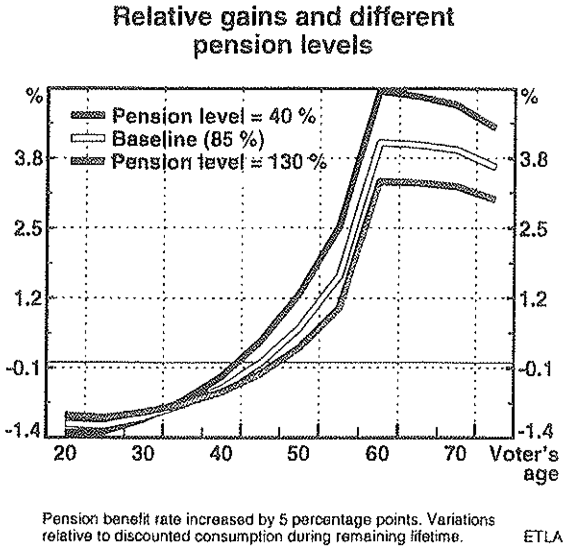
The voting equilibrium level of pensions is searched for by trial and error. The following chart shows the relative gain of the median age group (people between 45 and 50) from the 5 per cent increase in pension levels from 0 % to 200 % of the reference earnings level. The chart is rather flat, showing that the decisive voter really does not gain or lose much for a wide range of pension levels. The gain declines steadily as the the initial pension level increases. The sign changes around 85 per cent, which roughly is the equilibrium value. It is of course related to all the parameter values of the model (see Appendix). We do not try to pin down the voting equilibrium value in any greater degree of accuracy, as the number of required simulations is already quite large. We have also simplified the model from what it was in section 3 by leaving out changes in the age structure of the population: now all cohorts are of equal size.

Relative gain from 5 % increase in pension level in age group 45 - 50



Compensated variation as a percentage of discounted consumption expenditure during remaining lifetime.

The following chart shows that for some other cohorts the changes in utility are bigger. We notice that the shape of the relative gain curves also changes slightly. At the voting equilibrium the range of changes is rather large, and both below and above the equilibrium the changes are smaller. In all cases the old gain and the young lose.



Having found the voting equilibrium we carry out some simulations to find out how sensitive the equilibrium is to some features and assumptions of the model. This can be done simply by changing e.g. a parameter value and searching the new voting equilibrium in a similar fashion as before. As these simulations take quite a lot of time we in some cases use a shortcut. We calculate the relative gains by age from an increase in pensions from 85 % to 90 % with different parameter values. Comparing these gains with those obtained with the baseline parameterization we can deduce the direction of change of the voting equilibrium value.

4.2. Why is there a voting equilibrium?

When pensions are changed, the utility of an individual changes because of four effects. First, nominal pension incomes change. Second, compensation from work changes. Third, consumption prices change. And fourth, the initial wealth changes because the value of firms is re-evalued in the asset market. The total effect determines the median voter's attitude towards an increase in pensions. The existence of the voting equilibrium in our model says that the total effect is positive for low initial pension levels and negative for high initial pension levels.

The starting points for our dynamic simulations are always steady states. The capital stock in these initial steady states is smaller the larger is the pension level relative to wages. The reason for this is that high pension level reduces domestic saving and increases foreign debt. Debt servicing requires more exports and lower domestic price level. For a firm this means that the price of composite investment good rises compared to the price of output. Therefore the optimal capital stock is smaller.

All the four components of the utility changes (pensions, wages, consumer prices and wealth) get smaller as the initial pension level increases. This explains the pattern in the chart above.

Nominal pensions of course increase when pension level is raised, but the increases are less than 5 % because the pensions are indexed to wages which decline because the contribution rate increases. Pension increases gets smaller as the starting point increases.

Compensation from work consist of two parts, the wage and the effect on the future pensions. The wage part falls as pension level is increased. The fall gets smaller as the starting level increases. The future pension part increases, but this increase gets smaller the higher is the starting level of pensions. Depending on the pension right aggregation period, the increase in future pensions may be bigger than the wage decline during some periods. In our specification, the wage part dominates for the median voter except for the last working period. Thus the median voter's labour supply first decreases and later increases.

Consumer prices increase initially as pension level is raised, because labour costs increase. VAT rises also, because it is used to balance the public sector's budget, and public expenditure increases as labour costs rise. As the starting level of pensions gets higher, the increase in prices changes profile. During the first four periods the increases get smaller but after that they get larger.

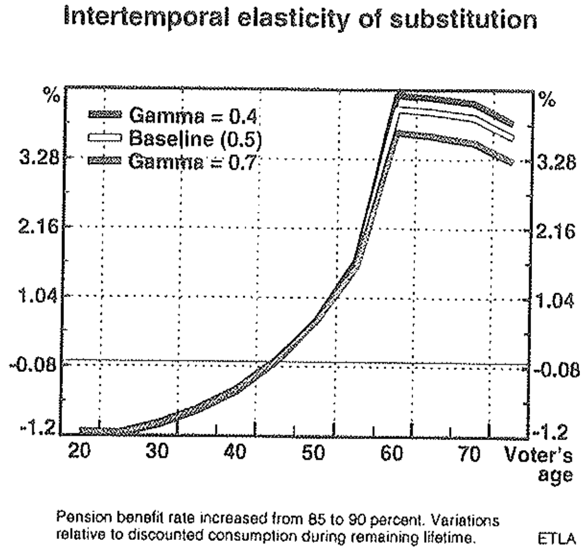
The changes in initial wealth turn out to be very important in our simulations. The wealth changes are due to revaluation of firms' share value. When pensions are increased, share values immediately fall. Its effects depend on the distribution of ownership of these shares. Some households have positive wealth, some negative. Usually old have positive wealth and young are indebted. The median voter's place is in between. When pension level rises in the initial steady state, the total wealth of the households falls. It may become negative, because foreign borrowing is possible. In that case the wealth of the median voter may also be negative, but still he may have a positive amount of shares in the portfolio. In our simulations the wealth of the median voter always falls when the share values fall. This wealth effect may well dominate the median voter's utility changes. Thus the median voter's main concern need not be his/her future wage and pension income development but simply the reaction of the stock market.

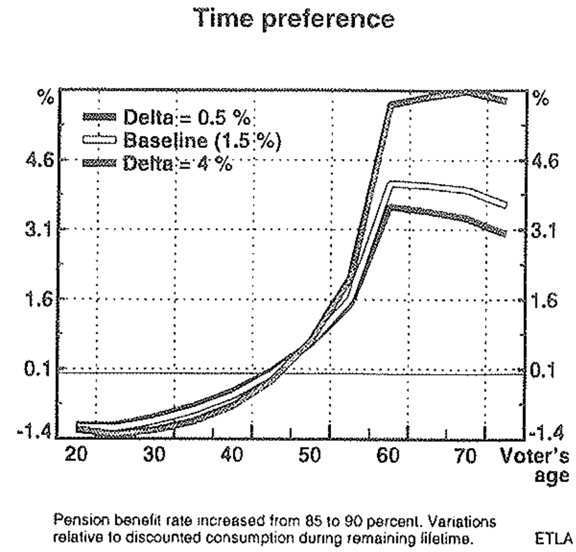
4.3. Household behaviour and voting equilibrium

The following charts show how the relative gains by age depend on the households' intertemporal elasticity of substitution and on the rate of time preference. A higher intertemporal substitution elasticity implies a higher voting equilibrium pension level. The median voter's utility change is very little affected compared with the changes in the utility of the older people. The lower the time preference the happier working-aged people are to wait the benefits from higher pensions, so the higher is the voting equilibrium. Again it is the old people whose utility changes are largest.

The lower is the intratemporal substitution elasticity between consumption and leisure the higher is the voting equilibrium pension level. How much people prefer leisure compared to consumption (parameter α_0), on the other hand, seems to have a minor effect on the voting equilibrium.

Sensitivity of relative gains by age to household parameteres





4.4. Rules of the pension system and voting equilibrium

The effects of the pension aggregation period. In many countries the pensions do not accrue smoothly during the working years. The Finnish earnings-related pension system, for example, gives high weights to the last years of each job. Thus people who stay with one employer get their pensions determined by the last four years of their working career.[2] During this short aggregation period their net compensation for working is higher than during other workyears, although a part of this compensation comes during retirement. Making the aggregation period longer evens out the compensation in time. Thus the increase in the pension level has effects over a longer time period for each individual. If the aggregation period is the total working period the voting equilibrium pension level rises, in our model to around 150 %.

What if the workers decide? The Finnish earnings-related pension system is ruled by employees' and employers' organisations, which make change proposals to the parliament. The parliament then accepts or rejects (usually accepts) the proposals, but seldom changes the proposals. We make the hypothesis that voting concerns alternatives decided by the employers and employees, that is, by the persons in the working age. They propose their majority voting equilibrium value to the whole population to vote (or to the parliament, which represents also those already pensioned). As the elderly would like higher pensions than those in the working-age, this leads to a situation where the people aged 20 - 60 decide the pension level. The median voter now belongs to the age group 35 - 40. The resulting equilibrium value is lower than the full population majority voting equilibrium value. With the basic parameterization there

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2 This will be changed to 10 years, starting January 1, 1996.

exists a positive pension value which is a voting equilibrium, but the level is low, around 10 %. If we make the assumption of perfect capital mobility, which gives a country the possibility to borrow at the international interest rate, the equilibrium pension level again becomes significantly higher, around 100 %.

4.5. Open economy assumptions and voting equilibrium

In an internationalised and integrated world the conditions under which a country participates in the international goods and capital markets are essential to the dynamics of the economy. The assumptions of the interest rate sensitivity of capital movements, substitutability of domestic and foreign goods in home markets and market power in export markets are important also when analysing the welfare effects and political support of a pension system. These elements have been noticed in some computable OLG studies (see e.g. Bovenberg, Broer and Westerhout (1992), Lassila, Palm and Valkonen (1995) and Perraudin and Pujol (1991)), but mostly neglected in the public choice literature. We have included those features in our model without explicitly modelling the optimising behaviour of the foreign agents, but we consider this as a minor deficiency compared to the total absence of the foreign markets in most models.

The possibility to participate in international financial markets have been extremely important to small countries like Finland, where business cycles have generated large variations in saving and investments. In most cases large current account deficits lead, however, to rising interest rate in foreign borrowing. This feature has been incorporated also in our model. The determination of the domestic interest rate is described as:

$$r_t^D = \frac{CA_t}{\varpi} + r_t^F$$

where CA is current account deficit, r^F is the foreign interest rate and ϖ determines the size of the interest rate reaction. High values of the parameter allow perfect capital mobility and low values describe a financially closed economy. The specification of the equation is from Perraudin and Pujol (1991).

We have used in the baseline simulation a parameter value which gives a fairly large reaction of the interest rate to current account imbalance. A hike in the pension benefit level induces in the first decades a larger fall in the savings rate than in the investment rate of the economy, so the domestic interest rate rises.

As an alternative case we simulated the effects of the benefit level hike with the domestic interest rate fixed at the same level as world market rate. This has surprisingly large effects on utility changes and thus on the support for the reform as can be seen from the chart below. The interest rate reaction does not any longer reduce investment and increase saving. Higher investment and consumption demand leads to bigger initial jump in the domestic price level. Because of stable interest rate there is not either a discounting effect to the value of the firms and the reduction of wealth is smaller. Smaller negative reaction in productive capital gives higher wages during workperiods and thus also a higher pension level. These incentives stay also in very high pension levels.

We performed some sensitivity analysis also with the price elasticity of exports. Our export demand function is simply:

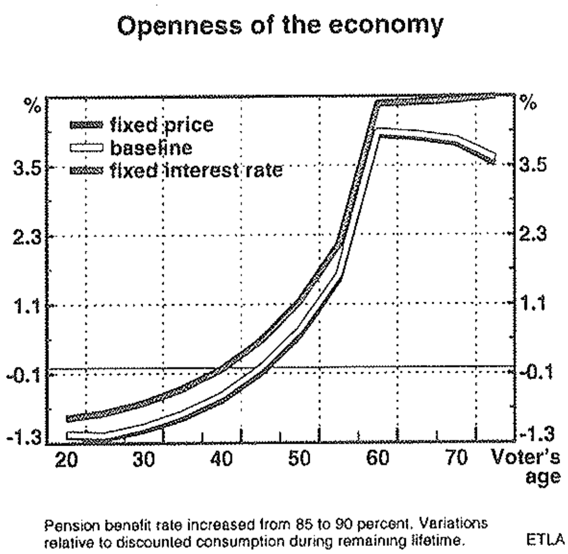
$$X_t = ex\left(\frac{p_t^D}{p_t^M}\right)^{\sigma^E}$$

where ex is a scale parameter, p^D is the price of the domestic good, p^M the price of the imported good and σ^E is the price elasticity. The baseline value of the five-year price elasticity has been chosen to be -4. It is most likely, however, that in the long run the difference between domestic and international price levels diminishes.

When the value of the elasticity parameter is very high the export price is fixed to the international price level. Now the interest rate bears alone the burden of balancing current account. Larger interest rate reaction reduces capital stock more in the first periods. Wages fall more, which makes the measure marginally less popular.

It seems that a common price level mitigates the effects of a fixed interest rate in a small open economy case. Still the interest rate reaction dominates the overall effect. If we consider a small open economy joining a currency union and having a profound increase in the number of elderly voters, these simulations give a very interesting message. The possibility to borrow abroad without raising interest costs causes increasing political pressures to raise the pension benefit level as a reaction to the unfavourable demographic trends.

Sensitivity of relative gains by age to openness parameters



4.6. Production technology and voting equilibrium

In the model domestic firms generate value added by combining labour and capital. The constant elasticity of substitution describes the reaction of the firm to changes in relative prices of the inputs. High elasticity means e.g. that a change in labour supply induces only moderate reactions in wages, because firms can substitute labour with capital. The simulation with higher value of the elasticity parameter shows that the elderly gain marginally more in that case from the reform.

Another important factor which affects the size of the reaction of the firms is the adjustment cost of investment. There are large variations in empirical estimates of the cost. In our baseline case the parameters have been chosen from the low end of the estimates. The costs are modelled as a loss in output of the firms. Higher adjustment cost implies slower reactions of the capital stock when the pension level changes. For the median voter that means marginally larger welfare costs, which implies that the voting equilibrium pension level will be lower.[3]

5. Concluding remarks

Numerical OLG simulation models can be applied in a straightforward manner to public choice issues. The models contain sufficient ingredients, as they are normally used to analyze changes in intergenerational distribution. It is to be expected that using these models to endogenize policy decisions will have impacts on the model development also.

We also argue that numerical OLG models should be used this way, even if one is not interested in the questions that the public choice approach presents. This is because expectations are so crucial in these models. The standard procedure is currently to use rational expectations, which in the absence of uncertainty means perfect foresight. Normal simulations assume that any alternative studied is believed with certainty by the agents in the model. This is an important assumption. Its appropriateness should not be taken for granted. There are alternatives, especially concerning permanent changes in policy variables. Results should be tested against alternatives where the policy variable in question has the same value in the future, so policy consists of temporary measures (temporary may well mean 50 or 100 years in this context).

Economic conclusions:

1. Some policies are more credible than others. Numerical simulation models help to study these. Our analysis shows that increasing the retirement age is more popular than reducing the benefit level if different methods of lowering the contribution rate are compared.

2. The economy described by the model has a voting equilibrium pension level, which the majority wants neither to increase nor decrease.

3. The responsiveness of the interest rate to the current account is extremely crucial. The majority voting equilibrium pension level is the higher the more inelastic the interest rate is. A small open economy with free capital movements may have very high voting equilibrium.

4. The aggregating period of the pension system is important. The analysis shows that the voting equilibrium pension level rises significantly the longer the aggregation period.

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3 In the model of Bovenberg, Broer and Westerhout (1992) increasing use of debt finance raises the investment costs of firms. These can also be considered as 'adjustment costs'.

5. Wealth effects are important and may even dominate the decisions of the median voter over a wide range of initial pension levels.

6. The decisive voter is rather indifferent over a wide range of pension values. This may bring about elements of randomness and instability.

Conclusions for simulations:

1. Numerical simulation models can study the credibility, from a future voting point of view, of any given policy path, compared to a set of specified alternatives.

2. The voting indicator is descriptive. It may help us find some future policy paths that are more likely than others. Comparisons are always made between well defined alternatives. The alternatives may be whatever the model assures is economically feasible.

3. The analysis requires a dynamic model, because the important voters are those living when the policy change is made or proposed, and by definition this situation is not a steady state.

4. With some parameter values only very high pension benefit levels would be credible. As the levels are higher than those observed in reality, one might conclude that the model is not well specified or calibrated. Adding altruistic features into the households´ utility functions would perhaps produce more sensible results. It probably would also change all standard policy analysis results. Indeed it is hard to imagine a feature of the model that would systematically affect the voting results without affecting policy analysis results. Thus credibility simulations should become a standard part of policy analysis in overlapping generations models.

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Appendix: The model

Household behaviour

Households maximise the utility from consumption and leisure in different periods. The life-cycle plan is the solution to the following problem.

$$\max_{C,L} \quad \sum_{t=1}^{T} \frac{1}{1-\frac{1}{\gamma}} \frac{U_t^{1-\frac{1}{\gamma}}}{(1+\delta)^{t-1}}$$

subject to budget constraint

$$\Sigma_{t=1}^{T_w}(1-L_t)e_t w_t(1-\tau^w-\tau^e)R_t + \Sigma_{t=T_w+1}^{T} Z_t(1-\tau^w)R_t - \Sigma_{t=1}^{T} C_t P_t(1+\tau^c) + \Sigma_{t=1}^{T} R_t B_t = 0$$

and subject also to the determination of pensions Z. U is the periodic utility

$$U_t = (C_t^{1-\frac{1}{\rho}} + \alpha_0 L_t^{1-\frac{1}{\rho}})^{\frac{1}{1-\frac{1}{\rho}}}$$

and R is the discount factor

$$R_t = \Pi_{s=1}^{t-1} \frac{1}{(1+r_s(1-\tau^r))}$$

C is consumption, P its price, L is leisure, and of the constant parameters γ is the elasticity of intertemporal substitution, δ is the rate of time preference and ρ is the elasticity of substitution between consumption and leisure. The model includes also a bequest motive and the possibility of liquidity constraints on households, but these options are not used in this study. The households do receive bequests B, however, from older people dying before the age of 80. The number of periods T is 12: the unit period is five years. A life-cycle plan is made at the age of 20, people retire at 60 and live until 80.

The pension system relates pensions to earnings during working years. The normal pension is the share θ of a pension wage, which depends on the wage levels both during the persons' working years and pension years. The share θ depends on the number of working years but is here held constant. Let

$$1-L_p = \frac{1}{T_w}\Sigma_{t=1}^{T_w}(1-L_t)$$

and

$$w_p = \Sigma_{t=1}^{T_w} \beta_t(1-L_t)e_t w_t/(1-L_p) \quad \text{where} \quad \Sigma_{t=1}^{T_w} \beta_t = 1$$

The pension Z in period t is now

$$Z_t = \theta(1 - L_p) w_p^{\lambda} w_t^{1-\lambda} \quad \text{where} \quad 0 \le \lambda \le 1$$

The weights β determine the pension rights averaging period. If the worker stays in one firm, the averaging period consists of the last four years, which roughly would mean that β_8 is equal to unity and all other weights are zeros. In practise, due to moves between firms and also to some technical reasons all coefficients are positive, but β_8 is the largest. T_w is 8 in the baseline scenarios.

The term e_t describes work efficiency, which varies with age. It makes the life-cycle wage-income profile hump-shaped. Parameter λ describes pension indexing: $\lambda = 0$ means that pensions are fully indexed to current wages.

The budget constraint says that discounted lifetime wage and pension income equals discounted consumption expenditure. Households start with no wealth and leave no wealth upon death. The terms τ^w, τ^c and τ^r are tax parameters and τ^e is the employees' pension contribution rate. The actual equations of the model are the first-order conditions derived from the optimisation problem.

The household sector consists of twelve households, of different age, in each period. Total consumption, labour supply, pensions received and taxes paid are aggregated from individual household decisions.

Firms

A representative small firm produces the domestic good using capital inherited from the previous period, intermediate goods and labour. Infinite horizon decisions of investment, employment and use of intermediate goods are made to maximise firm's market value. The firm takes the prices, demand of production and supply of factors at given prices, production technology and taxation as given. Intermediate and capital goods are costs minimising CES composites of domestic and imported goods. Investments are financed by retained earnings and debt.

Production structure can be described as follows:

$$Y_t = F(K_{t-1}, L_t) - G(I_t, K_{t-1}) + \zeta Y_t$$

$$G(I_t, K_{t-1}) = \xi \frac{I_t^2}{K_{t-1}}$$

The use of the composite intermediate good is determined as a fixed proportion of gross production. The production function F is a CES function of capital and labour. In the process of installing new capital some of the production is lost as investment adjustment costs. These installation costs depend positively on the investments and negatively on the amount of capital. Both the adjustment costs and the substitutability of capital for labour are important determinants of the firm's reaction to unexpected changes in the external environment.

Domestic households consider bonds and firms' shares as perfect substitutes in their portfolios. The arbitrage condition between after-tax returns on bonds and shares is:

$$r_t^D(1-\tau_t^r)V_{t-1} = (1-\tau_t^d)D_t + (1-\tau_t^g)(V_t - V_{t-1})$$

where the left-hand side describes the invested amount yielding the domestic after-tax interest rate. On the right-hand side the first term is the after-tax dividend income and the second term the after-tax capital gain.

The arbitrage condition can be transformed to a form where the market value of the shares equals the present value of expected future dividends, adjusted for capital income taxes:

$$V_t = \sum_{s=t+1}^{\infty} \frac{1-\tau_s^d}{1-\tau_s^g} D_s \prod_{v=t+1}^{s} \frac{1}{1+r_v^D\left(\frac{1-\tau_s^r}{1-\tau_s^g}\right)}$$

The dividends are a residual from the firm's cash flow identity:

$$D_t = (1-\tau_t^f)\left[p_t^F(F_t - G_t) - (1+\tau_t^l)w_t L_t - r_t^D B_{t-1}^c\right] - p_t^k I_t + \tau_t^f d\, p_{t-1}^k K_{t-1} + (B_t^c - B_{t-1}^c)$$

where the dividend in period t is determined by after-tax profits before depreciation minus investment expenditure plus depreciation allowances, which corresponds to real depreciation plus any increase in corporate debt. In this simple version all other allowances are included by using an effective average corporate tax rate. Corporate debt is preferred when financing investments, but its use is limited to a fixed ratio of the replacement value of corporate capital.

The firm chooses the optimal path of investment, use of labour and intermediate goods to maximise the current period after-tax dividend and the firm's value at the end of the period. If there are no unexpected shocks, there is no need to revise the optimal plan and it will be followed forever. Capital depreciates at a constant annual rate of d. The constraints of the maximisation are the initial capital stock and an equation describing its dynamics:

$$K_t = K_{t-1}(1-d) + I_t$$

Three of the four first order conditions of the constrained optimisation are used as model equations. The first implies that investments should be carried out until the marginal benefit from an additional unit of investment is as large as the marginal cost. The marginal cost includes the price of a unit of capital plus the installation cost. The condition can be transformed to a q-theory investment equation:

$$I_t = \frac{\left(\frac{1-\tau_t^g}{1-\tau_t^d} q_t - p_t^K\right) K_{t-1}}{(1-\tau_t^f)\xi p_t^F}$$

The optimality condition of capital says that capital should be installed until the after-tax return of an additional unit is large enough to cover the expenses of carrying the capital to the next period. These expenses include interest, depreciation and the change in the replacement price of capital. This condition is transformed to an equation describing the path of the shadow value of the capital:

$$q_t = \left(\frac{1-\tau^d_{t+1}}{1-\tau^g_{t+1}}\left[(1-\tau^f_{t+1})(p^F_{t+1}(F_K-G_K)-r^D_{t+1}bp^K_t)-bp^K_t+\tau^f_{t+1}dp^K_t\right]\right.$$

$$\left.+\frac{1-\tau^d_t}{1-\tau^g_t}bp^K_t(1+r^D_{t+1}\frac{1-\tau^r_{t+1}}{1-\tau^g_{t+1}})+q_{t+1}(1-d)\right)\frac{1}{1+r^D_{t+1}\frac{1-\tau^r_{t+1}}{1-\tau^g_{t+1}}}$$

In a steady state this marginal productivity condition of capital can be written as:

$$F_K-G_K=\frac{p^K}{p^F}\left[d+br^D+(1-b)r^D\frac{1-\tau^r}{(1-\tau^g)(1-\tau^f)}\right]+r^D\frac{1-\tau^r}{1-\tau^g}\xi d+\xi d^2$$

Inside of the brackets there is the depreciation rate d, the interest cost of debt-financed share b of the capital stock and cost of capital financed by retained earnings. The two terms after brackets are based on adjustment costs linked to replacement investments.

The third condition says that the marginal benefit of an extra unit of labour should cover wage costs plus the employer's social security contribution:

$$p^F_t F_L=(1+\tau^L_t)w_t$$

The fourth condition is a transversality condition ensuring that the discounted shadow value of capital goes to zero as time approaches infinity.

The market value of the firm is linked to the shadow value of the capital in the leveraged firm as follows:

$$V_t=K_t q_t-\frac{1-\tau^d_t}{1-\tau^g_t}B^c_t$$

where B^c_t is the firm's debt. This link has been derived using the homogeneity of production and capital installation technologies. The value of the firm jumps whenever unexpected news about the firm's future profitability comes to the market. Households are the main owners of the firms and changes in their wealth changes life-cycle plans immediately.

Pension fund

Pensions are paid by a fund. It collects contributions both from workers and employers. The latter's rate is endogenous and balances the budget each period.

Government sector

The government collects various taxes and uses the proceeds to pay interest on outstanding debt and to employ civil servants to produce public services. These services are provided free of charge and are not taken into account in individual utility considerations.

The model includes many possibilities to balance revenues and expenditures of the government every period. An endogenous value added tax rate is used most often, because it induces little changes in the intergenerational incidence of taxation. From the expenditure side it is possible to endogenise the number of government employees. There is also a possibility to let the government run a deficit or a surplus in the budget, but then a transversality condition must be determined so that the public debt does not blow up.

Foreign sector

The model imitates a small open economy, where the export share of the total demand is large. The amount exported depends on the price elasticity of the foreign demand:

$$X_t = ex\left(\frac{p_t^D}{p_t^M}\right)^{\sigma^E}$$

A large negative value for the elasticity implies that a small country has to adjust to the price level of international markets.

The imported good is used in consumption, investments and as an intermediate good in production. Its price is determined in the international markets. It is an imperfect substitute for the home-made good. The demand conditions are described with a CES structure.

The supply of foreign capital depends on the domestic interest rate. The current account deficit lifts the domestic rate above international rates.

$$r_t^D = \frac{CA_t}{\varpi} + r_t^F$$

The sensitivity of the domestic interest rate to differences in saving and investment can be changed in the model by the adjusting parameter ϖ. The extreme values of the parameter allows, on the one hand, for perfect capital mobility and, on the other, for a financially closed economy.

Markets

The model includes four markets, which balance every period. In the labour markets the firms demand labour following the marginal productivity of labour rule. Households' aggregate labour supply is divided between public and private employment. The wage rate is determined as equating supply and demand in the labour markets.

In the markets of the domestic good the firms are the sole supplier. The product is used by other firms as a part of the composite intermediate and investment goods, by households as a part of the composite consumption good and by foreign agents. The demand of the domestic agents is determined by a cost minimising CES structure. The export demand conditions are explained above. The equilibrium condition which determines the price of the domestic good is thus:

$$Y_t = Y_t^D + I_t^D + C_t^D + X_t$$

The domestic demand of the fixed-price imported good is also determined by minimising costs of the composite goods. The perfectly elastic supply adjusts to demand in these markets:

$$M_t = Y_t^M + I_t^M + C_t^M$$

The price of the imported good serves as a numeraire in the model.

The fourth markets are the capital markets. In these markets savings and investment are balanced. The arbitrage condition of domestic households ensures that they are ex ante indifferent between investing their savings in bonds and in firms' shares. The foreign agents are restricted to participate only in the bond markets. Total savings are a sum of domestic savings and foreign portfolio investments. The domestic interest rate r_t^D balances the markets.

The parallel stock equilibrium can be written as:

$$W_t + H_t = V_t + B_t^c + B_t^g + FA_t$$

where W_t is the household wealth, H_t is the value of the pension fund assets, V_t is the market value of the firm, B_t^c is the firms' debt, B_t^g is the public debt and FA_t is the net foreign assets of the country.

LIST OF VARIABLES

K	capital stock of the firms
Y	gross production of the domestic good
G	installation costs
F	value added
V	value of the firms
D	dividends
B^c	firms' debt
I	aggregate investment
I^D	demand of the domestic good in investment use
I^M	demand of the imported good in investment use
C	aggregate consumption
C^D	demand of the domestic good in consumption use
C^M	demand of the imported good in consumption use
Y^D	demand of the domestic good in intermediate use
Y^M	demand of the imported good in intermediate use
E	exports
I	imports
CA	current account deficit
FA	net foreign assets
r^D	domestic interest rate
p^D	price of the domestic good
p^M	price of the imported good
p^C	price of the composite consumption good
p^K	price of the composite investment good
p^F	price of the value added
q	shadow price of the capital
τ^l	employer's pension contribution
H	value of the pension fund's assets
B^g	public debt
τ^C	value added tax
W	household wealth
L	aggregate labour supply
w	wage rate
U	utility
Z	pension

PARAMETER VALUES

personal income tax	τ^{w}	0.3
dividend income tax	τ^{d}	0
interest income tax	τ^{r}	0.28
capital gains tax	τ^{g}	0.28
corporate income tax	τ^{f}	0.28
employee's pension contribution	τ^{e}	0.05
depreciation rate	d	0.09
installation cost parameter	ξ	0.5
share of the value of firms' capital financed by debt	b	0.7
input-output coefficient for the composite intermediate good input	ζ	0.1
labour share parameter of the value added production fuction	ε	0.36
elasticity of substitution between labour and capital	β	0.8
share parameter of domestic good for consumption	υ^{C}	0.7
share parameter of domestic good for investment	υ^{K}	0.7
share parameter of domestic good for intermediate use	υ^{I}	0.7
elasticity of substitution between imported and domestic good in consumption	σ^{C}	0.99
elasticity of substitution between imported and domestic good in investment	σ^{K}	0.99
elasticity of substitution between imported and domestic good in intermediate use	σ^{I}	0.99
scale parameter of export demand	ex	0.6
price elasticity of export demand	σ^{E}	-4
foreign interest rate	r^{F}	0.03
sensitivity parameter of capital movements	ϖ	3
elasticity of intertemporal substitution of consumption	γ	0.5
elasticity of substitution between consumption and leisure	ρ	0.75
rate of time preference	δ	.077

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