# SOCIAL SECURITY SYSTEM REFORM: RISK SHARING PROPERTIES. THE CASE OF UKRAINE

by

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Abstract

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Provision of adequate and robust old age income streams for numerous generations without distortion in labor supply and saving is the main objective of a national pension system. What design of such pension system will be optimal for the utility maximizing individual? The main determinant of return in fully funded system pension is interest rate, while for pay-as-you-go system this is wage growth. Historically, interest rates were higher than wage growth rates, though, interest rates were more volatile as well. Whether diversification of overall risk of pension system is feasible by means of establishing mixed pension system or it is better to have pure fully funded pension system with high return and high risk is subject to debates.

Mixed pension system will have advantages over fully funded system if wage and interest rate shocks are imperfectly correlated, thus compensating each other, and if presence of pay-as-you-go layer does not reduce benefits much. The model with stochastic interest rates that are correlated with wage growth applied for Ukrainian context attempts to analyze the optimal design of pension system. Results show that for the case of moderate correlation between interest rates and

wage growth and negative population growth, as a baseline scenario for Ukraine, pure fully funded system is preferable. This result is robust under reasonable changes in degree of risk aversity and discount factor.

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## *Glossary*

**Pay-as-you-go pension system** — pension system in which benefits to current pensioners are financed from contributions of current workers.

**Fully funded pension system** — pension system in which pension contributions of current workers are accumulated on pension accounts. Pensions to these workers are paid as monthly or yearly annuity after they have reached retirement age.

**Annuity** — series of payments made at equal intervals of time (Kellison, 1991).

**Replacement ratio** — ratio of average pension benefit to average wage.

# *Introduction*

The main purpose of social security system is to provide old-age share of population with secure source of income, which is usually depend on the working history of retirees. The issue of security and stability of retirement income became increasingly important for the countries that experience changes in pattern of demographic regeneration, i.e. increase in life expectancy and fall in rates of fertility and have pay-as-you-go (PAYG) pension system. The consequence of this is that state can no longer service its obligations imposed by PAYG system effectively. It is theoretically (Auerbach-Kotlikoff model) and empirically (by Chile for example) proved that under such conditions introduction of accumulation pillar of pension system can bring large gains in terms of increased capital accumulation and output, improved labor supply incentives, and rise in net welfare (Auerbach and Kotlikoff, 1987). These are gains achieved on macro level. The main issue that arises on micro level is whether fully funded system also brings efficiency with respect to reduction of risk of lowering benefit for any single retiree.

Chilean pension reform in 1981 that replaced public PAYG system with private funded system and made possible accumulation of significant capital at private pension funds inspired other countries to reform their old age security systems. Switzerland, on the other hand, in 1972 held a referendum to introduce mandatory fully funded component only as a part of overall system and implemented it in 1985 (Queisser and Vittas, 2000).

Peru (1993) and Kazakhstan (1998) preferred Chilean type of pension system with dominating fully funded component. Poland (1998), Hungary (1998), Argentina (1994) chose to maintain PAYG pillar and shift to fully funded system gradually.

In introducing multi-pillar social security system countries follow the advice of World Bank that implicitly assumes that different pillars are exposed to different risk, thus, simultaneous use of them provides diversification of risk. Chilean type of social security system is oriented on the higher returns and positive macroeconomic effects created by fully funded pillar, and attempts to maximize this positive impact. Which system is preferable for transition country like Ukraine is unclear and depends on country's specifics.

At the moment, Ukraine faces the need to resolve the crisis of its pension system as soon as possible. On January 1, 2000 Ukrainian pensioners constituted more than 25% of total population, and pension expenditures were equal to 9.5% of nominal GDP. But, the average pension for such a large share of population was far below the poverty level: UAH 68.91 of pension versus UAH 90.7 at poverty level (Pension Fund, 2000). In addition, expected lifetime for newly retired in Ukraine is high: approximately 22 years for women and 14 years for men. Taking into account the fact that during transformation period existing pensioners, that have retired under Soviet Union system, lost their savings due to hyperinflation, and other pensioners, who have retired in last 10 years, have not saved a lot either, it is obvious that the Ukrainian state fails to secure old-age people with retirement income and they are destined to end their lives in poverty.

On the other hand, retirement age under present legislation is set relatively low: 55 and 60 years for women and men respectively[1]. To be eligible to receive pension, Ukrainian male workers should have 25 years of working period. For female workers this requirement is 20 years. For the pension calculation the wage for the last two years or any five uninterrupted years of work are considered.

[1] For most of developed countries retirement age is set at 65 years for both women and men.

Certificates that testify about the last wage can be easily falsified. Moreover, disabled persons who are lacking two years for retirement age are also entitled to standard pension. If person at retirement has the required number of years of work, he/she is automatically granted 55% of wage as a pension. Every additional year of work above the required minimum adds 1% of wage to pension. After that the constraint of maximum pension is applied ("The Law on Pension Security", 1991). On the one hand, Ukrainian pension system is very liberal, setting low retirement age and required number of years of work. The effect of this generosity is that dependency ratio of pension system, determined by relation of number of pensioners to the number of contributors to pension system, is growing. On the other hand, existence of maximum pension eliminates attractiveness of retirement.

Thus, to finance pension expenditures, the state has to impose high payroll tax on wage of existing workers. At the moment this figure is equal to 32% of total wage bill paid by enterprises to the Pension Fund plus 5-6% (depending on the salary) of the salary, paid to other budget funds. This tax burden creates strong incentive for workers and enterprises to evade paying taxes, shifting activity to the informal sector or underreporting the amount of officially paid salaries, on which taxes are imposed. Clearly this reduces pension system efficiency even further.

In order to function somehow, state imposed limit on maximum pension paid. It is equal to 3 minimum pensions. Minimum pensions are subject to inflation indexing and occasional increases, thus affecting maximum pension as well. But this constraint almost completely eliminates differentiation among pensions for retirees with different working experience and wages, because most of them get no more than the maximum pension. Existing pensions are subject to indexing (inflation rate –5%). In such a situation, there are no incentives for workers to participate in the system. Meantime, there is a set of exceptions for use of maximum pension limit for several categories of workers (about 10% of all new retirees). These workers — civil servants, judges, members of parliament, people employed on harmful kinds of productions, etc. — can receive benefits that are significantly (ten times as much) higher than standard benefits. This situation seriously undermines the fairness of pension system and discourages non-privileged workers to participate even further.

Direct consequence of this policy is that pension system has a low, if not negative, rate of return on contributions made by workers. In this respect, introduction of accumulation pillar, which will provide the rate of return that is slightly below the market, is a desirable alternative.

The current design of pension system does not allow it to be in fiscal balance in long-term. Of course, if all the restrictions stay in effect for next several decades, the present PAYG system will stay in balance. But this would lead to further decrease in pension differentiation, fall in replacement ratio, and strengthening in incentives to evade paying contributions. But, if pension system is to maintain the replacement ratio of 38%, which it is now offering for new pensioners, it will not be sustainable in the future. (Sluchynsky, 2000).

Efforts towards reform of current Ukrainian pension system are primarily concerned with raising the pension age and changing the formula for benefit calculation. In particular, longer period of work than only five years should be taken into account for pension appointment. Age is supposed to be raised gradually to 65 years for men and, at least, 60 for women. But, these decisions require strong political will and are not universally accepted among parliament members. From this perspective, we can say that, for the moment, the process of reforming the Ukrainian pension system is concluded in creating the preconditions for deep pension reform[2].

Negative effects caused by the present design of pension system are further enforced by the poor macroeconomic performance during the period of independence. Accumulated pension and wage arrears stimulate the switch of labor force into the informal economy, both decreasing contributions to pension fund and increasing uncertainty in retirement income for these workers. Absence of output growth induces rise in unemployment and prevents wage growth. Thus, savings of Ukrainians are negligible and stable guaranteed pension income is the only alternative for them unless mandatory pension system is introduced.

Thus, for a number of reasons accumulated pension system is a way out of poor PAYG system performance. But this modification will also bring new risks that are exclusive for accumulation pillar. And this will make the whole pension system be vulnerable to a wider range of exogenous shocks. Is it better for Ukraine to have mixed pension system or stick to either PAYG or fully –funded system only? This question is discussed below.

In Chapter 2, I present a theoretical background on risk sharing analysis and review existing literature on this topic. In chapter 3, simulation model is described that allows to see the impacts of introduction of fully-funded pillar of pension system on individuals utility. In Chapter 4, I discuss empirical results and do sensitivity analysis with respect to different individual preferences, demographic scenarios and correlation between wage growth and interest rate. Chapter 4 ends with conclusions and policy implications.

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[2] These preconditions indude creation of system of personified accounts for all employees, for example.

*Chapter 2*

# THESIS HYPOTHESIS, THEORY AND LITERATURE REVIEW.

**Thesis hypothesis.**

Different pension systems are exposed to different types of risks. From the theoretical point of view, if risks in different pension systems are not perfectly correlated, reduction of overall pension system's risk is possible combining different kinds of pension system into one. The price for reduction of risk is decreased benefits (payoffs). The main question is as follows: is it worth combining different pension systems into one from the viewpoint of utility maximizing individual that participates in pension system?

So, my **Thesis Hypothesis is as follows:** mixed pension system should be preferred to the fully funded pension system, because utility maximizing individual will be better off giving up some benefit for a reduction in risk.

**Alternative Hypothesis:** fully funded pension is better than mixed pension system because a reduction in risk is insufficient to compensate for benefit reduction generated by mixed pension system from the viewpoint of utility maximizing individual.

## 2.1. Concept of risk.

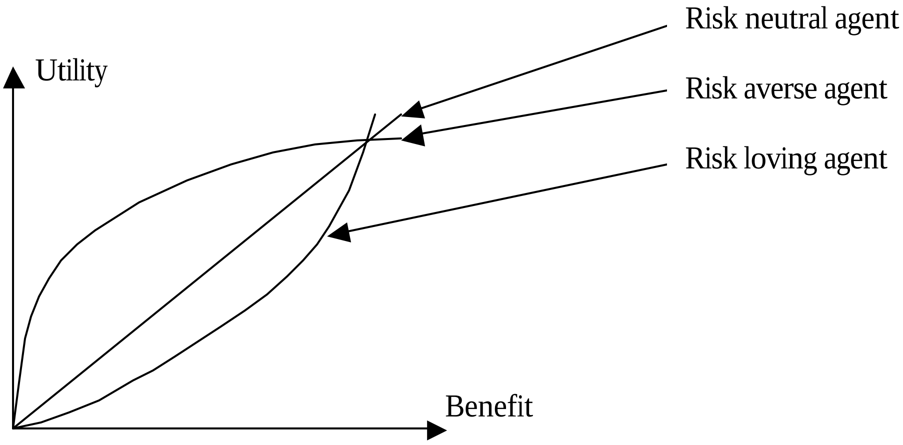
Situation of risk arises when agent is not sure what state of nature among several possible states will take place in the future. Agent only knows the probability with which each state can occur (Starmer, 2000). Situation of risk-taking is common for all decisions that will last in the future. Some of the risks can be met by social security system.

Green in "Social Security and Private Pensions" (1988) outlines three categories of risk that with which social insurance can deal. First, there are risks that are faced by all members of given cohort. The main risk of this category is hidden in size variability. Larger cohorts tend to have lower wages, lower returns on savings, etc., and this risk can be shared only by all members of the cohort. Second category includes risks that are faced by all living people. Most of economic changes are the sources of these risks: changes in wage growth, interest and exchange rates, etc. Different people are affected differently by this category of risk. The last category of risks is consisted of those that tend to changes the situation irreversibly. These are demographic changes, changes in pattern of lifestyles and others that can affect people's needs for social security.

Another dilemma associated with risks that can be socially insured is whether market can deal with them or government intervention is needed. Blinder (Social Security and Private Pensions, 1998) and Mitchell (1993) argue that government intervention is desirable due to adverse selection problem of annuity markets, risk diversification impact of pension wage indexing and positive redistributional impact of PAYG public pension system. Mandatory pension system is aimed to prevent people from undersaving for retirement during their working life.

Facing permanent patterns of life expectancy increase and tendency toward early retirement World Bank suggested countries to implement modification of their pension systems and to create multi-pillar system with a public PAYG layer, a mandatory private fully funded layer and a voluntary funded pillar (World Bank, 1994, James, 1996, Mitchell, 1993). To evaluate the risks of this pension system, special risks of each pillar should be identified.

The individual's willingness to undertake additional risk for higher return depends on his attitude toward risk. On the basis of expected utility theory, risk averse agent will prefer a certain payoff to the gamble with the same expected payoff as the certain one. The utility curve of such agent will be concave. Risk neutral agent will be indifferent between certain payoff and the gamble with the same expected payoff. The main determining factor for him, while choosing the design of pension system, will be an expected benefit provided by the pension system. His utility curve will be linear. Risk loving (seeking) agent will prefer to take a gamble and will gain additional utility from risk, because his utility curve is convex. (Pindyck and Rubinfeld, 1995, Nicholson, 2000). Their graphical summary is described by the graph below. Thus, different individual will have different opinions about desirable configuration of pension system basing on their utility preferences.




**2.2. Risks in PAYG system.**

Risks associated with the PAYG system depend on the principle of its functioning. Since present workers are paying for the pensions of present retirees, the larger the size of labor force, the more generous benefits can be offered for retirees.

a) ***Demographic risk*** that influences the size of labor force affects PAYG system significantly. When increase in number of pensioners due to increasing life expectancy is accompanied with the decline in number of contributors because of decreasing fertility, deficit of pension financing is likely to arise if other parameters of pension system are unchanged. Contrary to this, an increase in fertility rate is likely to produce growth in contributions and increase revenues of Pension fund.

b) Since contributions to the pension system are usually set as a percentage of wage, wage growth leads to higher contributions. Thus, ***economic risk*** of PAYG system is primarily associated with the fall of wage fund in times of recession and high unemployment. In transition countries this is strengthened by the increase of informal sector. In contrast, economic growth together with real wage growth positively affects revenues of pension fund.

c) ***Political risk*** is the third major risk attributed to the PAYG system. It is expressed in form of governmental change of pension legislation that negatively affects pension benefits (Palacios, 1998, PADCO, 1998, Gora, Rutkowski, 1999). Because PAYG pension system is mainly public, the possibility of such government intervention is constatnly high.

Another concern over pension system is that its cost tends to rise as system matures. Providing windfall gains to the first retirees, system then appears to be more costly as time goes on in societies as the demographic structure of society ages (Social Security and Private Pensions, 1998).

### 2.3. Risks in fully-funded pension system.

a) exposure of fully funded system to demographic risk is much lower than in PAYG, because pension benefit in fully-funded system depends solely on contributions of a single person, no matter how many contributors in total are there. The demographic risk is present due to the fact that increasing number of participants in fully funded system may result in lower returns for them.

b) The possibility of political risk in fully funded system is also lower than in PAYG one, because in this case government has no financial obligations concerning paying pensions and has less incentive to intervene.

c) Contributions to fully funded system are invested in equity or bonds. Thus, benefits are determined by the returns on these investments. So, ***interest rate risk or financial risk*** is the major issue of fully funded system. It concludes in the possibility that fully funded system will provide the rate of return which is far less than the market rate of return.

d) Another issue of concern is ***higher administrative costs*** that are attributed to fully funded system in comparison with PAYG system. These costs lower the return on contributions. Mitchell (1996) presents that US public old-age program was the least costly in 1990 with administration cost of 0.7% of all old-age benefit expenditures. In contrast, Latin America countries had much higher administrative costs with public programs (from 2.3% to 8%). Administrative costs in Chilean private pension system amounted to 17% of contributions to the system in 1993, though in the early 1980's this figure was even higher — 25-30%. The crucial factor for cost reduction is increasing the scale of the program (Mitchell, 1996). In countries with well-developed capital markets administrative costs can be substantially reduced using portfolios that are inexpensive to manage and saving on marketing costs (James, Smalhout and Vittas, 1999). In countries with weak capital markets such possibilities are obviously more constrained because they cannot benefit from returns to scale.

e) Finally, in a pure fully funded system workers with long periods of unemployment are not able to accumulate enough money for retirement. In PAYG system they would usually receive guaranteed minimum pension in this case, while fully funded system does not provide such option.

In general, different types of risks characterize two alternative pension systems. If those risks are imperfectly correlated, it is reasonable to introduce mixed pension system in order to diversify risk. In this thesis, only the correlation between interest rate risk and wage growth risk is considered.

**2.4. Review of relevant literature.**

There is extensive literature that unanimously shows positive macroeconomic impact of fully funded system implementation that brings incentives for labor force participation, increased capital accumulation and savings (Bernheim, 1985, Auerbach and Kotlikoff, 1987, Falkingham and Johnson, 1993, James, 1996, Serrano, 1998, Samwick, 1999). However, there is no agreement on the issue of what pension design system is the best to diversify risk.

Chile was the first country that have shown the alternative to traditional old-age social security. Having been introduced in 1982, reformed Chilean pension system embodied "….a revolutionary approach: a privately administered national system of individually owned, privately invested retirement accounts." (Pinera, 1998). Since that time the performance of this new pension system were accompanied by success. Requiring tax-deductible contributions of 10% of the wage, new pension system provided pension benefits that were significantly higher than those from the previous state-administered system that required 25% of wage contributions. Government involvement into new system was limited to provision of minimum benefits and overall control over functioning. Workers are free to choose the private pension fund to put contributions in, and this stimulates competition among funds. Rapid abandonment of old pension system resulted in accumulation of huge investment resources in hands of pension funds that reached 43% of GDP in 1997 (Pinera, 1998).

Though, it is natural that other countries view Chilean pension system with skepticism. Gora and Rutkowski in their work " The Quest for Pension Reform:

Security Through Diversity" (1999) claim that mixed pensions system is the best choice following the principle "not to put all eggs in one basket". Any pure pension system is viewed as a monopoly and, therefore, cannot be preferred to the mixed pension system. Unfortunately, they do not provide any strong statistical analysis for this statement even in the context of Polish pension reform.

Queisser and Vittas (2000) present overview of successful Swiss multi-pillar pension system. PAYG layer serves for purely redistributive purpose with maximum pension to be equal twice as much as minimum pension. No wage cap for contributions is introduced, and the poorest workers do not participate in mandatory funded system. Minimum requirement for pension funds in funded is to provide 4% annual return on deposited contributions. Aggregate replacement ratio for two-layer pension system is about 60-70%.

Kruse (2000) also supports this point of view noting, "….both PAYG systems and funded ones are exposed to the economic risk of low (even negative) return. To avoid the capital market risk in a funded system the recommendation would be to diversify, to invest in different assets and in different countries. To minimize the economic risk in PAYG system the design of the system should be such as to encourage economic growth…. A risk-reducing policy would be to choose a combination the two systems" (Kruse, 2000, page 8). With respect to the political risk she says that in pure fully funded system every generation has incentive to introduce PAYG system in order to capture welfare gains associated with it. On the other hand, Browning as sited in Krause states that PAYG system has intrinsic stimulus to "….expand beyond its optimal level, defined as the utility maximizing level…." (Kruse, 2000, page 13).

Shiller (1998) recognizes intergenerational, intragenerational and international aspects of risk sharing. Using a set of models he concludes "….that the optimal government intervention for … risk sharing, and the optimal level of investment in risky investment projects would amount to no more than a sort of PAYG security system indexed to incomes of the young and old… there is no need for the government to mandate the building of a large trust fund of investable assets" (Shiller , 1998, page 42-43).

Bohn (1999) uses neoclassical growth model with demographic uncertainty and endogenously defined factor prices to determine the best pensions system in terms of response to demographic shocks. He concludes that in case of birth rate shocks "….defined benefit social security system is more efficient ex-ante than a defined contribution or privatized system….", which is rather surprising result, because defined benefit system thought to be more vulnerable to demographic shocks. On the other hand, this result can be put under doubt by the fact that shocks in fertility are far more powerful than shocks in mortality in their impact on defined benefit system.

Alier and Vittas (2000) shows that funded pension plans are characterized by rather high investment risk, which can be reduced only using sophisticated financial engineering. This option requires well-developed financial markets and ability to implement new options for pension asset management, which can be impossible for the developing countries. Simple financial techniques do not reduce risk substantially.

Palacios (1998) analyzes the feasibility of introducing fully funded pension system in five OECD countries. He states that fully funded system's exposition to the capital market risk is often measured according to the past volatility of the capital market. He also outlines the existence of political risk associated with the government taxation of pension saving. "Returns on a sustainable PAYG scheme depend on the growth of covered wage bill". His analysis bases on the historical data of wage growth and market return for 5 OECD countries. Correlation between wage growth and equity return is found to be negative and insignificant as econometric analysis of historical data shows and applied to each country separately. Calculating standard deviations for both series in each country, he uses risk-return frontier in multi-pillar setting. The conclusion is that three out of five analyzed countries should introduce fully funded pillar as a part of pension system, assuming that individuals in these countries prefer to exchange some safety for higher returns (limited risk-aversion).

Feldstein and Ranguelova (2001) study risk properties of investment-based pension system. Interest rates assumed to be stochastic, while wage growth is taken from actuarial projections. They used simulations to estimate possible future annuity payments for the agent that participates in fully funded system only and compared annuity payments with projected pensions for the same individual under public PAYG system. Even under fairly low contributions median benefits of investment-based pension system is higher than those in PAYG system. Using constant relative risk aversion utility function they concluded that agents with reasonable degree of risk aversion would choose to participate in pure fully funded system.

Miles (2000) applies stochastic simulations for both wage growth and interest rates in order to estimate the reasonable split between PAYG and fully funded system. Labour income is assumed to rise proportionally to constant labour productivity growth and normally distributed stochastic element is added in order to reflect idiosyncratic labour income risk. Interest rate on pension assets of agent is set to be equal the mean return on financial assets plus stochastic normally distributed element. Calculations are done for static demographic structure of population, and each agent is assumed to know its probability of surviving to next age. Agent assumed to have additive constant risk aversion utility function with coefficient of risk aversion of 2. Miles finds that with reasonably high return of fully funded system (8%) it is worth keeping fully funded system only, even despite high volatility of return (17,5%). In case of lower return (4%) and lower standard deviation of fully funded system, 20% of total pension system should be given to PAYG layer.

Papers by Feldstein and Ranguelova (2001) and Miles (2000) assume wage growth to be uncorrelated with interest rate. The former paper takes wage growth from actuarial projections for USA, and the latter one sets both stochastic interest rate and labor income to be independent.

To sum up, there is no general agreement whether mixed system is really the best solution to diversify risk. Furthermore, the result of introduction of fully funded system in a transition countries, characterized by uncertain future development, and its impact on risk is, thus, remains unexplored and ambiguous because the history of these pension reforms is too short.

What is the attitude of workers in Ukraine toward risk is a controversial question. On the one hand, population seems not to trust to any institution of accumulation type. This testifies for risk-aversive behavior of workers. On the other hand, saving of the vast majority of them is so small that they definitely will prefer to close their eyes on some risk in exchange for higher return on their contributions to the pension system that is the evidence for possible risk neutrality. However, for the purposes of research and applicability of results the impact of pension reform on risk averse agents is examined.

Next chapter provides empirical results of correlation between wage dynamics and interest rates for a number of developed and developing countries and describes the simulation model used in research.

*Chapter 3*

# MODEL, DATA AND METHOD.

## 3.1. Correlation between interest rate and wage growth.

The argument for diversification of risk in pension system is based on the concept of correlation between interest rate and wage growth. In pure fully funded system, decline of real interest rate from the projected one brings decrease in accumulated funds on pension account, and, as a result, decrease in prospective pension benefits. In mixed pension system, where PAYG layer is present together with fully funded one, decrease in interest rate will have direct impact only on that part of pension that is paid from fully funded layer. Pension from PAYG system is affected by change in wage growth. If correlation between interest rate and wage growth were negative, decrease in interest rate would increase wage growth and, consequently, prospective pension benefit from PAYG layer. In fact, if correlation between interest rate and wage growth is positive but less than +1, it makes sense to have mixed pension system because variation of pension benefit in mixed system will be less than respective variation of benefit in pure fully funded system. The smaller the correlation between interest rate and wage growth, the less wage growth will be affected by interest rate volatility and the more stable will be prospective benefits from mixed pension system. However, these benefits on average will be lower than average benefits in pure fully funded system, because average wage growth is historically lower than average interest rate.

Short-term interest rates are thought to have highly pro-cyclical nature, while long-term interest rates have low conformity with business cycle (Sachs and Larrain, 1993, p.516). In turn, there is no general agreement as to cyclical nature of real wages. Abraham and Haltiwahger (1995) provides comprehensive overview of studies devoted to wage cyclicality issue. Different theoretical approaches provide drastically opposite conclusions concerning this issue, and the results of empirical studies depend on the time period selected for investigation. Therefore, their main conclusion is that "…. the cyclicality of wages is not likely to be stable over time." (Abraham and Haltiwanger, 1995, page 1262). On the basis of above considerations it is hard to predict precisely the possible correlation between interest rate and wage growth.

In order to assess the correlation between real interest rate and real wage growth pooled data estimation is used. The model is described by equation:

$$wg_{it} = a_i + q * ir_{it} + g * wg_{i,t-1} + e_{it}, \text{ where}$$

$a_i$ - intercept of equation that is different for different countries, thus, absorbing specifics of each country

$wg_{it}$ – real wage growth in i-th country in year t

$ir_{it}$ – real interest rate in i-th country in year t

$e_{it}$ – error term.

Estimating this regression, assumption is made that $e_{it}$ – is identically and independently distributed with mean equal to zero and variance $\sigma^2$. Present specification allows to estimate the impact of interest rate change on wage growth allowing for partial adjustment factor to be present. Allen (1992) investigates the sensitivity of nominal wages in US to business cycles and claims that such sensitivity was constant over the last century, and autocorrelation is a significant feature of nominal wages dynamic, which I allow to be true for real wages as well.

Data for estimation is provided by OECD countries database at McGill University in Canada[3]. Data series are for nominal wage growth, weighted nominal long-term government bonds interest rates and CPI that allows to obtain real values for interest rates and wage growth. Data covers 1961-1994 and is taken for Belgium, Canada, France, Germany, Great Britain, and United States.

Applied dynamic panel data estimator (fixed effects) is not unbiased and the order of bias is equal to 1/T, where T — number of period included in regression[4]. Under large values of T, above regression provides consistent results (Greene, 2000). To obtain unbiased estimators a number of transformations should be applied to the model. But for the purpose of the research it is useful to leave the present specification because it provides clear explanation of connection between wage growth and interest rate with minor bias, because T is quite large. In my case T=34. To overcome the problem of possible bias in coefficients, different values of coefficients is used in simulations.

Results of the regression estimation suggest that there is statistically significant positive connection between real wage growth and real interest rate. 1% increase in interest rate produces 0.7% increase in wage growth (detailed results are given in Table 1 of appendix). R-square and F-statistics rejects the hypothesis that coefficients are zeros. The correlation between interest rate and wage growth is estimated to be 0.3, meaning that 70% of variation in wage growth is due to factors other than interest rate. This implies the desirability of diversification of pension system's risk introducing multi-pillar scheme.

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3 Available at Internet address http://www.arts.mcgill.ca/oecd/

4 The order of bias shows the speed of convergence of biased estimators to unbiased ones (Greene, 2000).

### 3.2. Model description and algorithm of calculation.

The purpose of the model is to calculate the lifetime utility from consumption. Three different individuals that represent three different cohorts are considered in the model. They are those who were 20, 30, and 40 years old in 2000. All individuals are assumed to retire at 65 (i.e. in 2045, 2035 and 2025 respectively) and to die at 100 (i.e. in 2080, 2070, and 2060 respectively), so the horizon of calculation in the model is 80 years for individual who was 20 in 2000, 70 years for that who was 30 in 2000, and 60 for that who was 40 in 2000. Five variants of pension system is considered for these individuals:

| Variant | Share of PAYG component (%) | Share of fully funded component (%) |
|---|---|---|
| 1 | 100 | 0 |
| 2 | 75 | 25 |
| 3 | 50 | 50 |
| 4 | 25 | 75 |
| 5 | 0 | 100 |

The pension system variant that produces the highest utility is preferable for individual.

Individuals consume after tax income while being in working age, and pension constitutes their only income after retirement. Stochastic real interest rates determine the return that contributions to fully funded system earn, and real wage growth rates, which depend on stochastic real interest rate, determine the real wage of individuals over the lifetime. As a result, pension benefits from both fully funded and PAYG system are stochastic, because individuals do not know the exact wage at their retirement and the accumulated value on their pension account.

The algorithm of a single simulation in the model can be described as follows:

1. Generation of 80 random values of interest rates that are normally distributed with predetermined mean and standard deviation over the horizon of calculation, using built-in MS Excel procedure.
2. Calculations of corresponding wage growth rates that have certain correlation with interest rates.
3. Calculation of lifetime real wages on the basis of wage growth rates.
4. Calculation of after tax income on the basis of obtained real wages during working age of individual, taking into account contribution rates to pension system and other taxes.
5. Calculation of contributions to fully funded system and accumulated value on pension account at retirement.
6. Determining the sizes of pension benefit from PAYG layer and annuity payment from fully funded layer.
7. Calculation of lifetime utility from consumption on the basis of after tax income, pension and chosen utility function.

### 3.3. Calculations in the model.

Wage growth in t-th period is equal:

$$wg_t = q * ir_t + e_t,$$

where $ir_t$ - interest rate in t-th period, $e_t$ - random shocks that are normally distributed with N(0, $\sigma^2$).

Interest rate dynamics is simulated 200 hundred times, thus, producing 200 possible wage growth series.

Wage in t-th period is

$$W_t = wg_t * W_{t-1}$$

Pension contributions are determined by:

$contr_{PAYG} = W_t * tax_{PAYG}$ and $contr_{FF} = W_t * tax_{FF}$.

Consumption at i-th period during working age is:

$$C_t = W_t * (1 - tax_{PAYG} - tax_{FF} - tax_{other}), t < 65$$

Pension from PAYG layer is equal to the wage that individual has at age 64 multiplied by the replacement ratio that PAYG can afford to provide being in balance[5]:

$$payg_{65} = W_{64} * rr_{65}.$$

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5 Values of replacement rates are taken as outputs from PROST model created by World Bank for MS Excel. This model uses a number of demographic, economic, financial and labour parameters for the base year as a starting point. On the basis of projected dynamics of these parameters, which is also set by the user, the model calculates the values of various indicators of the future pension system, including number of contributors and pensioners, survival rates, replacement rates, etc. The model allows to change retirement age and consider different designs of pension systems.

Affordable replacement rate are calculated so as to keep the Pension Fund with zero balance each year. The balance of Pension Fund depends on the number of pensioners and the number of contributors in each year. Another important parameter is the average wage of contributors. Thus, affordable replacement rate will be different each year. The exact formula is:

Affordable RR = (Balance + Total payments to pensioners)/(Total number of pensioners*Average wage*contribution rate*collection rate)

This pension is indexed each year for 85% of real wage growth during the retirement[6].

Contributions to fully funded system are accumulated on the personal account. Money on the account assumed to earn each period the real interest rate. So, the last contribution is made at age 64 at the beginning of the period. By age 65 individual has accumulated some value of contributions $A_{64.}$ Individual will receive variable annuity as a pension from fully funded system. This approach is extensively described in Feldstein and Ranguelova (2001).

The first payment is made at the beginning of 65-th year of individual. "…The cost at age 64 of a fixed real annuity of $1 for life… is the actuarial present value (AVP) of that dollar with the discount rate equal too the expected real rate of return on the investment portfolio" (Feldstein and Ranguelova, 2001, page 8):

$$AVP = \sum_{t=64}^{100} \prod_{64}^{t} surv_t * (1+ir)^{-(t-64)}$$ , where

$surv_t$ — survival rate at age t, ir — expected real interest rate.

Because the total accumulated value of pension account is $A_{64}$, the first payment is $a_{65} = \frac{A_{64}}{AVP}$. Under stable interest rate ($ir$) over the period of retirement individual would get the same pension benefit each year. When returns are not the same, annuity payment is indexed for the change in value of accumulated assets. If interest rate in 65-th year is $ir_{65} \neq ir$, then annuity payment in that year is $a_{65} = \frac{A_{64}}{APV} * \frac{1+ir_{65}}{1+ir}$. By the same token, $a_{66} = a_{65} * \frac{1+ir_{66}}{1+ir}$ (Feldstein and Ranguelova, 2001, page 9).

[6] Oleksiy Sluchynsky uses this value of indexation for Ukrainian pension system (Sluchynsky, 2000).

In order to obtain aggregate numerical results of agent's preferences over different designs of pension system, utility calculations are involved.

Agents are assumed to be risk averse and have constant relative risk aversion utility function. Feldstein and Ranguelova (2001) propose the function of the form:

$$EU = E\left[\sum_{t=21}^{100} p_t b^{\,t-21} u(C_t)\right],$$

where $C_t$ – consumption at period t, $p_t$ – probability that agent will survive from age 21 till age t, β - utility time discount factor. This utility function is used in this research too. In case of Ukrainian volatile transitional environment it is reasonable to assume comparatively lower value of β = 0.95 as a reflection of higher valuation of present consumption. For comparison, Feldstein and Ranguelova use the value of β=0.98 for United States.

Utility function has the form $u(C_t) = \frac{C_t^{1-g} - 1}{1-g}$, where γ - coefficient of relative risk aversion (CRRA coefficient). $g = -\frac{u''(c) * c}{u'(c)}$ is constant and independent of age and consumption (Feldstein and Ranguelova, 2001, Romer, 1996). "…γ also determines the households willingness to shift consumption between different periods….If γ is nearly zero, utility is almost linear in consumption, and so the households is willing to accept large swings it its consumption…" (Romer, 1996, page 40). In contrast, a risk averse agent will prefer smooth path of consumption and will value sure present consumption more than uncertain future one, so γ will be more than one.

Feldstein and Ranguelova (2001, page 14) state:"….CRRA coefficient is less than 3 and probably less than 2". Thus, the value of 1.5 is taken as a starting point and lower and higher values are used for sensitivity analysis. Miles (2000) uses the value of 2 for his research.

So, for each simulated stochastic interest rate dynamics and corresponding age growth there exist one value of expected lifetime utility of a particular individual. Since such simulation is repeated 200 times, average expected utility is calculated. Pension system with the highest value of average expected utility would be the first-best solution.

### 3.4. Assumptions and inputs of the model.

Assumptions of the model are the following:

1. Period of utility calculation starts at 2000 and lasts till 2080 when individual that is 20 at 2000 dies.
2. Individual works from 20 till 65 and then retires and receives the pension till 100.
3. Individuals have identical constant relative risk aversion utility function.
4. Tax payments to PAYG and fully funded system are set as a percentage of average wage. This percentage is constant over the horizon of simulations.
5. Contributions to fully funded system are made at the beginning of the period, thus, earning real interest rate during the period. Pensioner receives annuity payments at the beginning of the period as well.
6. Pension from PAYG component is indexed to 85% of real wage growth in previous year.
7. No maximum pension limit is imposed on pensions from PAYG.
8. Real interest rate is stochastic and normally distributed over the period of calculation.

9. Wage growth depends on the interest rate and has predetermined correlation with interest rate over the period of calculation.

Input parameters of the model:

a) starting average annual wage ($w_i$) in the economy for 2000 — 2772.5 UAH (Ukrainian Economic Trends, 2000);
b) CRRA coefficient $g$. Values of 1.5, 1.3, 2 and 2.5 are considered in the simulations.;
c) coefficient of time preference(discount factor) $b$. Values of 095, 0.96 and 0.98 are taken for simulations;
d) correlation coefficient between real interest rate and real wage growth. For the purpose of simulations values of 0, 0.3 and 0.8 as examples of low, moderate and high correlation are chosen;
e) share of other taxes as a part of wage is assumed to be 30% for Ukrainian case. It represents the average share of other than pension taxes: personal income tax, tax to employment fund and social security fund, etc.
f) survival rates of individual are taken from output file from World Bank PROST[7];
g) PAYG system provides such replacement rates so as to be in balance over the horizon of calculations. These rates are taken as output from PROST model as well.

### 3.5. Baseline scenario analysed.

The baseline scenario of simulations for Ukraine includes:

[7] Input file for PROST model adapted for Ukraine by Oleskiy Sluchynsky (Sluchynsky, 2000)

- normal demographic projections. Fertility are assumed to be so as to provide average decline in population by 0.5% over the horizon of simulations;

- discount factor of 0.95 for utility function. This low value for a discount factor[8] reflects the tendency for high valuation of present consumption by Ukrainians and their unwillingness to shift it in order to decrease uncertainty;
- slope coefficient at the interest rate ($q$ ) is 0.7 and correlation between interest rate and wage growth is 0.3 as estimated in panel data regression above;
- CRRA coefficient is equal to 1.5;
- interest rate is normally distributed over the horizon of calculations with mean of 7% and standard deviation of 12%. Miles (2000) states that average return for developed countries was 6% with standard deviation 17% for the past. At the same time he uses 8% return for optimistic scenario. Feldstein and Ranguelova (2001) use 5.5% mean log return with 12% standard deviation as for United States. I start with relatively optimistic return, analyzing lower average return (5% and 3%) later in sensitivity analysis.

In order to provide a comprehensive picture, the sensitivity analysis is used after the baseline scenario is calculated. Sensitivity analysis aims at investigating the impact of change of different parameters on output results. Results of simulations and sensitivity analysis that follows them are discussed in Chapter 4.

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8 For United States the value of 0.96-0.98 used (Feldstein and Ranguelova, 2001).

*Chapter 4*

# RESULTS AND CONCLUSIONS

## 4.1. Simulations results.

Lifetime utility calculation for baseline scenario based on the following contribution rates:

| Variant | Tax to PAYG | Tax to Fully Funded |
|---|---|---|
| 100 PAYG — 0 FF | 20% | 0% |
| 75 PAYG — 25 FF | 15% | 5% |
| 50 PAYG — 50 FF | 10% | 10% |
| 25 PAYG — 75 FF | 5% | 15% |
| 0 PAYG — 100 FF | 0% | 20% |

Aggregate tax to the pension system is assumed to be 20%. This figure represents a compromise between two extremes. The present tax to PAYG in Ukraine is about 34%, which is too high. Meanwhile, the tax to pure fully funded system is unlikely to be higher than 10%, like it is now in Chile. Since an equal tax is needed to compare different designs of pension system, I am choosing nearly the "golden middle'.

Table 2 in Appendix provides description of sensitivity analysis done with description of inputs and output results for each scenario.

The main result of simulations obtained for baseline scenario (Scenario #1) is that introduction of fully funded system provides significant increase in the lifetime utility for all three categories of individuals taken into account. Utility is maximized under variant of pure fully funded system (Table 2 in Appendix, Scenario #1). Graphs 1, 2, 3 in Appendix describe utility from five different pension systems for three different individuals being analysed. Pattern of this result is identical for all of them, but the levels of utility are, of course, different.

The first parameter to test in the sensitivity analysis is a degree of relative risk aversion. Since, it is difficult to measure it, and there is no agreement among different authors about its value, it is interesting to see its impact on final result. Values of 1.3, 2, 2.5 are taken to represent different groups of population with different attitude toward risk.

Changing the degree of relative risk aversion does not affect the pattern of results (Table 2 in Appendix, Scenarios # 2, 3, 4). Pure fully funded system is preferred to mixed pension system. Though, the result that degree of relative risk aversion does not influence the attractiveness of different pension systems seemed to be strange at first, it is consistent with what Feldstein and Ranguelova (2001) found in their research. When comparing utility from pure fully funded system and pure PAYG only for retirement years, they established that fully funded system with 6% contribution rate is preferable to PAYG system with 18% contribution rate under values of CRRA coefficients up to 2.4. In case of 9% contribution rate to fully funded system, the critical value of CRRA coefficient goes up to 3.1. Consequently, the main conclusion is that the advantage of fully funded system maintains under reasonable values of CRRA coefficient (Feldstein and Ranguelova, 2001).

In this research, where different pension systems with equal contribution rates are compared, advantage of fully funded system should be even more robust, and it is supported by results.

Another factor that directly enters into individual's utility function is the discount factor. As it was previously mentioned, rather low value of discount factor of 0.95

is taken for the baseline scenario. It is reasonable to test the impact of higher discount factor, which characterizes developed countries, on ultimate result. Values of 0.96 and 0.98 are taken in this respect. Output of simulations reveals that the main result is robust to changes in discount factor as well, which is again consistent with what Feldstein and Ranguelova (2001) get in their research (Table 2 in Appendix, Scenarios #5, 6).

One more factor of interest is a degree of correlation between interest rate and wage growth. Values of 0 and 0.8 are taken as examples of low versus high correlation, and, desirability of diversification of pension risks is estimated. Change in correlation coefficient between interest rate and wage growth, taking into account the reason for diversification, should influence ultimate results. Higher value for correlation coefficient of 0.8 supports the general tendency that under pure fully funded system individual's utility is maximized as expected. Under high correlation reduction in risk is small, while reduction in total pension income from presence of PAYG layer is significant (Graph 5, Table 2 in Appendix, Scenario #7).

Surprisingly, in case of no correlation between interest rate and wage growth pure fully funded is preferred to PAYG system as well (Graph 5, Table 2 in Appendix, Scenario #8). Therefore, the theoretical argument for diversification is not confirmed by empirical results, and alternative hypothesis of the thesis that pure fully funded pension system should be preferred to mixed one appears to be true.

Demographic characteristics affect the affordable replacement ratio that PAYG system could provide to retirees. The most influential factor in this respect is fertility rate that affect population growth rate. Society with growing population is described by young demographic structure with more contributors and less pensioners compared to societies with stable or declining population. The higher the growth rate of population, the higher return PAYG system can potentially provide. In order to assess the impact of fertility rates on individual's utility, scenarios where Ukrainian population is not changing in number and when it grows at 0.5% annually are considered. Results of simulations show that even with population growth of 0.5% it is still better to have pure fully funded pension system (Graph 4).

Other issues of concern of sensitivity analysis are connected with the change in difference between average interest rate and average wage growth. If average wage growth is closer to average interest rate, return form PAYG system is closer to the return from fully funded system, and advantage of fully funded system becomes less obvious. Scenarios # 11, 12, 13 describe the situation when we change the influence of interest rate on wage growth. When this influence is higher as reflected by higher slope coefficient ($\theta$) of 0.8 (Scenario #11), the average wage growth is higher as well, and the difference between average interest rate and average wage growth is smaller. Nevertheless, pure fully funded system provides the highest lifetime utility in this case. In case of lower influence of interest rate on wage growth (Scenarios # 12, 13), average wage growth is lower than in baseline scenario, the difference between interest rate and wage growth is larger, and advantage of fully funded system increases, which is supported by output results.

The last option to consider is to change the expected mean of interest rate. For the baseline scenario, rather optimistic value of 7% was taken. Since slope coefficient between ($\theta$) interest rate and wage growth are assumed to be constant, decrease in average interest rate also implies decrease in average wage growth, though, the absolute difference between average interest rate and wage growth decreases. Variants of mean interest rates of 5% and 3% are considered. It is also interesting to consider interaction effects between low interest rates and high degree of risk aversity, because in this case preferences of individuals should shift to a less risky system. Results in Table 2 in Appendix for Scenarios #15, 17 shows that the general pattern of results under these changes from baseline scenario stays the same, and pure fully funded system is preferred.

Possible explanation for such robustness of fully funded system preference to different changes in parameters of analysis is that fully funded system requires significantly lower tax to provide individual with certain level of lifetime utility than alternative PAYG system with the same level of utility. This explanation is not new, since it comes as a direct conclusion from Feldstein and Ranguelova (2001).

However, a number of limitations of the model presume that results should be taken into account rather carefully. First, the model assumes that annuities market works perfectly, which is rather strong assumption even for developed countries. Integrating the degree of uncertainty of capital markets into the model is a subject for the further research.

Second, the model does not provide the possibility for optimization analysis. In other words, it is possible only to use comparative static analysis only, changing some parameters of the model.

**4.2. Conclusions.**

This research tries to determine the optimal design of pension system that provides the maximum utility for risk averse individual. Estimation is based on the model of stochastic interest rate dynamics that reflect uncertainty concerning future benefits. Wage growth is assumed to have a certain degree of correlation with interest rates. Results of the model suggest that countries with pure PAYG system should introduce the fully funded layer into pension system, and shift their preference toward pure fully funded system. Applying results for Ukraine, several conclusions can be drawn. Under ideal conditions of market functioning and declining population, pure fully funded system provides the maximum utility for representative individual. In no case PAYG pension system is preferable to mixed pension system.

Furthermore, Ukraine for the moment has purely PAYG system, which potentially provides the lowest utility. Taking into account that pension contribution tax in Ukraine is extremely high (34%), the introduction of fully funded system is an urgent task. The main point in this process is to determine the optimal size of fully funded layer. As predicted by the model, it should be pure fully funded system. However, there are a number of limitations that can prevent the quick creation of pure fully in Ukraine

First, effectiveness of fully funded system depends greatly on the market conditions that are unattainable for Ukraine for the moment. Primarily, existence of effective annuities market is required (Miles, 2000). This is still a problem of many developed countries. And as for Ukraine, the process of development of annuities market should be preceded by development of capital and stock market, and creation of attractive working conditions for insurance companies. Existence of deep and broad stock market is vital for use of sophisticated financial instruments while managing pension funds.

Second, fully funded system is characterized by high administrative costs that can be reduced in countries with well-developed capital markets saving on marketing costs and using inexpensive management portfolios (James, Smalhout and Vittas, 1999). In Ukraine, and many other transition countries, such possibilities are more than limited due to underdevelopment of capital market. Thus, returns from fully funded system should be estimated more conservatively.

Finally, there is a problem of financing implicit pension debt when PAYG layer is decreasing significantly. Since financial burden that falls on state budget is increasing, it naturally imposes political constraint for the reform expressed as government's unwillingness to reduce PAYG layer until it have been decided about the way in which the transition to mixed pension system will be financed.

Considering the above arguments, the feasible option for Ukraine at the moment is to introduce mixed pension system with future increase of fully funded layer in accordance with development of capital markets.

Abraham, Katherine G. and John C. Haltiwanger. 1995. "Real Wages and Business Cycle". *Journal of Economic Literature,* Volume 33, Issue 3, pp. 1215-1264.

Allen, Steven G. 1992. "Changes in the Cyclical Sensitivity of wages in the United States, 1891-1987". *The Amarican Economic Review,* Volume 82, Isssue 1, pp. 122-140.

Alier, Max, and Dimitri Vittas. 2000. "Personal Pension Plans and Stock Market Volatitlity". *World Bank Develpment Research Group.*

Auerbach, Alan J., and Lawrence J.Kotlikoff. 1987. *Dynamic Fiscal Policy.* Cambridge University Press.

Bernheim, Douglas B. and John B. Shoven. "Pension Funding and Saving". *National Bureau of Economic Research Working Paper #1622.*

Bohn, Henning. 1999. "Social Security and Demographic Uncertainty: the Risk Sharing Properties of Alternative Policies". *National Bureau of Economic Research Working Paper #7030.*

Falkingham, Jane, and Paul Johnson. 1993. "The Life-Cycle Distributional Consequences of Pay-As-you-Go and Funded Pension Systems". *World Bank Policy Research Working Paper # 1200.*

Feldstein, Martin and Elena Ranguelova. 2001. Individual Risk in Investment-Based Social Security System. *National Bureau of Economic Research Working Paper #8074.*

Gora, Marek and Michal Rutkowski. 1998. "Security Through Diversity". *Social Protection Discussion Paper #9923.*

Greene, William H. 2000. *Econometric Analysis.* Prentice Hall.

James, Estelle, and James Smalhout and Dimitri Vittas. 1999. "Administrative Costs and the Organization of Individual Account Systems: A Comparative Perspective".

James, Estelle. 1996. "New models for Old Age Security: Experiments, Evidence and Unanswered Questions". *World bank: paper prepared for the conference on Pension Systems: From Crisis To Reform.*

Johnson, Jack and John DiNardo. 1997. *.Econometric Methods.* McGraw-Hill.

Kellison, Stephen G. 1991. *The Theory of Interest.*

Kruse, Agneta. 2000. "Pension Reforms; Effects on Intergenerational Risk-Sharing and Redistribution". *Paper presented at the EISS Conference, September 6-10, 2000 in Gothenburg.*

Miles, David. 2000. "Funded and Unfunded Pensions: Risk, Return and Welfare". *Center for Economic Policy Research Discussion Paper #2369.*

Mitchell, Olivia S. 1993. "Trends in Retirement Systems and Lessons for Reform". *World Bank Policy Research Working Paper # 1118.*

Nicholson, John, 2000. *Microeconomic Analysis*. The Dryden Press.
PADCO-USAID. 1998. *Analytical Review of Pension Reform in Ukraine., Kiev.*
Palacios, Robert. 1998. "A Note on Diversification between Funded and PAYG Pension Schemes".
Pindyck, Robert S., and Daniel Rubinfeld. 1998. *Microeconomics.* Prentice Hall.
Pinera, Jose. 1998. "In Chile, They Went Private 16 Years Ago". *The Washington Post. March 22.*
Queisser, Monica, and Dimitri Vittas. 2000. "The Swiss Multi-Pillar Pension System: Triumph of Common Sence?" *World Bank Develpment Research Group Paper.*
Romer, David. 1996. *Advanced Macroeconomics.* McGraw-Hill.
Sachs, Jeffrey D. and Felipe Larrain. 1993. *Macroeconomics in the Global Economy.* Prentice Hall.
Samwick, Andrew A. 1999. "Is Pension Reform Conductive to Higher Saving?". *Dartmouth College Paper.*
Serrano, Carlos. 1999. "Social Security Reform, Income Distribution, Fiscal Policy, and Capital Accumulation". *Worldbank Working Paper # 2055*
Shiller, Robert J. 1998. "Social Security Institutions for Intergenerational, Intragenerational, and International Risk Sharing". *National Bureau of Economic Research Working Paper #6641.*
Sluchynsky, Oleksiy. 2000. "Ukraine PROST Simulations. Update". *Prepared for World Bank for Discussion.*
*Social Security and Private Pensions. Providing for Retirement in the Twenty-first Century.* 1988. Lexington Books.
Starmer, Chris. 2000. "Developments in Non-Expected Utility Theory: The Hunt for a Descriptive Theory of Choice under Risk". *Journal of Economic Literature, June.*
*The Law on Pension Security* #1788-12 from 05.11 1991.
*Ukrainian Economic Trends.* 2000. TACIS. December.
World Bank. 1994. *Averting Old Age Crisis.* Oxford University Press.

*Appendix*

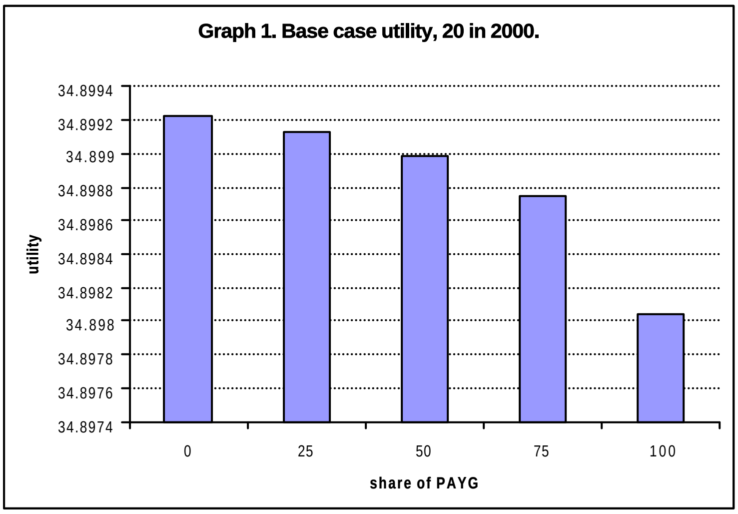
Table 1. Results of panel data estimation of wage growth and interest rate connection.

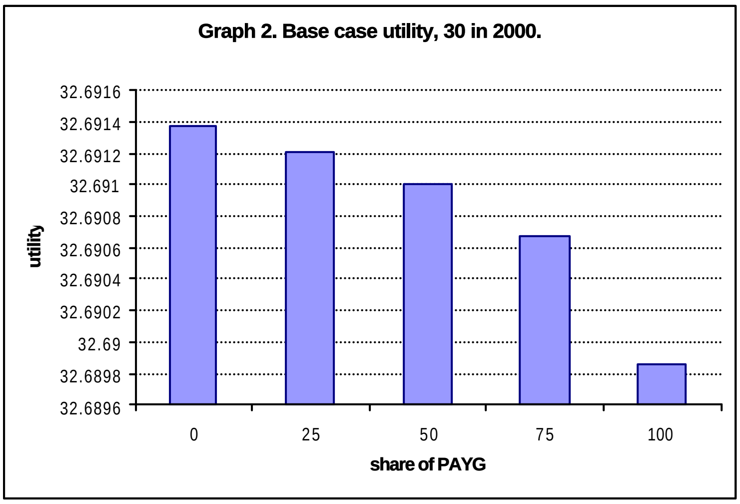
Dependent Variable: WG?
Method: GLS (Cross Section Weights)
Date: 04/17/01 Time: 15:59
Sample: 1961 1994
Included observations: 34
Total panel (balanced) observations 198
Convergence achieved after 6 iteration(s)
White Heteroskedasticity-Consistent Standard Errors & Covariance

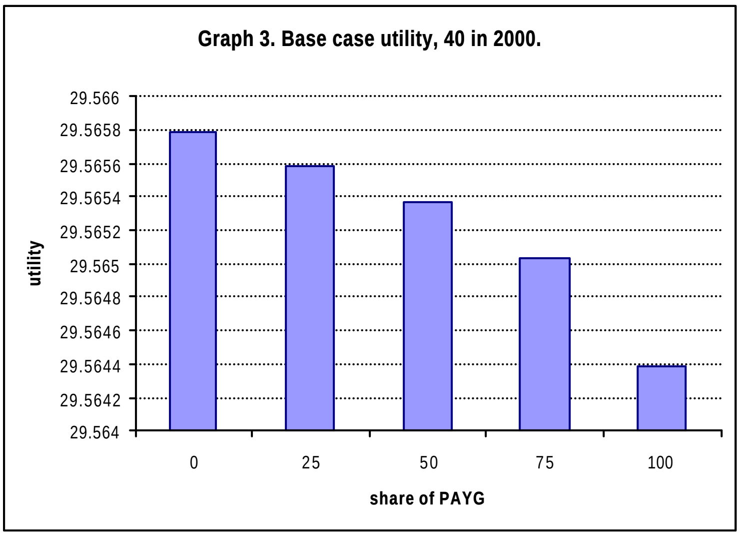
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| IR? | 0.691915 | 0.056898 | 12.16072 | 0.0000 |
| BELGUM--C | -0.003361 | 0.015487 | -0.217042 | 0.8284 |
| CANADA--C | -0.014172 | 0.017871 | -0.793007 | 0.4288 |
| FRANCE--C | -0.007024 | 0.010707 | -0.656040 | 0.5126 |
| GERMANY--C | -0.012081 | 0.017353 | -0.696184 | 0.4872 |
| GB--C | 0.007594 | 0.103625 | 0.073280 | 0.9417 |
| US--C | -0.022065 | 0.005879 | -3.753127 | 0.0002 |
| AR(1) | 0.853184 | 0.035702 | 23.89714 | 0.0000 |

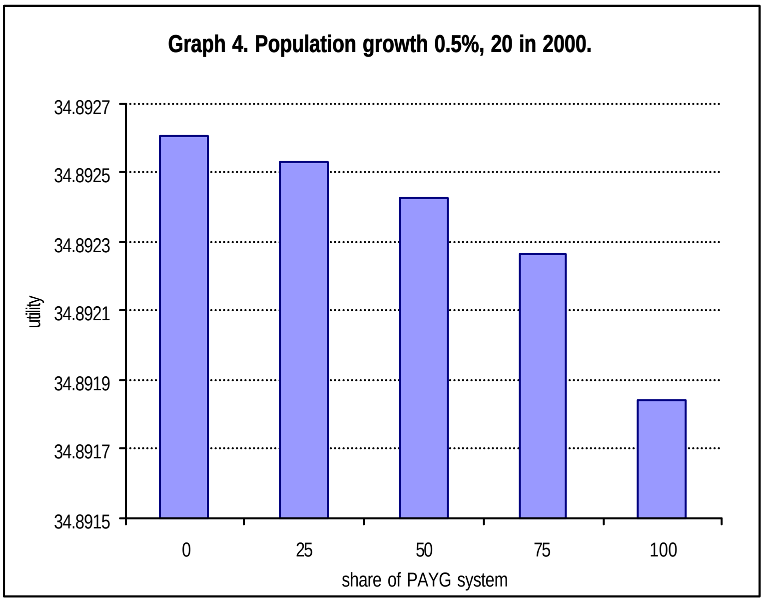
| Weighted Statistics | | | |
|---|---|---|---|
| R-squared | 0.659561 | Mean dependent var | 0.017372 |
| Adjusted R-squared | 0.647018 | S.D. dependent var | 0.040446 |
| S.E. of regression | 0.024030 | Sum squared resid | 0.109711 |
| Log likelihood | 530.0357 | F-statistic | 52.58611 |
| Durbin-Watson stat | 2.020690 | Prob(F-statistic) | 0.000000 |

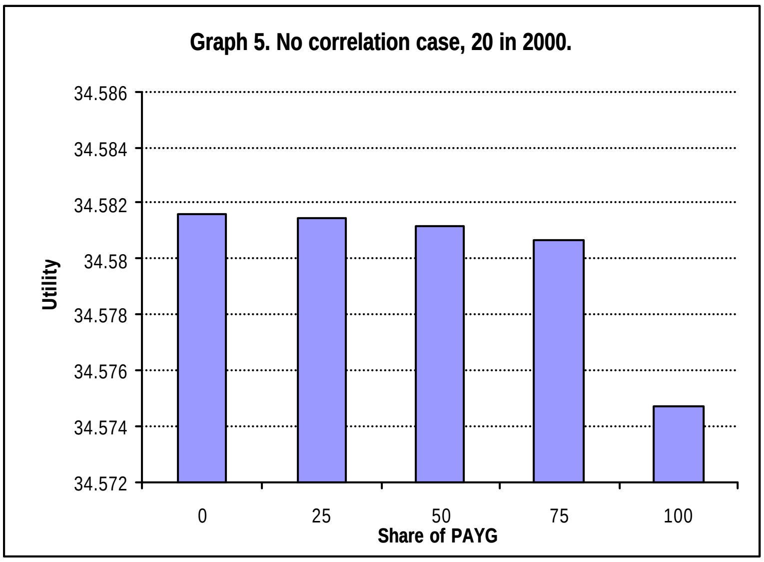
| Unweighted Statistics | | | |
|---|---|---|---|
| R-squared | 0.524853 | Mean dependent var | 0.014896 |
| Adjusted R-squared | 0.507348 | S.D. dependent var | 0.034233 |
| S.E. of regression | 0.024028 | Sum squared resid | 0.109696 |
| Durbin-Watson stat | 2.282376 | | |


Graph 1. Base case utility, 20 in 2000.
34.8994
34.8992
34.899
34.8988
34.8986
34.8984
34.8982
34.898
34.8978
34.8976
34.8974
utility
0
25
50
75
100
share of PAYG


Graph 2. Base case utility, 30 in 2000.
32.6916
32.6914
32.6912
32.691
32.6908
32.6906
32.6904
32.6902
32.69
32.6898
32.6896
utility
0
25
50
75
100
share of PAYG


Graph 3. Base case utility, 40 in 2000.
29.566
29.5658
29.5656
29.5654
29.5652
29.565
29.5648
29.5646
29.5644
29.5642
29.564
utility
0
25
50
75
100
share of PAYG


Graph 4. Population growth 0.5%, 20 in 2000.
34.8927
34.8925
34.8923
34.8921
34.8919
34.8917
34.8915
utility
0
25
50
75
100
share of PAYG system


Graph 5. No correlation case, 20 in 2000.
34.586
34.584
34.582
34.58
34.578
34.576
34.574
34.572
Utility
0
25
50
75
100
Share of PAYG

## Table 2. Results of sensitivity analysis.

| Input parameters | | | | | | | | | Shares of (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario # | IR mean | IR stdev | Slope coef $q$ | Pop growth | Average WG | IR_WG corr | Discount rate | CRRA coef | PAYG | 0 | 25 | 50 | 75 | 100 |
| | | | | | | | | | Fully Funded | 100 | 75 | 50 | 25 | 0 |
| | | | | | | | | | Age in 2000 | Output (utility) | | | | |
| 1 | **7%** | **12%** | **0.7** | **normal** | **4.24%** | **0.3** | **0.95** | **1.5** | 20 | 34.8992204 | 34.8991235 | 34.8989861 | 34.8987478 | 34.8980461 |
| | | | | | | | | | 30 | 32.6913750 | 32.6912135 | 32.6910064 | 32.6906723 | 32.6898643 |
| | | | | | | | | | 40 | 29.5657886 | 29.5655770 | 29.5653713 | 29.5650348 | 29.5643885 |
| 2 | 7% | 12% | 0.7 | normal | 4.24% | 0.3 | 0.95 | **1.3** | 20 | 52.9317756 | 52.9311847 | 52.9303912 | 52.9291182 | 52.9259670 |
| | | | | | | | | | 30 | 49.5336794 | 49.5328223 | 49.5317763 | 49.5301984 | 49.5268810 |
| | | | | | | | | | 40 | 44.7408050 | 44.7398409 | 44.7389568 | 44.7375764 | 44.7351562 |
| 3 | 7% | 12% | 0.7 | normal | 4.24% | 0.3 | 0.95 | **2** | 20 | 17.9338158 | 17.9338147 | 17.9338129 | 17.9338090 | 17.9337909 |
| | | | | | | | | | 30 | 16.8068779 | 16.8068753 | 16.8068714 | 16.8068641 | 16.8068382 |
| | | | | | | | | | 40 | 15.2089918 | 15.2089868 | 15.2089813 | 15.2089711 | 15.2089458 |
| 4 | 7% | 12% | 0.7 | normal | 4.24% | 0.3 | 0.95 | **2.5** | 20 | 11.9655639 | 11.9655639 | 11.9655639 | 11.9655638 | 11.9655633 |
| | | | | | | | | | 30 | 11.2138877 | 11.2138877 | 11.2138876 | 11.2138874 | 11.2138865 |
| | | | | | | | | | 40 | 10.1480182 | 10.1480181 | 10.1480179 | 10.1480176 | 10.1480165 |
| 5 | 7% | 12% | 0.7 | normal | 4.24% | 0.3 | **0.96** | 1.5 | 20 | 41.3138166 | 41.3136189 | 41.3133385 | 41.3128526 | 41.3114231 |
| | | | | | | | | | 30 | 38.0260070 | 38.0257110 | 38.0253315 | 38.0247193 | 38.0232403 |
| | | | | | | | | | 40 | 33.6995860 | 33.6992383 | 33.6989006 | 33.6983471 | 33.6972835 |
| 6 | 7% | 12% | 0.7 | normal | 4.24% | 0.3 | **0.98** | 1.5 | 20 | 61.9294351 | 61.9286268 | 61.9274820 | 61.9254994 | 61.9196812 |
| | | | | | | | | | 30 | 54.1005304 | 54.0995511 | 54.0982969 | 54.0962749 | 54.0913983 |
| | | | | | | | | | 40 | 45.3560457 | 45.3551181 | 45.3542207 | 45.3527431 | 45.3498999 |
| 7 | 7% | 12% | 0.7 | normal | 4.31% | **0.8** | 0.95 | 1.5 | 20 | 34.9686905 | 34.9686102 | 34.9685065 | 34.9683506 | 34.9680703 |
| | | | | | | | | | 30 | 32.7523454 | 32.7522235 | 32.7520931 | 32.7519195 | 32.7516607 |
| | | | | | | | | | 40 | 29.6158969 | 29.6157577 | 29.6156932 | 29.6155982 | 29.6154728 |
| 8 | 7% | 12% | 0.7 | normal | 4.21% | **0** | 0.95 | 1.5 | 20 | 34.9121120 | 34.9120240 | 34.9119004 | 34.9116860 | 34.9110245 |
| | | | | | | | | | 30 | 32.7026604 | 32.7025175 | 32.7023361 | 32.7020393 | 32.7012805 |
| | | | | | | | | | 40 | 29.5750028 | 29.5748359 | 29.5746747 | 29.5743794 | 29.5737501 |
| 9 | 7% | 12% | 0.7 | **0.5%** | 4.24% | 0.3 | 0.95 | 1.5 | 20 | 34.8926070 | 34.8926524 | 34.8924885 | 34.8921479 | 34.8900788 |
| | | | | | | | | | 30 | 32.6922352 | 32.6924374 | 32.6921165 | 32.6914667 | 32.6880556 |
| | | | | | | | | | 40 | 29.5564855 | 29.5571556 | 29.5565171 | 29.5552216 | 29.5490529 |
| 10 | 7% | 12% | 0.7 | **0.0%** | 4.24% | 0.3 | 0.95 | 1.5 | 20 | 34.8926070 | 34.8925191 | 34.8924002 | 34.8922080 | 34.8916761 |
| | | | | | | | | | 30 | 32.6922352 | 32.6920961 | 32.6919240 | 32.6916577 | 32.6910554 |
| | | | | | | | | | 40 | 29.5564855 | 29.5562910 | 29.5561127 | 29.5558122 | 29.5551955 |
| 11 | 7% | 12% | **0.8** | normal | 4.89% | 0.3 | 0.95 | 1.5 | 20 | 34.9183551 | 34.9182720 | 34.9181550 | 34.9179508 | 34.9173089 |
| | | | | | | | | | 30 | 32.7080902 | 32.7079673 | 32.7078088 | 32.7075419 | 32.7068547 |
| | | | | | | | | | 40 | 29.5794233 | 29.5792796 | 29.5791394 | 29.5788603 | 29.5782090 |
| 12 | 7% | 12% | **0.6** | normal | 3.77% | 0.3 | 0.95 | 1.5 | 20 | 34.8829984 | 34.8828980 | 34.8827555 | 34.8825090 | 34.8817983 |
| | | | | | | | | | 30 | 32.6759892 | 32.6758283 | 32.6756221 | 32.6752934 | 32.6745652 |
| | | | | | | | | | 40 | 29.5520630 | 29.5518392 | 29.5516251 | 29.5512908 | 29.5507052 |
| 13 | 7% | 12% | **0.5** | normal | 3.05% | 0.3 | 0.95 | 1.5 | 20 | 34.8670558 | 34.8669444 | 34.8667810 | 34.8664878 | 34.8655356 |
| | | | | | | | | | 30 | 32.6631168 | 32.6629311 | 32.6626843 | 32.6622803 | 32.6612908 |
| | | | | | | | | | 40 | 29.5425318 | 29.5422468 | 29.5419436 | 29.5414763 | 29.5405827 |
| 14 | **5%** | **10%** | 0.7 | normal | 3.43% | 0.3 | 0.95 | 1.5 | 20 | 34.8687530 | 34.8686328 | 34.8684691 | 34.8681979 | 34.8675080 |
| | | | | | | | | | 30 | 32.6645757 | 32.6644093 | 32.6642094 | 32.6638950 | 32.6632207 |
| | | | | | | | | | 40 | 29.5434720 | 29.5432990 | 29.5431619 | 29.5428953 | 29.5423689 |
| 15 | **5%** | **10%** | 0.7 | normal | 3.43% | 0.3 | 0.95 | **2.5** | 20 | 11.9655448 | 11.9655448 | 11.9655447 | 11.9655446 | 11.9655437 |
| | | | | | | | | | 30 | 11.2138705 | 11.2138705 | 11.2138703 | 11.2138701 | 11.2138691 |
| | | | | | | | | | 40 | 10.1480034 | 10.1480033 | 10.1480031 | 10.1480028 | 10.1480016 |
| 16 | **3%** | **7%** | 0.7 | normal | 2.26% | 0.3 | 0.95 | 1.5 | 20 | 34.8100315 | 34.8098734 | 34.8096749 | 34.8093706 | 34.8087697 |
| | | | | | | | | | 30 | 32.6132197 | 32.6130459 | 32.6128663 | 32.6125940 | 32.6121015 |
| | | | | | | | | | 40 | 29.5010122 | 29.5009398 | 29.5009741 | 29.5008911 | 29.5006719 |
| 17 | **3%** | **7%** | 0.7 | normal | 2.26% | 0.3 | 0.95 | **2.5** | 20 | 11.9655056 | 11.9655055 | 11.9655053 | 11.9655050 | 11.9655038 |
| | | | | | | | | | 30 | 11.2138355 | 11.2138354 | 11.2138351 | 11.2138347 | 11.2138335 |
| | | | | | | | | | 40 | 10.1479730 | 10.1479729 | 10.1479729 | 10.1479726 | 10.1479717 |