THE EFFECTS OF UNCERTAINTIES IN THE PENSION SYSTEM ON ECONOMIC WELFARE

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KEYWORDS
Macroeconomic modelling, OLG models, pension system, uncertainty

ABSTRACT

Uncertainties regarding possible policy changes in the pension system may have a significant impact on how people make their consumption and labor market decisions. If their expectations are mistaken, the distortion that this causes decreases their lifetime utility. In this article, we build a model with overlapping generations (OLG) and analyse how three different policy changes affect the behavior of economic agents if (1) the changes are announced previously, or (2) not.

INTRODUCTION

When people make decisions about their consumption path, they have to have some assumptions about their lifetime incomes. These lifetime incomes include the pension benefits that they can expect in the future. An important problem is that there are uncertainties about the pension system (see for example van Santen (2019)). Several decades pass between the start of employment and the retirement, and the rules of the pension system may change several times during that period. This uncertainty means that the expectations of economic agents matter. Therefore, if the government changes the parameters of the pension system unexpectedly, it can decrease economic welfare because the expectations of people prove to be mistaken.

Our OLG model contains representative consumers who live for two time periods and maximize their lifetime utility subject to a sequence of budget constraints. The consumer works in the first period and uses her incomes either for consumption or for saving. She also spends a fraction of the second period with working, then retires (the partition of the second period depends on the retirement age). Therefore, the consumer can use her labor income, the previously accumulated savings, and her pension benefits to finance her consumption in the second period. However, the optimal consumption–saving decision in the first period depends on the expectations of the consumer regarding the retirement age and the replacement ratio in the pension system.

We examine the welfare effects of uncertainty caused by the possibility of changes in the parameters of the pension system by comparing how the steady states of the model differ if the consumers are aware of a changed parameter at the beginning of the first period of their life (i.e., when they start working), or only at the beginning of the second period. Our analysis includes three policy changes (increased retirement age, decreased replacement ratio, increased social security contribution), and in all three cases we find that a sudden, unexpected change decreases the lifetime utility of the representative consumer compared to a pre-announced change.

THE MODEL

It is not unique to use an overlapping generation model to answer pension-related questions. The structure of the model enables us to separate groups of agents by their age, to endow one group with pension and investigate the effects of various changes in the exogenous variables or some changes in the behavior of the agents, the pension system, or the demographic elements (see for example in Tyrowicz et al. (2016) with changes in the retirement age, Bielecky at al. (2015) with different pension systems, Buyse et al. (2017) with heterogenous agents, Cipriani (2014) or Thøgersen (2015) with ageing).

Our model differs from these papers in three elements:

1. First, we assume that the agents in the age group of 60–100 years spend a fraction of their time by working and they obtain pension during only a fraction of these years. With this modification (1) we are able to include the retirement age in our model and (2) we get a more realistic effect if we change the amount of pension.
2. Second, we assume that only the senior agents are able to observe the actual value of various parameters in the model, the young agents assume that the parameters for the second period will be the same as those observed in the first period and that the wage will remain similar to the already obtained one.
3. Third, by announcing a policy action, the fiscal policy decision maker is able to affect the decisions of the agents.

Our model consists of representative agents who live and consume for two time periods. In period t, N_t denotes the number of those who are in the first, active part of their lives (aged 20–60 years), while N_{t-1} agents are in the

Communications of the ECMS, Volume 37, Issue 1,
Proceedings, ©ECMS Enrico Vicario, Romeo Bandinelli,
Virginia Fani, Michele Mastroianni (Editors) 2023
ISBN: 978-3-937436-80-7/978-3-937436-79-1 (CD) ISSN 2522-2414

second part of their lives (aged 60–100 years). The number of employed and retired agents are exogenous variables. If there is an increase in the retirement age, these numbers change unexpectedly and drastically.

Individual decision

In our model each individual agent makes decisions for two periods. A representative consumer (in this case she represents only the agents of her age group) who starts her life cycle at period t seeks to maximize her life-cycle utility function subject to a sequence of budget constraints. While doing so, she faces various types of uncertainty regarding parameters in period $t+1$: (1) she does not know whether the fiscal policy decision maker will change the mandatory retirement age; (2) she does not know whether there will be a change in the amount of the pension she could receive; (3) she also does not know whether the government will raise or decrease the rate of social security contribution; (4) additionally, she does not know her own life expectancy.

At the beginning of period $t+1$, these parameters become known. However, in period t, she must formulate expectations about them. Since her life spans only two periods, she does not have much information about the time series of these parameters, so she chooses the simplest method to formulate her expectations. She can observe the value of these parameters at period t and simply expect them to apply for period $t+1$ as well.

Formally, we define the representative agent's life-cycle utility over the path of her consumption $\{c_{t,1}, c_{t+1,2}\}$ and labor supply $\{l_{t,1}, l_{t+1,2}\}$, where the subscript indicates the time period t or $t+1$ for which the given variable applies, and the life stage of the representative agent: 1 if the variable characterizes her first life period and 2 if it describes a second period decision (or expected decision). Although we have normalized the length of the second period to 1, we do not expect the agent to live and be active throughout the whole period. γ^e_{t+1} represents the expected value of the fraction of the second period the representative consumer expects to live and make decisions and ρ^e_{t+1} represents the expected ratio of time spent working relative to the whole time period.

The expected utility is written as

$$U = \frac{c_{t,1}^{1-\sigma}}{1-\sigma} - \Psi_1 \cdot \frac{l_{t,1}^{1+\eta}}{1+\eta} + \\ +\beta \cdot \left(\gamma^e_{t+1} \cdot \frac{\left(c^e_{t+1,2}\right)^{1-\sigma}}{1-\sigma} - \rho^e_{t+1} \cdot \Psi_2 \cdot \frac{\left(l^e_{t+1,2}\right)^{1+\eta}}{1+\eta} \right)$$

where σ, η, β, Ψ_1, and Ψ_2 are positive parameters describing the preferences of the consumer, and in period t the agent simply expects parameter ρ_{t+1} and γ_{t+1} to be equal to the value of the parameters observed in period t, so $\rho^e_{t+1} = \rho_t$ and $\gamma^e_{t+1} = \gamma_t$.

During the first period of her life cycle, the consumer receives income from working and inheritance from the deceased members of the elderly age group. She spends a portion of her funds on goods and services, while the remainder is saved. Formally,

$$(1-\tau_t) \cdot w_t \cdot l_{t,1} + \\ +(1-\gamma_t) \cdot \frac{N_{t-1}}{N_t} \cdot (1+r_t) \cdot s_t = c_{t,1} + s_{t+1}$$

where τ_t is the tax rate (social security contributions included), w_t is the real wage rate, r_t is the interest rate effective for period t, and s_{t+1} denotes the individual savings in period t.

During a portion of the second period, the representative agent works and receives wage income. For the other part of the period – until her death –, she receives pension and earns a return on her previously accumulated assets. Since this is her last period in the life cycle, she spends all of her funds on goods and services. The consumer expects the following budget constraint to apply for the second period of her life:

$$\rho^e_{t+1} \cdot (1-\tau^e_{t+1}) \cdot w^e_{t+1} \cdot l^e_{t+1} + \gamma^e_{t+1} \cdot (1+r_{t+1}) \cdot \\ \cdot s_{t+1} + (1-\rho^e_{t+1}) \cdot \gamma^e_{t+1} \cdot p^e_{t+1} = \gamma^e_{t+1} \cdot c^e_{t+1}.$$

To obtain the variables for the first period, she solves a utility maximization problem subject to a sequence of budget constraints. She expects that the parameters for the second period will be the same as those observed in the first period and that the wage rate will remain similar to that already obtained.

At the start of the second period, the fiscal policy decision maker announces the rate of social security contributions, the value of pension benefits, and the mandatory retirement age. This allows the agent to adjust her optimal choices regarding labor supply and consumption by solving the following utility maximization problem:

$$U_{t+1} = \gamma_{t+1} \cdot \frac{\left(c^e_{t+1,2}\right)^{1-\sigma}}{1-\sigma} - \rho^e_{t+1} \cdot \Psi_2 \cdot \frac{\left(l^e_{t+1,2}\right)^{1+\eta}}{1+\eta}$$

subject to

$$\rho_{t+1} \cdot (1-\tau_{t+1}) \cdot w_{t+1} \cdot l_{t+1} + \gamma_{t+1} \cdot (1+r_{t+1}) \cdot \\ \cdot s_{t+1} + (1-\rho_{t+1}) \cdot \gamma_{t+1} \cdot p_{t+1} = \gamma_{t+1} \cdot c_{t+1}.$$

By solving the utility maximization problem and resolving it for the second period we obtain the following behavioral equations:

$$\Psi_1 \cdot l^\eta_{t,1} = c^{-\sigma}_{t,1} \cdot (1-\tau_t) \cdot w_t$$

$$\Psi_2 \cdot \left(l^e_{t+1,2}\right)^\eta = \left(c^e_{t+1,2}\right)^{-\sigma} \cdot (1-\tau_t) \cdot w_t$$

$$c^{-\sigma}_{t,1} = \beta \cdot \left(c^e_{t+1,2}\right)^{-\sigma} \cdot \gamma_t \cdot (1+r_{t+1})$$

$$(1-\tau_t)\cdot w_t\cdot l_{t,1}+(1-\gamma_t)\cdot\frac{N_{t-1}}{N_t}\cdot(1+r_t)\cdot s_t= \\ =c_{t,1}+s_{t+1}$$

$$\rho_t\cdot(1-\tau_t)\cdot w_t\cdot l^e_{t+1}+\gamma_t\cdot(1+r_{t+1})\cdot s_{t+1}+ \\ +(1-\rho_t)\cdot\gamma_t\cdot p_t=\gamma_t\cdot c^e_{t+1}$$

$$\Psi_2\cdot l^{\eta}_{t+1,2}=c^{-\sigma}_{t+1,2}\cdot(1-\tau_{t+1})\cdot w_{t+1}$$

$$\rho_{t+1}\cdot(1-\tau_{t+1})\cdot w_{t+1}\cdot l_{t+1}+\gamma_{t+1}\cdot(1+r_{t+1})\cdot \\ \cdot s_{t+1}+(1-\rho_{t+1})\cdot\gamma_{t+1}\cdot p_{t+1}=\gamma_{t+1}\cdot c_{t+1}$$

The solution of these equations – at given parameters and exogenous variables – provides us with the optimal value of the following endogenous variables: c_t, c_{t+1}, c^e_{t+1}, l_t, l_{t+1}, l^e_{t+1}, s_{t+1}.

The problem of the representative firm

As our main focus is on the decisions of the fiscal policy decision maker and how consumers react to those decisions, we aim to keep the behavior of the firm as simple as possible. The profit-maximizing agent utilizes labor and capital to produce goods and services, with the technology being described by a simple Cobb-Douglas production function. Under these circumstances the behavioral equations of the firm are the following:

$$Y_t=a\cdot K^{\alpha}_t\cdot L^{1-\alpha}_t$$

$$L_t=(1-\alpha)\cdot\frac{Y_t}{w_t}$$

$$K_t=\alpha\cdot\frac{Y_t}{r^K_t}$$

where Y_t, L_t, K_t are the aggregate output, labor and capital respectively, w_t is the real wage rate, and r^K_t is the real rental rate of capital. At given prices these three equations provide us with the optimal value for the following variables: Y_t, L_t, K_t.

The fiscal policy decision maker

The fiscal policy decision maker is responsible for collecting taxes, including social security contributions, and purchasing goods and services. If the revenue from taxing wage income is insufficient to finance government spending, the decision maker may accumulate debt. In our model, we distinguish between the fundamental roles of the fiscal policy decision maker and the social security provider. In the latter role, the social security provider collects contributions and pays pensions to eligible agents and may also accumulate debt. Therefore, the behavior of the fiscal policy decision maker can be described by the following formulas:

$$(\tau_t-\tau_{t,p})\cdot w_t\cdot L_t+D_{t+1}=G_t+(1+r_t)\cdot D_t$$

and

$$\tau_{t,p}\cdot w_t\cdot L_t+D_{t+1,P}=P_t+(1+r_t)\cdot D_{t,P}$$

where $\tau_{t,p}$ represents the rate of social security contributions, while P_t refers to the total amount of pension provided by the fiscal policy decision maker. It is worth noting that we have already used another variable, p_t, to represent the value of individual pension benefits. Since N_{t-1} senior individuals are eligible for pension for a $(1-\rho_t)\cdot\gamma_t$ portion of period t, we can calculate the total amount of pension as

$$P_t=N_{t-1}\cdot(1-\rho_t)\cdot\gamma_t\cdot p_t.$$

Market clearing conditions

In our simple economy we have four markets and all markets clear. In the market for goods and services the amount of goods and services produced by the firm equals the amount of goods and services purchased by the consumers, the government and the physical capital providers. Formally,

$$Y_t=N_t\cdot c_{t,1}+N_{t-1}\cdot\gamma_t\cdot c_{t,2}+I_t+G_t$$

where $I_t=K_{t+1}-(1-\delta)\cdot K_t$ is the investment.

In the factor markets the demand for the specific factor equals the supply of it:

$$L_t=N_t\cdot l_{t,1}+\rho_t\cdot N_{t-1}\cdot l_{t,2}$$

and

$$K_t=K_t.$$

Finally, in the asset market the supply of assets finances the investment and the total debt of the fiscal policy decision maker:

$$N_t\cdot s_{t+1}-N_{t-1}\cdot(1+r_t)\cdot s_t+(1+r_t)\cdot \\ \cdot\left(D_t+D_{t,p}\right)+r^K_t\cdot K_t=I_t+D_{t+1}+D_{t+1,p}$$

where the expected return on the physical asset must be equal to the return on the other assets:

$$1+r_{t+1}=r^K_{t+1}+1-\delta.$$

Summary of the model

The functioning of the economy is represented by 4 market clearing conditions, 12 behavioral equations and 3 definitions. As the sum of the constraints must provide the market clearing condition for the market for goods and services (if the other markets clear) and formally the market clearing condition for the capital market only means that the amount of capital used by the firm equals the amount of capital financed in the asset market, we have 17 equations that provide us the optimal values for the following 17 variables: c_t, c_{t+1}, c^e_{t+1}, l_t, l_{t+1}, l^e_{t+1}, s_{t+1}, Y_t, L_t, K_{t+1}, I_t, w_t, r^K_t, $1+r_{t+1}$, D_{t+1}, $D_{t+1,p}$, p_t.

CALIBRATION

We have calibrated our model using Hungarian data obtained primarily from the public domains of the Central Statistical Office of Hungary and the Eurostat. However, because of the strong impact of the Covid-19 pandemic and the war in Ukraine, we have decided to limit our data to the period before 2020.

- From 1996 to 2019, on average, 64.35% of domestic demand in Hungary came from consumption, 25.02% from investment, and 10.63% from government spending.
- Before 2020, the budget deficit closely fluctuated around 2 percent.
- The average dependency ratio between 2001 and 2019 was 24.6%. At any given time t, there are N_t young agents, $\rho \cdot N_{t-1}$ senior agents who are still active, and $(1-\rho) \cdot \gamma \cdot N_{t-1}$ who are receiving pension. If the retirement age is 65, indicated by $\rho = 0.125$, then in a steady state, we can solve for γ by setting $0.246 = \frac{(1-\rho) \cdot \gamma \cdot N_{t-1}}{\rho \cdot N_{t-1} + N_t}$, which yields a value of $\gamma = 0.3163$.
- The Hungarian tax table specifies an income tax rate of 15%, individual social contribution rate of 18.5%, from which the pension insurance contribution rate is 10%, and an employer's social contribution rate of 13% of the workers' gross income. Thus, $\tau = 0.465$ and $\tau_p = 0.1$.

RESULTS

At the given parameters neither the budget, nor the social security system is sustainable. If the simulation starts from 0 debt for the social security system and a 70 percent debt-to-GDP ratio for the budget of the fiscal policy decision maker, the evolution of debt over time is displayed on Figure 1 (red line: public debt, green line: debt of the social security system).

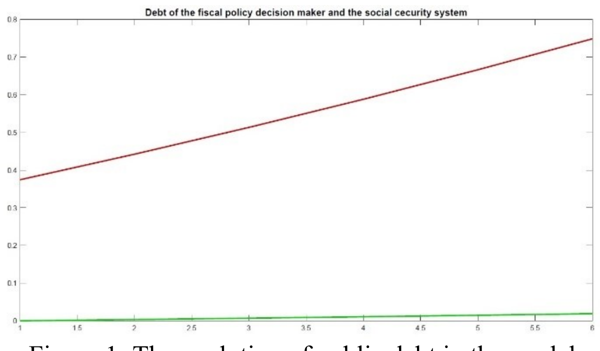

Figure 1: The evolution of public debt in the model

If we focus solely on the evolution of the social security system debt over time, two strongly connected questions arise: (1) which aspect of the social security system should we change to achieve a balanced budget, and (2) by how much. Furthermore, we are particularly interested in the following question: if the fiscal policymaker decides to introduce a new value for her policy tool, should she announce it to the economic actors well in advance, or only when the move is about to take effect?

In the following subsections, we will focus on these points in detail. In all the cases presented below, we assume that during the initial period, the government budget runs a 70% debt-to-GDP ratio, while the social security budget is in balance. The magnitude of the specific change keeps the social security budget in balance in the steady state. We will investigate three different tools: (1) a change in the retirement age, (2) a change in the amount of pension benefits, and (3) a change in the magnitude of contributions. For all these cases, we will explore two different timings regarding the announcement of the policy action. The fiscal policy decision-maker will either announce the specific action before executing it or at the time of execution.

More precisely, we run the following six simulations and detect the effect of these simulations on the utility of economic agents and on various macroaggregates.

1. The fiscal policymaker intends to change the retirement age and announces this in advance to economic agents, who incorporate the expected impact of this economic policy intervention into their current decisions.
2. The fiscal policymaker intends to change the retirement age, but only announces this to economic agents before the intervention is implemented, forcing them to redefine their current situation.
3. The fiscal policymaker intends to change the magnitude of pension benefits and announces this in advance to economic agents, who incorporate the expected impact of this economic policy intervention into their current decisions.
4. The fiscal policymaker intends to change the magnitude of pension benefits, but only announces this to economic agents before the intervention is implemented, forcing them to redefine their current situation.
5. The fiscal policymaker intends to change the rate of social security contribution and announces this in advance to economic agents, who incorporate the expected impact of this economic policy intervention into their current decisions.
6. The fiscal policymaker intends to change the rate of social security contribution, but only announces this to economic agents before the intervention is implemented, forcing them to redefine their current situation.

Change in the retirement age

In Hungary, the current retirement age is 65 years. Under the current model parameterization and starting from 0 debt in social security, increasing the retirement age to 66.36 years would maintain the balance of the social security system in the steady state. Implementing this action leads to the results displayed in Figure 2. As in all the remaining figures in the article, the red lines represent the scenario where the fiscal policy decision maker announces in period t that they will implement a policy change in the next period, while the green lines represent the scenario where the decision maker implements the action in period $t + 1$ without any prior announcement. Just as in the case of all the following figures in this article, time is measured on the horizontal axis, supposing that the possible prior announcement takes place in period 1 and the actual implementation of the policy occurs in period 2.

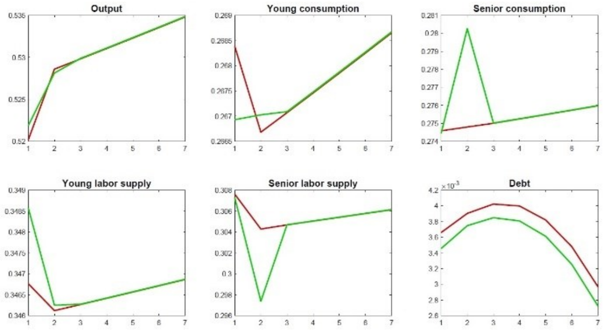

Figure 2: The effects of a change in the retirement age on different macroaggregates (output, young and senior consumption, young and senior labor supply, debt of the social security system)

Without the involvement of the second round effects, the evaluation of an increase in the retirement age would be a simple task: if the additional cost of working more in the second period is greater than the additional benefit of getting a wage higher than the pension benefit, than the senior agent (above 60) reduces her labor supply that may reduce her life-cycle income, which forces her to restructure her consumption path. But output can increase since this change in the consumption path reduces the effect that the decrease in the present value of income may have on the savings and through the savings, on the amount of capital. Finally, the debt of the social security system falls. This process is behind the picture shown by the red lines in Figure 2, where the policy change is totally expected.

The green line shows a slightly different path. If the fiscal policy decision maker does not make any announcement about the possible change in the policy tool, the agent who becomes senior in period $t + 1$ and faces the change in the retirement age at that period, had not had the opportunity to smooth her consumption path by reducing her savings and now, supported by her wealth accumulated before, is even able to work less and consume more. Even the debt of the social security system evolves better than it would evolve with the policy announcement.

The main goal of the fiscal policy decision maker ought to be to increase the well-being of the economic agents. Figure 3 displays the evolution of the utility of the senior agent, the utility of the young agent and the total utility over time. Total utility follows the life cycle utility of the senior agent, so the value at period t displays the total utility of an agent that was young in period $t - 1$ and old in period t.

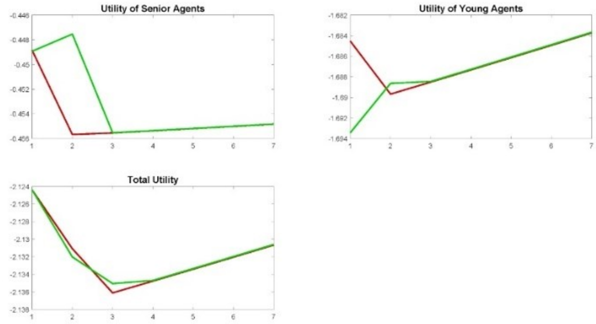

Figure 3. The ulility of a senior agent, a young agent and the total (retrospective life cycle utility) in the case of a change in the retirement age

On the horizontal axis of the graphs, 1 represents the period when the announcement occurs (or does not occur). Since the actual policy tool is implemented in period 2, this announcement does not affect either the old agents' decisions or their utility (nor has it any effect on their retrospective life cycle utility), but it actually increases the young agents' utility. The latter effect is due to the fact that at the given parametrization of the model the expected increase in the retirement age actually increases the lifetime income of economic agents and leads to a reduction in interest rates by reducing the debt of the fiscal policymaker. These two changes motivate the young agent to increase her consumption and decrease her efforts in the labor market. But in the second period, while facing the actual implementation of the policy action, the same agent ought to decrease her consumption and increase her labor supply resulting in a huge reduction in her utility.

Figure 3 also shows a result that differs from the current consensus in the literature. In the longer run, the fact that the fiscal policy decision maker announced the policy in period 1 creates a macroeconomic environment that makes the economic agents slightly worse off than they would be if the announcement had not been made and the government had simply implemented the policy in period 2.

Change in the amount of pension benefits

The 4.18% decrease of the amount of pension benefits (that is the change that keeps social security balanced in steady state) decreases the life-cycle income of the consumer and makes her to reduce her consumption path. It is not surprising that in this case the early announcement of the possible policy change motivates the agent to increase her first period labor supply to get the funds that reduce the effect of the second period negative income shock on the life-cycle income (red lines in Figure 4).

The same force does not hit the consumer if the fiscal policy decision maker decreases the pension in period

$t + 1$ without any prior announcement. Since the representative agent has kept a relatively high consumption and a relatively low labor supply over the first period, she is forced to drastically decrease her consumption and drastically increase her labor supply in the second period (as the green lines show in Figure 4). The evolution of the social security balance is better in the case of announcing the change in the policy tool than it would have been without prior announcement.

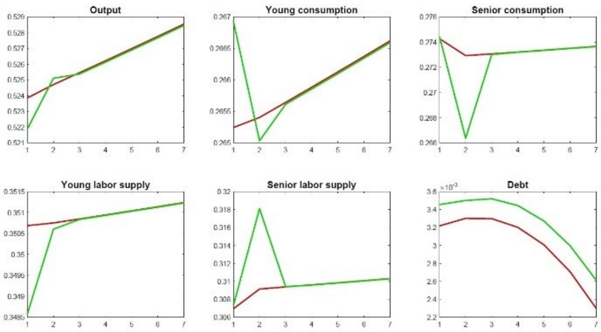

Figure 4: The effects of a change in the amount of pensions on different macroaggregates (output, young and senior consumption, young and senior labor supply, debt of the social security system)

This finding is supported by the evolution of utility over time, especially by the fact that even though in the short run the total utility in the case of prior announcement is lower than in the case of no announcement, in the long run the "announcement" scenario dominates the "no announcement, just implementation" scenario (Figure 5).

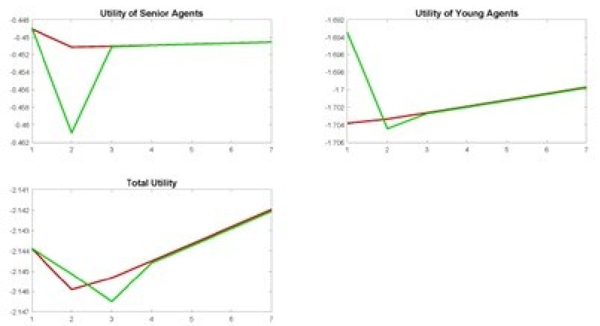

Figure 5. The ulility of a senior agent, a young agent and the total (retrospective life cycle utility) in the case of a chenge in the amount of pensions

Change in the contributions

The main driving force behind the impact of a 1 percentage point increase in social security contributions is the same as in the case of the reduction in pensions. If the consumer faces a loss in her life-cycle income, she reduces her consumption and increases her labor supply. But the magnitude of the effect is different, partly because this policy action involves an intratemporal substitution as well. Any increase in the contribution makes working more expensive and motivates the consumer to decrease her labor supply.

The magnitude of these effects also depends on the timing of the announcement. In case of a prior announcement (red lines in Figure 6), the agent is able to prepare for the change in the second period and reduce its effects by working and saving more in the first period.

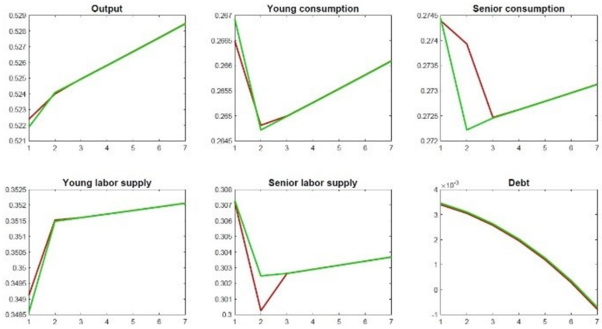

Figure 6: The effects of a change in the rate of contribution on different macroaggregates (output, young and senior consumption, young and senior labor supply, debt of the social security system)

It is not easy to see it on the last panel of Figure 6 (since the difference is small), but the prior announcement is better with respect to the balance of the social security system as well. It increases the debt by a smaller amount and makes it converge to zero at a larger velocity.

The problem of "small differences" also arises when examining the evolution of the total utility over time (Figure 7). For example, in period 5 the total utility in the case of a prior announcement is –2.14659, while if the fiscal policy decision maker does not announce its policy decision before the implementation it is –2.14662. Although the difference between the two cases is extremely small, we are still able to state that in the long run it is better from the consumer's point of view to make an announcement well before the implementation of the policy.

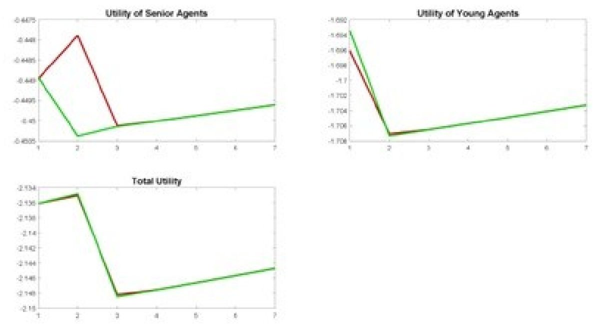

Figure 7. The ulility of a senior agent, a young agent and the total (retrospective life cycle utility) in the case of a change in the rate of contribution

CONCLUSION

In this article we introduced a model containing representative consumers living for two time periods: an entirely active and wage-earning first period, and a second period a portion of which the consumer still works, then retires. The number of people working in the second time period depends on the retirement age, while the number of pensioners depends on the retirement age and life expectancy. The representative agents make their consumption and labor market decisions in order to maximize their lifetime utility, but they face several types of uncertainty, including the uncertainty regarding the variables of the pension system.

We have analysed the effects of three policy changes that the fiscal policy decision maker can introduce in order to achieve a sustainable situation of the pension system. These three policy changes are: (1) increased retirement age, (2) decreased pension benefits, and (3) increased social security contributions. In all three cases we compared the effects of two situations: (1) the policymaker announces the planned change prior to its execution, or (2) the change is announced only at the time of its execution. In all three cases we see that a pre-announced policy change means that the representative agents have time to adjust their lifetime consumption and labor market decisions in order to maximize their utility, while the unexpected changes cause more sudden reactions from the side of the agents. One result that we found is strikingly different from the current consensus in the literature. If the fiscal policy decision maker announces the increase in the retirement age in advance, the short run decisions of the agents create a macroeconomic environment that reduces the well-being of the agents in the long run relative to the scenario with no prior announcement. We plan to continue our research with a more detailed analysis of this finding.

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