Simulation model to forecast the consequences of changes introduced into the 2nd pillar of the Polish pension system

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ARTICLE INFO	ABSTRACT
	The 2nd pillar of the Polish pension system was recently modified. The government lowered the amount for obligatory contributions transferred to private open pension funds and redirected the difference to notional accounts. A Monte Carlo simulation model was developed to compare two variants of the Polish pension system. In the previous system, the premium was accumulated in open funds, and interest was earned as a result of real financial market mechanisms. In the current system, the premium is split into two flows, where one flow accumulates on the notional account and is indexed according to the rules defined by legislation. Assuming the same macro-economic circumstances, the economic implications of the new and previous pension system strategies were formulated from an individual worker's perspective. Terminal value and risk associated with investment were used to compare both systems. Simulation analysis for the 2nd pillar was run for this portion of the contribution, which had previously been transferred to private open funds but is now deposited into two different accounts (i.e., public and private). The experiments are conducted simultaneously for two variants of the pension systems, and the identical values of macro-economic forecasts are defined as the input data.

1. Introduction

The Polish pension system was radically altered in 1999 with the establishment of a new legislative act. Previously, the *defined benefit pension system* was financed exclusively by employers' contributions, and the pension rate was approximately 100% of an employee's base salary. In the new *defined contribution system*, a pension contribution of 19.52% of earnings (split between employer and employee) is recorded for personal retirement accounts. One portion of this contribution is administered by the Social Insurance Institute (ZUS — Zakład Ubezpieczeń Społecznych), while the other portion is transferred into individual retirement accounts managed by private open pension funds (OFE — Otwarte Fundusze Emerytalne). Under this system, ZUS deposits 12.22% of an employee's salary into the public pension fund and 7.3% into a private pension fund (OFE). Under the new law, workers participate in a mixed pension system composed of public pension and private accounts. The system is also called a three-pillar system, as workers can also voluntarily contribute to a third individual retirement account.

OFE funds allocate their assets primarily in the bond and stock markets. For example, on 31 December 2010, a 58.69% share of the total value of OFE's investment portfolio consisted of bonds, 36.24% of stocks and less than 6% of other financial instruments (e.g., bank deposits, bank securities, treasury bills and other investments). In 2010, 50% of the growth in OFE's portfolio value was from contributions, and the remaining 50% was due to returns on investments. The three-year weighted average rate of return on OFE funds for the period 30 September 2008–30 September 2011 was 14.735%.

On 1 May 2011, a new legislative act was announced, and some key changes to the three-pillar pension system have emerged. Through this act, the government lowered the amount of contributions transferred to OFEs. The value of the 2nd pillar remains unchanged (it remains 7.3% of an employee's salary), but it is split into two streams: from 1 May 2011 until 31 December 2012, OFEs receive 2.3% of an individual's earnings, while 5% goes to ZUS, where it is registered in a separate sub-account created for each insured person. Beginning on 1 January 2013, the premium transferred to OFE will increase to 3.5% of the person's salary. Accordingly, the premium directed to ZUS will decrease from 5% to 3.8%.

The accumulated capital in ZUS accounts will be indexed to adjust for changes in price levels, wage levels and economic growth. The indexation process will take place annually, beginning in June. The process will address contributions recorded on ZUS accounts until 31 January of the year in which the indexation is performed and the amount of capital added to individual accounts based on previous indexations. The indexation ratio will be equal to the average yearly dynamics of the Gross Domestic Product (GDP) expressed in current prices and calculated for the five years preceding the indexation.

Debate around the new law has given rise to many arguments for and against the introduction of the changes. The government justified the amendments with the necessity of limiting increases in the public

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debt and lowering the deficit of public finances. According to the authors of the modified legal regulations, the changes in the pension system will significantly limit the need of the state to borrow money. At the same time, however, some informal guarantees were included with regard to retirement security. The new solutions, according to the authors of the reform, combine a comparable level of terminal values with lower risk. Although the "interest" earned on ZUS accounts is based on nonfinancial indexing mechanisms, the government promises high returns. Both experts and insured people are, however, divided in their assessments of the solutions. There was a large discussion on the influences of this reform on stock market, economic activities and the whole financial system. Some economists expressed views that the changes may decrease workers' future pensions. According to Gołębiowska (2011), the changes introduced to the pension system violate the general principle of the citizens' confidence in the state because the social agreement with the workers, who decided to join the 2nd pillar after 1999, was broken. It is feared that actual financial security is ensured at the cost of the security of future pensions.

This paper is an attempt to make forecasts based on the mathematical modelling. A Monte Carlo (MC) simulation model was developed to compare two variants of the Polish pension system: (1) the previous system with OFE premiums equal to 7.3% and interest gained as a result of real financial market mechanisms and (2) the current system with premiums split into two independent flows, one of which accumulates on the notional account and is indexed according to the rules defined by the government. The simulations enabled the calculation of the economic implications of the new pension system strategy from the perspective of the individual worker and for the comparison of the results of the previous system, assuming the same macro-economic circumstances. Terminal value and investment risk were used to compare both systems. The analysis concerned the 2nd pillar, and a simulation was only run for the portion of the contribution that had previously been transferred to OFEs and which is now deposited in two different accounts (public and private). The experiments were conducted simultaneously for two variants of the pension systems and identical macro-economic forecasts were used as input data.

The prototype version of this model has been described elsewhere (cf. Mielczarek, 2011). This paper recapitulates the previous model's basic assumptions, introduces certain modifications and extensions, presents a series of simulation experiments and compares the results from the point of view of an individual worker.

2. Simulation in retirement planning

There are many types of simulation methods, including discrete-event, system dynamics, microsimulation, Monte Carlo,[1] agent-based and others. The key element common to all of these approaches is the inclusion of *models* and *computer experiments*. To run a simulation, one must build a mathematical or logical model of a system or a decision problem and then experiment with the model using a computer. The model must be *set in motion*. Simulation is particularly useful when problems exhibit significant uncertainties, which give rise to stochastic analysis.

Simulation techniques are applied in retirement planning to examine the financial and economic implications of investment decisions and to test hypothetical "what-if" investment strategy scenarios. Two methods are preferred in this setting: MC approach and dynamic microsimulation. Microsimulation is used to investigate the effects of public policies, and it operates at the level of individual units. The model simulates life paths of virtual population by accessing the detailed demographic and pension payments records and applying mathematical formulas to model individual behaviour. The model allows for specification of complex demographic states that vary by individual. The major challenges of this methodology are the requirement for detailed and extensive input data sets and the need for sufficiently powerful computer software to execute large scale and complex models. This approach does, however, give the analyst the ability to examine demographic retirement dynamics of an entire population, which is valuable when studying global retirement policy options because outputs can be measured both for the whole population and for various groups of individuals. Van Sonsbeek (2010) developed a model that simulated life paths for a sample of the Dutch population to analyse the budgetary, redistributive and labour participation effects of ageing. He used both micro and macro data sources and formulated conclusions for policy measures intended to reduce state pension costs. A simulation of four life-cycle investment portfolio allocation strategies, each differing in terms of risk exposure, was performed by Bridges et al. (2010). The detailed earnings histories of 12,871 workers and historical annual return data were used as the input sample for the model. Schofield et al. (2012) used microsimulation to estimate the costs of early retirement in Australia resulting from back problems. They found that early retirement not only limits the retiree's income but also reduces their long-term financial capacity.

MC simulation is based on one or more typical individuals that are intended to describe the experience of a larger group. A number of input assumptions relating to the typical investor are made and the conclusions are valid for the pre-defined individuals only. The advantage of an MC simulation model is its flexibility to test any modification to fully understand the issue and the ability to estimate the risk involved in the decision process. Mathematical models operate on probabilistic distributions that are, in most cases, derived from historical data sets. A model simulates hundreds or thousands of potential scenarios and produces forecasted outputs, usually in the form of relevant means, probabilities and the dispersion of results around the expected value. Abeysekara and Rosenbloom (2000) compared the risk-return trade-offs of lump sum and dollar-cost averaging investment strategies. The authors defined a number of assumptions relating to stochastic processes that described monthly stock market returns and treasury bill rates. Cooley et al. (2003) analysed the problem facing investors of potentially outliving money saved for retirement years. McFarland and Warshawsky (2010) studied the influence of financial market volatility on the retirement security of a worker retiring at the age of 65. The authors used historical returns and interest rates over a long period (95 years) and tested two investment strategies. MC simulation can also be used to select a retirement age. Bieker (2002), based on the historical data, defined three input probability distributions (inflation rate, wage growth rate and life expectancy) and ran MC simulations for different retirement-age scenarios. The simulated individual was a black male who was 55 years old and had 25 years of employment. The MC method was used by Schleef and Eisinger (2007) to investigate the type of risks faced by an investor who chose different contribution strategies. The authors considered a 30-year-old investor who wanted to amass one million dollars by age 60.

The MC approach to solving decision-related problems in the area of financial planning and investment management is not the

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[1] The term *Monte Carlo technique* is derived from the code word for research conducted by von Neumann and Polish scientist Stanisław Ulam during World War II on the Manhattan Project's atom bomb. At first, the method was primarily applied in physics and mathematics, but numerous examples of its use can now be found in the fields of economics and management. Fishman (1996) defines Monte Carlo simulation as a sampling experiment carried out via computer whose purpose is to estimate the distributions of output variables. This definition means that any sampling experiment whose purpose is to estimate the distribution of an outcome variable that depends on several input probabilistic variables is called Monte Carlo experiment, and in fact, every type of stochastic simulation approach requires the Monte Carlo techniques to be performed internally. There is, however, one class of simulation models called Monte Carlo simulation models that is often used to evaluate the expected impact of policy changes and risk involved in the decision process. This type of simulation is normally performed using a spreadsheet program, Microsoft Excel being one of the most popular, and some authors use the term *spreadsheet simulation*. In this paper, the term "Monte Carlo simulation" is used with the latter meaning.