Economic Studies 157

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The Department of Economics at Uppsala University has a long history. The first chair in Economics in the Nordic countries was instituted at Uppsala University in 1741.

The main focus of research at the department has varied over the years but has typically been oriented towards policy-relevant applied economics, including both theoretical and empirical studies. The currently most active areas of research can be grouped into six categories:

* Labour economics
* Public economics
* Macroeconomics
* Microeconometrics
* Environmental economics
* Housing and urban economics

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Abstract

Essay 1 (with Juha Alho and Edward Palmer):
All around the world, public pension schemes are moving in the direction of non-financial (NDC) and financial defined contribution (DC) schemes. Both rely on accurate projections of life expectancy in the creation of annuities. Accurate projections are critical for system stability, individual utility and inter-generational welfare. This paper suggests a path-breaking innovation that changes the perspective from the Lee-carter (LC) family of trend models which assume a constant rate of change in mortality over time. Our approach is to project the cohort life expectancy on basis of the specific cohort rate of change in mortality. This relaxes the strong trend assumption underlying the LC model, which is the reason why LC model does not work well in the phase of accelerating or decelerating mortality. We use unisex mortality data for $8$ countries to test the performance of our approach both ex-post and ex-ante. The ex-post experiment shows that our approach generally performs better when the rate of change in mortality is accelerating and performs as well as LC model when the rate of change is time-invariant. The ex-ante experiment, on the other hand, shows that our model almost always delivers higher projection of remaining life expectancy than the LC model for the more recent cohorts, which is consistent with the ex-post experimental results.

Essay 2:
Due to the systematic underestimation of cohort life expectancy, NDC pension schemes face a financial risk that can leads to inter-generational unfairness, given the current practice. This paper proposes an alternative method of computing annuity to address this problem. The proposal is to adjust the annuity based on re-estimations of the remaining life expectancy at intervals after retirement, but only up to a ceiling age. The scheme is assessed using 208 cohort annuity pools from eight sample countries. This experiment shows that the proposed scheme succeeds in reducing the inter-generational unfairness for 60-80% of the cohort annuity pools, compared to current practice of fixing the annuity at age 65. Because the adjustment is borne by the relatively large group of younger persons, the per capita change in utility is rather small assuming risk neutrality.

Essay 3:
This paper studies how the incentive to retire in a DC (NDC) scheme is influenced by engaging private information on life expectancy. This is an important question since the decisions made under the two scenarios, optimizing using the private life expectancy or the cohort average made available by the pension provider, create different welfare and financial outcomes. The analytical framework is a standard life-cycle model, accounting for monetary gain from work and non-monetary gain from leisure. The unique feature here is that the individual life expectancy is an explicit driver of disutility of work. The theoretical result is that prevailing private information of a longer-than-average life expectancy can lead to both advancing and delaying retirement, depending on other factors determining utility. The numerical example using Swedish data proves the theoretical results and suggests a rather small average impact on the choice of retirement by engaging private information of life expectancy.
Essay 4:

Pensions in the increasingly popular Notional Defined Contribution (NDC) Pay-as-You-Go Schemes are granted based on cohort-specific life expectancy, regardless socioeconomic differences. This risks perverse intra-generational and unintended inter-generational transfers. This paper introduces an alternative with separate annuity pools for different socioeconomic classes. Using unique Swedish data and the Swedish NDC pension system as an example, the analysis shows a significant gap in life expectancy between socioeconomic classes defined by occupation. In the Swedish context, this implies a perverse transfer of 5% of the pension capital from the manual workers to the non-manual workers, which can be abolished by using the group plan. In addition, the group plan also lessens the risk of inter-generational transfers resulting from the gap in life expectancy.

**Keywords:** NDC, ageing population, life expectancy projection, Lee-Carter Model, benefit design, social gap in life expectancy, rate of change in mortality

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ISSN 0283-7668
ISBN 978-91-85519-64-4
urn:nbn:se:uu:diva-274253 (http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-274253)
Dedicated to my beloved husband, dearest parents and wonderful children
Acknowledgement

Taking up the Ph.D study is one of the most unexpected events in my life. When I packed up my luggage and boarded on the plane from Shanghai to Stockholm eight years ago, the idea of becoming a Ph.D had never come across my mind. However, “Life is what happens”. Now that I have not only started but also completed the journey as a Ph.D student, I recall them all with a deep sense of my bounded duty for whatever I own them.

I owe you, Dr. Per Johansson, Professor in Econometrics, Microeconomics and Statistics, my sincere gratitude. As my main supervisor, you devoted both your time and enthusiasm in educating me to be a qualified researcher. Without your brilliant comments and suggestions, my dissertation will not look the way it does today. Without your quick responses and efficient way of working, I would certainly not be able to complete my dissertation within the time frame. I would like to thank you for offering me the opportunity to take part in workshops and seminars. I would also like to thank you for encouraging and helping me realize my potential to take up research as my future career.

I owe you, Dr. Edward Palmer, Professor and Senior Adviser of Swedish Social Insurance Agency, my heartfelt gratitude. Without you, this exciting and valuable journey towards Ph.D would not have started. You are not only my supervisor, but also my friend and my role-model. Thank you so much for encouraging and leading me into this fantastic academic world. Thank you so much for guiding me throughout the whole journey with your diligence and your patience. You have been a tremendous mentor for me.

I owe special thanks to you, my beloved husband Dr. Serge de Gosson de Varennes. It is you who accompanied me days and nights during this tough journey. You always stood by my side, even when I was irritated and depressed. You spent your scarce spare time to proof read the mathematical parts of my dissertation. You encouraged me to be confident and persistent. You are absolutely an indispensable part of my success in completing the Ph.D dissertation. Thank you for everything.

I also thank you, my mom and dad, for your unconditional love and support. It is you who taught me the importance of hard work and discipline. It is you who give me a good foundation with which to meet life. It is you who helped taking care of my children and housework so that I can focus on my dissertation work. Without you, I would not be able to be where I am and who I am today.

There are many other people whom I owe gratitude to. I thank Juha Alho, Professor in demography and statistics, for your brilliant idea from which we
develop into one of the papers included in the dissertation. I thank my opponent in the final seminar, Bo Larsson, assistant Professor in economics, for your value-added comments. I thank Johannes Hagen, a fellow Ph.d student who shares the same interest in research topics, for your peer review and exchange of ideas. I thank Ingemar Svensson, analyst in the Swedish Pension Agency, for your support during the period when I collected critical data for my dissertation work. Last but not least, I would also like to acknowledge the financial support from the Swedish Pension Agency for providing and purchasing data.

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February 1, 2016
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INTRODUCTION

During the latest half century, the age structure experienced significant changes in a global perspective. The long run trend of increased longevity and decreased fertility have led to an ageing population in most countries around the world. This trend started in the traditional industrial countries but has thereafter followed by an increasing number of developing countries. Today, the old-age dependency ratio\(^1\), as a measurement of pressure on the productive population, is approximately 0.25 in OECD countries and 0.12 in BRIC countries (Brazil, Russian Federation, India and China), almost twice as high as the figures in the 1950s. This upward trend, however, is far from coming to a halt. In the next five decades, the old-age dependency ratio is expected to increase and to reach a new plateau, landing at around 0.45 in OECD countries and 0.35 in BRIC countries.

The phenomenon of aging population has important social and economic consequences. One important consequence is how to design a pension scheme that is sustainable. As the size of retiring population increases in proportion to the size of the working population, the traditional Pay-as-You-Go (PAYG) pension schemes, for example, Defined Benefit (DB), face tremendous strain on the budget. To make matters worse, the conventional DB schemes distort labor supply at old ages by adopting actuarially unfair design of pension benefits (Börsch-Supan, 1992). As a consequence, the effective retirement age decreased despite the fact that people live longer and healthier during the second half of the 20th century (See figure 0.1 for the demonstration of this negative relationship between the life expectancy and the effective retirement age for Sweden and the USA. The solid lines are the effective retirement age and the dashed lines are the period life expectancies).

\[\text{Figure 0.1. Effective retirement age vs. Period life expectancy}\]

Against this background, a global-wide pension reform was triggered in the 1990s in search of a more sustainable PAYG pension scheme. An original form of pension

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\(^1\)The old-age dependency ratio is the ratio of older dependents—people older than 64—to the working-age population—those ages 15-64.
scheme, known as the Notional Defined Contribution (NDC), emerged as a result of the interchanges of ideas and discussion among the pension experts and politicians from the countries considering pension reform. The first group of countries such as Sweden, Latvia, Italy and Poland implemented the NDC in the late 1990s and the second group including the Arab Republic of Egypt and Norway has recently legislated or implemented the scheme. A general thoughts of following the NDC approach also exists in other countries, for example, China and Greece.

The main difference of NDC from the PAYG DB is the stronger link between benefits and contributions in the NDC. In an NDC scheme, every marginal unit of contribution gives rise to an equivalent pension right which will then be transformed into benefit. Hence, NDC does away with the disincentive to contribute that characterizes the DB scheme. In principle, this exact link between contribution and benefit can also be expected to encourage formal labor force participation. Moreover, NDC grants benefit as life annuities, calculated from the individual’s accumulated pension capital and the life expectancy at retirement of the cohort to which the individual belongs. Together with an adjustable internal rate of return, the system can in theory maintain long-term financial balance at a fixed contribution rate for all generations. In this sense, it eliminates nontransparent and unfair redistribution that often characterizes the DB schemes.

There are two anthologies providing comprehensive discussion around the concept, implementation progress and issues of the NDC schemes in their newborn and teen stages (Holzmann and Palmer, 2006, Holzmann et al., 2012). As highlighted by the latest anthology (Holzmann et al., 2012), research on assessing the outcomes of NDC Schemes is called for. It is important to study whether the design of the NDC schemes in real life is in fact in line with the primary goals of pension system, namely, fair redistribution and financial sustainability. It is also of great interest to study the response of individuals’ labor supply to the NDC design characteristics, for example, the use of quasi-actuarial adjustments in the calculation of pension benefits.

Departing from the research suggestions mentioned above, the essays in this thesis conduct an in-depth discussion of evaluating and designing the pension plan under the general framework of NDC in terms of upholding both fair inter and intra generational redistribution. In addition, it also enhances the understanding of individual’s retirement decision in an NDC scheme. The focal point is the measurement of life expectancy currently applied in the calculation of annuities. In the current practices, the NDC annuity is quasi-actuarial, i.e., life expectancy is not precisely projected, and fair on average, i.e., life expectancy is only projected for the cohort average. The four independent, but closely related, essays contribute to this literature both theoretically and empirically.

The first essay is a joint venture with Professor Juha Alho and Professor Edward Palmer. We suggest a new method of projecting life expectancy for pension schemes. Essay two aims at tackling the essential problem of financial instability and unfair inter-generational transfer underlying the systematically underestimated life expectancy used in NDC. An alternative design of the annuity is proposed and tested on a wide range of countries. Essay three turns to the question of modeling retirement decision in NDC. The specific question is how the working/retirement incentive is affected if individuals use their own information of life expectancy when choosing retirement. The last essay focuses on the issues of unfair intra-generational transfer and
unintended inter-generational transfer in the NDC scheme that applies cohort average life expectancy when determining the annuity. To approach the issue, an alternative benefit plan is presented. In this plan, individuals of different socioeconomic classes are placed in separate annuity pool and subject to group life expectancy instead of the cohort average.

1 Projecting Life Expectancy

Almost all pension schemes in the world have either direct or indirect links between life expectancy and benefits. In DC scheme, NDC or FDC, the link is actuarial – that is, life annuity is granted according to the anticipated life expectancy at “the” pension age. The crux, however, is that anticipated life expectancy is unknown and hence needs to be estimated or projected. The methods (projection technology) used today almost always deliver underestimated life expectancy. For instance, the state-of-the-art model, known as the Lee-Carter Model (Lee and Carter, 1992), underestimates the life expectancy of the Scandinavian 65-year olds from the 1940s by around 2 – 5% (Alho et al., 2012). The Swedish Pension Agency uses the average of the latest 5-year period life expectancy as the annuity divisor, giving an error of about 5 – 7%.

The systematic underestimation exposes the system to a financial risk at the long run, which implies inter-generational unfairness under the rule of risk-sharing embedded in the current practice of NDC. Hence, seeking for a better modeling approach becomes the prior goal of this essay.

Essay 1 suggests a new approach of estimating life expectancy which accounts for the situation with a society characterized by increasing rates of decline in mortality. Indeed, the scenario that mortality drops at an accelerating rate is typical and is occurring in an increasing number of countries. It was first noticed in Sweden but was also seen in Japan already in the early 1960. From the 1980s, the acceleration is seen in most of the east European countries. The global expansion of the trend largely challenges the feasibility of current golden standard of projection models, i.e., Lee-Carter (LC) and its variants which are built on the maintained assumption of a time-invariant rate of decline in mortality.

The approach proposed in this essay does not impose any pre-defined assumptions on the long-term growth pattern of mortality. Cohort life expectancy is projected based on the parameter that characterizes the accelerating/decelerating mortality over time – that is the rate of change in mortality. The approach is applied on eight developed countries featuring different types of growth pattern in mortality over the last century. The results are compared to the benchmark LC model both ex post and ex ante. The ex post experiment shows that the proposed approach on average reduces the projection error when there exists long-run trend in the accelerating rate of decline in mortality as for Sweden, Denmark, Norway, France, Italy and the UK. Notably, it works extremely well for Sweden. For countries lacking of a clear trend, our approach works similar to the LC model, for example, the USA and the Netherlands. The ex-ante experiment shows a rather inspiring result that our approach almost always yields higher life ex-

\[ \text{The author calculated the life expectancy estimated using the Swedish method for the cohorts from the 1940s and compare with the actual figures.} \]
pectancy than the LC model. This implies a reduced risk of underestimation, which in turn implies a reduced risk of potential deficits for pension systems.

2 The Aggregate Longevity Risk–Financial Instability and Unfair Inter-generational Transfer

Maintaining solvency and upholding fair and transparent transfers among generations are the central features of an NDC scheme. A solvent pension system is the ground of honoring the long-term commitment to pensioners while fair redistribution stands for one of the fundamental principles of a public pension system. A properly designed NDC scheme can in principle hold its promise in terms of solvency and fair transfer at the average level. However, the statistical error in the estimation of life expectancy, as discussed in the first essay, is inevitable and imposes the system to a residual risk of long-term financial instability. This residual risk is denoted as the aggregate longevity risk in this literature. How to absorb the risk is then a design question and countries operating NDC have different solutions. Sweden adopts a balancing mechanism that is triggered when the aggregate liability exceeds the aggregate assets in the system – that is partly the consequence of granting annuity calculated with systematically underestimated life expectancy. To maintain solvency of the NDC scheme, balancing reduces the account value of future pensioners through adjusting the indexation. Other countries have no such build-in stabilizer but finance the potential deficits through the government budget, thus, implying the need of increasing taxes of future generations. Under both mechanisms, the inter-generational fairness is breached.

Essay 2 devises an annuity plan that distributes the aggregate longevity risk between the current and future pensioners in a fairer way than the present approach used in Sweden. To begin with, it is suggested that an approach that is less likely of providing downward biased estimates of life expectancy should be used in the calculation of the annuity, for example, the approach presented in Essay 1. It is also suggested that the annuity should be allowed to vary according to the re-estimation of cohort remaining life expectancy at intervals up to a relatively old age, i.e., 85 in this study, instead of being fixed to an once-and-for-all estimation at a relatively low initial retirement age, i.e., 65. In the context of accelerating improvement in mortality and continuously increasing longevity, fixing the annuity factor at such an early age provides a large model uncertainty in the projection of mortality. Hence, postponement of the setting of the final fixed annuity factor until a later age has the obvious advantage of incorporating an estimate that is likely to be closer to the final outcome (Chlon-Dominczak et al., 2012).

The proposed annuity scheme is simulated on 208 cohort annuity pools from eight countries, i.e., Sweden, Denmark, Norway, France, Italy, the Netherlands, the UK and the USA. It is shown that 60–80% of the sample cohort annuity pools face a smaller

3Note that the scenario can also occur when there is a negative shock in labor force or in economic growth
4They are the past cohorts that were at 65 from 1946 to 1975 for Sweden, Denmark, Norway, France, Italy and the Netherlands. For the UK, they are the past cohorts that were at 65 from 1957 to 1975. For the USA, they are the past cohort that were at 65 from 1967 to 1975.
residual risk under the proposed variable annuity scheme than the current fixed annuity scheme, depending on the specific projection model for life expectancy applied. This means that the residual risk, caused by the underestimated life expectancy of the current generation, left to be borne by the future generation is reduced. As a trade-off, the younger persons in the current generation bear the risk of a corresponding loss in life-time utility. However, the relatively change in utility is estimated to be rather small assuming risk neutrality.

3 Retirement Decisions with Private Information of Life Expectancy

Because of the actuarial link between the contribution and the benefit, the NDC (DC) plans do not include strong economic incentives regarding the timing of retirement as in the traditional DB plans. In these plans there is no need to set either a vesting period for eligibility or a fixed retirement age, which has been a characteristic of many DB schemes. Instead, ageing workers are only bound with a minimum retirement age, from which pensions can be claimed. After reaching this age, individuals are free to choose the timing and often the degree of exit from the labor force. The effect of stimulating working incentives among the ageing workers can be observed in the countries that have implemented NDC. In Sweden, for example, there was a clear turning point in 1999 when NDC was implemented. The trend of the labor participation rate for age group 60-64 (both male and female) was reversed completely from continuously decreasing to monotonically increasing (See e.g. Johansson et al. (2016)). As for the future prospect, the European Union Ageing Working Group (AWG) forecasts that the pension reforms would have a sizable impact on the labor market participation of older workers in most of the EU member states in the coming decades. The broad trend of retirement age is, according to Chlon-Dominczak et al. (2012), that it is going to increase and countries are likely to converge.

The questions remain what determines actual individual’s retirement choice in an NDC plan and how to model it. Besides the determinants such as wealth (Fields and Mitchell, 1984), labor disutility(Diamond (2003); Sheshinski (2003); Simonovits (2004)) and health (Deschryvere (2005); Bloom et al. (2005); D.S.Dwyer and Mitchell (1999)), individual’s subjective view of life expectancy should also play an important role in the decision process. According to the current view of research, the consequence of using private information of life expectancy when choosing retirement is that those with longer life expectancy retires later, ceteris paribus (Attanasio and Hoynes (2000); Finkelstein and Poterba (2002); Beauchap and Wagner (2013) and etc). This phenomenon is known as the adverse selection, which is said to have negative effect on the financial and welfare outcome of the pension scheme (Heidler et al., 2006).

Essay 3 studies how the retirement/working incentive is influenced if one uses her private information of life expectancy when making the retirement decision in an NDC scheme. The relationship between retirement decision and private information of life expectancy in an NDC scheme is modeled using a life-cycle modeling framework. This framework differs from previous models in several ways. In this model, disutility of labor and utility of consumption is separable. This is different from the
setting adopted in Stock and Wise (1990) and Lumsdaine et al. (1994). Meanwhile, the labor dis-utility is defined as a continuous function that increases with the retirement age instead of a fixed additive as used in Lachance (2003), Kingston (2000) and P. Esö et al. (2011). Moreover, the individual life expectancy is endogenized in the dis-utility function as an explicit driver of labor dis-utility as in Bloom et al. (2007) and Prettner and Canning (2012).

The theoretical result is that the rule-of-the-thumb scenario, i.e., a longer-than-average/shorter-than-average life expectancy means delay/advance retirement, may not necessarily occur at the individual level. A specific criterion needs to be fulfilled (Refer to Proposition 3.1) for this to happen. The numerical analysis using the Swedish Pension data verifies the theoretical results. It is shown that around 50% of the population would have behaved according to the rule of the thumb, 25% of the population would have behaved the other way around. The rest of the population retirement decision is barely influenced by their private information of life expectancy. On average, the effect of using private information of life expectancy on retirement choice complies with the rule of thumb, i.e., individuals with higher than average life expectancy increase the retirement age while individuals with lower than average life expectancy decrease their retirement age. However, as demonstrated using the Swedish scheme as an example, the positive respond to a higher life expectancy is estimated to be much smaller than the negative respond to a lower life expectancy. In other word, this selection behavior should not have substantial negative impact on the financial and welfare outcome of the pension system.

4 Social Differences in Life Expectancy, Intra and Inter-generational Unfairness

The rise in social gaps in life expectancy has been a common feature in many developed western countries since the last decades of the 20th century. A substantial amount of work has been devoted to study both the actual gap and the its trend of growth among different socioeconomic classes, using different indicators such as income, education, gender and occupation. For example, Montex et al. (2011) and Attanasio and Hoynes (2000) showed the educational gap in the USA population. Longitudinal Study Development Team from the Office for National Statistics (ONS) of the United Kingdom analyzed the data of England and Wales from 1972-2005 in order to study occupational effect on life expectancy. Lampert et al. (2007) and Kroh et al. (2012) use German data to compare the differences in life expectancy at the later age, i.e., 65, between income groups. Shkolnikov et al. (2012), Eriksson et al. (2014), Myrskylä et al. (2012) studied the gap using data from the Scandinavian countries and found both the existence and the increasing trend of the gap. To sum up, the social differences in mortality and life expectancy exist in a global range and exhibit the tendency to increase in almost all countries.

However, the public pension schemes, including the newly emerged NDC, pay no attention to the social gaps in life expectancy in its construction of insurance collective and the design of the benefit rule. In the currently existing NDC schemes, all individuals from the same birth-cohort are placed in a joint annuity pool and are subject to a
uniform life expectancy factor estimated for the cohort. This means that the annuity is only actuarially fair on average.

The uniform policy together with the existing heterogeneity in life expectancy creates a regressive transfer from the low to the high class. This is against the key purpose of a social security system. Despite the consequences on redistribution, the uniform policy also implies an unintended cost that arises with the gap in life expectancy and wealth inequality between classes. This means that even if the average life expectancy of the cohort is perfectly predicted, there still exists a residual risk of deficits in each cohort insurance pool. This risk is thereafter borne by the future generations, raising the issue of an unintended inter-generational transfer. Furthermore, the implementation of the uniform policy together with the flexible rule of retirement age in the NDC schemes lead to a selection behavior of rational individuals who opt to retire according to their own expectation of remaining lifespan. This entails, on average, that those with longer life expectancy would retire later while those with shorter life expectancy would retire earlier (Waldron, 2001). According to Heidler et al. (2006), and P. Esö et al. (2011), the selection behavior generates a loss in social welfare and an extra cost on the budget of the system. However, essay 3 shows that the average effect on retirement age in NDC scheme is expected to be small and therefore should not cause substantial cost on budget and change in social welfare. Similar results can be seen in Brinch et al. (2015) and Finkelstein and Poterba (2002).

Essay 4 studies the problem of regressive intra-generational transfer and the unintended inter-generational transfer in the current NDC scheme with uniform benefit rule. The alternative suggested is to divide the cohort annuity pool by socioeconomic classes, e.g. occupation, and to use group life expectancy in the calculation of annuity for individuals from respective groups. The idea of group plan is currently implemented in many private insurance plans as well as occupational plans. It is also suggested and examined in some previous literature for the public pension schemes, e.g., Nalebuff and Zeckerhauser (1985), Simonovits (2006) and P. Esö et al. (2011) and etc. This essay performs an in-depth study of the effect of a group plan in the NDC scheme on both inter and intra-generational redistribution. In addition, the effect on efficiency, i.e., the change in social welfare caused by the selection behavior in the group plan, is also examined by employing the decision model presented in Essay 3. The analysis is not only limited to the theoretical level but also includes empirical illustration using unique Swedish data.

First, it is predicted that the gaps in life expectancy between the low class, i.e., the manual workers, and the high class, i.e., the non-manual workers of the sample cohorts (birth-cohorts from 1940 to 1945) are significant, regardless the estimation method used to project life expectancy. Assuming the optimistic scenario that the current estimation method applied in the Swedish pension scheme can perfectly predict the life expectancies, i.e., the average difference in life expectancies at around 2 years, over 5% of the pension capital from the manual workers is transferred to the non-manual workers. Moreover, the gaps in life expectancy and inequality in pension capital between the two classes also gives rise to an excess cost which amounts from 1.3% to 1.8% of the total pension capital of each cohort annuity pool. This is a substantial risk to be borne by the future generation of pensioners in a closed system as the one in Sweden. Last but not least, it is shown that the net effect on social welfare
caused by the selection behavior of rational individuals is positive but very small in magnitude, which is consistent to the prediction made in Essay 3.
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Bank.


