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Efficient Investment Strategies in Defined Contribution Pension Plans in Israel

Efektywne strategie inwestycyjne w planach emerytalnych ze zdefiniowaną składką w Izraelu

PhD thesis

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Abstract

Pension systems, both in Israel and worldwide, have been through major reforms during the last 30 years, expanding the defined contribution (DC) invested in capital market plans. There is increasing consensus that the risk of a pension portfolio should be decreased towards retirement age, but the strategies for implementing this are still under debate. Research regarding efficient strategies has been carried out around the world, but in Israel it is being done for the first time. The purpose of this dissertation is to present the results and conclusions of research that is focused on finding the most efficient investment strategies for Israel's pension system, according to the tradeoff between mean return and risk.

Risk measurement is carried out using an advanced method of Conditional Value at Risk (CVaR), which is superior for measurement of extreme risk, while most of the former research has used Value at Risk (VaR) for this purpose.

In order to answer the research questions, Monte Carlo simulations were run 10,000 times, and efficiency frontiers for 15 investment strategies of five types were drawn: fixed, linear, stepwise, piecewise and stepwise-shorter; and for each of six representative agents of males and females with different salaries.

Firstly, the efficient strategies according to mean return versus Conditional Value at Risk (CVaR) of returns are examined. The second step is to find the mean versus Conditional Value at Risk (CVaR) of net replacement rates, based on assumptions of continuous employment. The third step examines the influence of periods of unemployment with withdrawals of severance pay on replacement rates and efficient strategies. Based on this scenario, two other scenarios are examined: early retirement and different allocations of earmarked bonds.

The main conclusion derived from the study is that for all the scenarios, a life cycle of dynamic strategies with a high portion of equities, switching gradually to a fully bonds portfolio at retirement, produces the highest returns and replacement rates for a given risk. Withdrawals of parts of severance pay significantly reduce the replacement rates. Early retirement reduces the replacement rates after the official retirement age, and much more so during the period from

actual retirement till official retirement age. Changing the allocation of earmarked bonds, where contributors up to the age of 50 do not receive any bonds and retirees get 60% instead of 30% bonds, as a proportion of the total portfolio, brings higher replacement rates as well as higher risk for all.

Based on the data of different growth rates for the salaries of males and females, and the higher salaries of males, the research also examines the influence of these factors on the gender gap, by examining whether the pension system is reducing or expanding it.

The conclusion is that the gap between genders during the work period expands during the retirement period. Reducing the gap requires dealing with the salary gap created during the working period and raising the retirement age of females.

Keywords: pension, portfolio, strategy, replacement rates, simulation, pension gender

Introduction

Defined contribution (DC) pension funds that are invested in capital markets are one of the major pension instruments. The process of turning pension systems from a defined benefits (DB) to a defined contribution (DC) funded system with investments in capital markets accelerated after the 1994 "Three pillars model" of the World Bank was published. The number of countries with a mandated and funded "second pillar" jumped to 30 in 2008 compared to 6 in 1994 [Holzmann 2012, p. 3]. The accumulation on retirement is the sum of contributions during the employment period and the returns on investments less the management fees. On retirement, the accumulation is converted to a monthly annuity according to the pension factor. This means that the annuity after retirement depends on the accumulation at retirement age.

Investments in capital markets are highly exposed to market risk. The major problem is not the normal volatility of capital markets, but rather the risk of market crashes, which have taken place much more often in recent decades. The major problem is protecting the accumulation of retirees and older people who are close to retirement, who have no time left to gain from the recovery of markets after crashes. This emphasizes the need for investment strategies that will allow risk and high returns during most of the accumulation phase but will also significantly reduce the risk on the last phase of accumulation to avoid losing much of the accumulation.

Pensions are a complicated field, hard to understand and manage for most of the population, even though it is one of the most important issues in the human life cycle. People make a decision and let it stand with no changes or adaptations deemed necessary [Barr and Diamond 2010a, p. 123-124]. This includes planning the future annuity, deciding on the type of insurance for survivors and disability, managing fees, withdrawing severance pay and investment policy. Researchers agree that a good default system is essential [Barr and Diamond 2010b, p. 9], but do not agree on what shape of default system is required [Antolin et al. 2010, p. 88]. The meaning of a default system is a system where the needed adaptations are done automatically, without any active involvement of the contributor, such as changing the investment risk automatically according to age, or automatically changing survivors' insurance when there is a change in the family status of the contributor.

One of the fields being researched is the investment strategies needed to gain enough return and less risk. This research is at the heart of pension theory that seeks to find ways to achieve better replacement rates and a smoothing of income from the work period to the retirement period [Barr and Diamond 2010a, p. 27-28]. Most researchers agree that the solution of a default scheme in which the risk of the portfolio is reduced toward retirement is crucial. "There is increasing international consensus that some type of life-cycle strategy is desirable for default options, with decreasing risk exposure as the individual ages. However, the specific allocation to risky assets, such as equities, at different ages is a matter of much debate, both in academic and policy circles. There is also an on-going debate on the relative merits of deterministic investment strategies with a fixed glide path over the life cycle and dynamic investment strategies that regularly adjust their portfolio based on past performance and value at risk" [Antolin et al. 2010, p. 89].

Much research in the pensions field is aimed at solving the scientific problem of finding the efficient investment strategies in DC plans in order to obtain better mean replacement rates and at the same time reduce the risk to the portfolios, especially of the elderly, from an extreme market crash. An efficient strategy is one with higher mean returns or replacement rates and with no higher risk than another strategy, or with the same mean of returns or replacement rates and lower risk. Previous researches have tried to find the recommended strategies, using simulations as the main research method.

Among the research conducted on efficient strategies for DC pension plans, the following should be noted: Berstein et al. [2013] ran a simulation on the Chilean pension system; Basu and Drew [2009] presented a model for a default investment option in a DC plan in Australia; Gomez-Hernandez and Perez-Sosa [2014] did research on the Mexican pension system; Antolin et al. [2010] conducted comprehensive research on German and American historical data that presented the efficient frontier of the strategies. Their results were that life cycle strategies with high portions of equities in most of the accumulation phase, switching slightly to bonds in the last decade, produced the highest net replacement rates for a given risk, and were the most successful strategies for annuity purposes [Antolin et al. 2010, p. 88]. Most of the research results were very similar to the results of the research of Antolin et al. Few researchers used standard deviation as

the risk measure, but most researchers used the more advanced method of Value at Risk (VaR). A minority of research in this field used Conditional Value at Risk (CVaR), which is superior to VaR as the risk measure, since it takes care of the "blind spot" in the α-tail of the distribution and is coherent, while VaR is not coherent [Artzner et al. 1999, p. 216]

Chile was the first country to develop an age-based default system that automatically reduced the portfolio risk per age. The Chilean system is a multi-funds system that includes five funds under management of the same pension provider. The first fund A is the most aggressive with a high portion of equities, while the last one E has no equities at all. The default fund for ages less than 35 is B. At the age of 35 contributors are automatically transferred to C, which is less aggressive than B, and so on till at retirement they are transferred to E with no equities at all [Hormazabal 2010]. The Chilean model was successful in 2008, and the loss of accumulation value for the elderly and retirees was minimal.

The Israeli pension system was a defined benefits (DB) system for government employees and pension funds. All instruments were invested in earmarked government bonds, and no investments in capital markets were made. The Israeli system has faced many reforms in the last 27 years. The major reforms that have a direct connection to the subject of this thesis turned all new joiners towards pension funds which were funded, defined contribution (DC), privately managed and invested in capital markets; thus, increasing the portion of accumulation invested in capital markets by significantly reducing the portion of earmarked government bonds and adopting the age-based default model.

The Israeli pension system, like other defined contribution (DC) funds which are invested in capital markets, faces the same problem of obtaining returns on investment to create enough accumulation and annuity while not exposing the accumulation, especially of the elderly, to extreme market risk. Finding the efficient investment strategies in Israel is essential but was never researched in Israel.

The aim of this research is to solve this scientific problem, using the most advanced scientific methods: Monte Carlo simulations and the use of CVaR as a risk factor. The scientific problem is divided into the following research questions:

1. What are the most efficient investment strategies for the risky part of Israeli defined contribution pension plans, according to the mean return versus CVaR of returns?
2. What are the most efficient investment strategies for Israeli defined contribution pension plans, according to the mean versus CVaR of the net replacement rate of six biographies of participants differentiated by gender and income in an ideal world where continuous work and no withdrawal of severance pay is assumed?
3. What are the most efficient investment strategies according to the mean versus CVaR of net replacement rates, when contributors have two leaves from work and partly withdraw severance pay? What is the change in net replacement rates?
4. How are the results for net replacement rates and winning strategies affected if the basic assumptions are changed. In particular, we consider:
    (a) early retirement of four years.
    (b) different allocation of government earmarked bonds where contributors till the age of 50 will obtain no earmarked bonds at all.
5. What is the influence of different wage growth per gender and per decade of the work phase on the net replacement rates and on the absolute pension gap between genders? Is there any change in the winning strategies? What is the change if, in addition to different wage growth, different starting salaries are also assumed?

To find the efficient strategies, the model contains three different biographies for each gender: median salary, average salary and starting salary for the high-tech industry, which is very developed, very appreciated in the world, pays higher salaries and attracts the young generation. The minimum salary was not added due to two reasons: (a) most of the minimum salary earners did not have any pension until the mandatory pension was declared in 2008 with gradually increasing contribution rates, so that actual full contributions started in 2014-2015, (b) the results are supposed to be very similar to the median salary because they are close (6,000 NIS compared with 5,000 NIS), both pay no income tax and pay the same rate of National Institute fees. Despite this, a simulation run on female minimum earners was added to answer the question of the gender gap. This biography should be included in future research. A total of 15 strategies of five types were examined: fixed, linear, stepwise, piecewise and stepwise-shorter. The strategies

include different starting portions of equities, and methods of reducing the equity portion, but all strategies must be with no equities at all on retirement.

The pension portfolio in Israel is created as a sum of the portfolios of all pension providers in Israel by groups of investments, and for each group the suitable investment index is found. Data on the indexes was collected for 25 years on a quarterly basis and is used to generate 10,000-time Monte Carlo simulations of returns. According to the simulated returns, the annuities and replacement rates were calculated, creating a distribution of 10,000 results for each strategy and biography. The mean and Conditional Value at Risk (CVaR) of the distribution were calculated and efficiency frontiers were drawn to answer the research questions.

The next simulation changed the basic theoretical assumption to make the model more similar to reality. The assumption of continued employment, contributions and no withdrawal of severance pay is changed, and the replacement rates and efficient strategies are examined again.

Based on the results of the previous scenario, two more scenarios that changed the basic assumptions were examined. The first assumption to be changed was early retirement four years before official retirement age. About 12.4% of females and 29.5% of males are retirees four years before the official retirement age. This scenario examined the influence of early retirement on replacement rates after the official retirement age, and during the early retirement period till the retirement age.

The second scenario changed the assumption of 30% government earmarked bonds to pension funds only for all contributors, which led to a total risk-free portion of 29% out of the portfolio of all instruments. According to the new allocation, younger people up to the age of 50 will not receive any earmarked bonds and from the age of 50 to retirement will have a 30% allocation as before. The influence on replacement rates and on the winning strategies was examined.

Based on the results of the scenario with two leaves, the gender gap was examined. According to the Central Bureau of Statistics (CBS) and National Insurance Institute, males' salaries are 50% higher than females', and the growth rate for males is higher than for females and is different in each decade. The last research question was:

1. What is the influence of different wage growth on replacement rates and on the absolute pension gap between genders? Is there any change in the winning strategies? What is the change if different wage growth and a different starting salary is assumed?

The thesis contains four chapters. The first three chapters contain a literature review regarding the issues of this dissertation and the fourth chapter contains the research: the model's assumptions; the way data was collected and used; the results and conclusions.

The first chapter describes pension theory: pension objectives, types and structures. The reforms to pension systems, mainly in the spirit of the three pillars model are described with alternative methods such as notional defined contribution (NDC). Finally, the Chilean age-based default model is described with its implementation in different countries.

The second chapter describes the Israeli pension system and the reforms to the system. The system was pay as you go (PAYG), with defined benefits (DB), and was changed to a funded, defined contribution (DC), invested in capital markets. The government involvement and responsibility were reduced significantly. The chapter also includes a description of the implementation of the age-based default model that was adopted in Israel in 2016.

The third chapter relates to risk measurement, theoretical issues of capital markets, and simulation methods. Firstly, the characteristics of the distribution are discussed: mean, standard deviation, Value at Risk (VaR) and Conditional Value at Risk (CVaR). After that, popular finance theories are presented - beginning with stand-alone investments and followed by the portfolio theory of the efficient frontier devised by Markowitz. The last part of the chapter describes simulation methods and the use of simulations in pension field research.

The fourth chapter contains the research. Firstly, the model is described, including the biographies, the data (pension portfolio, returns, wages growth) and the process of research. Later, the research questions are posed, and the results of the research are described and analyzed.

The last part of the dissertation comprises the conclusions of the research.

The research examines the efficient strategies at the starting point of the full adoption of the age-based default model in Israel in 2014-2015, to be fully adopted in 1 January 2016. Monte Carlo simulations were run on a pension portfolio of 31 December 2014 collected from Ministry

of Finance websites. Salaries of 2014-2015 and other factors such as tax rates were according to statistics and official publications. Returns for the period of January 1990-March 2015 were collected from Tel Aviv Stock Exchange publications and from the Yahoo Finance website. The literature mainly comprises published books, articles and other scientific sources concerning the theoretical issues of this dissertation and Israeli government publications.

1. Pension systems and their reforms

1.1 Pension system objectives, types and structure

1.1.1 Pension system objectives

Pension systems have primary objectives and secondary objectives [Barr and Diamond 2010a, p. 26-27]. The objectives can be viewed from the individual point of view, or from the perspective of families or public decision makers in any state.

The primary objective of a pension system, common to individuals, families and public policy, is old age security, achieved through consumption smoothing. A pension system should provide a mechanism for consumption smoothing that will enable people to transfer consumption from the young and mid period of life (employment period) to the retirement period [Barr and Diamond 2010a, p. 26-29]. People seek to maximize their consumption throughout their whole lifetime. Hence the need to transfer economic sources from the employment period to the retirement period, which will enable people to maintain their living standards. Maintaining living standards is measured by the replacement rate – which is calculated by dividing the income after retirement with the income prior to retirement. There are several ways to define the replacement rate [OECD 2015, p. 138], but in this dissertation, it is defined as the first full net income after retirement (including pension annuity and the National Insurance old age pension) divided by the last full net income before retirement. The objective is that the replacement rate will be high enough to enable people to maintain their living standards after retirement. Previous research has found that consumption tends to decline towards and after retirement, which is known as the retirement consumption puzzle [Blanchett 2014], and hence the desirable replacement rate should be smaller than 100 percent. The mechanism for consumption smoothing will be discussed later.

The second primary goal of a pension system, from an individual's point of view, is to provide an insurance for survivors and against the occurrence of disability to work, whether temporary or permanently. Protecting against the risk of survivors and disability is an important goal of a social system, although the risk is different to the risk of ensuring economic resources for the retirement period. Both goals (old age security, survivors and disability) can be financed and managed

together with accumulation for retirement (as is done for example in Germany or Israel) or separately, as it is done in Poland. Since consumption smoothing relates to the family and not only to individuals, it is essential to protect children or widows/widowers. Studies find that a survivor of a couple needs about 65%-70% of the couple's income to maintain the previous living standard [Barr and Diamond 2010a, p. 27]. A comprehensive pension (as exists in Israel) or social protection systems include those insurances and protect against the risk of old age security together with survivors and the disability risk. Of course, the pension system does not have to be comprehensive and can be operated without these insurances.

The third primary goal for individuals is to reduce the longevity risk [Barr and Diamond 2010a, p. 28]. Life expectancy is unknown for individuals but can be better predicted and managed for a large group of individuals by statistical means that use probabilities and actuarial methods. Managing such risk is done by experts with large data bases that can predict risks, and for insurance companies with enough capital that can observes shocks. In the modern world, the covering of such risk is done by governments, insurance companies or by other large pools of insured people (such as employees' unions or big corporations) and allows an individual to get an annuity based on the individual's accumulation or rights [Barr and Diamond 2010a, p. 28].

Public policy has two more primary objectives [Barr and Diamond 2010a, p. 29-30]:

- Poverty relief: intended to take care of poor people who do not earn enough in the employment period and need to be supported on retirement.
- Redistribution of income: this can be achieved through tax on high annuities, minimum annuity and other steps that redistribute income.

The secondary objectives are not related directly to the purposes of the system itself. The most common secondary objective is that the system will improve, or at least not diminish, economic growth [Barr and Diamond 2010a, p. 30]. Other goals include a positive or at least a non-negative influence on the labor market and limiting public expense on pensions or the public budget deficit [Ebbinghaus and Whiteside 2012, p. 267].

Sometimes reforms made in pension systems were based on short term secondary objectives and less on long term primary objectives[1].

The redistribution of income among various contributors and pensioners is not agreed by all researchers and is dependent on one's values. The act of redistribution influences the individual's work-leisure decisions and can reduce economic efficiency since individuals' decisions might not be optimal for the economy as a whole. "A definition of an economically efficient pension scheme is a scheme that does not influence individual work-leisure and consumption-saving decisions" [Palmer and Góra 2004, p. 3]. Others see redistribution as one of main goals of the pension system [Barr and Diamond 2010a, p. 26]. Despite this disagreement, redistribution of incomes is in fact part of many pension systems.

1.1.2 Pension types

The pension system in the modern world was first introduced by the German Chancellor Bismarck at the end of the 19th century. The pension system and pension theory are part of the wider subject of social affairs and the welfare state. Fifty years later, a different approach was introduced in the UK by Beveridge. Since then, most social systems in developed countries are either of the Beveridgian type, the Bismarckian type, a combination of the systems or a modification of one of those systems.

Researchers in social sciences distinguish mostly between a flat rate pension system, where the benefits are paid equally regardless of contribution rate (if it exists at all) and pension systems where the benefits depend on the contribution [Cremer and Pestieau 2003, p. 1-2]. A pure Bismarckian system is based on an earnings-related rule, which means that there is a strong relationship between contribution and benefits, and hence the system is not redistributive among various people. In a pure system, one is entitled to claim benefits only if one has contributed before, and if not, only if one is incapable of working and contributing. The basic principle of this system is insurance that can be covered by the contributions of insured people, run mostly by the state. The state can also carry part of the risk of longevity or market volatility, or contribute to

[1] An example is the Polish reforms that took place in 1999-2013 [Ratajczak-Tucholka 2013, p. 133].

the pension fund, especially if some redistribution among pensioners is made. This type of system is considered fair by economists who tend to prefer systems that do not influence the individuals' work-leisure decisions and is also preferred by mid-high-income earners [Kolmar 2007, p. 666]. Bismarckian systems are common in continental European countries, especially Germany and France, where the size of the system, relative to GDP, is high. The Nordic countries have also adopted a Bismarckian model, in which social protection is extremely generous, financed by high taxes and redistributive [Cremer and Pestieau 2003, p. 1].

A pure Beveridgian system, on the other hand, is based on a flat rate rule of benefits, and hence has a distributive character [Kolmar 2007, p. 650]. The basic idea is that all residents are entitled to minimum benefits, regardless of their payments of the tax that finance the system. This means that mandatory payments are made to social security, but not only are those who pay entitled to benefits, but also residents who cannot pay, temporarily or permanently, with their benefits being covered by others who pay the mandatory social security payments. The meaning is that the system is basically redistributive. Beveridgian systems are common in Anglo-Saxon countries where the overall size of the programs is small relative to GDP.

1.1.3 Basic features of pension systems

Pension systems can be divided into funded systems versus PAYG systems or into defined benefits (DB) versus defined contribution (DC) . According to Barr and Diamond [2010a, p. 32-34], funded and PAYG differ according to the source of the paid annuity. Funded system resources are the accumulation of contributions during the employment period and total returns on the assets purchased [2] . PAYG resources derive from government tax on the current workforce or by contributions paid by the current workforce.

A Defined Benefits program is a pension program in which the employee is entitled to pension rights per the period of employment and wage history. It can be funded or non-funded, though the pension rights are not based on the accumulation. The claims for pensions are paid from a central pool of assets, and the fund manager should financially balance the fund. A common DB program is government PAYG, where the "assets" are tax that the government collects or

[2] In Israel, the returns are calculated before managing fees, and managing fees are subtracted separately.

contributions by state employees. Other DB programs can be funded pension funds, where the annuities are paid from the accumulation, but are based on the contributor's rights and not on the personal accumulation. Naturally, one of the most important issues in a DB system is keeping the funds actuarially balanced.

A Defined Contribution plan, also called a funded individual account, is based on contributions that are used to purchase assets, and every contributor is entitled to his/her contribution and the return on the assets as were recorded in its individual account. On retirement, it can be withdrawn as a lump-sum, can be withdrawn in monthly payments or any other means of withdrawal till no balance is left, or can be used to buy life time annuity. While the DB type can be either PAYG or funded, the DC type can only be funded.

Notional Defined Contribution (NDC) is a PAYG scheme that mimics the DC way of calculating one's balance and annuity. Contributions are registered in a personal account, and the "notional" returns are set by government and not by capital markets. The annuities are calculated and paid according to the contributor's personal virtual balance on retirement and the pension factor.

DB, NDC and PAYG plans are based on the important assumption that the next working generation will have enough economic resources to support the future pensioners, i.e. the current workforce. The annuities paid in a PAYG plan are financed by current taxpayers or contributors' payments, and changes in the actuarial balance, such as a falling proportion between the number of the workforce and pensioners (known as the old age support ratio) might cause a deficit.

Nicholas Barr [2002, p. 2,8] claims that in fact there is no real difference between claims for rights and collecting money for the future. In both cases the purpose is to consume products and services that will be produced by future employees. If future production falls, then the prices of products and services will rise and real consumption due to the collected money will drop – the same effect as in the case of fulfilling only part of the obligations in PAYG schemes.

1.2 The need for reforms in pension systems

After the Second World War, PAYG and DB systems were popular in Continental Europe while in the UK, USA and Australia the common type was mostly funded DC.

Since PAYG payments are part of budget expenses, of government or other non-governmental organizations, and can be financed by taxes or social contributions, and the budget size is dependent on economic growth, the need to reduce the budget expense on pensions occurred mostly when the economy was slowing. A slowdown in the economy that brings less tax income applies fiscal pressures and forces governments to cut expenses, including pension expenses, to prevent a higher budget deficit.

Other reasons for reforms were changes in the political atmosphere. The oil crisis after 1973 caused high energy expenses in western countries and a slowdown in those countries' economies. In the eighties, conservative politicians, who promoted free markets, reduced state involvement in the economy and privatization came to the fore in many western countries. The main leaders who also influenced other countries were Ronald Reagan in the USA and Margaret Thatcher in the UK. Reforms to pensions were a part of the reforms that the World Bank and IMF demanded from countries that needed their assistance, and the political atmosphere was to transfer responsibility from the state to individuals [Orenstein 2011, p. 67-68].

1.2.1 Life expectancy and fertility rates

The main reasons for reforms were permanent change in demographic factors. These factors have been the rise in life expectancy and the drop-in fertility rates that have not been compensated enough by other factors that could raise production such as technological improvements or higher productivity. This makes the retirement period longer, reduces the workforce and "with all else equal will put tremendous pressure on economies in general and on pension systems in particular" [OECD 2014, p. 19]. Other reasons are mostly cultural: higher mobility of employees, a rise in part-time jobs and self-employment, the possibility to work from distance, immigration of people in mid ages that don't have enough time to save for pensions and late marriage age. All those effects cause pension system costs to rise. [Barr and Diamond 2010a, p. 3-11]. Life expectancy in the developed countries crossed the age of eighty and is expected to

rise in about more four years in 2045-2050 [UN 2015, p. 24-39]. The problem in the pension world is that, assuming no change in all other factors, if the retirement age is not changed, then growing life expectancy means that the insurer should pay more pension payments financed by an unchanged period of contributions. It creates an imbalance and an urgent need to make reforms that will return the system to being balanced. Figure 1 presents the life expectancy after age of 60 by world region:

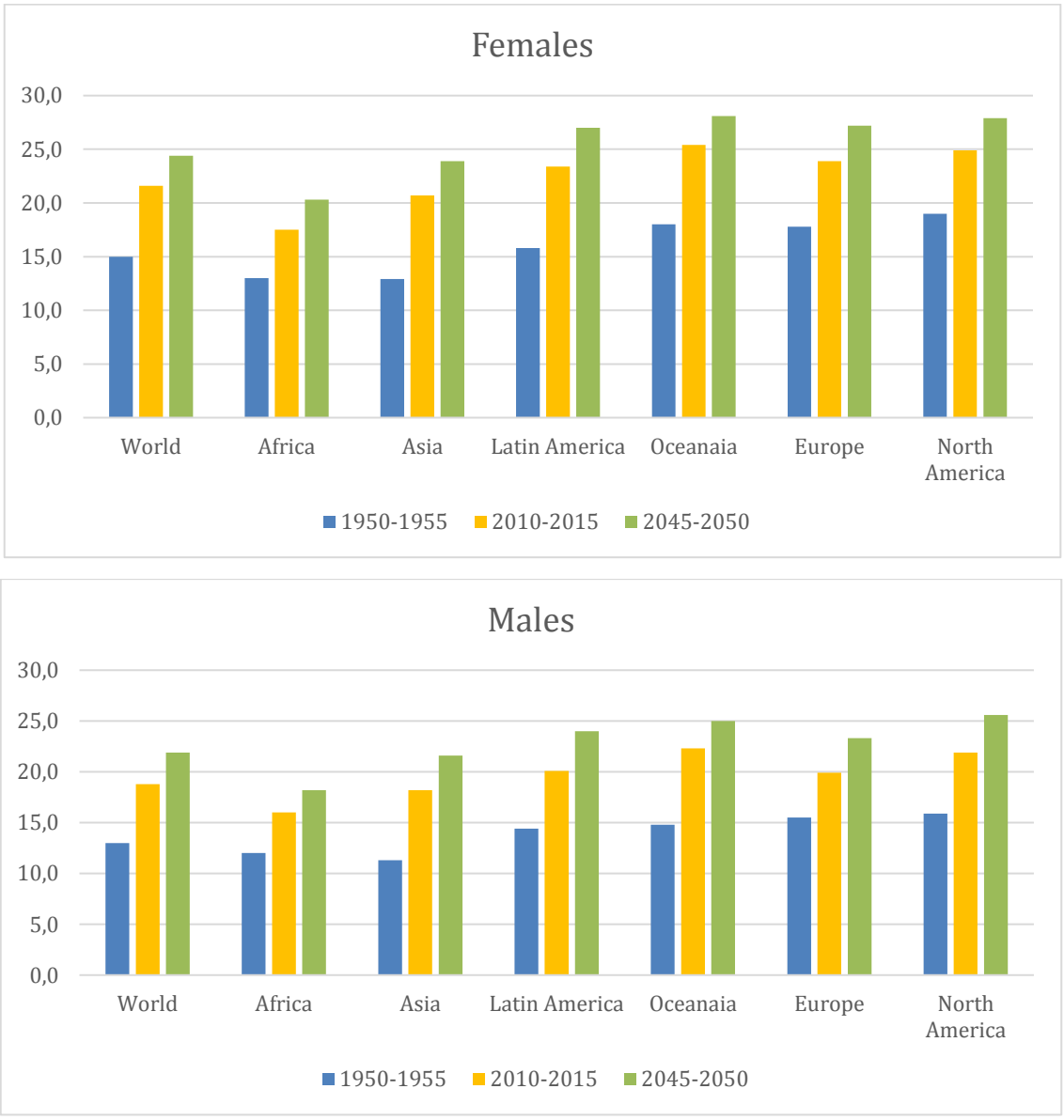


Figure 1. Trends in life expectancy at age of 60 by gender and region

Source: UN 2015 p. 54, UN 2017a, p. 14.

Life expectancy of females is greater than males, while in some OECD countries the female retirement age was lower than the male [OECD 2005, p. 150]. Meanwhile, in many OECD countries the retirement age was changed and in 2015 in some of the countries the retirement age of males and females is identical [OEDC 2015, p. 131].

Growing life expectancy is not the only problem. On the other hand, fertility rates, presented in Figure 2, have fallen and the basic nuclear family of a couple and their children is becoming smaller in developed and developing countries, where smaller means one or two children if at all, or a single mother family [Barr and Diamond 2010a, p. 5].

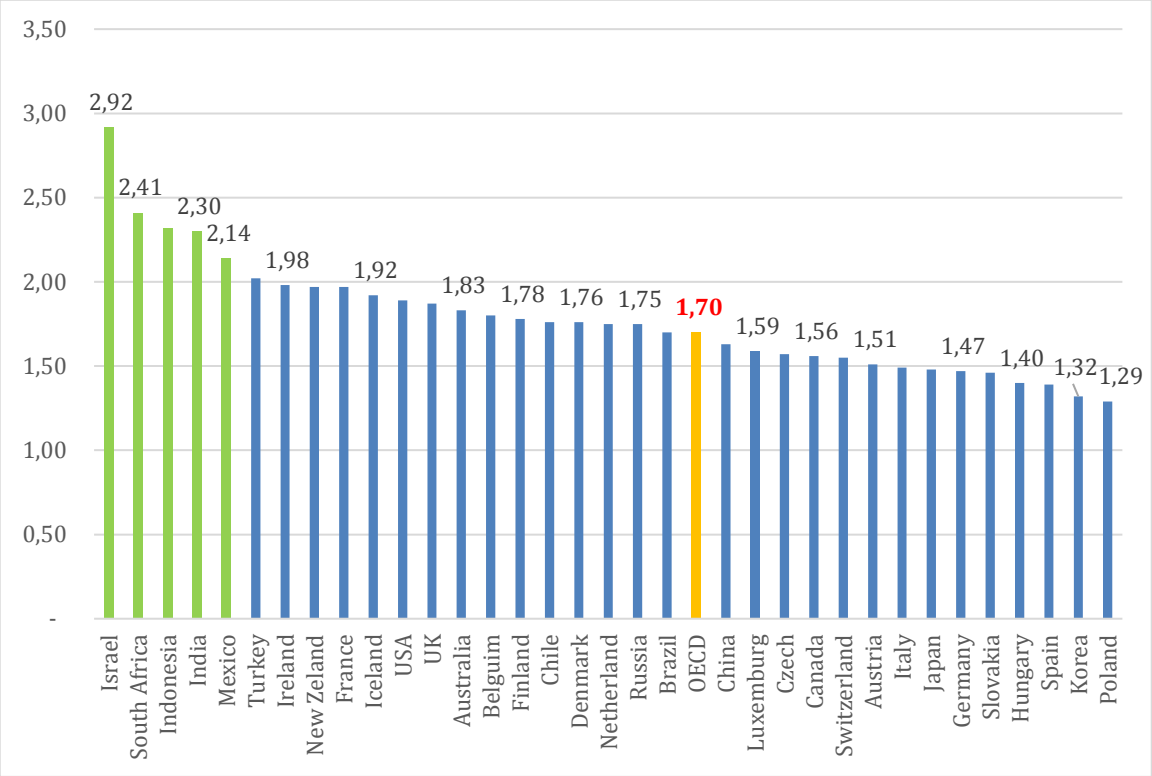


Figure 2. Fertility rate[3] in OECD countries 2015

Source : OECD 2017, p. 119.

Most of the western world, and especially Europe, Japan and Korea, countries have low fertility rates. Since 2.1 children per woman is the balance rate [OECD 2011, p. 44], it means that without immigration to most OECD countries, their populations are expected to drop significantly in the

[3] Defined as the number of children which would be born to every woman at the end of her childbearing years.

coming decades[4]. Immigration to Western Europe has been very popular in recent decades, especially to Germany, France, Holland and the UK. Today many immigrants are poor and low skill employees, and in the short term cause a heavy burden on social systems. Without any significant change they probably will be a future burden also on pension systems.

1.2.2 Dependency Ratio and Old Age Support Ratio

Combining the rise in life expectancy with reduction in fertility rates, means is that if the retirement age is unchanged, the next working generations will be smaller while the number of pensioners will rise. This means that less people will have to work for more people, and the burden on the working generation will be high. It is common to express this with the dependence ratio, calculated as the proportion between the unemployed, including children, to the labor force, or in the old age support ratio which is the number of the labor force (aged 16-64)per older people (aged 65 and over) . Figure 3 presents the trend in old age support ratio by regions of the world.

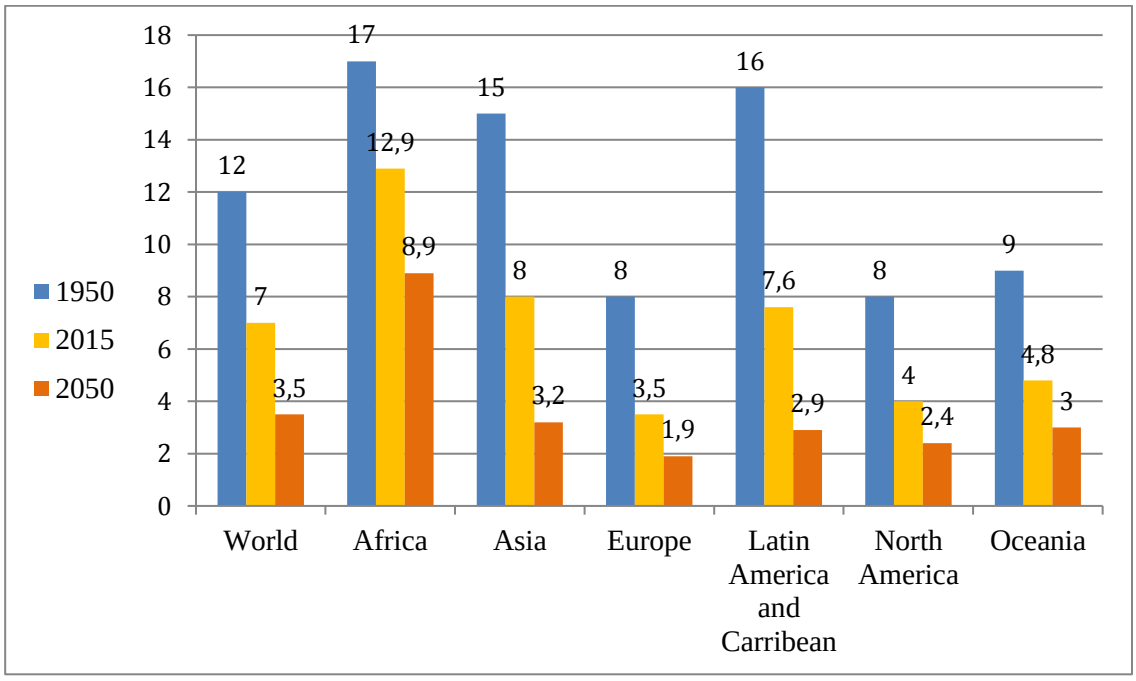


Figure 3. World Old Age Support Ratio by regions 1950-2050

Source: UN, 2017, p. 87.

[4] The problem is mainly the change in population structure rather than the drop-in population.

Europe and North America have a big problem. In Europe, 3.5 employed people support a pensioner today, compared with eight employed people supporting a pensioner in 1950, and it is expected that in 2050 only less than two employed people will support a pensioner.

Based on the UN's data [2017b, p. 132], in 2015 the dependency ratio of the world was 73.5 per 100 employed. The factor in the developed countries was 65.1 per 100 employed and expected to rise to 80.1 in 2050. The rise is because of the growing share of elderly people (65 years old and over) and the decline in the share of the younger generation (up to 15 years old) because of low fertility rates.

Unless different changes take place, and if the retirement age is unchanged, these forecasts emphasize that future pensioners will consume a bigger proportion of future production, while on the other hand future production growth is very unpredictable and might be negative if the next generation's workforce (i.e. current children) is smaller than the current workforce and if it is not compensated by other factors. It is already hard for the current generation to support the current pensioners, and without significant reforms it will be impossible to do this.

These entire elements together cause a rise in pension costs as a percentage of GDP. As is shown on Figure 4, in most OECD countries public expenditure on pensions is above 10% of GDP and is expected to be higher in 2050. Even in US where the rate is 4.9, it is expected to grow to 5.9 in 2050. Reform is needed and can be a change in parameters such as the retirement age without changing the system itself or changing the system or a combination of both.

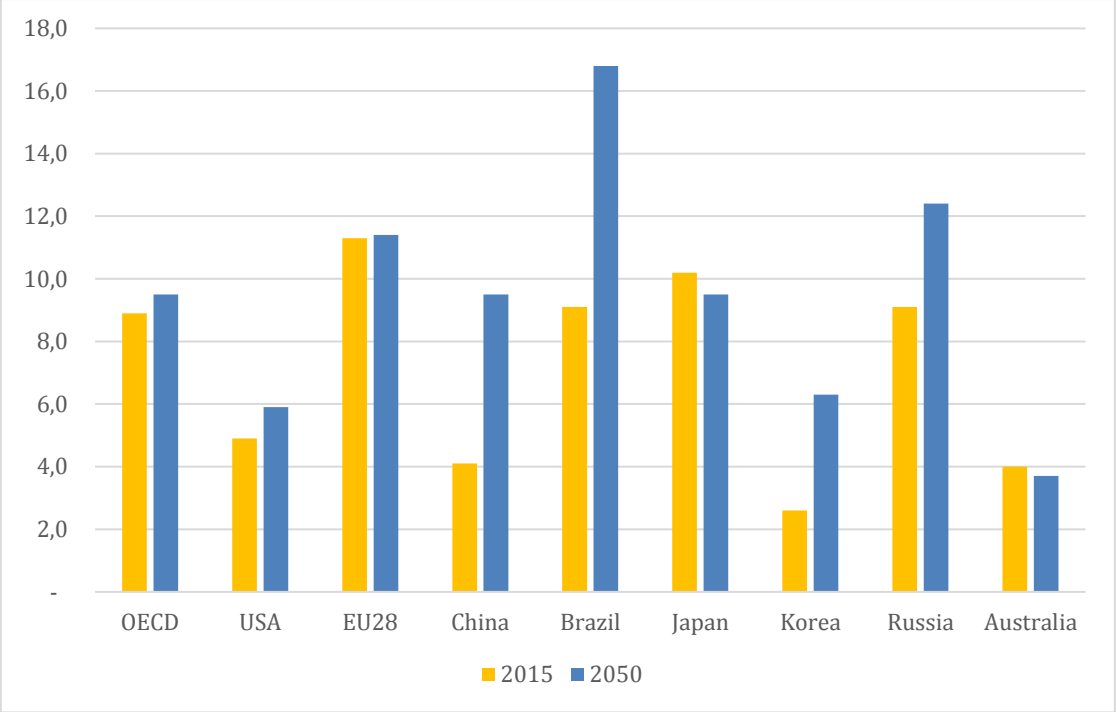


Figure 4. Public Expenditure on Pensions - percentage of GDP 2010 and 2050 in OECD countries

Source : OECD 2017, p. 147.

1.3 Reforms in the pension system

1.3.1 The three pillars model and its implementation

In 1994 the World Bank published its ideas about the reforms which needed to be introduced [World Bank 1994]. The recommended approach was to create a three pillars model:

- First pillar: Public PAYG scheme.
- Second pillar: Mandatory Defined Contribution fully funded pillar, managed by the private sector, to replace the old PAYG system for efficiency and growth." The important point is that it should be fully funded and privately managed" [World Bank 1994, p. 238].
- Third pillar: Voluntarily funded.

Later, the World Bank separated the first pillar to better differentiate between consumption smoothing (first pillar) and poverty reduction/redistribution (zero pillar) [Holzmann 2012, p. 8].

"The advantages of a mandatory defined contribution saving scheme - which requires people to save when they are young so that they will have adequate income when they are old - are that coverage can be broad and benefits are fully portable. Having a rudimentary banking system is a precondition, but a mandatory saving scheme can be part of a national policy to develop new financial institutions, deepen capital markets, mobilize saving, and allocate it to the most productive uses, including uses in the private sector. It also allows employees to increase their returns and insure against political or other country-specific risks through international diversification of investments." [World Bank 1994, p. 244]. This pillar should "emphasize on savings and therefore be non- redistributive and fully funded" [World Bank 1994, p. 244] and redistribution of income should be made only in the first pillar. The model is designed for developed countries that have at least a rudimentary banking system, deepened capital markets and developed government regulation to overcome market failures.

The World Bank's full support of a funded, privately managed pillar caused many years' debate concerning the solution to transferring a public PAYG scheme to a fully funded, privately managed system. The World Bank approach is based on the Anglo-American philosophy of minimum government involvement in the economy and letting the private sector manage business. This approach claims that a fully funded DC pension scheme will increase long term savings and capital accumulation, and hence will increase economic growth. Other important benefits of such a scheme are increasing labor mobility and reducing public spending on pensions [Baroni 2007, p. 26].

A long debate was held on the World Bank's basic assumptions. The assumption that a funded system will raise savings and increase growth was one of the most criticized assumptions. Barr [2013, p. 9-10] doubts that a mandatory funded system will raise savings. If a country has a high savings rate there's no need to raise it, and mandatory savings might reduce voluntary savings. A higher saving rate does not necessarily increase growth since asset prices might go up and a risk of low return on investments might happen when investment products, like urban land, are in shortage, and since high availability of cheap sources drive investor to less productive investments.

Another major issue is the transition cost. A move from pay as you go (PAYG) to a funded system puts a heavy and long burden on current employees who need to finance both the current pensions for the retired generation and their individual accumulations for future pensions. The outcome is higher public spending financed by either higher deficit or debt [Barr 2013, p. 9-10]. In Chile, after seventeen years, spending is still high and in Israel it is expected to remain at a high level for more than fifty years [MOF Accountant General 2017a].

Administrative costs are higher in a funded system, especially for small accounts, and since 1% of management fees reduce a pension by 20% in forty years of accumulation, it is important to pay attention to this [Barr 2013, p. 10].

Until the financial crisis in 2008, the World Bank's three pillars model had great influence on world pension systems. Many countries established a mandatory, privately managed, funded DC scheme, mostly to replace a public PAYG scheme [Holzmann 2012, p. 2]. The successful reform in Chile and other Latin America countries, and the conversion of Eastern and Central Europe to market economies encouraged more countries to join the trend [Holzmann 2012, p. 2]. The number of reforms making countries grew rapidly and thus the spread of the second pillar. The rapid growth, especially in 1994-2008, of the second pillar can be seen clearly in Figure 5.

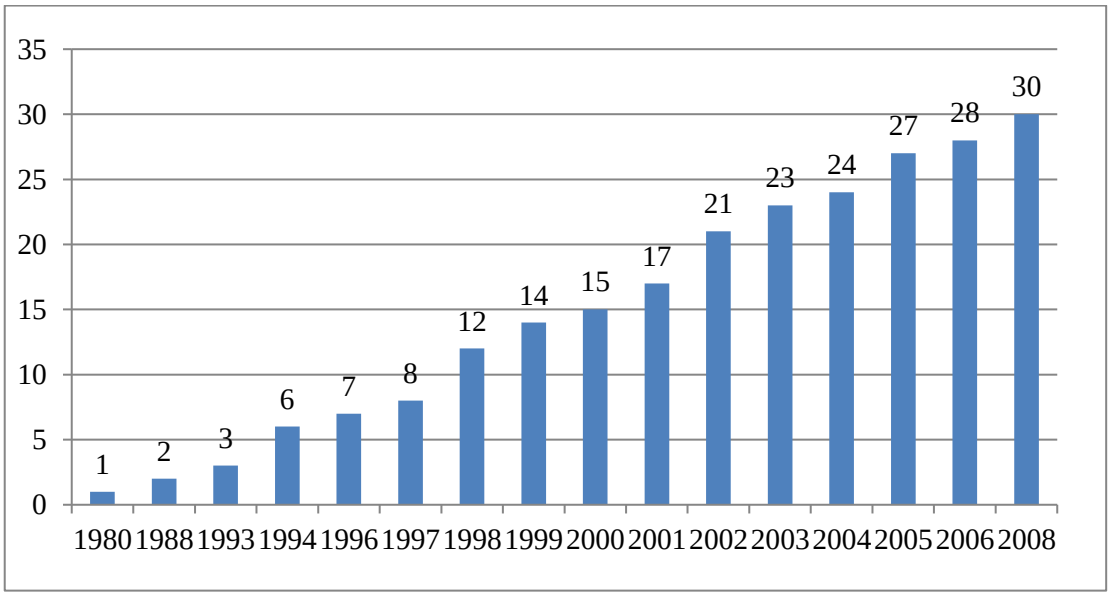


Figure 5. Evolution in the number of countries with a mandated and funded "second pillar" as of 2008

Source: Holzmann 2012, p. 3.

A high coverage of private pension schemes is usually found in countries that implemented mandatory private pension arrangements. "Australia, Chile, Estonia, Finland, Iceland, Israel, Sweden and Switzerland have coverage rates around or above 70% of the working age population. Iceland has the highest coverage rate of any OECD country, at 85.5% of the working age population. In all these countries, private pensions are mandatory: employees must join a pension plan and minimum contribution rates, or benefits are set by the government. The only countries where mandating private pension provision has yet failed to generate such high coverage rates are Mexico, Norway, and Poland" [Antolin et al. 2012 p. 9]. Meanwhile, in 2013-2014, Poland, Hungary, Slovakia and Estonia reconverted most accumulation to PAYG schemes [Whitehouse 2012, p. 41]. This issue will be discussed later.

The low coverage rate in Mexico and Norway is explained by the recent and gradual introduction of the mandatory private pension scheme and is expected to grow in the future [Antolin et al. 2012, p. 10].

An effort is being made to raise the coverage rate of voluntary pension savings. Some countries such as the USA and UK have a long tradition of voluntary savings. Those schemes can be optional in two senses [Whitehouse 2013, p. 32]: an occupational program is where the pension contribution is subject to an agreement between employers and employees. Employers are free to decide whether to join the plan, and once established, the employers can make the plan compulsory to all or part of the employees, and employees can have the choice to join it or not. The second scheme is a personal one, where voluntary pension contributions are made by the contributor to expand the coverage and raise the future annuity.

There is a long debate about how to encourage voluntary pension contributions. The major tools are tax incentives, education and choice architecture (automatic enrollment, investment choices).The OECD found that the link between tax incentives and coverage of voluntary pension plans is weak [Whitehouse 2013, p. 35]. Automatic enrollment was found to be an important tool for increasing the coverage of private pension plans. It was successfully implemented in the USA, UK, Italy and New-Zealand (Kiwi saver program). In Italy the coverage rate increased from 8.5%

in 2006, prior to automatic enrollment, to 13.3% in 2010 after automatic enrollment [Antolin et al. 2012, p. 20-22].

"Private pensions[5] provide about twenty percent of retirement income on average in OECD countries. In most countries, this share has been increasing for at least two decades. The trend is likely to continue, thanks to the introduction of compulsory private pensions and the fact that more private retirement savings are needed to fill the pension gap resulting from lower public benefits in the future" [Whitehouse 2013, p. 35].

1.3.2 Risks in a funded system

Pension systems are exposed to major risks. Some risks are common to all systems and others are unique to each system. All pension systems share the major risks of [Barr and Diamond 2010a, p. 41-42]:

- Economic risk: Macroeconomic risk that affects output, prices or both.
- Demographic risk: Growing life expectancy and declining fertility rates have much influence on pension systems. In a PAYG system, this might reduce benefits promised by government, and in a funded system the accumulation might not be enough for future consumption due to less output that will raise the consumption price.
- Political risk: Political uncertainty influences PAYG and funded systems.

Political risk is considered a typical risk of PAYG systems [Barr 2002, p. 3]. Since PAYG is based on government commitment it is easier for politicians to reduce benefits due to economic problems or fiscal pressure. "The budgetary consequences of the financial crisis render the financing of transition costs for a newly introduced funded pillar more difficult. Cash flow problems, already substantial on their own, are aggravated by debt accounting under the Maastricht treaty, which takes insufficient account of the fact that with the reform, part of the increased explicit debt merely reflects a reduced implicit pension debt. These financing issues have been used by some countries as an excuse to legally (e.g. Argentina) or virtually (e.g. Hungary and Slovakia) end the funded pillar and to divert pension fund assets for public debt reduction

[5] Pension plans that are managed by private providers, based on contributions of the member or/and the employer.

purposes. Other countries have implemented temporary (e.g. Estonia and Latvia) or permanent (e.g. Poland) reductions in the contribution rate to the funded pillar at the benefit of the unfunded pillar to reduce public deficit and debt" [Holzmann 2012, p. 6].

These changes show that the funded system is also exposed to political risk, especially in countries that do not have a tradition of protecting the rights of private property ownership. In countries with a long tradition and culture of protecting private property, such as the USA and UK, as well as in countries that have a special law which protects private savings, such as Israel, the political risk is much smaller in a funded system versus PAYG. The tradition and culture of protecting private property is defined by laws that protect private property and which allow government to nationalize private property only in extreme cases and with proper compensation agreed by courts defending people from the authorities, protecting the owners of private property from invasions on real estate, or from stealing intellectual property.

Demographic risks are changes in fertility or mortality rates or other demographic factors [Barr and Diamond 2010a, p. 43]. In the case of a life time annuity, a funded system also faces these risks. Whether DB or DC, the annuities are paid from the contributors' accumulation, and the annuity depends on life expectancy after retirement. Increasing life expectancy causes imbalance to a funded system, and actions should be taken to balance the system again. This risk difficult to manage for individuals, but can be managed by insurers or government [Barr and Diamond 2010a, p. 44].

On the other hand, funded systems are exposed to additional risks [Barr and Diamond 2010a, p. 41-42]:

- Investment risk: Pension assets are exposed to volatility, and to the risk of bankruptcy of the issuer. This risk is considered one of the most significant risks, especially for people close to retirement. This risk will be discussed in the third chapter
- Management risk: Through incompetence or fraud.
- Longevity risk: the assets should match annuities.
- Annuities market risk: Involves market risk and longevity risk.

Beside those risks, funded systems have the problem of higher administrative costs compared to PAYG systems. These include record keeping costs, investment managing costs, actuarial calculations costs, marketing costs and control costs [Barr and Diamond 2010a, p. 75].

1.3.3 Notional Defined Contribution (NDC)

Another alternative to a DB PAYG scheme and to the solution of a funded DC scheme was developed in Sweden. "An NDC scheme is a defined contribution, pay-as-you-go (PAYG) pension scheme. Contributions are defined in terms of a fixed contribution rate on individual earnings. These contributions are noted on an individual account. As opposed to a financial defined contribution (FDC) scheme, the contributions of participants noted on individual accounts are not 'funded'. More specifically, individual account money is not invested in financial market elements. Compared to an FDC scheme, where individual account money is invested in financial market assets, by definition, the pay-as-you-go individual account DC scheme is a notional DC scheme" [Holzmann and Palmer 2006, p. 18]. The accumulation is converted to annuity on retirement, and the system is actuarial balanced.

The first pillar NDC scheme was introduced and implemented in the 1990s in Sweden and Italy and later was adopted in Poland, Latvia and other countries. Some of the countries also established a second pillar of a funded DC program in addition to the NDC first pillar.

An NDC scheme has some advantages over defined benefits PAYG and FDC (funded DC) [Barr 2011, p. 38] :

- It has a direct relationship between accumulation and annuity (like FDC).
- The notional accumulation is in the contributor's personal account (like FDC).
- The program has no transition cost: contributions are used to pay current pensioners.
- It is centrally administrated, and hence has low administrative costs compared to FDC.
- It avoids much of the risk of FDC individual accounts, since it avoids the volatility of capital markets.
- It is a simple program from the contributor's point of view.

A major difference between NDC and FDC schemes is the rate of return. In an FDC scheme, the accumulation is invested in capital markets: bonds, equities and derivatives and the returns are

per investments made. The accumulation is exposed to volatility and the return might be negative. NDC participants earn an internal rate of return which is determined by economic factors, usually the growth rate of the population added to the productivity rate. In a generic NDC this rate is similar for contributors and pensioners [Holzmann and Palmer, 2006 p. 24].

The actual rate of return is different in the countries that implemented NDC. In Italy, the accounts were indexed to the growth rate of GDP, and although in the long run there is a correlation between the growth of GDP and the rise in wages, the system can be imbalanced if for a large period the GDP grows faster than wages. In Latvia, accounts are indexed by the rate of growth in wages, and in Poland the indexation of notional accounts "was changed to 100 percent of wage-sum growth, but not less than the increase in prices. At the same time, indexation was changed from 1999, ex post, to comply with the new rules." [Chłon-Dominczak et al. 2012, p. 53] This kind of indexation could create imbalance in NDC accounts if inflation is higher than wage growth. In this case, current assets and liabilities will grow faster than the accumulation, and in the future, the liabilities will be higher than the assets. The indexation rule in Poland was changed in 2011 where sub-accounts in the PAYG financed pillar were introduced. They are indexed by another factor than individual accounts in the PAYG financed pillar. Part of the accumulation is indexed per the nominal rate growth of GDP and the rest is indexed per the nominal average growth for the last five years. In any case, the indexation of both funds cannot be negative [Jablonowski and Muller, 2014 p. 18, 24].

1.3.4 Rethinking of privatization and the influence of the 2008 crisis

The spread of pension privatization was criticized by researchers [Baroni 2007, p. 28-31] and by politicians, but under the World Bank and IMF's push to privatization, most countries continued the process. Researchers claimed that the three pillars model's basic assumptions, that a funded system increases savings and hence growth, is not necessarily true [Barr 2002, p. 9-10].

A significant retreat came in 2006 in Chile. Chile was the major leading pension reformer in Latin America and one of the world's leading reformers. Its reforms were mimicked by other countries, such as the establishment of age based default funds in Mexico, Columbia, Lithuania and Israel and were often analyzed by researchers like Barr and Diamond [2010a, p. 150-152],

Antolin and Fuentes [2012], Holzmann [2012], Berstein et al.[2010], Asher and Vasudevan [2008] and others. In 2006, Chile made a major change in its pension policy. "President Michelle Bachelet initiated a major reform of Chile's pioneering private pension system in 2006. In her introduction to the report of the Pension Reform Commission, Bachelet announced that the privatized system had "low coverage (...) very little competition and high commission charges (...) and discriminates against women" [Orenstein 2011, p. 71]. It was an incredible admission for a country whose pension system was held up as an international model. Bachelet's reforms dramatically increased benefits for the poor, women and the lowest sixty per cent of earners by replacing a previous minimum pension with a much more generous solidarity pension [Rofman et al. 2008 p. 36], along with a variety of other changes aimed at reducing costs and increasing equity. "The Bachelet reforms proved highly popular and sent a strong signal worldwide that pension privatization had major drawbacks that needed to be addressed" [Orenstein 2011, p. 71].

Other problems of the funded system were criticized before 2008 but were paid much more attention after the crisis. The financial crisis in 2008 caused a sharp worldwide decline in stock market value which dropped by about 28 trillion USD [Orenstein 2011, p. 69]. The significant sudden drop in pension accumulation revealed the weakness of a funded system based on capital markets, and the need to protect the accumulation of elderly people from a sudden crisis in the financial markets.

The budgetary crisis followed the financial crisis. Many governments of the OECD such as the USA, UK, France, Italy, Spain, Ireland, Switzerland and others, saved the banking system and increased the debt to very high levels of 80% - 105% debt to GDP in most OECD countries, much more than the Maastricht treaty maximum rate of 60% [Lojsch et al. 2011 p. 7]. The budgetary crisis caused fiscal pressure, deep cuts in state services, a sharp decline in assets value, especially in real estate, and a high unemployment rate – all contributing to economic recession. The recovery, especially in Europe 2009-2012, has been very fragile and growth has been low. It has improved only in recent years as follows in Table 1:

Table 1. Growth rate in percentage of GDP 2006-2016 major OECD economies

Region	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
USA	2.7	1.8	-0.3	-2.8	2.5	1.8	2.8	1.7	2.6	2.9	1.5
Euro area	3.3	3.0	0.4	-4.4	2.0	1.7	-0.5	0.2	1.6	1.5	1.8
UK	2.8	3.4	-0.8	-5.2	1.7	1.1	0.1	2.0	3.0	2.3	1.8
Japan	1.7	2.2	-1.0	-5.5	4.7	-0.6	2.0	2.0	1.3	1.1	1.0
Switzerland	3.8	3.8	2.2	-1.9	3.0	1.8	1.0	1.9	2.4	1.2	1.4
Australia	3.8	3.8	1.6	2.1	2.4	3.4	3.7	2.1	2.8	2.4	2.5

Source: OECD data base, 2018.

The central banks of the USA, Europe, UK and Switzerland tried to encourage economic growth by lowering interest rates. The European Central Bank (ECB) lowered the interest rate to 0.25%-0.1%, compared to 3%-4% prior to the crisis, and has bought government bonds to supply liquidity to markets. The American Federal Reserve (FED) lowered the interest rate to 0.25% and from 2008 to October 2014 bought mortgage-based securities (MBS) and treasury bills to an amount of 3,300 billion USD [Federal Reserve 2015]. On January 2015, the ECB reduced the rate for deposits to -0.2% and operated a plan to purchase government bonds to an amount of 60 billion euros per month until September 2016 [ECB 2014, p. 1].

The crisis had a significant impact on pensions. The major influences were:

- The accumulation of pension portfolios dropped 20%-25% in 2008 in OECD countries due to a market fall in the value of securities [Antolin and Stewart 2009, p. 4].
- The concern caused by long time low interest rates and low returns that will lower the accumulation and future annuity. This subject will be discussed in the next paragraph.
- Slowing the turn from a PAYG to a funded system and causing many more people to believe that the assumption that privatization and a funded system is superior to PAYG (as was shown by the World Bank) is not necessarily true.
- The need to deal with the risk in pension portfolios, especially to protect the accumulation of participants who are not far from retirement or retirees.

The low interest rates since the crisis in 2008 continue to be low in 2018. They will probably go up in the future, a process that has started slowly in the USA, but it is not clear if and when interest rates will return to their level before the crisis. Such low interest rates will reduce future

returns, and hence will reduce future accumulation, future annuity and the replacement rate. The PAYG system shares a similar problem, where the return registered in a PAYG scheme depends on economic growth which has been low since the crisis [OECD data base, 2018].

The crisis revealed the fact that privatization created winners and losers. "Typically, women and lower-income earners are the big losers from pension privatization, since they may have significant non-contributory periods, broken employment histories and/or lower levels of savings. High-income earners are usually big winners, since the contributions made to their individual accounts are based on higher earnings throughout relatively uninterrupted work lives (…) The even bigger winners, however, are financial services companies, who earn enormous administrative fees running pension funds. These administrative fees are as much as four to five times those of state social security systems" [Orenstein 2011, p. 68]. It was clearly known that management fees under private management are much higher than those under public management, but the public was told again and again that due to better returns and less political risk it is better under private management rather than state. In 2003-2007, when capital markets produced high returns[6], this seemed to be true, but the crisis revealed the problems of a funded system, and that the winners are always the financial services companies. These winners and losers are not the results of the crisis, but derive from the DC structure itself, and steps to limit management fees by regulation are essential to improving the pension accumulation and replacement rates of contributors, and to reduce future possible support to pensioners by government.

As a result, the World Bank and IMF, which prior to the crisis had demanded privatization (also but not only the pension system), changed their behavior, and in this crisis did not demand it from countries that needed their assistance [Orenstein 2011, p. 72]. Even the great supporters of the funded approach admit that readjustments should be made such as a refocus on basic protection for the vulnerable elderly, a deferred retirement age to deal with population aging, and a realistic view about the capacity of funded schemes to manage risks [Holzmann 2012, p. 6]. The challenge of the funded private pillar is adapting to the new era by limiting administrative and marketing

[6] S&P index went up 67% to December 2007, compared to December 2002.

costs, adopting to much tightened regulation including the adoption of risk methods developed for banks' supervision [Holzmann 2012, p. 12].

The financial problems were used by governments as an excuse to nationalize the pension system fully or partly. Argentina, Hungary and Slovakia ended the funded pillar and diverted the accumulation for public debt reduction. "Other countries have implemented temporary (e.g. Estonia and Latvia) or permanent (e.g. Poland) reductions in the contribution rate to the funded pillar to the benefit of the unfunded pillar to reduce public deficit and debt" [Holzmann 2012, p. 6]. Poland, which was the only EU country with positive GDP growth, made a few reforms from 2011 that also included changing the rules of investment: forbidding private pension funds from investing in government bonds, transferring about 51% of pension funds accumulation to NDC instead of to the funded system, and other reforms that reduced the funded private pension pillar [Zabkowicz 2014, p. 56]. Even in Chile, which is considered the leader in pension reforms and was the first to adopt privately managed age-based default funds, the president sent a new law proposal to the congress in June 2014 to establish a state-owned pension fund [Cervera 2014, p. 1].

On the other hand, the decrease in pension benefits and rise in the retirement age in PAYG schemes accelerated the shift from DB to DC benefits, and caused greater concern regarding the future fulfilment of the pension obligation in PAYG plans [Ebbinghaus and Wiss 2011, p. 25].

The other major problem is handling the risk in pension portfolios. After the crisis, it is clearer than before to experts, decision makers and the public that pension accumulation is exposed to high risk and faces two challenges:

- A crisis that will erase a significant portion of the accumulation. To deal with this problem the risk should be defined as a risk of disaster case and not the regular standard deviation. Methods to deal with such risk were developed before 2008, but were heavily implemented after 2008 for banks [Holzmann 2012, p. 12]. The most common methods to measure risk are Value at Risk (VAR) used by those banks, and the stress test performed by central banks on the banks under their inspection. These methods will be discussed in chapter three.
- The need to reduce the portfolio risk close to retirement is critical. A young contributor still has a long time to recover from crisis, but older people, close to retirement age, cannot

recover. A free market and rational choices by customers do not exist in the complicated pension world, and people tend to stay with the same choice all the way till retirement. The solution is to design a good default option [Barr and Diamond 2010b, p. 9], and a method of reducing the risk automatically according to participant age. Naturally, the portfolio risk after retirement should be low, mostly only fixed income instruments, especially government bonds, to prevent a significant decline in accumulation.

1.4 Age based default investment model of multi-funds

Mutual multi-funds have been known in capital markets for many years. These are funds that are managed under the same manager but have a different investment policy. The popular investment policies are per type of investments (only equities, only fixed income elements), by geographic base or by type of countries (developed countries, emerging markets).

Pension multi-funds exist in the USA. The 401(k)-pension program allows the participant to choose a group of mutual funds as their pension portfolio, and in that way pension multi-funds' portfolios are created.

Age based default funds are multi-funds where the participant is transferred automatically to a more conservative fund according to age. The first pension age based multi-funds system was introduced in Chile in 1997-2002 [Hormazabal 2010, p. 3-4].

Despite the benefits and importance of pension multi-funds that have different investment policies, the idea did not spread to the major economies of the USA, most EU countries, the UK, Japan and China. It was assessed mainly in Latin America and CEE countries.

Table 2 summarizes all the countries that operated a pension multi-funds structure in 2014. From 2010 there was a regression in CEE countries from the funded second pillar, so the multi-funds system exists mainly in Latin America.

The age-based default funds structure includes an automatic transfer from a riskier fund to a more conservative one when the participant reaches the transfer age as shown in Table 2. In Chile, for example, at the age of 35 the participant is transferred for the first time to a less risky fund.

Table 2. Pension age-based default multi-funds system 2015 by country

Country	No. of funds	No. of default funds	First default fund- Most aggressive	Second default fund: less aggressive	Third default fund: median	Fourth default fund: conservative	Fifth default fund: most conservative
Chile	5	3	Under 35	36-55 M 36-50 F	From 56 M From 51 F		
Estonia[1] Latvia[1] Lithuania[1]	3	1 (conservative)					
Mexico	5	5	Under 27	27-36	37-45	46-55	Over 55
Peru	3	1	Over 60				
Slovakia [1]	3	1	Over 47 cannot choose aggressive, over 55 – only conservative fund				
Hungary [2]	3	3	Over 15 years from retirement	5- 15 years from retirement	Less than 5 years from retirement		
Columbia	3	3	Under 57	57-60	Above 60		

1 Reduced the funded pillar contributions for PAYG system temporarily or permanently.

2 Eliminated the funded pillar and nationalized the pension system.

Source: based on AFP 2010, p. 4 ; Gomez 2012, p. 15.

1.4.1 Chile Multi-funds Pension Structure[7]

The first age-based default model was introduced in Chile. In 1997, a single fund C was introduced, in 2000 the conservative fund E was introduced and in 2002 the whole system of five funds was operated with default automatic transfer between three funds per the participants' age as presented in Table 3.

Type A is the most aggressive and E is the most conservative [Hormazabal 2010, p. 3-4]. A participant can choose another fund than the default, but some funds cannot be chosen, basically a risky fund for older participants. These funds are marked in Table 3 as "not available" funds. Young under 35 can choose any fund, including the most aggressive or the most conservative. A retiree can choose the most conservative but cannot choose the most aggressive fund.

[7] Data is collected from researches. No public free data available, and hence part of data on accounts, accumulation and returns could not be updated.

Table 3. Default transfer by age and restriction in Chilean Pension System

Men	35 or less	36 to 55	56 through retirement	Retirees (over 60 males, 55-females)
Women	33 or less	33 to 50	51 and older	Retirees
Fund A	Allowed	Allowed	Not available	Not available
Fund B	Default	Allowed	Allowed	Not available
Fund C	Allowed	Default	Allowed	Allowed
Fund D	Allowed	Allowed	Default	Default
Fund E	Allowed	Allowed	Allowed	Allowed

Source : Berstein et al. 2010, p. 17.

The difference between the funds lies in their investment policy. Fund A is investing a high portion in equities, while fund E has no equities at all. Table 4 presents the minimum and maximum equity portion according to the regulations.

Table 4. Multi-funds and their investment limits in equity as percentage of portfolio

Limit	A Riskiest	B Risky	C Intermediate	D Conservative	E Most conservative
Maximum	80%	60%	40%	20%	5%
Minimum	40%	25%	15%	5%	-

Source: Tapia 2008, p. 15.

Fund A is investing most assets in equities and other risky investments, while the conservative funds invest mainly in fixed income investments such as bonds and deposits. During the first years, the main purpose is to achieve a high return, while in the last years of accumulation and after retirement, the main investment target is not to lose the accumulation even with the cost of a low return. The fixed income group of investments includes investments that guarantee the buyer receives an income yield and an option to receive the invested fund or to sell the property. Examples of investments in this group are bonds, real estate for renting, desalination plants that have long term contracts with government to sell the water and power plants that have long term contracts for selling the electricity. Investment in a domestic market is considered as more secure. Per investment regulations, investments abroad have a limit of 80% in fund A, 60% in fund C and 25% in fund E. The risky funds invest most accumulation in foreign securities, while the

conservative funds invest mostly in local markets. The distribution of investments per group is presented in Figure 6.

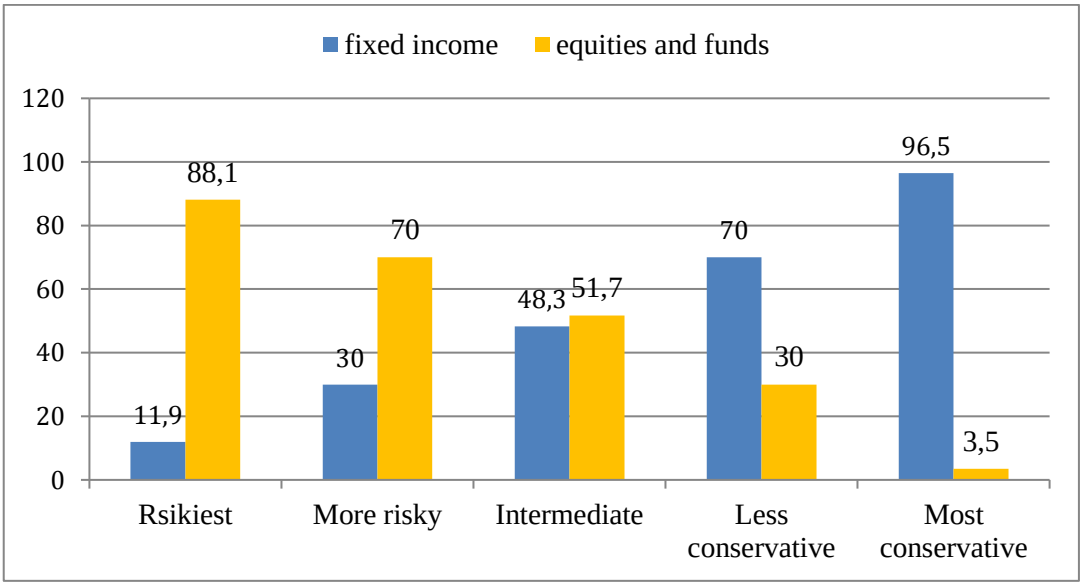


Figure 6. Distribution of investment groups by fund as percentage of total, Chilean Pension System 2014.

Source: Da et al., p. 6.

In 2014, the total assets of all pension funds were 150 billion USD. Out of it fund C the intermediate fund was 40.4% out of accumulation, the two aggressive funds were together were 37.3% out of accumulation, and the two conservative funds were together only 22.3% out of accumulation [Da et al. 2018, p. 6]. As can be seen in Table 5 and as expected most affiliates investing in the risky funds are young. Older people's accumulations are in the conservative and most conservative funds.

Table 5. Proportion of affiliates by type of fund and age group, March 2010 - only the default funds - Chilean multi-fund system

Age	B Risky	C Intermediate	D Conservative
Under 30	48%	2%	1%
31-45	46%	48%	3%
46-55	3%	42%	28%
Over 55	2%	8%	68%

Source: Hormazabel 2010, p. 6.

As expected, the actual results of Chilean pension funds clearly demonstrate the return and risk relationship. The more aggressive the fund, the higher its return and volatility. The return is defined as the pure return on investments before management fees. In 1996-2009 the riskiest fund had an annual average return of 7.7% with standard deviation of 22%, while the conservative fund had 3.5% return and 4.1% standard deviation [Berstein et al. 2010, p. 34]. The real average annual return after adjustment to inflation from September 2002 to May 2014 was 4.1% for the lowest risk fund to 6.9% for the highest risk fund [Cervera 2014, p. 1].

Affiliates can choose the fund, if it is allowed. This means that a young affiliate can choose to be in a conservative fund and a pensioner can choose to be in a riskier fund, but he cannot choose the two most aggressive funds

The automatic transfers between funds, for those who choose the default path, is done over five years, in which 20% of the amount before the transfer is transferred annually. An affiliate who is 35 years old is transferred automatically from fund A to fund B, 20% of accumulation every year till the age of 40. This structure goes on until the age of 55, and then the transfer is from B to C, and so on. Belonging to a fund which is not available according to his age (male, 56 in fund A), the affiliate will be transferred automatically to fund B over 5 years, 20% of the amount before the transfer every year.

The purpose of introducing a multi-funds system was to encourage active participation in the investment process and to increase affiliates' awareness and involvement in their future pension [Asher and Vasudevan 2008, p. 22]. The multi-funds system allows many more investment options that participants can choose. If no active choice is made then participants are transferred to the default path, that is they are allocated to the fund that matches the risk profile of their age. At the same time, the regulation eased the investment restrictions and allowed funds' managers to have more freedom to invest in equities and in foreign markets to diversify the funds' investments. In 2002, 75% of members did not choose any fund and were assigned to the default investment allocation. In 2010, 65% were assigned to default investment allocation [Hormazabal 2012, p. 5]. Despite the improvement, most members are still not active in investment decisions and thus a good default choice is crucial.

To understand the reason for the automatic transfer to a less risky fund according to age, it is necessary to explain the role of a state as a guarantor. Pension funds are managed by six special privately owned, public limited companies (AFPs) that collect the contributions, manage the investments, do the record keeping and maintain the survivors' and disability insurance [Asher and Vasudevan 2008, p. 9]. Every AFP must operate five funds A-E according to the investment regulations. Every AFP must achieve a minimum return based on the average return of the industry in each fund and must have a reserve equal to 1% of the assets value of the fund. In case the return is not achieved, then it is covered by the reserve. If the reserve is not enough to cover the gap, the government must provide compensation. In that case, the AFP is shut down and the assets and participants are transferred to another AFP [Kritzer 2008, p. 71].

The government has another important guarantee for pension contributors called MPG (a minimum pension guarantee), given to participants who contributed at least 240 contributions (20 years), but do not have enough accumulation to ensure a minimum annuity, which is 75% of the minimum salary or 25% of the average salary. The government will complete the annuity to the minimum required [Asher and Vasudevan 2008, p. 14].

A sudden crash in capital markets can mostly harm older participants who do not have enough time to gain back their loss. This can cause a heavy burden on the state budget, if the government must fulfill its obligation to guarantee the funds' returns and the MPG. Forbidding investments in equities and derivatives and investing in less risky elements, such as government bonds, when the participants are pensioners or close to retirement, can reduce the need for government support and the potential fiscal pressure on the state budget. The reason for automatic transfer to a less risky fund per age, and the restriction on elders to invest in risky funds is to prevent high social spending based on the government guarantees to the funds' participants [Hormazabal 2012, p. 4].

The crisis that occurred in 2008 was a good opportunity to test the multi-funds system and the Chilean model, as it should have protected the older affiliates.

The results, presented in Table 6, were as expected, and the pensioners and older affiliates were minimally damaged during the crisis and in an average of three years (2007-2010) most

funds had a positive annual average return. The results are not updated after, since the purpose is to examine the results in 2008 crisis and the recovery after the crisis.

Table 6. Real returns in 2008 crisis and after

	A Riskiest	B Risky	C Intermediate	D Conservative	E Most conservative
November 2007- 23 November 2008	-48.6%	-37.19%	-24.35%	-13.06%	-6.88%
May 2009 - April 2010	35.42%	26.91%	18.08%	11.44%	5.34%
Annual average May 2007 - April 2010	-3.03%	-0.91%	0.68%	2.11%	3.69%

Source: Hormazabel 2010, p. 13-14.

The results clearly prove the efficiency of the model in protecting pension accumulation, especially for pensioners and contributors close to retirement, compared to the option of staying in the same fund without any automatic transfer. If the system was without automatic transfer per age, then probably most participants would have stayed in B or C types of investments even when the age was close to retirement. In that case their portfolios would have dropped 24%-37% in the crisis, while the automatic transfer to D brought a loss of only 13% in the crisis [Hormazabel 2010, p. 3].

The Chilean pension system is facing another reform to come in 2018, as declared by President Pinera. Demonstrations spread in Chile in 2017 demanding reform since the annuity is small and is 40% of the minimum salary. The problems that were found by an expert commission in 2015 were [Santoro 2017, p. 4-5]: low replacement rates of 0.6 for males and 0.45 for females, short contribution periods due to discontinuing periods of work, narrow coverage of the system, aging is expected to accelerate in next decades; high administrative costs and low contribution rates of only 10%. In august 2016, the government announced that the steps to be taken will include [Santoro 2017, p. 4-5]: raising the contribution rates by 5%, which will be added to personal accounts or to a new PAYG plan and reducing administrative costs. According to newspapers, the government will also open the market to increase competition between pension providers.

The reforms are not supposed to eliminate the DC second pillar plans and the age-based default model is expected to continue.

1.4.2 Assessing the Chilean model in other countries

The model was adopted in other countries, adapted to the specific country. It was adopted in Latin America and in a few CEE countries. Since the funded multi-funds system was suspended in CEE countries, temporarily or permanently, only Latin American multi-funds system is described.

Mexico

The system was introduced in 2004 with two funds and in 2008 expanded to five funds: SB1 – SB5. SB1 is the most conservative with no equities at all, and SB5 the most aggressive with a maximum of 30% in equities. The other funds contain 15%, 20% and 25% of equities. It is clearly that the system is more conservative, and regulations allow investments in high ranked fixed income elements.

Participants who do not choose a specific fund are transferred automatically per their age as follows in Table 7.

Table 7. Age Dependent Default Options in the Mexican multi-funds

	X<=26	26>X<37	37<X<45	45<X<=55	X>55
SB5	Default	Not Allowed	Not Allowed	Not Allowed	Not Allowed
SB4		Default	Not Allowed	Not Allowed	Not Allowed
SB3			Default	Not Allowed	Not Allowed
SB2				Default	Not Allowed
SB1					Default

source : Impavido et al. 2009, p. 95.

Peru

The multi-funds system was introduced in 2003 and modified in 2005 [Tapia 2008, p. 35]. It contains three funds: first fund is the most conservative with a maximum 10% exposure to equities. Second fund has maximum 45% equities and third fund has maximum 80% equities.

Participants older than 60 years old must choose the conservative fund. Younger participants may choose a fund, and if not they are assigned to fund two [Impavido et al. 2009, p. 95-96].

Columbia

The system contains three funds: conservative (maximum 20% risky assets), moderate (maximum 45% risky assets) and aggressive (maximum 70% risky assets). A participant aged 22-57 can choose the fund and can change it every 6 months. On reaching the age of 57 (male), the participant will be automatically transferred to a less risky investment, 20% every year. At the age of fifty seven, 20% is invested in a conservative fund, at fifty eight - 40% and so on up to 100% in a conservative fund at the age of sixty one [Gomez 2012, p. 15].

2. Pension system in Israel

2.1 The pension system until 1986 prior to reforms

The system until 1986 was based on three pillars [Ahdut and Spivak 2010]:

- First pillar: National Insurance old age pension.
- Second pillar: partly obligatory pension (mainly for union members and managers).
- Third pillar: voluntary pension.

The first pillar was obligatory and comprehensive, and included all employees. The second pillar was mandatory only for organized employees according to agreements between the unions and the employers but has not been obligatory for the self-employed. The retirement age regarding benefits from first and second pillars was 65 for men and 60 for women.

Until 2008 there was no obligatory pension regulation, and the system was based on agreements between the unions and employers. Hence, it is clear that pension obligations were based on agreements and covered only employees who were union members under the agreement. They were employed mostly in the public sector or in the private sector where the employees were organized. Before 2008, it was considered that "40% of employees did not have any pension plan and 57% of all the elderly population did not receive any pension annuity except for the National Insurance Institute pensions" [Gavious et al. 2009, p, 6]. The third pillar has been voluntary, and mostly aimed at savings for lump-sum withdrawal.

The pension elements of the second and third pillars were: budget pension (pay as you go plan) for government employees including defense forces and police, pension funds for the rest of the public sector and most organized employees in the private sector (mostly members of labor unions), provident funds that were partly used for pensions, mostly by the self-employed. They were mainly used for 15 years' savings with tax benefits and not for pension and executive insurance plans, mostly purchased by managers and the self-employed. Table 8 summarizes the pension elements prior to the reforms:

Table 8. Pension elements in Israel until 1986

	First pillar	Second pillar		Third pillar
	Obligatory	Partly obligatory		Voluntary
Type of pension	National Insurance Institute old age pension	PAYG budget pension for government employees	Pension funds Provident funds Life insurance with saving component	Provident funds Life insurance with savings
Contribution	Employee: 3.85% up to 60% of average salary and 13.75% above it. Employer 15.2%	None	Employee and employer 18.33%, 17.5%. depends on element.	Per contributor
Investments	5.5% linked to CPI[1] earmarked government bonds[2] No investments in capital markets.	Budget. No accumulation. No investments in capital markets.	4%-6.2% linked to the CPI earmarked government bonds[2]. No investments in capital markets.	4%-6.2% linked to the CPI earmarked government bonds[2]. No investments in capital markets

[1]CPI: Consumer Price Index that includes prices of all products and services consumed by individuals and families.

[2]These have been bonds issued by the government of Israel: pension funds, provident funds, life insurance contracts and to the National Institute and have not been traded in the stock exchange, and bear a fixed yield linked to the CPI.

Source: Spivak 2013, p. 22-23.

Contributions of employees to the National Institute included not only old age pensions but also disability insurance and other social insurances. The rates were 3.85% for incomes up to 60% of the average salary, and 13.75% for incomes higher than 60% of the average salary. In addition, the employer had to contribute 15.2%. The low rates for low earners have been due to social reasons, easing the burden for them.

Contributions to life insurance and provident funds have been 18.33%: 5% employee, 13.33% employer. For participants in pension funds, the contributions were 17.5% to the pension funds: 5.5% employee, 12% employer and another 2.33% from the employer that was deposited in a provident fund.

The participants contribute on a monthly basis to pension funds during the contribution period and get an annuity for their life time on reaching the age of retirement. The fund also provides insurances for survivors and for disability. The participant's rights have been set per the fund regulations and can be changed.

Provident funds are based on monthly or lump-sum contributions. The accumulation could be a lump-sum withdrawn or any other way per participant choice, until the participant's balance was zero. The provident funds for employees can be withdrawn only at retirement age, while provident funds for non-employees can be withdrawn after 15 years. No additional insurance exists for survivors or disability.

Life insurance with a saving component is a contract between the participant and an insurance company that has been based on monthly or lump-sum contributions (mostly monthly). The participant gets an annuity (in an annuity type of contract) or a lump-sum withdrawal (in the capital type of contract). The contract also includes insurances for survivors and disability. The participant's rights have been guaranteed by the contract and cannot be changed by one side. The most common type of life insurance with a saving component has been the Executive Insurance Plan.

There were certain arrangements for early retirement. Defense forces had an agreement of early retirement at the age of 45. Government employees, in a limited number every year, could withdraw early. Most of them were low productivity employees with high seniority and close to official retirement. Private employers offered early retirement to lay off old expensive employees and hire new cheap employees or not to hire anyone instead and save costs when the business became weak [Beor 2001].

2.1.1 First Pillar: The National Insurance Institute Old Age Pension

The basic pillar of the pension system has been the National Insurance Institute old age pension. Israeli residents have been eligible for an old-age pension when they reach the age specified in the National Insurance Law [National Insurance Institute 2015a], if they were insured for the period required by the law and if insurance contributions were duly made for them. The time required has been at least 60 months during the 10 years prior to retirement or 144 months in total [National Insurance Institute 2015a].

The contribution has been 3.85% (0.40% employee, 3.45% employer) from incomes up to 60% of the average salary[8] and 13.75% (7% employee, 6.75% employer) from incomes above it. The

[8] In 2015 the 60% is about 1550 USD.

self-employed contribute 6.72% and 11.23% respectively. The unemployed must also pay 4.61% from 15% of the average salary, which was about 18 USD per month in 2014. These rates have been not only for pensions, but also cover the other social insurances of disability, accident injuries, burial expenses, unemployment and other insurances [National Insurance Institute 2015b]. In 2014, pension payments were about 23.5 billion NIS (about 6.7 billion USD) and were 39% of all social payments of the National Insurance Institute[9], [2015c, p. 20]

The basic old age pension has been 16% of the average salary, and it is earned after a minimum 10 years of accumulation, and the maximum has been 24% of the average salary as described in Figure 7:

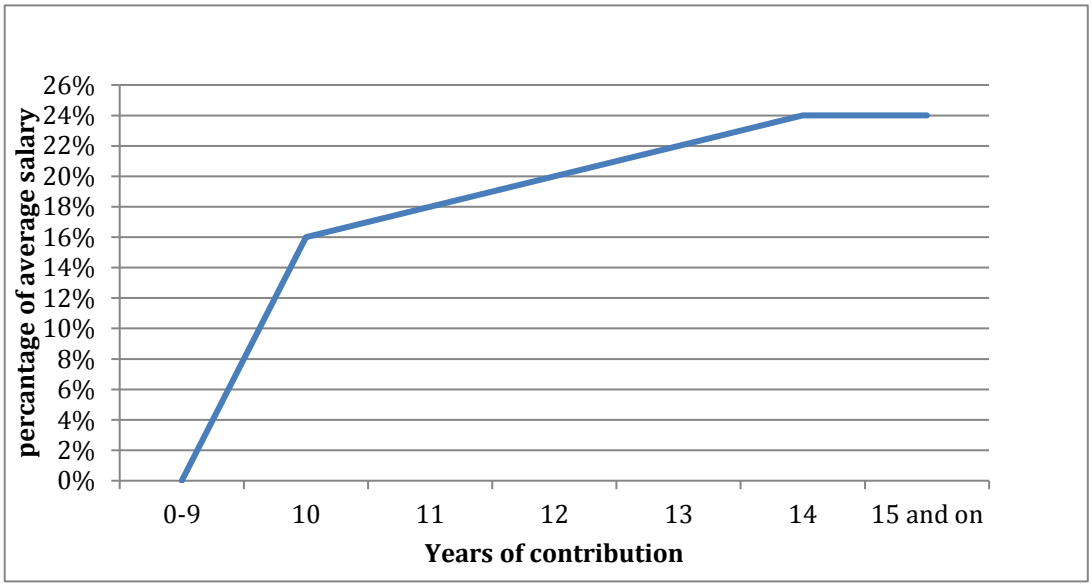


Figure 7. National Institute old age pension as percentage of average salary per contribution phase

Source: National Insurance Institute 2015b.

The old age pension was at that time linked to the average income and was updated once a year per the change in the salary of the employee's rank. Most updates were due to changes in the consumer price index (CPI) and the rest was due to the real growth in salaries beyond indexation [Ahdut and Spivak 2010, p. 20]. The old age pension has been a flat rate, regardless of the contribution made during the period of employment.

[9] Social payments such as benefits in the case of disability, birth and unemployment.

2.1.2 Second pillar instrument: budget pension - PAYG

The budget pension for government employees has always been part of the state budget, financed by state tax income and appears as a liability in the state balance.

Government employees had a very generous pension plan. There was no contribution at all, and the pension was 2% per year of employment from the last or average of the last three years of insured salary up to 70% after 35 years of employment. It is a classic PAYG DB plan.

The salary in Israel was divided between the insured salary for pensions, which was about 70% the total salary, and the unpensionable salary[10], which was about 30% of the total salary. The contribution for pensions was based only on the insured part of the salary. On retirement, after 35 years of employment, the employee had a 70% (2% per year) pension from the insured salary. This means that the annuity has been 49% (70% of 70%) of the total salary, which has been a replacement rate of 49% before tax and before adding the National Insurance old age pension.

The pension also included extra insurances. These insurances have been part of a comprehensive pension plan and have been in addition to insurances run by the National Insurance Institute[11]:

The plan provided also survivors' insurance. In the case of death, the widow/widower will get 60% of the pension and in addition 20% for each child under 21 years of age up to a limit of 100% from the basic pension. If the employee passed away during the employment period, the pension for the widow and children was calculated as if he had been employed until retirement age.

As for a disability insurance: in the case of disability the employee will get an immediate pension calculated as if he had been employed until retirement age.

Annuity has been taxed as follows. Thirty five percent of the annuity is free of tax and the rest is added to all other income sources (if they exist) and is taxed per salary tax rates.

[10] Mostly reimbursement of expenses, payments for extra hours. Pension contributions are not taken from this parts of the salary.

[11] A PAYG pension is a comprehensive pension that includes survivors and disability (temporary or permanent) insurance.

2.1.3 Second pillar instrument: pension funds

Seven pension funds were established in years 1942-1958 as part of the umbrella labor union that represented most of labor unions in Israel ("Histadrut"); a part of them were specifically open to one sector of members, such as the construction employees' pension fund, and a part of them to all sectors. The biggest funds were: Mivtahim, Makefet and Kagam. In 2002, the assets of those three funds were 83% of the total assets of the seven funds under the Histadrut [Avnimelech 2003, p. 33].

The Histadut has been the umbrella organization of all labor unions in Israel, which according to socialist ideology was not only a union but also the owner of large businesses and services. The Histadrut was established in 1920 and also had the political role of the Jewish government in the times of British rule in Israel, and the senior officials later became the first Israeli ministers, including secretary general David Ben Gurion who was Israel's first Prime Minister. The Histadrut built itself up as the employee's "home", so members of the Histadrut had all their needs taken care of by the organization: health care, housing, industry, insurance, banking and pensions. The Histadrut controlled the biggest bank (Bank Hapoalim), the biggest health care organization (Kupat Holim), the biggest insurance company (Hasne) and most pension funds.

The basic contribution for pension funds was 17.5%: 6% employee, 6.5% employer for pensions and 6% employer for severance pay. The other 2.33% of severance pay was deposited in provident funds.

The Ministry of Finance (MOF) and the Histadrut reached an agreement in 1957 that the funds will invest 46% of the assets in special earmarked government bonds which was actually a loan to the government. UP to 46% of the accumulation could be invested in Histadrut businesses such as construction or industry plants in equity and in loans, and 8% was for free use. This agreement enabled the investment of pension accumulation in industry and construction, supplied financing to those businesses and helped to achieve high growth in the economy. In 1981, the Minister of Finance decided to raise investment in government earmarked bonds to 93% of the funds' assets, meaning that almost all the accumulation was to be transferred to the government as a loan. The money was used to help cover the huge budget deficit in the years after the 1973 war and high oil price in the 1970s, and not like in the 1950s and 1960s, when the money that the government

borrowed was used to invest in infrastructure, industry and construction to develop the economy [Avnimelech 2003, p. 62-72]. The special bonds bear interest of 5.57% linked to the CPI [Avnimelech 2003, p. 47].

The funds were pure DB. On retirement age (65 male, 60 female), the pension was calculated in the same way described for a PAYG system and included the same insurances and additional insurance of loss of working capacity. The pension was linked to the average salary [Ahdut and Spivak 2010, p. 93].

Contributors get a good incentive to contribute through the tax system. For every contribution, up to the limit according to tax laws, income tax is reduced by 35% of the contribution, so actually the government participates in 35% of the contribution. This calculation is done every month. On retirement, 35% of the pension is free of tax, the rest taxed per salary tax rates.

2.1.4 Second pillar instrument: provident funds

Provident funds include a few different kinds [MOF- Director of Capital Markets and Insurance 2012, p. 51-52]: provident funds for a special non-pension purpose such as study or sickness; central and individual severance pay provident funds for employers or the self-employed to deposit contributions covering severance liability and provident funds for pension purposes.

Employers deposit 8.33% every month from the salary either to the personal pension account of the employee or to the employer’s account in the central provident fund. This is the employers' financial source to pay severance pay to employees who were laid off.

Provident funds for pensions are pure DC savings accounts without any insurance, where the accumulation can be withdrawn if there is balance in the account and stops when the accumulation balance is zero. They include two types: for employees and for the self-employed. The differences are in the contribution phase and the way it can be withdrawn. In benefit provident funds for employees, the contribution rates are: employee 5% for the pension and employer 5% for the pension. The 8.33% contribution for severance pay is deposited in central or individual provident funds for severance pay. It can be withdrawn as a monthly payment, a lump sum or any way the participant chooses, and can be withdrawn only at retirement age.

The self-employed can contribute any amount they wish to the benefit provident funds for the self-employed but are entitled to tax benefits only up to the maximum allowed contribution.[12] The accumulation can be withdrawn free of tax after 15 years from the opening day of the account in any way the participants decide. These accounts were used for self-employed pensions and as pure saving accounts and were very popular among parents or grandparents seeking to save money for children or grandchildren.

More than 60% of the assets matured (reached the time they can be withdrawn free of tax) [MOF - Director of Capital Markets and Insurance 1998a, p. 6]. In 2014 the provident funds for a lump-sum withdrawal were 90% of the accumulation in provident funds for pension purposes [MOF - Director of Capital Markets and Insurance 2014a, p. 20].

The banks controlled the provident funds market with their spread and efficient distribution channels that reached almost everyone. In 1998 the banks managed 84% of provident funds' assets [MOF- Director of Capital Markets and Insurance 1998a, p. 7], most of it in three major banks.

Investments were solely in earmarked government bonds bearing an interest rate of 5.4% linked to the CPI [Balas 1996, p. 9]

Contributors got a good incentive to contribute through the tax system. For each contribution, up to the limit per tax laws, income tax was reduced by 25% of the contribution, so actually the government was participating in 25% of the contribution. At the age of 60 the accumulation, at least, can be withdrawn free of tax. The participant can choose how to withdraw it: a fully lump sum withdrawal, few partial lump-sum withdrawals, a monthly or quarterly payment or any combination of periodic payments with lump sum withdrawals and all as long as there is balance left in the account.

2.1.5 Second pillar instrument: executive life insurance

Executive life insurance plans were popular among managers of companies, the self-employed and for the new young generation of high-tech employees that did not want to be part of the DB system and guarantee others but preferred their own account with a personal contract with an

[12] 16% out of 17,400 NIS (about 5,000 USD) per month in 2014.

insurance company. The account had an advantage over DC provident funds and the policy had built in insurances for risks, disability, loss of working capacity and other insurances.

Sales were based on the distribution channel of agents that sold comprehensive life insurance among other insurance products (cars, houses, businesses, liabilities and other insurance products).

The premium fees were divided between insurances for death, disability, survivors and management fees, all together totaling 28% of the premium and savings account for pensions, which was 72% of the premium. The contribution rate was 20.83%: 5% employee for the pension, 5% employer for the pension, 8.33% employer for severance pay and 2.5% employer for disability to work. The accumulation could be withdrawn at retirement or at the end of the insurance period. The savings account was personal and managed by the insurance company as part of the company's assets and liabilities.

Basically, two types of executive insurance plans were common: insurance combined with a DC savings account for a pension, lump sum withdrawal or monthly payment at retirement or at the end of the insurance period. The second type was insurance combined with savings for a pension annuity at retirement per an unchanged life expectancy factor that was valid on contract signing day. The annuity was linked to the CPI.

The terms of the contract with the insurance company cannot be changed by a government decision or a one-sided decision. The terms agreed remain till the end period of the contract. That is the reason why any reform made by the authorities in the pension field did not affect existing policies but only new ones. So, not unlike provident funds, executive insurance plans have been built with many layers according to the starting time of contract [MOF, Director of Capital Markets and Insurance 1998b].

The accumulation was invested in earmarked government bonds linked to the CPI with the interest rate from 4% to 6.2%[13]. No investments were made in capital markets [Shatz 2015]. Contributors had a good incentive to contribute through the tax system. For each contribution, up to the limit per tax laws, income tax was reduced by 25% of the contribution, so the

[13] Depends on the year of issue.

government was participating in 25% of the contribution. At the age of 60 the accumulation, at least, can be withdrawn in the way the participant chooses free of tax.

2.1.6 Third Pillar: voluntary savings for retirement

Voluntary savings have been for provident funds and executive life insurance. The same account could be used for accumulation for the pension purposes of the self-employed or for long term savings according to participant's decision after completing the minimum saving period. The only information that is known today is how much out of the accumulation is liquid, but there is no way of knowing if it was used for pension purposes or another purpose. This was true for all contributions made prior to 1 January 2008. From that day on contributions can be withdrawn only at retirement age.

Voluntary executive life insurance has been very similar to the executive life insurance of the second pillar. The difference has been that contributions have been made solely by the contributor, without any participation of the employer, and it is charged via the bank account and not from the salary. The contribution has not been a percentage of salary, as in the second pillar, but an amount agreed between the contributors and the insurance company. Another difference was that executive life insurance matures mostly after 20-25 years and not necessarily at retirement age.

Provident funds were basically a savings account where one could deposit an unlimited amount, but tax benefits were given only in the form of a deposit until the limit. This account could be withdrawn after 15 years in a lump sum or a monthly payment (not life time annuity) or combination of them. These funds were very popular for parents/grandparents seeking to save money for children or grandchildren for any purpose including housing, academic degrees and other purposes. All accumulation of provident funds and life insurance were invested in earmarked government bonds with the same interest rates as explained in the second pillar. Employees could get tax benefits only on the part of the salary that was not insured for a pension by the employer. There could be a lump-sum withdrawal free of tax when the policy matured. The contribution of the self-employed earned tax benefits per tax law, basically like employees' benefits, and the accumulation was tax free on withdrawal at retirement age.

2.2 Reforms in the pension system 1986-2017

Since 1986 many reforms have been made in the pension funded system. The direction of the major reforms has reduced the involvement of government, transferring from a defined benefits system to a defined contribution system, investment in capital markets and privatization [Ahdut and Spivak 2010, p. 9]. A summary of the reforms is presented in Table 9:

Table 9. The reforms in the Israeli pension field in 1986-2017 by time scale

Year	Reform
1986	No more earmarked government bonds for provident funds. Accumulation will be invested in capital markets.
1989	No more earmarked government bonds for new life insurance contracts. Accumulation will be invested in capital markets.
1995	▪ DB pension funds are shut down for new participants. ▪ New participants are transferred to new, actuarial balanced pension funds. This means that participants will bear future risks. The new funds are subsidiaries of the old funds. ▪ 70% of accumulation will be invested in earmarked government bonds instead of 93%. Rest of accumulation will be invested in capital markets.
2001	No more PAYG plan for new government employees. They are transferred to funded system.
2002	Old age pension of the National Institute will be linked to the CPI instead of average salary.
2003-2004	▪ Nationalization of the old pension funds. ▪ Program to save old pension funds from bankruptcy: cutting participants rights by about 25%, raising the contribution rate from 17.5% up to 20.5% and government aid of 83 billion INS [about 24 billion USD] in years to come. ▪ Actuarial balance mechanism will be operated in old pension funds. This means that the participants will bear future risks. ▪ Introduction of management fees in PAYG pensions from current employees and pensioners and management fees in old pension funds from pensioners. ▪ Reducing earmarked government bonds in old and new pension funds to 30%. The rest of accumulation is invested in capital markets. ▪ Raising maximum allowed management fees in pension funds and executive life insurance. ▪ Rising retirement age to 67 males, 64 females [62 for female immediately and gradually to 64].
2004-2006	▪ New pension funds (and their managing companies) were sold by government to insurance companies. ▪ Provident funds (and their managing companies) were sold by banks to insurance companies and investment houses. ▪ Transparent life insurance contracts. The components of contribution are presented clearly: savings, insurances and management fees. Savings component of contribution rose to 90% instead of 72%.
2008	▪ Mandatory funded pension for all employees who didn't have pension arrangement.

	▪ The contribution in all elements is for annuity purposes. Lump-sum withdrawal is allowed only at retirement, and only the part of accumulation that is above an amount that guarantees minimum monthly annuity of 3,850NIS [about 1,100USD].
2012	Start to implement the Chilean model for retirees.
2013-2014	▪ Reduction of maximum allowed management fees from 2% to 1.05% in provident funds and executive life insurance. ▪ Banned guaranteed life expectancy factor for joiners under 55 years old in executive life insurance. This means that protection from risk of aging is not given any more to young participants. ▪ New order regarding the implementation of age-based default investment funds (the Chilean model). To be implemented from 2016.
2016	▪ Full implementation of the age-based default model. ▪ New provident funds with lump-sum withdrawal. ▪ New default pension funds with much lower management fees.
2017	▪ Change allocation of earmarked bonds: more to pensioners, none to young contributors.

Source: Manor 2015, p. 95

2.2.1 Reforms in pay as you go pensions

National Insurance Institute old age pension

The major change was in 2002-2004. It was decided that the pensions would be linked to the Consumer Price Index (CPI) instead of the average income. Since the average income increases on average above inflation it means the erosion of the pension, which in 2002-2009 was 3.5% [Ahdut and Spivak 2010, p. 19]. In 2005-2008, according to coalition agreements, the pension was raised correcting most erosion. Today the same mechanism of linking pensions to the CPI is still valid.

Government employees PAYG

Per an agreement from 1999 between the government and the Histadrut, new government employees will contribute to the fund and the PAYG arrangement will be stopped for new employees. The agreement was implemented in 2001. In 2004, it was also implemented for defense forces that enjoy a pension from the age of 45. In 2010, it was decided that the retirement age for defense forces will rise to 50-55.

The agreement between the MOF and defense forces ensures that despite the change, PAYG payments will go on. Per the agreement that was signed in 2008, retroactively from 2004, the state will pay the pensioner the gap between the age of retirement (45-55) and the retirement age for the rest of the population (67 M, 64 F). The monthly pension will be calculated as if the

employee had been employed till retirement age. This means that the PAYG plan will partly go on only for the defense forces.

At the end of 2016 the full state obligation for PAYG plans, after a reduction to 2% management fees, is 660 billion NIS (188 billion USD), and annual pension payments are about 19.6 billion NIS (5.6 billion USD) and will increase in the following years. Most obligation [275 billion NIS (78 billion USD) is for defense forces [MOF Accountant General, 2017a p. 322]. The obligation does not include future obligations for employees who are still employed and will gain benefits in the years to come. Including those benefits, the obligation will rise to 747 billion NIS (213 billion USD), which is 61% of GDP [MOF Accountant General, 2017a p. 321]. The annual payments of the obligation are presented in Figure 8.

The annual expense is about 4%-5% of the 2016 budget for years 2016-2062 (20-38 billion NIS) where the growth rate is 3% annually, and after that it is reduced to about 2%-3% (10-20 billion NIS) of the budget in 2049-2071 [MOF Accountant General 2017a, p. 336]. It is a heavy burden for this and the next generation to carry both the PAYG payments and the funding of future pensions.

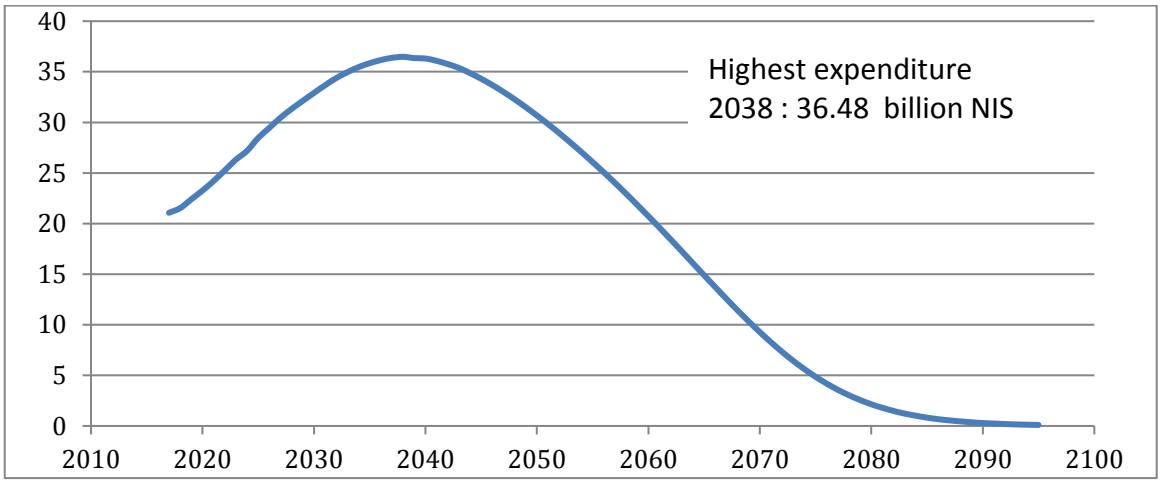


Figure 8. Budget pension payments PAYG distribution by time in million NIS

Source : MOF Accountant General 2017a, p.336.

In 2003, as part of the reforms that took place in the pension field, the MOF charged all state employees who are insured in PAYG pensions to pay 2% management fees. Until then, state

employees had contributed nothing to pensions and it was the first time that state employees had to contribute to pensions [Yosef and Spivak 2008, p. 16].

2.2.2 Mandatory pension for all employees since 2008

The mandatory pension went into effect on 1 January 2008 via an agreement between the Histadrut (Labor Union) and the manufacturers' association that was expended to all employees by the Minister of Economics. In 2016, the parties agreed to raise the rates of the previous agreement, and it was again expanded by the Minister of Economics. According to the new agreement, the obligatory contribution rates changed gradually, as it is shown in Table 10.

Table 10. Mandatory pension contribution rates

Year	Total	Employee for pension	Employer for pension	Employer for severance pay
2008	2.5%	0.83%	0.83%	0.84%
2009	5%	1.66%	1.66%	1.68%
2010	7.5%	2.5%	2.5%	2.5%
2011	10%	3.33%	3.33%	3.34%
2012	12.5%	4.16%	4.16%	4.18%
2013	15%	5%	5%	5%
2014-June 2016	17.5%	5.5%	6%	6%
July 2016-Dec 2016	18.0%	5.75%	6.25%	6%
2017	18.5%	6.0%	6.5%	6%

Source: MOE 2016.

As explained before, the contribution rate in provident funds, new pension funds and life insurance is 18.33% and can be raised voluntarily up to 20.5% by the voluntary contribution of the employee (7% instead of 5%), so in 2014 the rates of mandatory pensions are very close to the rates of participants that had pension arrangements before, and from 2017 the rates are even higher. Per the expansion order, if the contribution rates in the previous agreement are lower than the order, the rates will be matched to the new order. This means that contribution rates for pensions, not including mandatory pensions, are 6% employee for the pension, 6.5% employer for the pension and 8.33% employer for severance pay, totaling 20.83%.

The mandatory pension has been operated only for employees who were not covered by any pension arrangements before. A large proportion of this population are low income employees, and people who are employed in temporary jobs such as security guards, housekeepers, waiters etc. [Gavius, Spivak and Yosef 2009, p. 8]. The aim was to create a funded pension that would enable them to have a certain pension on retirement besides the old age pension.

Each party of the agreement had its own interests. According to Beor [2007] the Histadrut wanted to achieve social achievement for employees, especially before the elections to the Histadrut. Another reason was to prevent a new government law proposal regarding the mandatory pension that was on the way to the Parliament, since the Histadrut objects to legislative interference in labor affairs and prefers negotiation. The Manufacturers' Association leadership has been mostly made up of big-medium companies that already had pension plans. They were also against legislative interference in labor affairs and wanted to prevent the government law proposal. The government, especially the MOF, was pushing the agreement and the expansion. Also, this was for reasons of public image, but mostly to prevent poverty in retirement age for the uncovered population. The MOF suspected that the state budget will have to carry the burden of assisting those pensioners that had no pension arrangement and tried to minimize the future problem [Tamkin and Noyman 2011]. Brender [2011, p. 30] suggested that "a significant segment of the target group views mandatory pensions as a burden and tries to avoid it". This is mostly because they earn law salaries, need it today and have no tax benefits at all. Small employers tend not to comply whereas big organized companies usually join the arrangement. His research examined only the first year of the mandatory pension.

The mandatory pension is only for employees and not for the self-employed. For them it is still voluntary.

According to the MOF's Director of capital markets, the mandatory pension has succeeded. It is suggested that 1.3 million employees joined the reform under the expansion order as is seen in Table 11 and they constitute 33% of the total members of new pension funds at the end of 2013.

Table 11. Registration for new pension funds - mandatory pension 2008-2013 (number of participants)

Year	Number of registrations
2008	309,713
2009	224,855
2010	186,582
2011	177,374
2012	190,517
2013	187,586
Total	**1,273,669**

Source: MOF Director of capital markets 2013, p. 71.

At the end of 2013 the labor force in Israel was 3.48 million people [CBS 2015a]. Out of the labor force, around 40%, which is about 1.39 million employees, were not covered by any pension plan [Gavious et al. 2009, p. 6]. This means that the coverage of the mandatory pension was high since it covered 1.27 million employees. Most new joiners are paid very low salaries as can be seen in Table 12.

Table 12. Registration for Mandatory Pension by salary level 2011-2013

Salary level [NIS]	2011		2012		2013	
	Registration contributing at agreement rates[14]	Percentage of total registration at the same salary level	Registration contributing at agreement rates	Percentage of total registration at the same salary level	Registration contributing at agreement rates	Percentage of total registration at the same salary level
Up to 2,000	69,782	44.76%	72,788	42.58%	62,632	37.82%
2,001 – 4,000	60,352	53.84%	60,957	52.37%	56,375	46.63%
4,001-6,000	31,608	39.37%	38,251	40.62%	43,790	42.18%
6,001 – 8,000	8,804	28.14%	10,935	26.51%	14,379	34.71%
Above 8,001	6,828	19.18%	7,586	17.11%	10,392	23.41%
Total	**177,374**	**42.72%**	**190,517**	**40.79%**	**187,586**	**39.39%**

Source: MOF Director of capital markets 2012, p. 68, MOF Director of capital markets 2013a, p. 72.

[14] The rates in 2011 are 10% and in 2012 12.5%. In 2014 and later it will be 17.5%.

The average salary in 2013 was about 9,200 NIS per month, so all the joiners earn less than the average salary and 70% of them earn less than half the average salary.

In new research [Bank of Israel 2015b, p. 42], it was found out that the rise in salaries among employees who joined the obligatory pension was slowing down by 4%-4.5% in 2012, which is similar to the employer contribution of 4.16%. The conclusion is that the new pension contribution was actually fully financed by the employees.

2.2.3 Reforms for all pension instruments

One of the most significant reforms was that pension providers would invest the accumulation in capital markets instead of earmarked government bonds. In 1987, the MOF stopped issuing new bonds for the provident funds, in 1989 for life insurance and in 1995 and 2003 the portion of those bonds was reduced to 30% for pension funds and the return dropped to 4.8% [Ahdut and Spivak, 2010, p. 33]. The reason was to reduce government involvement and establish a DC system based on investments in capital markets. This reform had a few major impacts [MOF-Director of Capital Markets and Insurance 2004, p. 4]:

- It developed the capital market which grew significantly and made Israel's capital market much like international capital markets and included building new facilities to invest in capital markets.
- It created competition between pension providers, based on return and risk.
- It made pension portfolios more volatile according to the nature of capital markets.

Another major step to assure future pensions was made in 2008 by the third Amendment to the Provident Funds Law [Kneset 2008]. According to the new rule, all contributions are meant only for annuity purposes. The basic idea of the reform is that pension contribution should be for pension annuity and not for lump-sum withdrawal. When we take into consideration that the old age pension is not sufficient, there is a need to have a minimal annuity to ensure a minimum income on retirement [Ahdut and Spivak 2010, p. 34-35].

The minimal pension was set to 3,850 NIS (1070 USD) which is equal to savings of 800,000 NIS (222,000 USD) all linked to CPI. In June 2014, the amounts were 4,418 NIS (1,260 USD) which was about 49% of the average salary. That, in addition to the old age pension, constituted a minimum

pension of 6,000 NIS (about 1,600 USD) in 2014 [Ahdut and Spivak 2010, p. 36]. Only the rest of the savings above the limit can be withdrawn as a lump-sum. Of course, it can instead be a part of the annuity and make the replacement rate higher.

To calculate the total amount, on retirement all accumulations should be transferred to one paying fund. "Paying fund" is a fund that can pay an annuity and can manage risk on an actuarial base. Pension funds and insurance companies are paying funds, but provident funds and lump-sum life insurance are not and are specialized only in managing portfolios.

The new reform is for contributions dated 1 January 2008 and from that day on. Contributions prior to 2008 will be managed according to the previous rules.

To create higher pension annuities the authorities took action to reduce the high management fees. Prior to all the reforms, management fees were low in pension funds and provident funds and high in life insurance. The reforms of 2003-2005 caused the management fees to rise because the buyers paid the banks and the government large amounts for the management companies of pension funds and provident funds and needed to raise the management fees to make a quick return on their investment [Shwartz 2010, p. 10], but later they went down because of public pressure and competition.

The change in management fees of pension funds was as follows: contribution fees were 6% of the contribution for operation and managing and an additional 2% of contribution for the actuarial reserve. The reform in pension funds of 2003 allowed pension funds to charge a contribution fee of 6% and an additional management fee of 0.5% of accumulation. That was a significant rise in management fees that will reduce the future pension by about 12% [Yosef and Spivak 2008, p. 19]. The reason was to help cover the deficit of old pension funds, and to assist the state in selling the new pension funds to insurance companies. Competition caused pension funds to reduce the fees, and in 2014 most contributors, not including the mandatory pension, pay 0.2%-0.25% of accumulation and an additional contribution fee of 2%-3%. In 2014, a small pension fund, Meitav-Dash, reduced the fees to 1.49% of contribution +0.19% on accumulation for all joiners [Meitav- Dash 2015].

In 2016 the government made one more important step to reduce management fees. It chose two small pension funds which offered very low management fees to be the default pension

funds for new employees in case the employee did not actively choose any pension fund. If the employer has an agreement with any pension fund, he must prove that the agreement was after a process of competition where the main factor was management fees. The fees of the default funds are: Meitav-Dash: 0.01% managing fees +1.31% contribution fees and Helman-Aldobi: 0.001% managing fees +1.49% contribution fees.

As a result, for the default pension funds, the competition became stronger and management fees have been reduced. The new funds are still small, but they are growing because of new joiners' contributions.

Management fees for life insurance have changed a few times. Until 2004 they were 0.6% of accumulation +15% of real profit above 3.5%. In 2004, it was changed to 1% of accumulation +6% contribution fee, to reduce the incentive to take risks by the fund manager, and in the last legislation to 1.05% of accumulation and in addition a 4% contribution fee, due to public pressure to reduce management fees

Management fees for provident funds were changed too**.** Under the banks' management, provident funds charged 0.6% of accumulation. After being purchased by insurance companies and investment houses in 2005, management fees grew by about 58% to cover the purchase price]. The new legislation limits the management fees to 1.05% of accumulation and in addition a 4% contribution fee, due to public pressure to reduce management fees. Since contribution to provident funds has been very poor since 2008, the actual maximum fees are 1.05%, and large accumulations enjoy much lower management fees. [Shwartz 2010, p. 8].

2.2.4 Reforms in pension funds

The first significant reform was the establishment of new pension funds in 1995. At that time, the pension funds, owned by Histadrut had an actuary deficit. The MOF and Histadrut, the umbrella labor union, signed an agreement to deal with the problem. The agreement included a few major steps [Spivak and Yosef 2008, p. 10]: establishing new actuary balanced funds, while the old funds were not built with such demand. In the case of deficits over 5%, the members' rights to balance the funds were reduced [Ahdut and Spivak 2010, p. 32]. The old funds were closed to new members, but old members could go on contributing; the government was to cover

the deficit in old funds, and the new funds would invest only 70% of the assets in earmarked government bonds instead of 93%. The interest rate was reduced from 5.57% to 5.05%. The rest was invested in capital markets and had an MOF guaranty of minimum 3.5%.

It was the first step from DB to DC funds. The new funds had a fixed minimum return of 4.58% calculated as 70% of 5.05% in addition to 30% of 3.5%. Every contribution was translated at the deposit point to a pension unit per age and insurance coverage. The future pension was set as the sum of all units.

From 1995 to 2003, the new funds were a mix of a DB system and a DC system [Ahdut and Spivak 2010, p. 31]. There was no investment risk, because of the minimum return guarantee, which is a DB characteristic. Life expectancy risk was divided between the member and the fund, which is a mix of DB and DC systems. Since every contribution was divided according to the pension factor immediately, and not at retirement, then the fund carried the longevity risk of each specific contribution. On the other hand, if the pension factor increased over time, then the upcoming contributions would be converted to an annuity based on the new factor, and this was the contributors' risk.

The agreement left all funds, old and new, under the Histadrut. The government at that time was a coalition of the Labor Party, which also ruled the Histadrut.

The light reform of 1995 was just the prolog to the big reform of 2003-2004. This reform nationalized old pension funds, to find a solution to the deficit of funds. In 2003, the actuary deficit of old pension funds was 130 billion NIS [37 billion USD] which was about 24% of GDP in 2003, according to the MOF or only 20 billion NIS [5.7 billion USD], 3.7% of GDP according to Histadrut [Peleg 2006, p. 101]. The difference is due to the level of the discount interest rate. It is possible that the high deficit published by the MOF was exaggerated to justify actions taken later. In mid-2004 it was published that the deficit before the reform was only 90 billion NIS, 16.6% of GDP [Yosef and Spivak 2008, p. 15]. The deficit existed because the 1995 government's support was not implemented and also due to a delay in raising the retirement age.

Contrary to the 1995 agreement, the 2003 reforms were forced upon the union in legislation [Yosef and Spivak 2008, p. 11]. In 23 July 2003 special managers on behalf of MOF took control of

the funds and laid off the existing managers, and all the managing companies of the funds were nationalized.

The reforms included a few major steps.

- Raising the retirement age gradually to 67 for males. For females, it was 62 in the first stage and in 2016 it was to be updated to 64, unless a different decision was made in 2016.
- Raising the contribution rate from 17.5% to 20.5% in old pension funds, 1.5% employer and 1.5% employee. In the other elements, a choice for the employee was given to raise the contribution rate from 5% to 7% and for the employer to raise the contribution from 5% to 7.5% and get tax benefits [Yosef and Spivak 2008, p 14].
- Changing the pension calculation to a mix of 35 years of high salaries (average system) and the last three years' salary, instead of last three years system. Usually, older employees earn more than the young because of promotion and seniority. In that case, the last three years' salaries are higher than the average of all years. The new annuity was reduced compared to the calculation prior to the reform.
- Old and new funds would invest only 30% in earmarked government bonds. The interest rate was reduced to 4.8%.
- Pensioners had to pay a new management fee of 1.75% from the annuity.
- The increase in insured salaries was limited to 2% annually. Sums above this could be deposited in provident funds.
- Changes were made to the management fees of pension funds (discussed earlier).
- The government was obliged to a level of support of 83 billion NIS (23 billion USD) during the following years from 2003 till the end of old pension funds to close the deficit of old funds and to guarantee a minimum return every year [Ahdut and Spivak 2010, p. 32].
- All discounts and benefits to large groups were banned. All members were to have the same rights.

The significance of the reform was to transfer the system of new funds to a full DC and reduce the future pension by 20%-30%. [Yosef and Spivak 2008, p. 11-16]. Also, the old pension funds were not pure DB any more since an actuarial balance mechanism was created, and participants

had to bear from that point on the risk of any future deficit, besides the deficit that the government agreed to cover [Yosef and Spivak 2008, p. 12].

After being nationalized, the old pension funds had the same ownership and control as the new pension funds. The government sold the new pension funds to insurance companies and used the received money to reduce the old funds' deficit [Ahdut and Spivak 2010, p. 34].

In 2017, the MOF decided to change the allocation of earmarked government bonds to the members of pension funds [MOF 2017]. Until 2018, 30% of each portfolio of pension fund members was invested in government earmarked bonds linked to the CPI and bore a 4.86% interest rate. From 2018, and gradually up to 2024, instead the allocation will be changed in such a way that pensioners will get 60%, from the age of 50 until retirement 30% and until the age of 50 they will not have any earmarked bonds. The reason for the change is to allow the pensioners' portfolios, which cannot be invested in equities, to reach the target return of 3.74%. The yield to maturity of traded government bonds is 0.1%-2%, and it is impossible to reach the target return when 70% of the portfolio is invested in low return and risk instruments. Without the change, annuities should have been cut by 25%, or the current contributors should have paid the gap.

2.2.5 Reforms in provident funds

Banks were in control of most financial services before 2004. They controlled the credit market, the deposits and saving accounts, the brokerage activity and management of clients' assets. This created a conflict of interest as the banks could be the major underwriters of an IPO of a company that owes a great debt to the same banks, and as the major institutions participating in the IPO are those of the same banks.

The huge control of banks and the high concentration of the system were the major reasons that Bahar committee[15] recommended in 2004 that banks should be forced to sell provident funds and mutual funds and could now be objective advisors [Bahar Committee Report 2004].

During 2004-2006, the funds were sold to insurance companies and to investment houses. The outcome of those changes was that the provident funds market was diversified, but the pension

[15] Dr. Yossi Bahar was at that time the General Manager of the MOF. The committee was established by the MOF to recommend a reform to the high concentration in the financial sector, held mainly by the three large banks.

market that included all the segments (provident funds, pension funds and executive life insurance) became a very concentrated market and was dominated by five insurance companies [Ahdut and Spivak 2010, p. 4].

Because of the sale, management fees rose significantly [Shwartz,2010, p. 8]. The buyers had to make quick returns to cover the amount paid to the banks. Therefore, management fees rose 58% after the sale [Shwartz 2010, p. 8].

Until 1987 most provident fund investments were in earmarked government bonds with a fixed return linked to the CPI. In 1987 the MOF decided to stop issuing new bonds for the funds, and the funds had to invest in securities traded in the stock exchange in Israel and the rest of the world. These securities are exposed to volatility since their value is based on market price. This step was very significant for provident funds, and it turned them into a volatile investment. As can be seen in Table 13, in the first years the funds had mostly positive returns (except 1990) and even high returns with high volatility. The real change was in 1994 with negative high returns, especially in the first half of the year. The real effect was in 1996 with high levels of withdrawals that threatened to collapse the system and the banks who owned the funds. Only the interference of the central bank stopped the process.

Table 13. Provident Funds Returns 1988-1998

Year: 19XX	88	89	90	91	92	93	94	95	96	97	98
Return %	5.2	12.0	-2.1	4.0	11.3	2.7	-8.3	3.0	1.1	7.1	1.4

Source: MOF, Director of Capital Markets, Insurance 1998a, p. 32.

Since then the funds' cash flow has been negative, and the returns are volatile, contrary to the fixed return before the reforms. In 1988 the funds had a market share of about 40% from the funded pension market, and it declined in 2014 to 16.8% (181.7 million NIS out of 1,079 million NIS) [MOF- Director of Capital Markets and Insurance 2014a, p. 20].

Another significant reform for provident funds that took place in 2008 was the elimination of the option of a 15 years savings account and that all contributions were only for annuity purposes. Since provident funds do not have extra insurance nor a guaranteed life expectancy factor, no

competitive advantage was left for them. Contributions to provident funds in 2014 were only 4.4 billion NIS (1.25 billion USD) compared to 25 billion NIS (7.1 billion USD) to pension funds [MOF- Director of Capital Markets and Insurance 2014a, p. 20]. The contributions for lump-sum provident funds were reduced sharply. In 2006 the contribution to this type of funds was 32.8% of total contributions to provident funds and 13.7% of the total accumulation for pensions, including pension funds and life insurance [MOF- Director of Capital Markets and Insurance 2007, p. 25]. In 2012, it was 20.9% and 6.3% respectively [MOF Director of Capital Markets and Insurance 2012, p. 53]. Investment houses[16] do not have such efficient distribution channels as banks, so it is much harder for them to market the funds. Unions and employers turn most accumulation to pension funds and only a small fraction to provident funds.

In 2016 the MOF returned the possibility of a lump-sum withdrawal to provident funds. The order regarding new provident funds [Kneset 2016] allows deposits to provident funds to a maximum amount of 70,000 NIS annually that can be withdrawn as a lump-sum any time with 25% capital gains tax. Where the accumulation will be withdrawn as a lump-sum but will be joined to a pension accumulation it will be free of tax. This order is supposed to help provident funds to receive contributions, mainly for saving purposes and less for pension purposes.

2.2.6 Reforms in life insurance programs

The important reform in 2004 regarding transparent life insurance programs, was aimed at ensuring more transparency. The old policies included 70% of contributions to saving accounts and 30% reimbursement of expenses, insurance and management fees, with the customer not being informed how much of the contribution was for savings and how much for insurance or fees. The new policies are based on 90% savings and the insurance company must give a detailed breakdown of the contribution per the components: savings, survivors insurance, disability insurance, management fees and other insurances that sometimes were added to the contract.

In 2013 the regulator banned the guaranteed life expectancy factor for joiners under 55 years old. The product of executive life insurance for pension purposes is expensive compared to pension funds due to higher management fees and more expensive insurance of disability and

[16] Companies that manage investments in capital markets, brokerage activity and underwriting.

survivors. Pension fund costs for those insurances is smaller due to a big collective insurance fund, which covers millions of participants, while the insurance of a transparent life insurance policy is private. On the other hand, transparent life insurance had a significant competitive advantage: It guaranteed a constant life expectancy factor, meaning it ensures protection from a rise in life expectancy.

New policies from 2013 will guarantee the existing life expectancy factor only to customers aged 55 years old and above, an action that eliminated the most important competitive advantage of transparent life insurance. This action was taken to insure the companies' stability. Until 2008 most people holding pension contracts used to withdraw it lump sum and didn't use the policy for annuity. From 2008 it had to be used first for annuity, and the advantage of the unchanged factor that protected against rises in life expectancy, and paid by insurance companies, came to the public's knowledge. Since the insurance companies had borne the risk, the regulator suspected that it might erode the insurance companies' capital in the future and decided to ban selling new policies to customers under the age of 55 [MOF 2012]. Since the beginning of 2013 the new policies lost their major competitive advantage and the sales declined sharply. The largest life insurance company "Migdal" reported a decline in sales of 32% in 2013 compared to 2012 [Migdal 2014, p. 2-12].

2.3 Age Based Default Investment Strategy in Israel

2.3.1 Multi-funds in Israel

A multi-funds system has existed in Israel since the 1990s. Most pension funds, provident funds and life insurance, offer few funds to the investor. The difference between the funds of the same provider is in their investment policy. The popular funds are with high percentage of equities, no equities at all, investment in state bonds, investment in companies' bonds and combinations of investments. In 2014 most funds were multi-funds, but this was only a small portion of the investments, and 93% of accumulation is in the "General Fund", a fund that has no specific investment specialty, such as equities funds, bonds funds or foreign investments funds. The General Fund assets are invested mostly in bonds (about 70%) and the rest 30% is invested in

equities. This fund is the default fund if no other fund is chosen specifically. The distribution of assets is shown in Table 14.

Table 14. Pension accumulation in Israel, April 2014

	Assets Apr 2014 million NIS	General Funds Assets million NIS	Percentage of Assets in General Fund
New Pension Funds	167,141	151,474	91%
Old Pension Funds	355,015	355,015	100%
Provident Funds	185,083	154,208	83%
Life Insurance [17]	195,819	180,511	92%
Total million NIS	**903,059**	**841,208**	**93%**
Total million USD	**258,017**	**240,345**	**93%**

Source: Author calculations on the base of MOF websites pensyanet,gemelnet and bituahnet.

The General Fund was always the preferred fund for the public and was offered by sales agents. The main reason for that is most people do not have financial knowledge, the pension issue is complicated, and it is convenient for most people to choose a default fund offered to them. This behavior is the same as was found in other countries [Barr and Diamond 2010b, p. 8-9].

The opening of funds based on age changed the behavior. In November 2017, according to MOF websites, still 86% of pension funds' accumulation is invested in the general funds, but only 67% of executive life insurance accumulation is invested in the general funds. Most of the other accumulation is invested more conservatively with more bonds and less equities. It seems that in the future the portion of accumulation that is invested based on age will be higher.

2.3.2 Implementing Age Based Default Investment Strategy

After the 2008 crisis, attempts were made to find a solution to the high risk of elder participants' pension portfolios. In July 2010, the Director of the Capital Market, Insurance and Savings in the MOF published a draft of regulation to pension providers [MOF- Director of Capital Markets and Insurance 2010] with the following orders.

[17] Excluding policies with earmarked bonds.

- Each provider's board of directors had to adopt the model of an age-based default investment strategy and bring it to public knowledge not later than the end of 2010. The model was to be updated every two years.
- A few default funds had to be part of the scheme:
  - a fund for retirees (over 67 males and 62 female), that would not be invested in equities at all; this is the lowest risk fund.
  - a fund for contributors who were 60 years old through retirement that would hold equities in small portion; this was a low risk fund;
  - a fund for contributors aged 55-60 that would hold equities in higher portion; this was a medium risk fund.
  - a fund for contributors aged 55 and less that would hold equities in higher portion; this was the riskiest fund.

Pension providers would automatically attribute contributors to the fund per their age. The accumulation of retirees would be attributed no later than the end of 2012. The accumulation and contributions of those aged 60 through retirement would be attributed no later than the end of 2014. The accumulation and contributions of those aged 55-60 would be attributed no later than the end of 2015 and those of contributors aged 55 and less would be attributed no later than the end of 2016.

By 1 January 2015 only pension funds and two small provident funds had implemented the new regulation. The accumulation for 30 April 2014 in those funds was 7.7 billion NIS (2.2 billion USD), about 1% of all pension assets. The pensioners' fund had no investment in equities.

The draft was subject to approval of the Sub-Committee for Pensions of the Finance Committee of Parliament to become new legislation. The approval was not given, and arguments regarding the way to implement the draft caused a delay of a few years. The delay was mainly for three reasons: pension providers asked for a delay to prepare the implementations; the director of capital markets and insurance in the MOF was replaced twice during those years and this caused delays in negotiations and implementation; the chairman of the parliament sub-committee demanded guarantees for the protection of the elderly, mainly via earmarked bonds, and postponed the meetings of the committee regarding this subject.

In November 2014, the MOF Director of Insurance and Capital Markets published a new draft [2014b] ordering pension providers to establish three more funds besides the retirees' fund per the participants' age. The funds would have a different investment policy and would invest a lower portion of equities when the age was higher. The funds would be: a fund for participants aged 50 and younger, a fund for participants aged 50-60 and a fund for participants aged 60 – retirement age.

New participants would be automatically transferred from the more aggressive fund to the next less aggressive one according to their age. The fund would inform the participants on the change, and only where the participant actively objected to the change would it not be made. The draft was to be implemented no later than 1 January 2016. The draft turned into an order on February 2015 [MOF- Director of Capital Markets and Insurance 2015a]. From 1 January 2016, it was fully implemented by all pension providers. Most of them choose to turn from the General Fund to the new fund until the age of 50 and reduce the equity rate in the more conservative funds.

The order is only obligatory for new participants. Current participants can join the new funds and to be transferred automatically to a less risky fund according to their age, but they can also change nothing and not join the new model.

The MOF did not define the investment policy for the pension providers and left it to their decision. No research was made to determine what the preferred investment strategies are. There can be many strategies such as: linear monthly, linear every five years, high portion of equities till 40 and only then reduce the portion of equities and so on. Since reducing risk involves reducing the return, it is necessary to find the "efficient frontier" in terms of return versus risk. The theoretical issues of simulations and strategies will be discussed in chapter 3.

In 2018, the facts are that most accumulation is still invested in the General Fund or in an investment policy like the one of the General Fund. The model is fully implemented only for new joiners or contributors that change pension provider, but not for other current contributors, which constitute most of the accumulation. However, in years to come, most of the accumulation will be gradually managed according to the age-based default model.

The investment policy of the new funds was based on the investment policy of the general fund. Most pension providers set an equity level of 35% for the general fund, to be the equity level of the 50-60 years old fund, while the younger fund has a slightly higher portion of equities, and around or less than 40% for most funds. Others adopted an equity level of 35% for the young fund and reduced the portion for other funds. In 2018 the investment policy of pension funds is still more conservative, even for young contributors.

2.3.3 Alternatives to the age-based default model

In recent years, other opinions have come to public knowledge regarding the way to protect the elderly's accumulation. This included senior staff in the MOF and in the Parliament Labor Committee, in the academic world and among journalists and experts. A group of researchers wrote a working paper for a convention in 2012 [Amstradamsky 2012a] and suggested 2 options. Issue earmarked bonds only to older participants and for all elements or issue earmarked bonds only to the basic salary of 3,000 NIS (about a third of the average salary). The previous director of insurance and capital markets, close to his term end, suggested an exchange [Arlozorov 2012]: The earmarked government bonds that are now 30% of pension funds' portfolios for all participants in pension funds, and are not issued to provident funds and life insurance, will be issued only to those older than 60 years old with multi-funds of all the elements and will be a high proportion of their portfolios, while younger contributors will not have earmarked government bonds at all.

The forum [2015] suggested issuing more earmarked government bonds to all the elements, and to manage the accumulation in a special government fund that will invest in equities, bonds and in special infrastructure projects. The government will assure a 4.5% return linked to the CPI. According to this suggestion, the government will function as an insurer that promises a fixed return and will bear the volatility.

Another suggestion was to issue more earmarked bonds only to pension funds: 30% to participants who are 60 years old and younger, 50% for participants aged 60-retirement age and 70% for retirees.

Prof. Spivak[18] suggested [Forum 2015, p. 3] issuing earmarked bonds only to participants with a low salary and that all those participants' accumulations will be covered in earmarked bonds, while the other participants' accumulations will be invested fully in capital markets. This suggestion is from the social point of view and does not deal with the portfolio risk of the elderly.

The forum and the financial companies which manage provident funds and transparent life insurance appealed in 2014 to the Supreme Court, demanding the state issue earmarked bonds to all elements and not only to pension funds [Forum 2015]. The appeal was rejected by the Supreme Court in December 2017. The MOF objects to issuing more earmarked bonds, mainly because of the budget burden of the interest subsidy. This subject will be discussed later.

2.4 Pension system in Israel 2018

2.4.1 Concentration and competitiveness

After the reforms, in 2018 new pension funds are the most important segment of a market that is growing fast. The funds have many competitive advantages: paying annuity, cheap survivors and disability insurances, 30% earmarked government bonds and reduced management fees. Their only disadvantage, for those who prefer a personal account, is that the balance of the participant account is influenced by the actuarial balance that derives from all the fund's members.

The aggregate impact of turning the contribution to the annuity purpose and the elimination of earmarked bonds was very significant for provident funds. They lost their competitive advantage and suffer from negative cash flow. Another problem they have is how to manage the portfolio. Since the funds' portfolio is a mix of accumulation for pensions and accumulation as a saving account that can be withdrawn immediately, it makes it hard to manage the funds' portfolio. The short-term savings accounts are very sensitive to volatility, while long term pension accounts will bear more risk to gain extra return. The change in 2016 was supposed to increase the deposits in provident funds, but most deposits will not be for pensions but for lump-sum withdrawals.

[18] Prof. in Ben Gurion University, previous deputy to the Governor of Israel Bank, one of the leading researchers in the pension field in Israel.

Until 2013, the reforms improved the competitive advantage of life insurance programs, mainly due to the weakness of provident funds. However, the reform in 2013 eliminated the major advantage of life insurance programs. Since 2013 new sales have dropped by around 30% [Migdal Insurance Company, p. 2-12]. The product is expensive and not so attractive with management fees of 1.05% compared to 0.5% for pension funds, and higher fees than pension funds for survivors and disability insurance.

In 2018 the Israeli pension system is highly concentrated, especially in Pension Funds and Life Insurance. In February 2018, 76% of the total assets of pension funds, provident funds and executive life insurance were managed by the five big insurance companies as shown in Table 15.

Table 15. Managers of pension assets February 2018

Company	**Market share**
Clal	14%
Feonix	11%
Harel	15%
Menora Mivtahim	17%
Migdal	20%
Total market	**823 billion NIS**
Percentage five companies from market	**76%**

Source: Author calculations on the base of MOF websites pensyanet,gemelnet and bituahnet.

Looking ahead to the future market, pension funds will remain the growing segment of the pension market, while provident funds will be mainly for savings and not for pension purposes. It seems that the concentrated market today can be less concentrated in the future, the new default pension funds will create more competition for the big five companies and are supposed to gain new participants and accumulation in the near future, but the process will need the assistance of the regulator, otherwise it will fail.

Another important issue regarding competition is that the reforms made the provident funds irrelevant for new contributions and life insurance irrelevant for new joiners. The main advantage of provident funds was the option of a lump-sum withdrawal after 15 years, and of life insurance: the guaranteed life expectancy factor. Those advantages no longer exist, and therefore for new contributors the pension funds have much higher advantages than the other elements. The

mandatory pension contribution is also accumulated only in pension funds. So, we can find a system where only one segment will grow rapidly while the others will not grow or shrink, and this segment is becoming more concentrated.

Transfers are possible from provident funds to new pension funds and vice versa, provident funds to provident funds and new pension funds to new pension funds. Transfers are not permitted to old pension funds.

To create more competition, the MOF should give provident funds and life insurance policies some competitive advantage. If the MOF fails to do so, those elements will become irrelevant and the only competition will remain between the pension funds themselves. The step taken in 2016 strengthens provident funds, but more as a saving instrument and not as a pension instrument.

2.4.2 Investment regulations

After many changes, the system today is deregulated, as most restrictions were removed, and the existing ones mainly limit the exposure to one company or group of companies.

According to the investment regulations [Kneset 2012, p. 7-12] pension providers can invest in the Israeli market or in international markets. They can also invest part of the portfolio in real estate, projects for toll roads, transportation, electrical power plants and so on. They must keep a few percent's cash for regular and unexpected payments. The regulations limit the pension providers only in the following ways.

- Pension funds should invest 30% of the assets in earmarked bonds.
- The investments, including holding securities, loans or deposits, in a single company will not exceed 5% of the assets, and the investments in a group of companies under the same ownership will not exceed 10% of the assets.
- The portion of the five most invested stocks out of the equity portfolio will not exceed 20%.
- The investment in a company share is limited to 20% of the company's capital and an institution body cannot hold control in a company.
- Direct investment in real estate, not including shares of traded real estate companies, will not exceed 15% of the assets; the fund can invest in none fixed income real estate till a maximum 2.5% of the assets and it cannot invest in one real estate asset more than 3% of assets.

- Investments in non-government bonds are limited to 25% of each series of bonds.
- Investment in options is limited to 5% of the assets.
- It is forbidden to invest in the securities of a company where its employees' accumulation is more than 10% of the institutional body's assets. If the company is traded, the limit is 5% of each security of the company.
- Old pension funds can invest in non-government bonds, loans or deposits only if they are ranked.

2.4.3 Return, accumulation and coverage

Pension providers produced high returns (before management fees) in the last decade. The average annual return of 2003-2014 was 8%-9.34% compared to average annual inflation of 1.85%, meaning a real return of 6%-7.4%. The highest return in 2003-2014 was for executive life insurance, but in the last six years pension funds have had better returns as shown in Table 16.

Table 16. Average annual return 2005-2017 in pension elements

	Average annual return 2003-2014	Average annual return 2011-2016	Annual return 2017
New pension funds	7.0%	5.73%	8.10%
Provident funds	7.1%	4.37%	6.83%
Executives life	8.2%	5.17%	7.90%

Source: MOF- Director of Capital Markets and Insurance 2017, p. 27; MOF websites.

In Israel, the interest rate of the central bank that was 9.3% in January 2003, dropped to 1.77% in January 2009 and was lowered in March 2015 to 0.1% [Bank of Israel 2015a]. The high profits to bonds holders will not go on in the future. The decline in interest rates has caused the bonds' yield to maturity to decline as well and created a rise in the bonds' prices and capital gains. These gains have produced high returns for pension elements that have invested most of the portfolio in bonds.

The yield to maturity of bonds is now very low, and this means that the future return will be low as well, and even negative when the interest rates go up. In 2015, the returns were only between 2.1% and 3.3%, much lower than in previous years.

The government's policy is to increase financial education and knowledge of financial affairs including pensions [MOF- Director of Capital Markets and Insurance 2012]. In addition, the mandatory pension added many people to the pension system and the numbers are growing all the time. In 2014 -2016 the contribution grew as follows in Table 17.

Table 17. Contribution to pension elements in billion NIS

	2013	**2014**	2015	**2016**
Old pension funds	4.7	4.5	4.3	6.1
New pension funds	21.6	25.0	28.3	30.9
Provident funds	4.2	4.4	6.5	9.8
Executive life insurance	27.6	30.6	29.8	28.2
Total	**58.1**	**64.5**	68.9	**75.0**

Source: MOF- Director of Capital Markets and Insurance 2017, p. 22.

2.4.4 Subsidy to pensions and budget burden

The budget for supporting pensions is on the rise and has become a significant expense. The total annual budget expense was 54 billion NIS (0.44% of GDP, 10.7% of the state budget) in 2016 and the structure of the expenses was as follows

- National insurance institute old age pension: 29.7 billion NIS [National Insurance Institute 2017, p. 136]
- PAYG pension: 15.8 billion NIS [MOF Accountant General 2017a, p. 208].
- Support for old pension funds: 4.2billion NIS [MOF Accountant General 2017a, p.114].
- Subsidy of interest on earmarked bonds: 4.3 billion NIS [MOF Accountant General 2017b, p. 16].

If we add this expense to the contributions for pension elements (Table 17), the outcome is that in 2016 the total expense for pensions was 129 billion NIS, which is 10.5% of GDP.

The first three subjects were discussed in previous sub-chapters. The subsidy of interest for pension funds needs to be clarified. The government used to issue earmarked bonds for all

pension providers prior to 1986. During the reforms, this was eliminated for provident funds and new executive life insurance and was reduced to 30% of assets for pension funds. Today, only old bonds for old executive life insurance programs that have not matured yet and earmarked bonds for pension funds still exist.

The problem is that the reforms caused the pension funds to be the only valuable pension instrument, and the contribution to pension funds grew significantly. In 2016, the contribution to pension funds (old and new) was 37 billion NIS and is expected to rise in the future. The government needs to issue 30% of it as new earmarked bonds, meaning new bonds of 10 billion NIS annually and in addition to issue new earmarked bonds for bonds that have matured and for high returns that add to the accumulation value. The total issue of new earmarked bonds for pension funds is as follows in Figure 9:

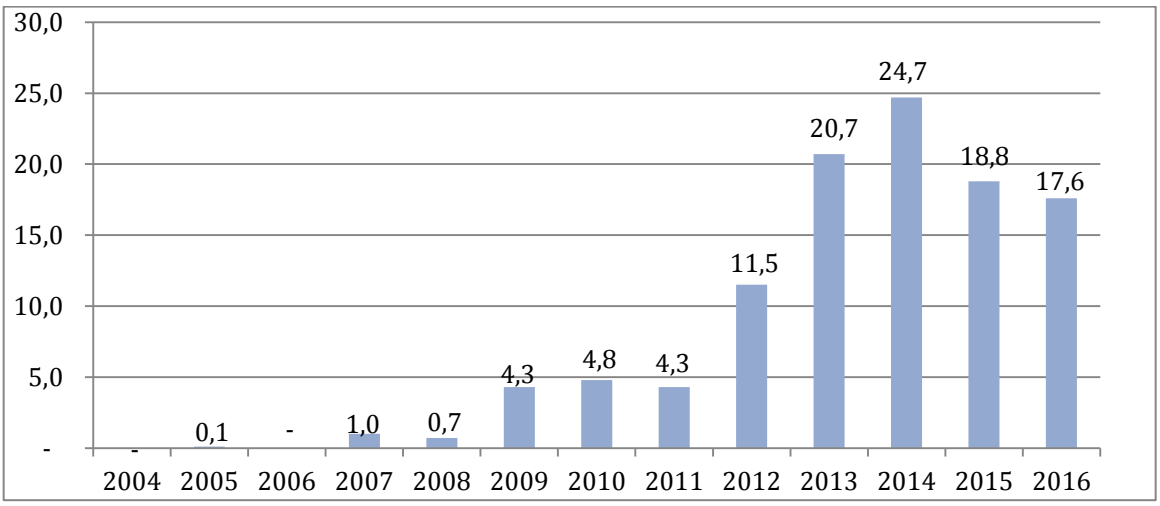


Figure 9. New issue of earmarked bonds to pension funds in billion NIS

Source: MOF Accountant General 2017b, p. 34.

The total debt from earmarked bonds to pension funds at the end of 2016 was 141.7 billion NIS (11.6% of GDP) compared to 94 billion NIS (11.6% of GDP) in 2011.

The decline in interest rates in the world and in Israel caused the subsidy to grow much more than the growth derived from the accumulation growth. The subsidy in 2011 was two billion NIS, which is the gap between the earmarked interest rate of 4.8% and the yield to maturity of traded government bonds [Arlozorov 2012]. In 2016 the subsidy rose to 4.3 billion NIS per debt of 141.7

billion NIS and an interest gap of 4.86% of the earmarked bonds compared to 0.52% of the traded government debt [MOF Accountant General 2017b, p. 16].

Since no significant increase in interest rates is expected soon, and the accumulation of pension funds is growing rapidly due to the success of government policy in pension education and as all contributions should be for an annuity purpose, it is expected that the subsidy will continue to grow and put more pressure on the budget.

It is very probable that the government will have no choice but to take care of the subsidy, and since there are those who call upon the government to increase the volume of earmarked bonds, reducing the subsidy seems to be hard to perform. It might happen in a package that will contain other changes such as giving earmarked bonds to the elderly and for all elements, and not as a stand-alone act.

2.4.5 Replacement rate in Israel

The replacement rate in Israel, defined as "The individual net pension entitlement divided by net pre-retirement earnings, taking account of personal income taxes and social security contributions paid by workers and pensioners" [OECD 2013, P. 140] is considered high compared to the OECD countries. In 2013, on an average salary, the Israeli net (after tax) replacement rate is 83.2% for men and 74.7% for women, compared to the OECD average of 65.8% and 65% respectively [OECD 2013, P. 141]. In September 2017, the Israeli net replacement rates decreased to 0.75 for males and 0.67 for females but are still higher than the OECD average as demonstrated in Figure 10.

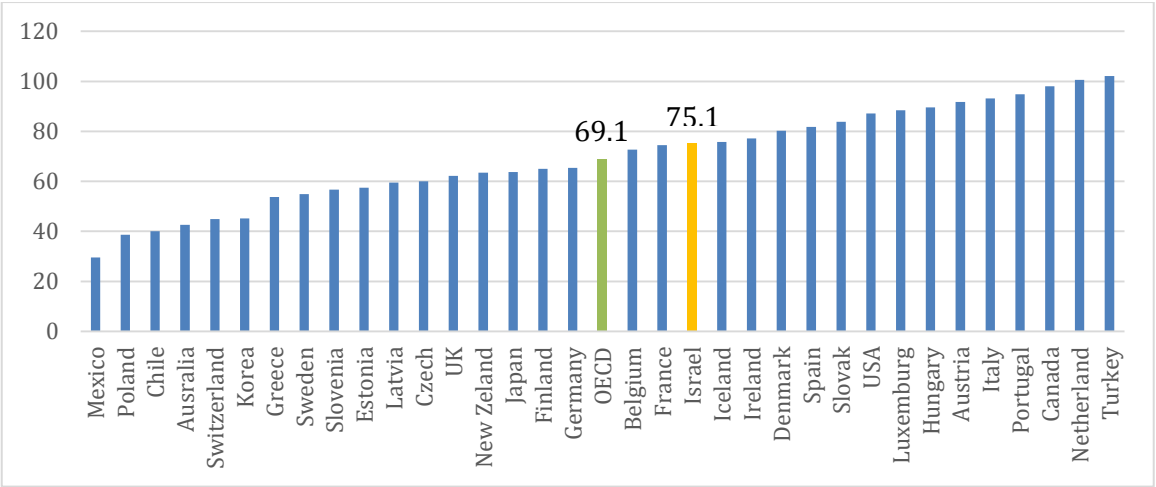


Figure 10. Net pension replacement rates Sep 2017, males average earner

Source : OECD 2017, p. 109.

Low income earners in Israel have a higher replacement rate of 106.2% compared to the 69.4% OECD average. This can be explained by the first pillar of the National Insurance old age pension which is 16%-24% of the average salary and is flat rate, regardless of the income before retirement. For low earners, the addition of the first pillar can put them in a total replacement rate higher than 100%. For those who earn 1.5 of the average salary, the Israeli rate of 54.9% is less than the OECD average of 65.9% [OECD 2017, p. 109].

The reforms in pension funds in 2003-2004 reduced the current pension and especially the pensions of those that will retire in the future. It is estimated that the gross replacement rate of the second pillar dropped by 30% after the 2003-2004 reforms, but after tax and old age pensions the erosion is lower, and the average replacement rate is about 80% [Spivak, 2013 p. 25]. The reforms included increasing the retirement age, raising contribution rates, reducing the interest rate of earmarked bonds, raising management fees for pensioners and raising management fees in pension funds and more steps that were described before. Only the raising of management fees is equal for the participants to a 12% reduction in the future annuity [Yosef and Spivak 2008, p. 20].

The OECD comparison is based on two basic assumptions: continuous employment from young age till retirement and that all salary is insured for a pension [Spivak 2013, p. 25].

The first assumption is valid only after the 2008 mandatory pension. Before that, people, especially the young and low paid, could work for years without pension contributions and pension rights. Since 40% of employees did not have any pension arrangement before 2008 [Gavious et al. 2009, p. 6], the reform improves their replacement rate from 2008 and on, but they will still have a low replacement rate on retirement due to the years before 2008 where they did not have any pension savings at all.

The second assumption is not accrual for Israel. On average, only 70% of the salary is the basis for pension contributions. The rest includes reimbursement of expenses, bonuses and other elements that are not part of the insured salary [Spivak 2013, p. 25]. In the last decade, this was improved for organized employees, and some of those components are pensionable (contribution to provident funds). This means that the actual replacement rate is lower than the replacement rate mentioned by the OECD.

3. Theories and methods for assessing investments

In this chapter, the theoretical aspects of returns on investments versus risk and simulation methods will be discussed. The first part of the chapter presents the main concepts concerning uncertainty and distribution of expected returns, the characteristics of distribution and the use of these characteristics to measure risk.

The second part of the chapter presents theories of ranking stand-alone investments including maximum mean return, stochastic dominance and expected utility. The focus is on a mean-variance approach that ranks investments based on return versus risk, which is measured by standard deviation.

The next step is to present theories of ranking portfolios of investments. We present the basic advantage of creating portfolios, namely the ability to reduce risk through diversification. At first a portfolio consisting of two assets will be presented, and after that a multi-assets portfolio. The efficiency frontier, described by Markowitz, is the most relevant models for this research, will be the main model that will be discussed when a portfolio consisting of multi-assets is presented.

The crashes in financial markets in recent decades, and especially the 2008 crisis, turned the focus from normal volatility on the markets to the ways to deal with extreme risk, especially of financial institutions. Central banks widely use stress tests to evaluate the stability of banks and their capital requirements. The tests run hypothetical scenarios, create future distributions of outcomes by simulation, measure the potential loss, mostly by VaR and CVaR, and determine the capital needed to ensure stability in the case of extreme events. The third subchapter presents the stress tests and the different types of simulations, especially Monte Carlo simulations.

In this research we are going to use Monte Carlo simulations to draw the efficiency line of investment strategies for DC pension plans in Israel. Due to those reasons, the fourth part discusses the use of simulations in the pension field and presents former research that used simulations to find efficient investment strategies for DC pension plans.

3.1 Distribution characteristics

Return on investment is defined as (Amenc and Le Sourd, 2005 p. 28):

$$R_t = \frac{V_t - V_{t-1} + D_t}{V_{t-1}}$$

where:

V_t is the value of the investment (single asset or portfolio) at the end of the period.

V_{t-1} is the value of the investment (single asset or portfolio) at the beginning of the period.

D_t is the cash flow generated by the investment during the evaluation period.

If there is no risk concerning the future returns of an asset, the possible choices of investments are to be ranked according to maximum return criterion [Levy and Sarnat 1994, p. 218]. In case where future returns from an investment are not known in advance but only expected, the investment involves a risk. In this case this simple rule is not enough, and different rules must be adopted.

Risk is used to describe a situation where the return of an investment is unknown, but the probabilities of the outcomes are known or at least can be predicted, based on past performance or other objective or subjective probabilities, meaning that the distribution of the expected returns is known or can be predicted [Levy and Sarnat 1994, p. 216].

It is usually assumed that the distribution of returns is normal and normal distribution is completely characterized by its mean and standard deviation and is symmetric around the mean. Normal distribution describes a chance of 68% of falling within +/- one standard deviation of the mean, and 95% chance to fall within +/- two standard deviations of the mean [Snopek 2012, p. 7]. Rare events or financial crises are underestimated by normal distribution and are better described by an asymmetric distribution, where returns are not symmetric around the mean [Snopek 2012, p. 7]. In this case the distribution has a left heavy tail that describes a significant loss even if the probability of such a loss is low.

The ways to measure risk are found in the distribution characteristics. Three major characteristics are defined to measure risk: standard deviation, VaR and CVaR

3.1.1 Standard deviation (SD)

Variance measures the dispersion of returns around the mean return. The mean return and variance are calculated by the formulas:

$E(r_i) = \sum_{i=1}^{n} P_i \, r_i$ mean return

$V(r_i) = \sum_{i=1}^{n} P_i \, (r_i - E(r_i))^2$ variance

where:

r_i is the possible return

P_i is the probability of r_i

The standard deviation is defined as:

$SD(r_i) = \sqrt{V(r_i)}$ standard deviation of the return

The outcome is the mean as a measure of the expected return, and standard deviation as a measure of risk.

3.1.2 Value at Risk (VaR)

In 1994, J.P. Morgan bank developed a new method: Value at Risk (VaR), that turned out to be the leading approach for managing and monitoring extreme risk in most financial institutions and regulators. The VaR methodology was adopted, among others, by the Federal Reserve, the European Central Bank, the International Accounting Standards Board and the U.S. Securities and Exchange Commission. It is also implemented in the EU Capital Adequacy Directive [Xiao et al. 2014, p. 5]. The three regulations of the Basel Committee of Banking Supervision use VaR to measure risk and determine the minimum capital requirements [Basel Committee 2011].

VaR is defined as "an estimate of the loss from a fixed set of trading positions over a fixed time horizon that would be equaled or exceeded with a specified probability" [Dowd and Rowe 2004, p. 909].

The general formula of VaR is [Dowd and Rowe 2004, p. 912]:

$VAR_\alpha = -X_\alpha S,$

where:

S is the value of an investment.

X_α is the lower α percentile of the distribution of returns on investment.

$1 - \alpha$ is the confidence level for calculating VaR. In practice, in most cases, one assumes that α equals 1% or 5%.

Under normal distribution of returns, VaR can be calculated by the formula [Dowd and Rowe 2004, p. 912]:

$X_\alpha = Z_\alpha \sigma + \mu$ where

μ is the mean return on investment.

Z_α is the lower α percentile of the standard normal distribution. For the standard normal distribution, and 95% level of confidence, the value of $Z_{0.05}$ is -1.65.

σ is the standard deviation of the distribution of returns on investment.

The three parameters to determine loss are the value of the investment, the time, and the probability. For financial institutions, the usual period is a day, a week or a month, but it can be another period such as a quarter, depending on the portfolio [Dowd and Rowe 2004, p. 910]. The level of confidence depends on the target of the VaR estimation. For solvency problems and capital requirements needed for solvency, the confidence level is mostly high: 99% and above, while for another purpose of holding a portfolio a 95% confidence level is accepted [Dowd and Rowe 2004, p. 911]. This means that α will be 5% for regular portfolios or 1% for financial institutions for a short term VaR.

The three basic methods of calculating VaR are: historical, analytical (also known as the variance-covariance or delta-normal approach) and the Monte Carlo simulation method. Enclosed are more details regarding the methods [Linsmeier and Pearson 2000, p. 50-57]:

- The historical method is based on the current portfolio and the historic data of market prices. Per the portfolio and actual prices, the profit or loss for the determined term (day/week/month/quarter) is calculated and the results are sorted to set an empirical distribution. The empirical quantile of appropriate order (for example α= 5%) is the VaR. The historical approach predicts future values based on actual historic data, and hence there is no need to assume any distribution, and a specific forecast for future market prices is not accepted. The method is easy to use and easy to explain since it is based on actual market performance.
- The analytical model is simple to use and calculate. It assumes a normal distribution of financial asset market prices. What is needed is only to calculate the standard deviation of the portfolio from past performance, and the period of the past should be long enough to

enable reliable results. Once the standard deviation is calculated the VaR can be calculated with the formula that was presented before under a normal distribution assumption.

The analytical model has a few disadvantages. Since it is based on a normal distribution assumption, it cannot be used if the actual distribution is not normal. It cannot be used for heavy tail distribution, meaning for extreme cases, and it cannot be used for non-linear assets such as derivatives. It is used mainly for portfolios of equities and bonds that are highly diversified.

- The Monte Carlo simulation method is very powerful and can deal with the cases where the analytical approach is not useful. It has much similarity to the historical method. The main difference is that in the Monte Carlo simulation only the distribution parameters are needed, mostly the distribution of historic performance, but it can be adjusted according to expectations for the future. After capturing the "correct" parameters of the distribution, one generates random numbers representing hypothetical returns on investment (usually several thousands of such numbers, up to 10,000) and according to each random performance, the profit or loss of the portfolio is calculated. The result is a distribution of profits/losses and from that VaR can be calculated for the chosen confidence level. The large number of generated returns guarantees that the distribution is as similar as possible to the actual distribution. In this case the VaR is calculated directly from the empirical distribution and one cannot use the formula that is valid under a normal distribution assumption.

The Monte Carlo simulation method has many advantages over the analytical method [Dowd and Rowe 2004, p. 919]. It can capture a wider range of market behavior. It can deal effectively with nonlinear and path dependent payoffs, also of very complicated financial instruments. It can capture risk that arises from scenarios that are not extreme cases and provide detailed insight into the impact of extreme scenarios that lie well out in the tails of the distributions, beyond the usual VaR cutoff.

On the other hand, the Monte Carlo simulation method is not easy to perform or to explain to managers and supervisors, compared to historic or analytical methods. Since it has many advantages, and computers can easily run the simulation, it has become the most popular approach to measure the risk of financial portfolios, mainly for banks, but also pension providers.

3.1.3 Conditional Value at Risk (CVaR)

The main problem of using VaR is that it has a "blind spot" in the α-tail of the distribution. VaR represents the minimum loss within a specific time and given confidence level α [Lleo 2009, p. 10]. This means that VaR might ignore the possibility of extreme loss and is not proficient enough to deal with extreme cases.

There is also another disadvantage of VaR as a risk measure. It is not a coherent measure of risk, which means that it does not measure risk of a single investment and a portfolio of such investments in a coherent way. A coherent measure of risk needs to satisfy the four axioms of translation invariance, subadditivity, positive homogeneity and monotonicity [Artzner et al. 1999, p. 210]. The meaning of this follows [Kisiala 2015, p. 7-8]:

- Monotonicity: higher losses mean higher risk. A risk measure ρ is monotone if for all X, Y: $X \leq Y \Rightarrow \rho(X) \leq \rho(Y)$.
- Translation invariance: increasing (decreasing) the loss increases (decreases) as well the risk by the same amount. A risk measure ρ is a translation invariance if for all X, c: $\rho(X + c) = \rho(X) + c$.
- Subadditivity: diversification reduces risk. A risk measure ρ is subadditive if for all X, Y: $\rho(X + Y) \leq \rho(X) + \rho(Y)$.
- Positive homogeneity: doubling the portfolio size doubles the risk. A risk measure ρ is positive homogenous if for all $X, \lambda \geq 0$, $\rho(\lambda X) = \lambda(\rho X)$.

VaR fails to be a coherent measure of risks, since it fails to satisfy the subadditivity property [Artzner et al. 1999, p. 216]. This means that using VaR as a risk measure does not provide sufficient diversification.

To overcome the disadvantages connected with VaR Rockafellar and Uryasev [2002] developed its modification known as Conditional VaR (CVaR). It was shown [Rockafellar and Uryasev 2002, p. 1445] that CVaR is a coherent measure of risk. CVaR is aimed at taking care of the "blind spot" that is present in the VaR approachand since its development it became widely used. For normal distributions using VaR or CVaR is equivalent, but for other distributions and heavy tail, CVaR is superior [Rockafellar and Uryasev 2002, p. 1444].

CVaR is defined as "(equal-weighted) average of all the possible outcomes in the left-tail of the profit and loss distribution of asset or portfolio X" [Lleo 2009, p. 12]. The formula of CVaR is [Kisiala 2015, p. 6]:

$$CVaR_{\alpha}(x) = E\big(X \big| X \leq VaR_{\alpha}(X)\big).$$

And by using Acebri's integral formula, the CVaR of a random variable X, which represents loss at the confidence level of $1 - \alpha$ is [Acerbi and Tasche 2002, p. 1492]:

$$CVaR_{\alpha}(x) = \frac{1}{\alpha}\int_0^{\alpha} VaR_{\beta}(x)\, d\beta,$$

which means that CVaR is the average of VaR_{β} for $\beta \epsilon [0, \alpha]$.

The relationship between VaR and CVaR is illustrated in Figure 11.

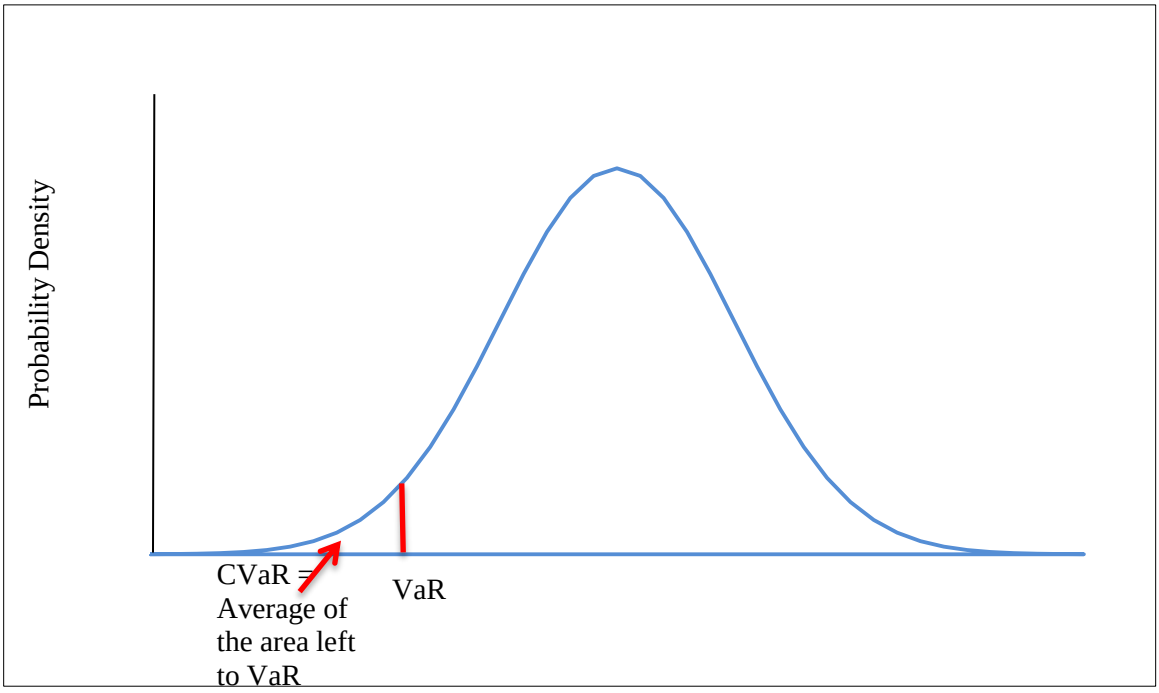


Figure 11 CVaR and VaR – Probability Density Function

Source: Lleo 2009, p. 12.

While VaR only estimates the point of loss in each confidence level, CVaR also estimates the expected loss behind that point and for higher confidence levels. CVaR can quantify the tail risk which characterizes extreme cases and is more useful to investors. CVaR is superior to VaR in measuring the potential loss of derivatives and the asymmetrical risk profile [Kido 2012, p. 3].

It turned out that CVaR is also useful for portfolio selection. According to Markowitz, an efficient portfolio would be the portfolio that maximizes the return for a given risk or minimizes the risk for a given return. This subject will be developed in the next subchapter on portfolios.

In practice, to compute risk measures, it is often necessary to draw the distribution of results ordered from largest loss to the highest profit, which is exactly the procedure to calculate VaR and CVaR. If returns are distributed normally, then mean-variance analysis, VaR optimization and CVaR optimization will coincide [Lleo 2009, p. 13].

3.2 Rules for ranking stand-alone investments

This subchapter describes how stand-alone investments are ranked by combining the expected returns with the risk. The description includes: maximum mean of expected returns; expected utility theory and stochastic dominance and mean-variance rule.

3.2.1 Maximum mean of expected returns

Suppose we should choose the best alternative among a few possible investment opportunities. For each investment there are possible returns r_i and their probabilities P_i respectively. According to the rule, the superior investment is the one with the highest mean calculated according to the formula presented in subchapter 3.1.1

The rule is very simple, but the outcome can be problematic, since no attention whatsoever is made regarding risk. For example, we will have two investment possibilities: investment A with returns of 10% and 14%, while both possibilities have a probability of 50%, and investment B with returns of 6% and 24%, with a 50% probability for each one. The mean of A is 12%, and of B is 15%, hence B is superior. This calculation ignores the fact that B is more dangerous since it has a much lower downside than A. Hence, this criterion ignores the risk, and is not sufficient for ranking investments in uncertain conditions. The criterion for ranking investments should combine the mean expected return with the risk.

3.2.2 Expected utility theory

A well-known theory for investment decisions is the expected utility theory. According to the theory, what matters is not the amount of the return itself but the utility from the amount received or paid.

The utility function is unique to each individual, reflects one's approach to risk and is expressed as $U = U(x))$, where $U(x)$ is the utility and x is the amount received. The function is increasing (which means that the additional amount x makes additional utility) and concave. Mathematically it is expressed as: $U'(x) > 0$ and $U''(x) < 0$ where $U'(x)$ is the first derivative of the function $U(x)$ and $U''(x)$ is the second derivative of $U(x)$ [Levy and Sarnat 1994, p. 224].

That kind of slope means that additional money causes less additional utility than the same amount received before. It also means that losing the same amount causes us more pain than the pleasure of gaining the same amount. The shape of the function is derived from one's personal risk aversion, and it was found that most people are risk averse. The more concaved the function is, the more risk averse the investor is. In the case of a linear function the investor is indifferent to risk.

According to the theory, the decisions are based on the utility and what matters is expected utility rather than the expected value of future wealth, as shown in Figure 12. The amount (obtained with certainty) that gives you the same utility as the utility from taking a gamble is called the "Certainty Equivalent" (CE). The difference between the certainty equivalent and the amount mean is the risk premium (RP) or the price one is willing to pay for insurance [Levy and Sarnat 1994, p. 221-227].

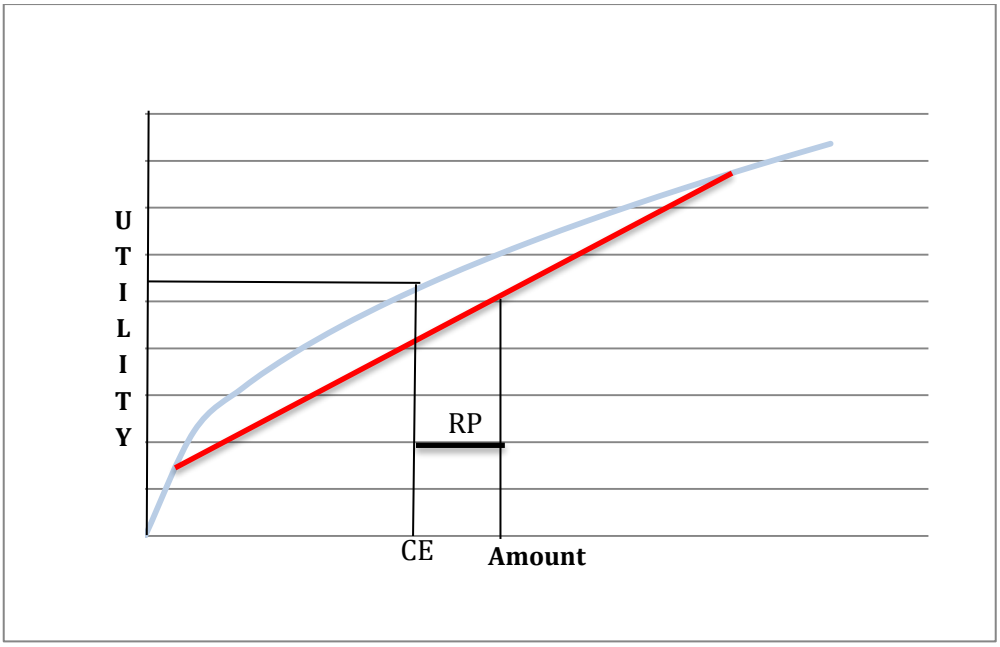


Figure 12. Utility curve and risk premium

Source: Levy and Sarnat 1994, p. 224.

The degree of risk aversion for a person with wealth x can be measured by absolute risk aversion coefficient, which is expressed by the formula [Eeckhoudt et al. 2005, p. 11]:

$$A(x) = -\frac{U''(x)}{U'(x)}$$

$U'(x)$ and $U''(x)$ are the first and second derivative of the utility function. This formula was developed by Pratt and Arrow in 1963-1964 [Eeckhoudt et al. 2005, p. 11]. The coefficient $A(x)$ is called the absolute risk aversion coefficient, as its measures risk aversion of an investor to absolute changes in his wealth supposing that the initial wealth is x. "Absolute risk aversion measures the rate at which marginal utility decreases when wealth is increased by one currency unit" [Eeckhoudt et al. 2005, p. 17].

A unit-free measurement of sensitivity is given by the relative risk aversion, which is expressed by the formula:

$$R(x) = -x\frac{U''(x)}{U'(x)}$$

It measures the wealth elasticity of marginal utility, meaning measures "the rate at which marginal utility decreases when wealth is increased by one percent" [Eeckhoudt et al. 2005, p. 18].

3.2.3 Stochastic dominance

Consider two investment alternatives F and G with a stochastic return on investment x, which is bounded in the range $[a, b]$. Let $F(x)$ and $G(x)$ be the cumulative probability functions of returns from these investments, as shown in Figure 13 [Levy M. and Levy H. 2001, p. 235]. According to the first- order stochastic dominance rule (FSD), F dominates G only if $F(x) \leq G(x)$ for all x with the strict inequality for at least one value of x, i.e. $F(x) < G(x)$, as shown in Figure 13.

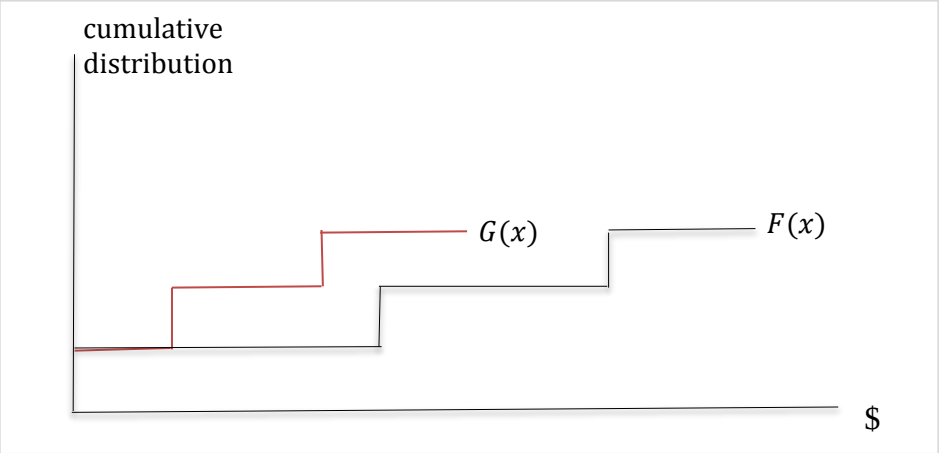


Figure 13. First order stochastic dominance

Source: Levy M. and Levy H. 2001, p. 238.

Stochastic dominance has a deeper connection with the expected utility theory. It can be shown that given two investment opportunities F and G such that F stochastically dominates G, any investor with an increasing utility function would choose investment F. "The FSD criterion corresponds to all types of utility functions as long as they are non-decreasing in wealth. FSD only relies on the fact that investors are rational in the sense that they prefer more rather than less wealth" [Levy M. and Levy H. 2001, p. 235].

If the rule cannot be matched, and in at least one case the amount received in G is higher than the amount received in F in the same cumulative distribution, although in most cases the amount of F is higher, than the second order stochastic dominance rule (SSD) can supply the answer. According to the rule, F dominates G only if $\int_0^x [\mathrm{G(t)} - \mathrm{F(t)}]dt \geq 0$ for all x with a strict inequality for at least one value [Levy M. and Levy H. 2001, p. 236].

Again, second order stochastic dominance is connected with the expected utility. It reveals preferences of any risk-averse investor. If F stochastically dominates of the second order over G, then for any increasing and concave utility function the expected utility of F is higher than the expected utility of G.

The advantage of the first and second stochastic dominance rules is that they can rank investments when the specific utility function of the investor is unknown.

3.2.4 Mean-variance rule

The mean-variance rule was developed by Harry Markowitz. According to this rule, investment A will be preferred over investment B if one of the following conditions holds [Levy and Sarnat 1994 p. 242]. The expected return of A exceeds the expected return of B and the variance of A is less or equal to the variance of B; or the expected return of A exceeds or is equal to the expected return of B and the variance of A is lower than the variance of B.

In a case where the expected return of A is greater than the expected return of B and the expected variance of A is also greater than the expected variance of B, according to the rule there is no way to determine which investment is superior. A is riskier than B, and hence, according to the financial theory, it is necessary that A has a higher expected return to compensate the extra risk of A. The principle is that the riskier the investment is, the higher its return should be. Figure 14 presents ranking of four possible investments according to mean-variance rule.

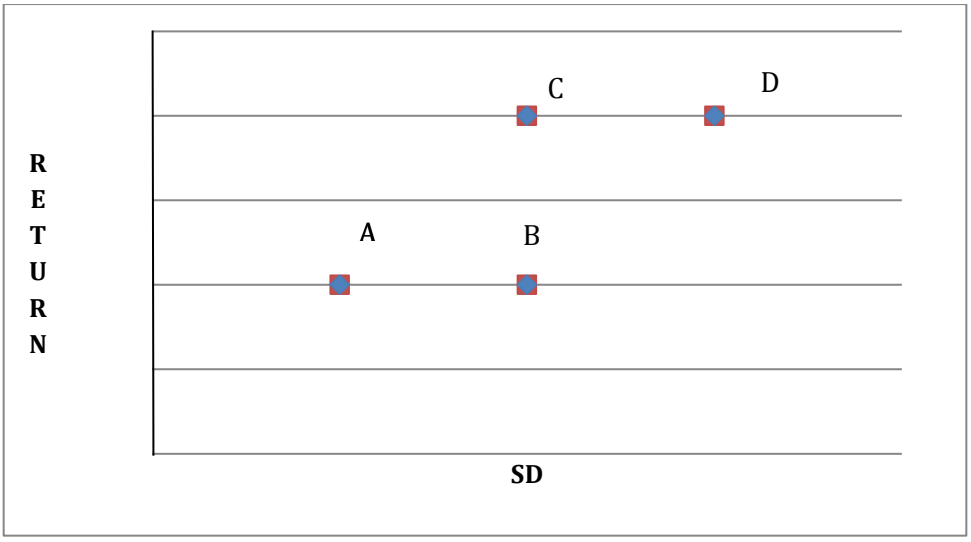


Figure 14. Mean-variance rule for ranking investments

Source: Author presentation based on Levy and Sarnat 1994, p. 241-243.

Investment A and B have the same expected return, but B is riskier with higher expected standard deviation (SD). Hence, A is superior to B. In the same way, it can be seen that C is superior to D. Also, C is superior to B since they share the same risk, e.g. the same expected SD, but C has a higher expected return. The superior investments are A and C.

The mean-variance rule cannot determine which of the investments A and C is superior. C has a higher expected return than A, but also a higher risk. Those who are willing to take a higher risk will choose C, while the more conservative investors will prefer A.

Although in most cases the investments ranking is correct, the use of the rule fails to rank investments in the following situations:

- It can return an answer that no investment is superior although there is a superior investment per common sense. For example, if the possible returns of B are 10% or 14%, and the possible returns of A are 50% or 150%, the worst case of A is better than the best case of B, and hence it's clear that A is superior. However, if the probabilities of both outcomes in the considered investments are the same (i.e. in A the probability of obtaining higher return is 50%; the same with obtaining higher return in B), then the expected return of A is 12% and the expected return of B is 100%. The standard deviations of returns in A and B are 2% and 50%,

respectively. Using mean-variance rule one cannot say that the investment B is superior to A (or vice-versa).

- The rule is not effective in measuring the risk of extreme cases. This subject will be discussed later in this chapter.

The rule is effective in normal behavior and when measuring a large scale of results and is common in financial markets where much data exists.

When there is no superior investment according to the mean-variance rule, two other ways to identify the superior investment are presented: the coefficient of variation and stochastic dominance. Stochastic dominance was discussed before.

Coefficient of variation can be used instead of the variance when the mean-variance rule cannot supply an answer. It is defined as:

$$C = \frac{\sigma_i}{E(r_i)}$$

where:

C is a coefficient of variation.

σ_i is the standard deviation of returns of investment i.

$E(r_i)$ is the mean return of investment i.

It is a relative parameter that calculates the risk relative to the return and solves the problem that the mean-variance rule cannot point out a superior investment.

3.3 Portfolio assets allocation

Until now, the main focus of the discussion was to present ways to rank stand-alone investments and deciding which one is superior. In reality, investors can have more than one investment, and mostly create portfolios of investments. Actually, most investments are in portfolios that include risky investments together with risk-free investments.

A portfolio is created when investors decide not to invest in one asset only, but to divide the investment between more than one asset. The important decisions to be made are which assets to invest in and in which proportion divide the wealth between different assets. Since there are

many assets and many possible combinations of assets, it means that also many different portfolios can be made.

The main economic motivation to create a portfolio is that diversification reduces risk as will be presented in the following sub-chapters. Firstly, a portfolio of only two assets will be discussed and then it will be expanded to a multi-assets portfolio. The focus in this dissertation is on the efficient frontier, developed by Markowitz, that analyzes how risky investment or portfolios should be ranked.

3.3.1 Portfolio consisting two risky assets

Two risky assets are available to the investor: A that has an expected mean return $E(r_a)$ and standard deviation σ_a and B with $E(r_b)$ with σ_b respectively. Until now the discussion has focused on how to choose one out of those two assets. Now an option of combination of the two assets is also relevant, i.e. creating a portfolio out of the two assets.

Creating a portfolio will reduce the risk in most cases. The formulas of the mean and variance of the portfolio are [Elton et al. 2007, p. 68-69]:

$$E(r_p) = E(r_a)\mathrm{W} + E(r_B)(1 - \mathrm{W})$$

$$V(r_p) = W^2\sigma_a^2 + (1-W)^2\sigma_b^2 + 2\,W(1-W)\sigma_a\sigma_b\rho_{ab} \qquad \text{where}$$

$E(r_p)$ is the mean return of the portfolio,

$E(r_a)$ is the mean return of A,

$E(r_b)$ is the mean return of B.

W is the value of A divided by the value of the portfolio (i.e. the part of the wealth invested in A)

$V(r_p)$ is the variance of the portfolio.

σ_a is the standard deviation of A.

σ_a is the standard deviation of B.

ρ_{ab} is the correlation coefficient between A and B.

The variance of the portfolio is much influenced by the correlation coefficient between the assets. The correlation coefficient has values of -1 minimum to +1 maximum. Three special cases are [Elton et al. 2007, p. 70-77] :

- If the correlation coefficient is +1, the portfolio standard deviation is $\sigma_p = \sigma_a W + \sigma_b(1 - W)$ which is a linear combination of the risks of A and B. All combinations lie on the linear line of return and risk that connects the individual assets as demonstrated in Figure 15. No reduction in risk is achieved from combining a portfolio.
- If the correlation coefficient is -1, the portfolio standard deviation is $\sigma_p = \sigma_a W + \sigma_b(1 - W)$. This equation allows a unique solution where the portfolio standard deviation can be zero. It is achieved when $W = \frac{\sigma_b}{\sigma_a + \sigma_b}$ and is the only case where an investment in risky assets can produce a risk-free return. The risk of the portfolio lies on a linear line between the risk of A to zero (point C in Figure 15). It means that the risk of portfolio is smaller than the risk of a stand-alone investment.
- If the correlation coefficient is zero, the portfolio variance is $V(r_p) = W^2\sigma_a^2 + (1 - W)^2\sigma_b^2$. A derivation of the formula will lead to an equation of the minimum risk that can be achieved if the fraction of A in the portfolio is $W = \frac{\sigma_b^2}{\sigma_a^2 + \sigma_b^2}$. The shape of the combinations line is not linear but is concave as is shown in Figure 15. All the points that lie on this line, which are combinations of investment A with investment B, have lower standard deviation than the standard deviation of A or B.

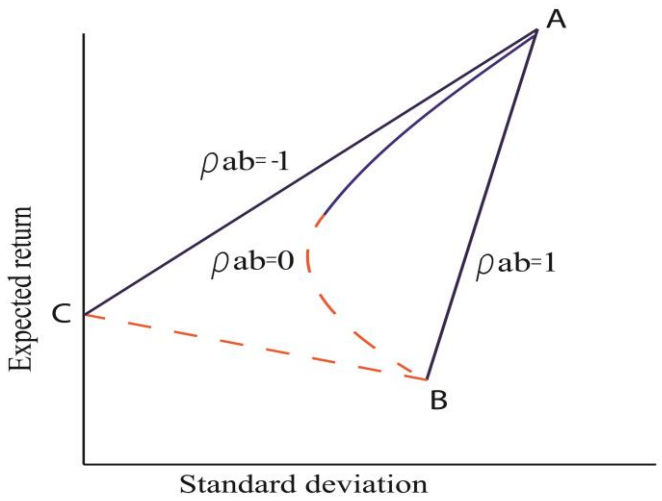


Figure 15. Portfolio combinations per correlation coefficient.

Source: Elton et al. 2007, p. 77.

This means that diversification can indeed reduce the portfolio risk, but not eliminate the risk, besides one special case.

3.3.2 Portfolio consisting of many risky assets: the efficient frontier

In cases where more securities can be added, and portfolios can be created, the assets allocation is up to the investors' taste and risk aversion. Out of all the possible portfolios only part of them are efficient according to the mean-variance rule.

The way to find the efficient portfolios and to allocate investments was introduced by Harry Markowitz [Markowitz 1952]. He showed that adding more securities to a portfolio reduces the variance, if the correlation between the securities is less than one. The model is for an investor with one single period investment, who seeks to maximize the expected returns and bases the investments allocation on the mean-variance rule.

Let us assume that there are n assets with expected return $E(r_i)$, $i = 1,2, \dots, n$. Let W_i be the proportion of wealth invested in the asset i – the weight of this asset in the portfolio. These proportion for all assets should sum up to one:

$\sum_{i=1}^{n} W_i = 1.$

The expected return of the portfolio is presented by the formula:

$E(r_p) = \sum_{i=1}^{n} W_i\, E(r_i)$,

where:

$E(r_p)$ is the expected return on the portfolio,

$E(r_i)$is the expected return on asset i,

W_i is the weight of asset i in the portfolio.

Each asset included in the portfolio is correlated with all other assets in the portfolio (although in some cases the correlation coefficient can be equal to zero). We denote by ρ_{ij} the correlation coefficient between the returns on assets i and j. The variance of the portfolio is:

$V_p = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i\, W_j \sigma_i \sigma_j \rho_{ij}$,

where:

σ_i is the standard deviation of r_i,

σ_j is the standard deviation of r_j,

ρ_{ij} is the correlation coefficient between the returns on assets i and j.

"An efficient portfolio is defined as a combination of securities which maximizes the expected return for a given variance (or standard deviation)" [Levy and Sarnat 1994, p. 297]. The line A-E-B in Figure 16 represents combinations of portfolios of the assets A and B, but not all the combinations are efficient. A comparison between two portfolios D and F suggests that per the mean-variance rule portfolio D is superior to F. because $E(r_d) > E(r_f)$ and $V_d = V_f$ Where $E(r_d)$ is the mean return of portfolio D, $E(r_f)$ is the mean return of portfolio F, V_d is the variance of returns of portfolio D and V_f is the variance of portfolio F. In the same way it can be proved that any portfolio lies on line A-D-E is superior to a portfolio lies on the line E-F-B, and hence the dashed segment E-F-B is irrelevant since these portfolios are inferior to portfolios lie on A-D-E. The only efficient combinations lie on the segment A-D-E. This line is called “the efficient frontier”.

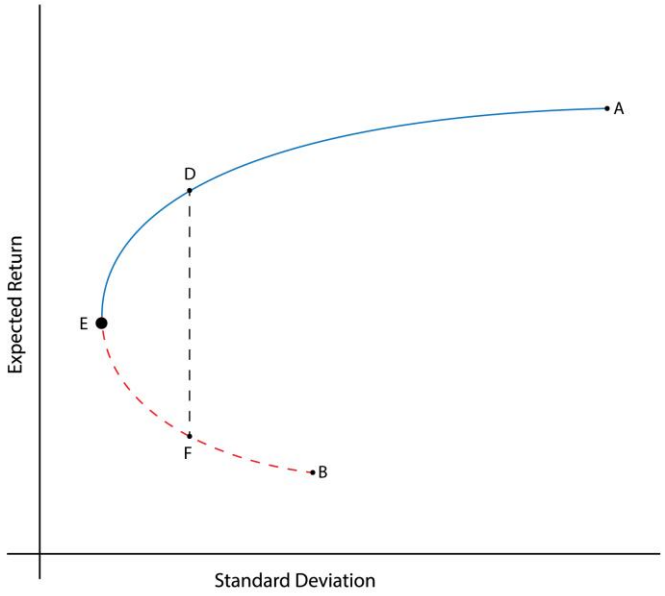


Figure 16. Possible portfolios and efficient frontier

Source: Markowitz 1952, p. 82.

The indifference curve is a chart that represents combinations of expected returns versus variances that are indifferent for the investor. The indifference curves for a risk-averse investor rise from left to right and are convex, which means that the investor expects to be compensated for more risk, and that the additional increment of return should be higher than the additional increment of risk. The higher the indifference curve, the more the investor can improve his situation by having more return for the same risk. The curves that lie above the efficient frontier cannot be reached, and those who lie below are not efficient, since it is possible to get better utility by choosing a higher curve. In Figure 17 the efficient frontier is presented together with the indifference curves. The chosen portfolio is point D which is the tangency point of the efficient frontier with the indifference curve [Levy and Sarnat 1994, p. 296-297].

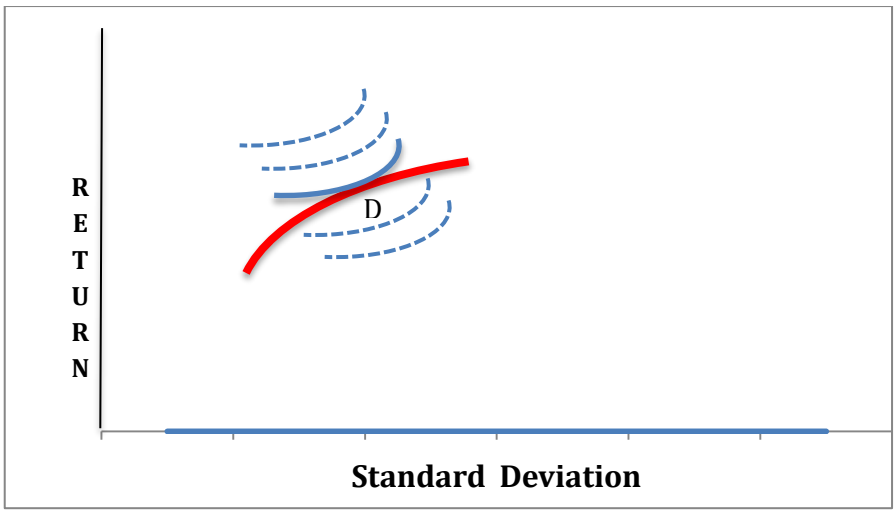


Figure 17. Efficient frontier and indifference curves

Source: Levy and Sarnat 1994, p. 296-297.

As we move along the efficient frontier from left to right, the portfolio risk is higher. More conservative investors will choose portfolios with less risk, that lie to the left of D. Investors who are willing to risk more, and demand higher compensation for that, will choose portfolios that lie to the right of point D on the efficient frontier.

3.4 Extreme risk

The classic theories that were presented in this chapter were introduced in 1950s and 1960s. They defined risk in terms of standard deviation. Extreme collapses, such as the big collapse of the stock market in the USA in 1929, occurred also before that time, but the crashes did not happen so often and were not spreading globally as in recent decades. Examples of events are 1987, 1989, 1990 (USA and global), 1991 (Japan), 1995 (UK), 1998 (USA and global), 2000 (USA and global), 2007 (China) and 2008 (USA and global).

In recent decades, investors and financial institutions have faced much higher market risks and volatility than before. The intensive use of derivatives in capital markets and in currency markets intensified the risk and the results of the crash. In 1995 Barings Bank collapsed after massive gambling on the Japanese stock market through derivatives. In 1998, the LTCM fund collapsed

due to high exposure through derivatives to the Russian market. Since then more extreme cases have occurred, such as 2008 sub-prime crisis and a bear market in December 2018.

Those events emphasized the need to develop efficient and clear elements for managing and monitoring risks, and especially risks of extreme cases with significant impact on the global economy. The central banks adopted a method, stress tests, for checking the stability of banks in the case of extreme cases. Financial system used two main indicators to calculate the potential loss in extreme cases: Value at Risk (VaR), and Conditional Value at Risk (CVaR) in order to predict future forecasts of profit/loss. VaR and CVaR are calculated from the distribution of estimated values. By the law of large numbers, the more observations of a random variable we have, the greater the accuracy of the distribution and of VaR and CVaR. Using simulations, and especially Monte Carlo simulation enables to increase significantly the number of observations, and hence the accuracy of VaR and CVaR. By using VaR and CVaR the financial institution can define in advance the portfolio that will limit the loss in the case of extreme cases up to what the institution can bear.

3.4.1 Stress tests

Stress tests are designed to find the possible loss in a certain scenario and use VaR and CVaR for measurement of the potential loss. “In stress testing, the risk manager analyzes the behavior of the portfolio under several extreme market scenarios that may include historical scenarios as well as scenarios designed by the risk manager” [Lleo 2009, p. 10]. Stress tests are performed mainly by central banks to examine the capital needed for the banks to withstand a serious crash in markets or the economy (extreme cases). The scenarios mostly relate to economic growth, inflation, currency rates, interest rates and the prices of financial assets and liabilities. Stress tests often complete internal models and management systems used by financial institutions for capital allocation decisions [Majnoni et al. 2001, p. 4].

Stress tests were developed in early 1990s. In 1996 the Basel Committee on Banking Supervision highlighted the need for stress tests, and the IMF in 2001 published its stress tests methodology and experience [Majnoni et al. 2001, p. 6-8], but until the sub-prime crisis, stress tests were not so common.

According to IMF methodology, stress tests are usually applied at the level of a portfolio or an individual financial institution. However, it can also be applied to an aggregate level of portfolios or institutions and measure the aggregate risk of the whole system. The goals of performing stress testing at the different levels of aggregation are different. Stress tests of a single institution aim at examining a possible loss under an extreme scenario regarding the main parameters such as inflation, interest rates, currency rates, default rates of loans and so on. The potential loss will require capital demands to ensure the institution's stability. This test is done only for the institution itself without any cross implications for other financial institutions. Aggregate stress tests, on the other hand, examine the stability of the financial system and help regulators to identify structural vulnerabilities and overall risks or market failures.

These are the issues that should be considered when preparing and performing stress tests at a portfolio or institution level are [Majnoni et al. 2001, p. 4-6].

- Type of risk:
  - credit risk,
  - market risk (such as: interest rates, currency rates),
  - liquidity risk, operational risk.
- Type of stress test:
  - sensitivity test - includes only one parameter,
  - scenario test - includes extreme changes in multiple factors that may also be correlated,
  - extreme scenarios or maximum loss.
- Types of scenarios:
  - Historical scenarios are based on actual events that took place in the past. It is the easiest scenario and easy to explain, since it is based on the actual past. The disadvantage of a historical scenario is that it is backward looking, which might not be relevant due to changes in markets and institutional structures.
  - Hypothetical scenarios that are determined by the institution are based on parameters and events that might not have occurred in the past but might occur in the future. This type of scenario is more flexible and allows much freedom to

the test architect. The difficulty is in determining which events will occur and why. An example of a plausible stress scenario by the Federal Reserve is a 200 basis points parallel shift in interest rates, yielding a curve [Majnoni et al. 2001, p. 15]

    - A Monte Carlo simulation is the third option that can be used in stress tests. A Monte Carlo simulation allows stress tests to simulate the impact changes at the same time of a wide variety of combinations of variables and is very powerful for non-linear characteristics such as derivatives. Running a Monte Carlo simulation demands high skills, both of risk managers and supervisors; for running the simulations and interpreting the results, and hence is recommended as an additional tool for limited use [Majnoni et al. 2001, p. 21].

- A time horizon determines how much time the shock will last, and for what period losses are counted.
- Which assets should be shocked: only core assets or also peripheral ones? Core assets are assets such as loans and securities, for which a change in their value can strongly influence the bank's stability. Peripheral assets are assets for which a change in their value is not significant to the bank's stability such as bank buildings and non-traded investments.

Stress tests at the aggregate level are more complicated and involve cross sectional influences. The major problem is how to aggregate the tests. Two major possibilities are to compile the results of all institutions' tests to the industry level or to obtain the data on portfolios from the institutions and perform a stress test based on the aggregate data [Majnoni et al. 2001, p. 8-11].

For central banks, the first choice is easier, but might be problematic. Institutions might adopt different methodologies to assess the test, and in that case the results cannot be summarized. Other problems might arise if the portfolios have much diversification and are hard to aggregate. Perhaps the most problematic issue is that compiling all the risks of institutions results in a lower risk than the real industry risk, which happens by paying less attention to the interrelations between the institutions [Majnoni et al. 2001, p. 9]. The second choice demands central banks to perform the tests by themselves, which is a burden on central banks, but this approach is more accurate.

In 2009 the American Federal Reserve operated a comprehensive stress tests program called the Supervisory Capital Assessment Program (SCAP). SCAP was designed to estimate losses, revenues and reserve needs for banks under various macroeconomic scenarios including one that is more adverse than expected, and estimate the capital needs per the scenarios, [Federal Reserve 2009, p. 3]. In practice, only two scenarios were examined: the average of consensus projections and a more adverse version of the assumptions developed by the supervisors. The banks were asked to evaluate their loss in each scenario, and the supervisors checked it and made further calculations to evaluate the expected loss as well as the capital at the end of two years term compared to the needed capital. Banks which had too little capital resources were asked to raise capital or change their portfolios [Federal Reserve 2009, p. 5-6].

In a speech at the convention in 2013 [Bernanke 2013], the FED chairman Bernanke said that since it had been operated for the first time, the plan was not changed significantly, but many more financial institutions joined the program, and now the banking system seems stronger and more stable than before. Ten out of 19 large banks holding groups had to increase their capital base by 75 billion dollars due to the stress tests.

Stress tests were adopted in most developed countries. The European Central Bank, during 2013-2014, did comprehensive stress tests on 130 banks that covered 82% of the banks' assets. The results were published in October 2014 [ECB 2014] and pointed out that extreme cases will cause a shortfall in the European banks of 24.6 billion euro. Because of this study, European banks had to strengthen the capital base to be better prepared for the new shocks that might happen.

3.4.2 Simulations of return and risk

Performing stress tests and using VaR and CVaR for measuring risk have become much easier due to the improvements in computer hardware and software that enable complicated calculations. This progress also enables laptops to run 10,000 times simulations that once could only be done by huge and powerful computers. Therefore, using simulations for risk management has become more and more popular among financial institutions, regulators and researchers.

As described before, a Monte Carlo simulation is probably the best option for calculating VaR, CVaR and for performing stress tests. As computers have become more powerful and capable of

more complicated calculations, the use of simulations, and particularly Monte Carlo simulations, for large scale research is becoming more and more popular. The scale includes risk management, currencies market portfolio analysis and many more.

3.4.3 Microsimulation

Microsimulation is a computational technique in which one simulates the behavior of micro-units [Li 2013, p. 4.]. The concept was introduced in 1957 by G. Orcutt [1957, p. 116-123], and it is used mainly in the social sciences to give better predictions for a complicated system that contains few micro units, and where the behavior of each unit influences the other units. "The basic feature of the new approach is a radical shift, from aggregate relationship (of macroeconomic models), to the behavior of micro units forming a system: individuals, households, firms and so on" [Baldini 2001, p. 2]. The idea is to use the Monte Carlo method to simulate changes in the behavior of micro units and obtain in this way changes to the full system. For example, assume that we consider a system that contains a labor market, welfare, taxes and so on. A policy decision changing tax rates influences not only tax income, but also has an impact on individuals, households, the labor market, unemployment rates, companies and other factors. The whole impact of changes can be reached through this simulation.

Microsimulations that study individuals and household behavior or influence the micro effect of public policy are divided into dynamic population models, dynamic cohort models and static models [Baldini 2001, p. 2-3]:

- Static models do not usually consider the behavioral reaction due to a policy change and refer mostly to a single period.
- Dynamic population models allow simulations to see the dynamic changes and influence of policy decisions on all the population for a few periods of time.
- Dynamic cohort models allow a life cycle study of a single cohort that can be real, such as males that were born in a specific year or created by a computer.

Static models are used to evaluate the immediate impact of policy changes on individuals and households, without considering the time dimension and the behavioral adjustments. Dynamic models, on the other hand, allow individuals or households to change their behavior according to

endogenous factors included in the model and allow individuals to progress over time. Dynamic models for pensions, such as Pensim and Sesim's [Li 2013, p. 4], allow for changes in individual factors over time, such as a bachelor who gets married, later has kids, and maybe later gets divorced. Because of those changes the individual might need to change the character of his work (maybe work more) or other behavioral factors. The program calculates his income, tax, net income, social payments, disposable income and other factors per new parameters, and creates integrated long-term projections [Li 2013, p. 4].

The dynamic models are fit mostly for decision making. For this research, it was enough to use a static model with changes in parameters to obtain information on what happens to the replacement rate if a parameter is changed.

3.5 Using simulations for pension portfolios

The use of simulations for pension portfolio analysis is the main issue dealt with in this research and it will be discussed in this chapter. The growing shift from defined benefits plans to defined contribution plans, which are funded and invested in capital markets, has expanded the sphere of the research, regarding the best way to achieve high returns and reduce risk, especially close to retirement. The use of Monte Carlo simulations for this kind of research is very common.

"Default options are often regulated, especially in those countries where DC plans are mandatory. Some have gone as far as designing a specific investment strategy for the default option. There is increasing international consensus that some type of life-cycle strategy is desirable for default options, with decreasing risk exposure as the individual ages. However, the specific allocation to risky assets, such as equities, at different ages is a matter of much debate, both in academic and policy circles. There is also an on-going debate on the relative merits of deterministic investment strategies with a fixed glide path over the life cycle and dynamic investment strategies that regularly adjust their portfolio based on past performance and value at risk" [Antolin et al. 2010, p. 89].

Shiller [2005, p. 7-11] set up a simulation to assess the possible outcomes of a life cycle personal account option within the Social Security system in the United States. He used historical data of returns from 1871 to 2004 and ran 91 scenarios for 44 years of accumulation.

Shiller used a deterministic simulation. This type of simulation uses values of variables that are known in advance and leave no room for random variation, and thus each repetition of simulation will lead to the same result. It is often used in the natural sciences where the experiment has the same results each time that it is performed. However, the deterministic method is not very common and seems to be inadequate when exploring human capital markets returns over a long period. A more appropriate method is to use a stochastic simulation that enables taking into account random events and generates various ranges of outcomes under basic assumptions of contribution period, contribution rate and salary [Gomez-Hernandez and Perez-Sosa 2014, p. 50].

A few researchers, like Chai et al. [2009], have favored the utility function approach for replacement rates or accumulation on retirement [Antolin et al. 2010, p. 91].

These models include stochastic simulations on mortality, returns and incomes. Most papers ran simulations of mean or median replacement rates, while the main difference between the models was the risk measurement: some used standard deviation, some used CVaR, and most models used VaR to measure risk.

Berstein et al. [2013] present similar ideas in their research regarding investment strategies for Chile, where the investment strategies were according to Chile's age-based default system, funds A to E. Although they expanded the research to see differences in contributors' profiles [Berstein et al. 2013, p. 381, 384]. They also concentrated on simulating random replacement rates and measuring the median replacement rate versus risk 10,000 times. The main difference is that for risk measurement they used the standard deviation instead of the VaR that Antolin et al. used. They found no dominant strategy, where all strategies lied on the efficient line, and that an increase of one percentage of risk is equal to a gain of 0.85 points of replacement rate [Berstein et al. 2013, p. 381].

A stochastic model for a default investment option in a DC plan in Australia was presented by Basu and Drew in 2009. They ran a 5,000-time Monte Carlo bootstrap simulation, using the CVaR for measuring risk and wealth after retirement compared to the income before retirement as the

target factor, which is quite like the replacement rate idea [Basu and Drew 2009, p. 9]. They compared life cycle strategies with fixed assets allocation strategies. Their conclusion was that a high portion of equities in the pension portfolio contributes not only to higher wealth or replacement rate but also proved to be less risky [Basu and Drew 2009, p. 31]. This conclusion is somewhat surprising, since equities are riskier than fixed income instruments, and per finance theory a high portion of equities should improve the return at the cost of increasing the risk.

A comprehensive simulation was made in 2010 by Antolin et al. They examined thirteen investment strategies as follows [Antolin et al. 2010, p. 95]:

- Fixed strategies in which the allocation does not change.
- Dynamic life cycle strategies where the portion of equities from the pension portfolio decreases to the point that at retirement the portfolio does not contain equities at all. There are several models for decreasing the proportion of equities in the pension portfolio.
    - Linear decrease.
    - Stepwise decrease in which the portfolio allocation is changed every few years.
    - Piecewise linear approach: the allocation does not change for the first period (five up to twenty years) and only then decreases in a linear way or a stepwise way.
    - Multi shape strategies that minimize the expected shortfall after retirement.

The research aims to find a probability distribution function of the replacement rate and from the distribution derive the efficient frontier of the median replacement rate versus risk. The replacement rate was chosen as the main factor since it is considered one of the most important factors when pensions are concerned. The risk is measured as the left VaR of the 5% percentile of the replacement rate, just like in the work of Antolin et al. [2010, p. 96]. They ran a Monte Carlo simulation 10,000 time according to German historical data of returns on equities, bonds and cash for the period 1954-2008, which are much similar than US data.

The results show that life cycle strategies with high portions of equities for most of the accumulation phase, switching slightly to bonds in the last decade, produced the highest replacement rates for a given risk, and were the most successful strategies for annuity purposes [Antolin et al. 2010, p. 88].

Cannon and Tonks [2013, p. 115] ran a simulation regarding four strategies: all equity, all bonds, 50% equity and a life cycle strategy where equities slightly fall as the participant ages. They used international data from various countries. The outcome is the median replacement rate and the risk is represented by the left 5% VaR of the distribution. They found that life cycle strategy is superior to fixed allocation strategies.

A simulation for Mexican data was made in 2014 by Gomez-Hernandez and Perez-Sosa [2014, p. 58]. They used the Mexican age-based default funds asset allocation as the strategies and ran a Monte Carlo simulation on the return of each investment group 10,000 times, calculating the replacement rates under assumptions of starting age, contribution period and contribution rates. The risk was measured as the left 5% VaR of the replacement rate distribution. Their results showed that dynamic life-cycle strategies with higher portion of equities, reducing towards the retirement, and investments in international markets were the winning strategies.

3.6 Summary and conclusion

This chapter includes the models and theories for handling risk and the simulation methods of pension portfolios. It is quite clear that for the purposes of handling extreme “catastrophes” that might cause the contributors to lose much of their accumulation, the classic measure of standard deviation for risk is not sufficient. VaR and CVaR seem much more appropriate for this purpose, and of those methods CVaR is better because it measures the negative tail itself and not only the point where it starts.

Monte Carlo simulation is preferred to historic simulation. "There are no rules for the exact number of bootstrap new samples to be used for academic research, but as a general guideline 1,000 new samples are often enough" [Wang 2012, p. 59]. Most researchers in the pension field use 5,000 to 10,000 random runs of the simulation, and it seems that the appropriate approach would be to run the bootstrap simulation 10,000 times. Analytical simulation is useful only for normal distribution and is not recommended for other distributions.

4. The research: methodology and results

4.1 The research methodology

In this thesis our main goal is to answer the following questions:

1. What are the most efficient investment strategies for the risky part of Israeli defined contribution pension plans, according to the mean return versus CVaR of returns?
2. What are the most efficient investment strategies for Israeli defined contribution pension plans, according to the mean versus CVaR of the net replacement rate of six biographies of participants differentiated by gender and income in an ideal world where continuous work and no withdrawal of severance pay is assumed?
3. What are the most efficient investment strategies according to the mean versus CVaR of net replacement rates, when contributors have two leaves from work and partly withdraw severance pay? What is the change in net replacement rates?
4. How are the results for net replacement rates and winning strategies affected if the basic assumptions are changed. In particular, we consider:
    a. early retirement of four years.
    b. different allocation of government earmarked bonds where contributors till the age of 50 will obtain no earmarked bonds at all.
5. What is the influence of different wage growth per gender and per decade of the work phase on the net replacement rates and on the absolute pension gap between genders? Is there any change in the winning strategies? What is the change if, in addition to different wage growth, different starting salaries are also assumed?

To answer to these questions a simulation is done on six biographies of participants differentiated by gender and income. For each gender three levels of income were chosen: the median salary in Israel, the average salary and the higher initial salary that is a typical salary for high tech employees. The Monte Carlo simulations were run 10,000 times and are based on the

pension providers' portfolios and the data of returns for January 1990 to March 2015. The method to answer these questions is:

- To answer the first research question, the simulation relates only to the risky investments. As will be explained, only 71% of the portfolio is invested in risky securities and the other 29% in risk free government earmarked bonds, cash and deposits. Each contribution is divided into risky investments (71%) and risk-free investment. The first simulation ran on a portfolio of 71% of the contributions, and per the returns of the risky investment groups. For each biography a mean and a CVaR of the distribution were calculated, based on 95% confidence level.
- To answer the second question relating to the replacement rate, the following steps were taken:
    - For each of the 10,000 results of accumulation that were simulated, the risk-free part of the contribution was added, and a new accumulation was calculated. The real return on the risk-free part of the contribution that was added is 0.95% quarterly. It was calculated by combining 0.4% annual return on cash and deposits and 4.8% annually on earmarked bonds.
    - Each accumulation was divided by the pension factor expected in 40 years for new joiners to obtain the size of the pensions after retirement. The factor is the average of the factor used by pension funds and the factor used by life insurance programs and is based on net present value (NPV) of monthly one NIS paid according to the life expectancy after retirement (in months) at a 3.74% annual interest rate, which is the rate determined by the regulator. The annuity is taxed per tax law in Israel.
    - The old age pension of the National Institute was added, and total income after retirement was calculated.
    - The total income after retirement was divided by the calculated net salary before retirement to get the net replacement rate.
    - From the distribution of 10,000 replacement rates, mean and CVaR were calculated for each strategy and biography. The CVaR is based on 95% confidence level.
    - Efficiency lines were drawn from the results, and the best strategies were found.

- To answer the other questions different scenarios were created, and all steps taken to answer the second question were taken again for each scenario. The scenarios and the results will be described later.

This subchapter describes the biographies, wage changes, the contributions rates for pensions, the way the portfolio for simulations was built, the data of returns, and the solution to correlation and autocorrelation problems. The second subchapter answers the first question and analyzes the results. The third subchapter answers and analyzes the second and third questions. The fourth subchapter describes the different scenarios of salaries of males and females and presents the results and the analysis of each scenario.

4.1.1 Biographies, wages and contribution

The average salary in Israel is around 9,000 NIS (in November 2015 it was 9,384 NIS and the average for 2014 was 9,373 NIS. In August 2018 the average salary was 10,329 NIS). The median salary was around 6,000 NIS in recent years (6,707 NIS in 2014 and 6,716 in 2015 and 7,452 in 2017). Engineers in high tech companies, researchers in bio-tech and pharmaceutical companies, good salesmen and experts in financial markets get paid in the first years around 15,000 NIS per month.

Minimum salary in 2014 was 4,300 NIS and in 2014 an agreement was achieved between the government and the unions (Histadrut) that it will be raised to 5,000 NIS. In 2018 the minimum salary rose again to 5,300 NIS. The first reason for not running simulation on minimum salary was that minimum earners did not have any pension savings till mandatory pension was operated in 2008. It was operated gradually and only in 2015 the contribution rates were close to the rates of regular pension. The meaning is that the accumulation of minimum earners was very small, almost meaningless, in 2014-2015. He second reason is that the results of minimum and median salaries should be very close. Tax calculations lead to a conclusion that both minimum salary and median salary are not taxed at all (only males with median salary should pay 17 NIS, 0.3% out of salary). National institute fees are the same percentage 3.5% for both minimum and median salary. The annuity will be exactly 5/6 from the median annuity. The only difference is the flat rate first pillar that will influence more on minimum salary earners and will bring a little higher

replacement rates for minimum salary earners. This will not affect the winning strategies or the conclusions, and hence a simulation of a minimum salary biography will result close to the results simulation of a median salary. Despite it, a simulation of minimum salary for females was ran in the scenario of gap between genders, and results proved what was assumed before. A simulation of minimum earners can be more affective in years to come and should be included in further research.

To examine the influence of the investment strategies on the accumulation before retirement, six biographies were chosen: males and females with a starting average of 6,000, 9,000 and 15,000 NIS per month.

The contribution period is different for males and females. Army service is obligatory, but females serve for two years and males for three years. Many young Israelis tend to work one year to save money for travels around the world and after that start their studies for 3-4 years. The age that they start the employment phase after graduation is around 26 for female and 27 for males. The official retirement age for males is 67 and for females 62 and was supposed to rise in 2018 to 64. It probably will happen in 2019 after the elections and establishing a new government. This means that the contribution period for males is 40 years and for females 38 years.

The data for wages, contributions and returns was analyzed on a quarterly basis since for a pension period of 40 years the resolution should be higher than monthly, but on a yearly basis there would not be enough data to analyze.

The model's assumption is a permanent employment period. Females after birth are entitled to full pension cover and full contribution for the period they cease working after giving birth, which is 15 weeks. If this period is extended, she should pay the contribution by herself. The model also assumes the consecutiveness of contribution. In reality, people sometimes do not contribute when they are on leave, and withdraw severance pay. Firstly, permanent employment and contribution will be examined and later these assumptions will be changed.

The model assumes a 0.17% quarterly real growth in salaries, according to the data for 1989-2014 published by the Central Bureau of Statistics (CBS) as described in Appendix 1.

The common contribution rate from 2017 is 20.83%: 6% employee, 6.5% employer and 8.33% employer for severance pay.

4.1.2 Pension portfolio

Pension providers in Israel are pension funds, provident funds and executive life insurance. Pension funds invest 30% of their assets in earmarked, non-traded government bonds bearing a 4.8% interest rate linked to the CPI. The rest is invested in capital markets. Provident funds and executive life insurance do not get earmarked bonds. According to the MOF, on 31 December 2014 the pension providers' portfolio was as described in Table 18.

Table 18. Pension portfolio 31 December 2014

	Pension Funds	Provident Funds	Life Insurance	Total
Cash and deposits	30,266	26,384	17,724	74,374
Earmarked non-traded bonds	279,207			279,207
Israeli government bonds	86,248	133,969	48,411	268,628
Corporate bonds	38,248	75,132	38,444	151,824
Private loans in Israel	18,287	14,715	13,419	46,421
Equities in Israel	36,626	40,837	28,930	106,393
Investments funds in Israel	3,318	4,161	3,249	10,728
Real estate in Israel	3,292	609	9,254	13,156
Foreign government bonds	608	1,872	622	3,101
Foreign corporate bonds	14,754	18,643	16,287	49,684
Private loans abroad	992	761	1,068	2,821
Foreign equities	75,078	43,357	42,524	160,959
Foreign investments funds	10,325	5,882	9,254	25,460
Foreign real estate	279	212	937	1,429
Structures	2,564	2,186	1,002	5,752
Total	600,091	368,720	231,126	1,199,936

Source: MOF- Director of Capital Markets and Insurance, 2015b.

All investments were gathered into four major groups of risky investments which constitute 71% of the portfolio, while the risk-free component (cash, deposits and earmarked bonds) is 29%. These major groups of the risky portfolio, excluding cash, deposits and earmarked bonds, are presented in Table 19, and from those groups was derived the distribution of the simulated portfolio.

Each contribution is divided into the risk-free element which consists of 29% of the whole contribution, and the risky element – 71%. The risky contribution is divided into four groups: 45%

to bonds (divided equally between government bonds and non-government bonds) and 26% to equities (62% of it to foreign equities and 38% to local equities).

Most investments in foreign equities are in equities that are traded in the USA. Many Israeli high-tech companies are traded on the NASDAQ, and Israeli pension providers invest in those companies and in international companies, mostly American. A part of the investments is invested directly in those companies and a part invested by the ETFS and mutual funds. Out of a representative portfolio of pension providers that have a majority of the market share, 81% of the international investments are in USD, and most of this is in American companies or indexes. The minority is invested in world indexes like the MSCI world and other regional indexes.

Table 19. Risky pension portfolio by groups of investments

	Pension funds	Provident funds	Life insurance	Total	Percentage
Government bonds	86,855	135,841	49,033	271,729	32.1%
Fixed income non-government assets	75,852	110,072	79,411	265,334	31.4%
Equities in Israel	39,944	44,998	32,179	117,121	13.8%
Foreign equities	87,966	51,426	52,780	192,172	22.7%
Total	290,617	342,336	213,402	846,356	100%

Source: Author's calculations.

4.1.3 Returns

This dissertation uses the data of returns during the period Jan 1990 - March 2015 to simulate the expected returns of the pension portfolios. Measurement of returns is done by relating the proper index to each group of the traded investments as follows:

- Three groups of government bonds are traded in the Tel Aviv stock exchange. The first group is of bonds that bear a fixed interest rate. The second group of bonds bears variable interest rates and the third contains fixed interest rate bonds which are linked to the CPI. Each group has its own index. Pension providers invest in all those groups, and so the proper index to reflect the return on government bonds is the general government bonds index (GB).

- Corporate bonds that are traded on the Tel Aviv stock exchange include a variety of bonds. All three groups of government bonds also exist in corporate bonds, but the bonds differ according to their own unique risk. They are ranked differently according to the specific bond risk factor. Since pension providers invest in all those groups, the proper index to reflect the return on corporate bonds is the general non-government bonds index (NGB).
- Other fixed income instruments include real estate, private loans and untraded corporate bonds. They tend to behave in the same way as traded fixed income investments. According to the regulations, pension providers should valuate every month the fair value of the untraded investments. The fair value is the net present value (NPV) of the bond/loan future cash flow and per a changing interest rate, published by a company that is nominated by the regulator. This means that the fair value is changed in a similar way to traded bonds. For that reason, all these investments were added to the non-government bonds group and are measured by the general non-government bonds index (NGB).
- Foreign fixed income investments include corporate bonds, foreign private loans and foreign real estate, and constitute a relatively small group. Its value is changed per the changes in interest rates. Today, the developed world's capital markets are open, and the interest rates in the USA, EU, Japan and Israel are very similar. A big difference causes capital transactions and influences currencies exchange rates. Since the value of any bond depends on the risk-free interest rate and the specific bond risk factor, and risk-free interest rates behave basically in the same way in the developed world, the change of price of foreign fixed income investments can be measured by the same factor as Israeli corporate bonds, i.e. the general non-government bonds index (NGB).
- Equities traded on the Tel Aviv stock exchange mainly include the big companies that are part of the TA100 index which contains the 100 biggest companies. Investments also include stocks of smaller companies. The index that was chosen for all equity investments in Israel, including untraded companies which constitute about 10% of the traded equities, is the General Index of Equities and Derivatives which includes all equities, warrants and convertible bonds traded on the Tel Aviv stock exchange (GE).

- As explained before, the American equity market is the most common foreign equity investment. The index that reflects the American market is the Standard and Poor 500 (SP). This index contains equities traded in NYSE and NASDAQ and is not narrow like the Dow Jones index.

Returns are measured in real terms, after reducing for inflation according to the Central Burau of Statistics [CBS 2015b]. Inflation in Israel till 1985 was very high (maximal rate was 400% in 1984), and after a stabilization program in 1985 inflation dropped to about 20% for the next five years, and to 10% for the next five years, and only from 1999 did it drop to a normal inflation rate of 1%-2%. The instability of inflation left no choice but to measure the real returns. The returns for January 1990 - March 2015 on a quarterly basis are introduced in Appendix 2.

4.1.4 Correlation and autocorrelation

Simulation of returns involves data taken from long periods of returns, and of some groups of investments: local equities, international equities, local bonds and international bonds, and there could be more types of investments. This might create two problems: cross correlation and autocorrelation.

Cross correlation is defined as correlation between returns of different classes of assets in the same period. It is well known in capital markets that equities and bonds are correlated, and off course local capital markets are much influenced by major capital markets such as Wall Street, Japan and Europe. Globalization has made the correlation much stronger than before.

A well-established solution to the cross-correlation issue is to use the block bootstrap method developed by Efron in 1979 [Wang 2012, p. 57-61]. The bootstrap became a very popular econometric technique. Finding the actual statistical parameters of a whole population, such as mean and variance, can be done by observing all of the population, which mostly is expensive and unrealistic, or by taking observations that cover a small portion of the population and estimating on this basis the parameters of the whole population. The law of large numbers suggests that the more observations are made, the closer the estimated parameters will be to the population parameters.

Bootstrap is a computer-intensive method that simulates much of the population. It is done by taking the empirical observed values and creating new samples by re-sampling it hundreds or thousands of times. Each of the new samples[19] contains values that were taken only from the original values, but an original value might appear a few times or not at all in a specific sample out of the many new samples. As a result, one obtains many empirical distributions and can calculate mean and variance for each of them. This method does not need a normal distribution assumption and can also be used in the case of a different distribution.

The autocorrelation problem is also familiar to everyone who makes use of Monte Carlo simulations. It is a time series correlation of the same values in different periods. For example, returns of equities in period t can be correlated with the return of equities in period $t + 1$ and so on.

This problem of cross-correlation and autocorrelation is solved by the moving block bootstrap technique [Wang 2012, p. 59-61]. The original data are divided into blocks of length *k*. The length should be not too short to capture most forms of time dependence and not too long that the number of blocks will be significant. Wang used blocks of 10 in data containing 108 periods.

The moving blocks in this example are *X1…X10, X2…X11* and so on. From that point on a simulation is made by acquiring the blocks many times and this method solves the autocorrelation problem and is needed only if autocorrelation does indeed exist. It also solves the problem of cross correlation and keeps cross sectional correlation within the block.

As was explained, it is obvious that there is correlation between government bonds and non-government bonds, between equities in Israel and the American equities market, and between equities and fixed income investments.

To overcome the problem a bootstrap method is used. The simulation randomly generates the quarterly returns. These results include the returns of all investment groups and not each group separately. In this way, the problem of correlation is solved.

To examine whether there is a problem of autocorrelation we have calculated the autocorrelation coefficients (ACF) and performed Ljung-Box tests. The results are presented in

[19]Example: the origin values are "1,6,5,9". The new samples can be: "1,1,9,5", 6,9,5,5","6,5,9,1" and so on.

Appendix 3. We assume that in all cases where the results of ACF test are equal or greater than 0.2, autocorrelation exits and need to be taken care of. According to the results no autocorrelation was found. Ljung-Box test p-values results for all the groups of investments were greater then 0.05, meaning it can't be assumed that the values are dependent.

4.1.5 Investments strategies

Fifteen strategies, presented in Table 20, of five types of strategies were chosen per the types that are common among researchers:

- Fixed strategies where the allocation does not change - three strategies.
- Dynamic life cycle strategies with linear decrease and a different starting percentage of equities - two strategies.
- Stepwise decrease in which the portfolio allocation is changed every few years - four strategies.
- Piecewise decrease with linear approach: The allocation does not change for the first period and only then decreases in a linear way - five strategies.
- Stepwise-shorter decrease in which the portfolio allocation is changed every few years, but portfolio must not contain any equities five years before retirement.

Table 20. Summary of all strategies

Strategy number	Type of strategy	Starting percentage of equities	First decrease point	Type of decrease
1	Fixed	80%	-	-
2	Fixed	50%	-	-
3	Fixed	30%	-	-
4	Linear	100%	-	Linear from starting point
7	Linear	80%	-	Linear from starting point
5	Stepwise	100%	Five years	Step each five years
6	Stepwise	100%	Ten years	Step each ten years
8	Stepwise	80%	Five years	Step each five years
9	Stepwise	80%	Ten years	Step each ten years
10	Piecewise	100%	Ten years	Linear
11	Piecewise	100%	Twenty	Linear
12	Piecewise	80%	Ten years	Linear
13	Piecewise	80%	Twenty	Linear
14	Piecewise	80%	Thirty years	Linear
15	Stepwise-Shorter period	80%	Five years	Step each five years. Ending point with no equities is five years before retirement.

Source: Author simulation.

All strategies must be with no equities at the retirement point. Strategy no. 15 must be with no equities five years before retirement. The decrease in the linear strategies and in piece wise strategies is done each quarter and calculated per the formula:

$$PD = \frac{\mathrm{EQP}}{\mathrm{QN}},$$

where:

PD = decreased percentage of equities,

EQP = starting equity percentage,

QN = number of quarters from the first decrease point to retirement.

In the stepwise strategies, the decrease is done each period (five or ten years) and is calculated with the same formula where the number of quarters is replaced by the number of decreases from starting point to retirement. A decrease every ten years on 40 years of accumulation means

four decreases, and if the starting point is 80%, this means that in the first 20 years the equities are 80%, the next 10 years 60% and so on.

4.1.6 Pension factors

The research is based on the current pension factors for pension funds and life insurance programs, presented in Table 21. At retirement the annuity is calculated by dividing the accumulation by the pension factors according to the gender and retirement age, where the factors represent life expectancy after retirement and where calculated assuming 3.74% interest rate. The factors are for a retirement age of 67 for males and 64 for females, and a birth year of 1990. These factors refer to a contract that includes survivors' insurance where the survivor is entitled to 60% annuity from the basic annuity for a lifetime and a minimum of 240 months annuities. The factors are:

Table 21. Pension factors

	Males	Females
Pension funds	204.8	211.83
Life Insurance	211.12	234.42
Average	207.96	223.12

Source: Clal Insurance 2016, Menora-Mivtahim 2016.

In an interview with the chief actuary of life and health insurance in the Direct Insurance Company in May 2017, she agreed that these factors represent the current future forecast of insurance companies, regarding the factor that will be effective 40 years from now. The increase in life expectancy is slowing and life expectancy 40 years from now is supposed to be seven years higher, compared to 10 years increase in the past 40 years. This is also confirmed by a UN research [2010] as its projection is similar to her updated data.

4.2 Efficient line of returns on risky investments

The efficient line is related only to 71% of accumulation which is invested in capital markets (bonds and other fixed income instruments, equities, derivatives) and is managed by private pension providers. The rest is invested in untraded earmarked bonds, cash and deposits with fixed

return, so there is no need for investment strategies. The question is what are the best investment strategies that pension managers should adopt. The efficient line is according to the mean IRR of the investment strategies compared with the CVaR of the IRR of the pension portfolios.

4.2.1 Results

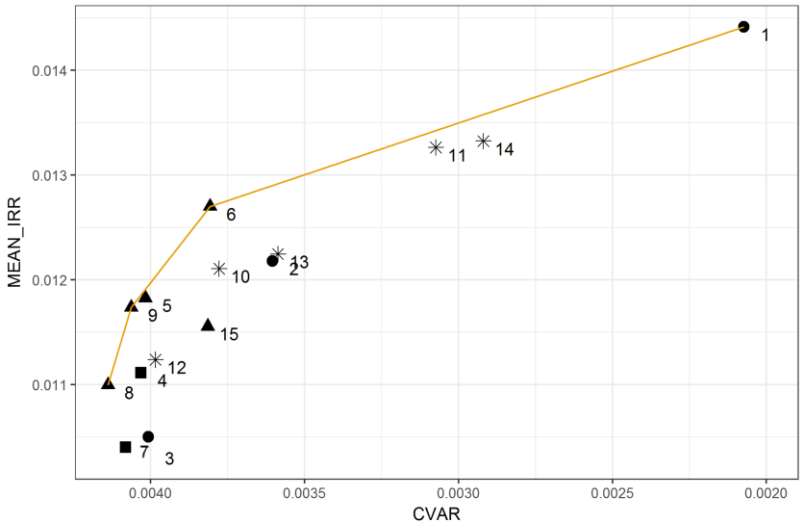
The only difference between the biographies of the same gender, regarding the first question, is the basic salary and so the results of the returns in percentages versus the CVaR in percentages should be the same. Also, the difference between genders is 40 years of contribution for males and 38 years for females. This means that there is no need to run the simulation of returns separately for each gender; the simulation of females could be derived from the first 38 years of the males' simulation of returns.

At first, six different simulations for six different biographies were run, and it was expected that the results would be a little different, but not significantly. This supposition was found to be true, and only one simulation could be chosen to represent the results of the efficiency line.

According to simulations that were made on pension portfolios in other countries and were described in chapter 3.4, the expected results for this part of the simulation are:

- Dynamic strategies are expected to give better results than static strategies.
- The best results are expected for portfolios that have a high portion of equities at the starting point and change to a fixed income in the last period of contribution, or gradually during the contribution period.
- A strategy of a fixed high portion of equities will provide a high mean, but also a low CVaR and will not match the desire to protect the elderly's portfolios.
- The starting salary should not make a difference to which strategy is superior.
- Results should be the same for males and females, since the contribution period is not much difference and other factors are the same.

The results of the efficiency line are in Figure[20] 18.



1-Fixed 80%, 2-Fixed 50%, 3-Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 18. Efficiency line of IRR for investment strategies

Source: Author's simulations.

In the graph, the horizontal axis was modified to reflect the efficiency lines according to Markowitz' theory. Efficiency lines graphs usually present the standard deviation (SD) at the horizontal axis as the factor of risk. Standard deviation is based on the difference between the real value and the mean value and has a straight relationship to the risk: the greater the SD, the greater the risk. That is the reason that the horizontal axis of SD values is going up from left to right.

CVaR represents the mean of the lowest results of the factor, IRR in this figure. A lower CVaR means high risk, and high values of CVaR represent low risk. To get a figure for the efficiency lines which look the same as Markowitz' efficiency lines, the x-axis values must go down from left to right.

[20] In the graphs fixed strategies are marked with circles round, linear with squares, stepwise and stepwise-shorter with triangles and piecewise with stars.

4.2.2 Analysis of the results

The results by strategy groups are:

- Fixed strategies where the allocation does not change proved to be inefficient and do not meet the target of reducing the risk for the elderly. Strategies no. 2 and no. 3 were inferior to other strategies that had higher returns with the same risk. The only fixed strategy that lies on the efficient line is no. 1 with 80% all along. This strategy has much higher risk than other strategies: CVaR is 0.201% compared to the next strategy that has a CVaR of 0.294%. This strategy does not meet the target of reducing the risk towards retirement.
- Dynamic life cycle strategies with linear decreases (no. 4 and no. 7) were also inefficient. They are not dangerous and had low risk (CVaR of 0.38%). On the other hand, these strategies did not produce enough returns (only 1%-1.1%), much lower than the 1.2% for stepwise strategies no. 5 and no. 9 that had the same risk.
- As for piecewise decreases with linear approach strategies, where the allocation does not change for the first period and only then decreases in a linear way: most of these strategies were not successful (no. 10, 12, 13) and had lower returns for the same risk compared to other strategies. Only two strategies of this kind lie on the efficient frontier or close to it: strategy no. 11 where the starting point is 100% in equities, no change for the first twenty years and no. 14 where the starting point is 80% in equities and no change is made for the first 30 years. Since these strategies produce very similar returns and risk it can be concluded that a higher percentage of equities at the starting point is equal to a lower starting point with a longer period of an unchanged portfolio.
- The strategy of having no equity at all five years before retirement (no. 15) was not useful and lies much below the efficiency line.
- Stepwise decreases in which the portfolio allocation is changed every few years is proven to be the best strategy. It was found that all strategies of this kind (no. 5, 6, 8, 9) lie on the efficient line.

To determine which strategy out of those lying on the efficient frontier was the best, the additional return divided by the additional risk was calculated. The results are presented in Table 22.

Where the return and risk of A are greater than B, according to the mean-variance rule it cannot be determined which investment is superior. In this case we need to use the coefficient of variation defined as the risk divided by the return, to measure the relative risk to returns as explained in subchapter 3.1.2.

Using the same formula is not possible in the case of mean return vs. CVaR of returns. As explained before, a higher CVaR means less risk. In order to reflect a relative parameter, the $factor$ of additional return divided by additional risk was used. The factor presents the same idea of a relative ratio of return to risk. Since additional risk means a negative change in CVaR the formula is:

$$factor = \frac{\Delta\, mean}{-\Delta CVaR}$$

If the $factor$ >1 it means that the added return is higher than the added risk,

If the $factor$ =1 it means that the added return equals the added risk,

If the 0< $factor$ <1 it means that the added return is lower than the added risk,

If the $factor$ <0 it means that the change of mean is in the opposite direction to the change of risk (such as higher return and lower risk), which is very unlikely situation.

Table 22. Relative added return compared to added risk

Strategy	Mean return	CVaR of return	Additional mean return	Additional CVaR of return	$factor$
8	1.11%	0.42%			
9	1.18%	0.41%	0.07%	-0.01%	9.21
5	1.19%	0.40%	0.01%	0.00%	1.84
6	1.27%	0.38%	0.09%	-0.02%	4.11
11	1.33%	0.31%	0.06%	-0.07%	0.77

Source: Author's calculations.

The meaning of the results is that strategy 6 is the best for investing the risky part of the pension portfolio. The starting point is 100% equities, reducing the equities in steps every ten years. The added return of strategy 11 is smaller than the additional risk.

4.3 Efficient line and values of net replacement rate

After finding the efficiency line of strategies for the risky part of the accumulation, the next step is to find it for replacement rates that represent the ability to maintain the living standards of the working period after retirement. The replacement rate calculation combines the risky accumulation with the risk-free accumulation and the National Insurance old age pension. Since the calculation is made on net annuity and net salary, as well as tax, National Insurance fees and contribution rates are taken into consideration.

It is expected that the same strategies which dominated the efficiency line of the IRR will also be the successful strategies for the efficiency line of the replacement rates. The factors of the replacement rate are:

- the gross salary,
- tax rates on salary,
- national insurance fees on salary,
- contribution rates,
- management fees and contribution fees,
- accumulation of risky portfolio,
- accumulation of risk-free portfolio,
- pension factor,
- tax rates on pension,
- national insurance old age pension.

Besides the accumulation of the risky portfolio, which was analyzed in the previous sub-chapter, all the other parameters are exogenous to the investment policy of the risky portfolio and are not influenced by investment strategies. Hence, it is expected that the winning strategies will not be changed. The only reasonable change can be that a riskier strategy out of the winning

strategies will be the dominant one, since the risk-free accumulation and old age pension that are taken into account are risk free.

It is expected that the replacement rates for males will be higher than those for females, since males contribute more years than females, and get a pension for a shorter period due to the higher life expectancy of females.

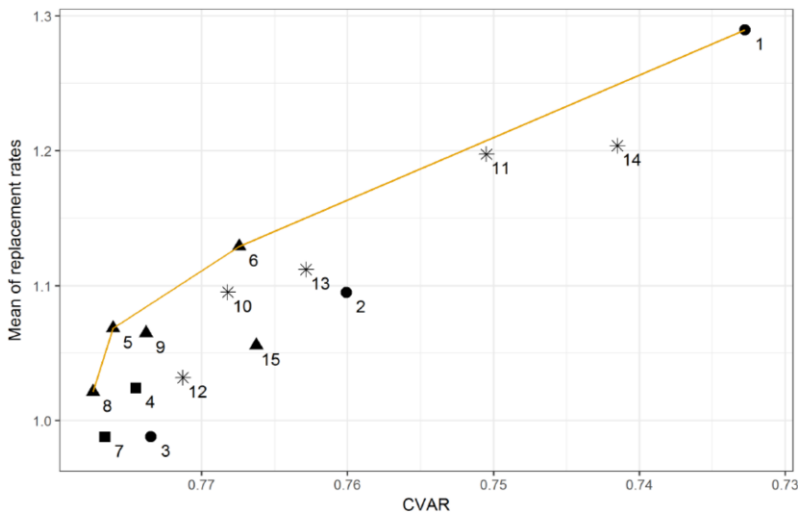
Income tax and the national insurance old age pension should have the following influence on the replacement rates.

- The old age pension is very significant for low earners and can be around 50% of the total income after retirement, and mostly the salary and the annuity are free of tax or only a little tax is paid.
- Higher earners pay tax and national insurance fees on salaries, and hence the net salary is around 70%-80% of the salary. On retirement, they get the National Insurance old age pension and do not pay national insurance fees. Tax is much reduced, since the annuity has a tax-free amount of 4,106 NIS per month and only the rest is taxable.

It is expected that the replacement rates of low earners will be the highest and they will be reduced as the income rises. I suspect that for very high earners the replacement rate will rise again due to significantly reduced income tax, but this is not examined in this research.

4.3.1 Results

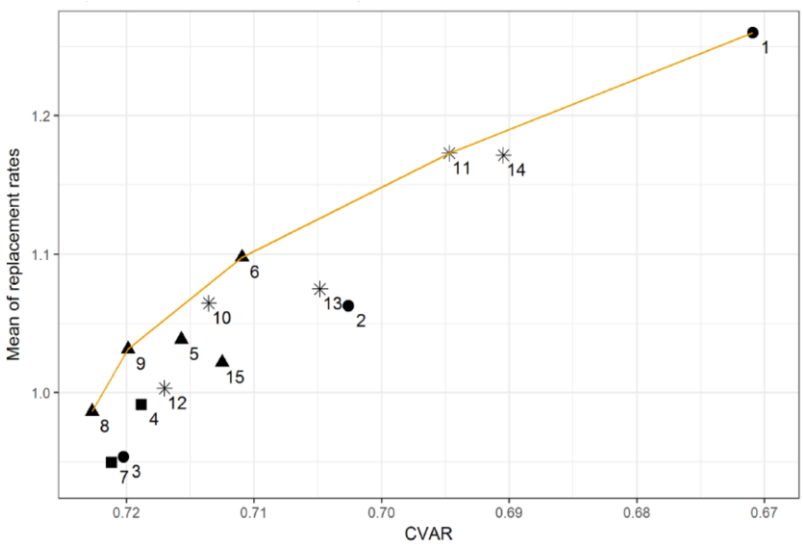
Figures 19-24 contain the efficiency lines for all biographies based on the simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- inear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 19. Efficiency line of replacement rate: a female with salary of 6,000 NIS

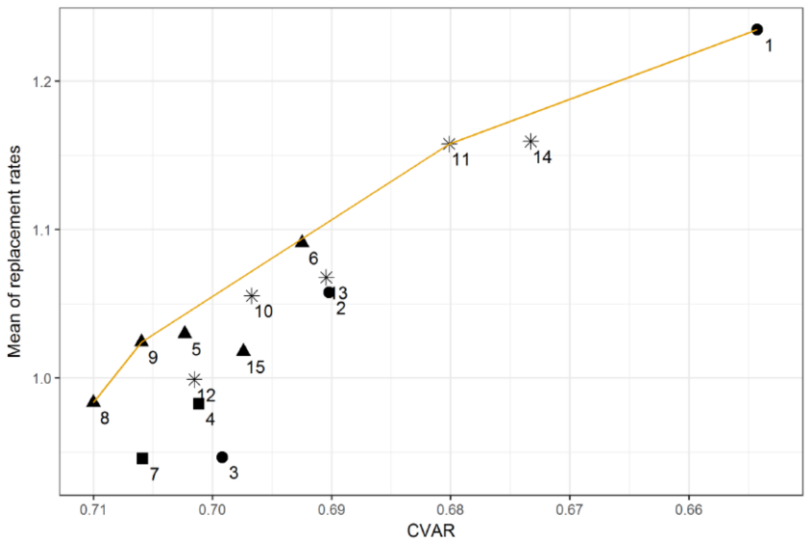
Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 20. Efficiency line of replacement rate: a female with salary of 9,000 NIS

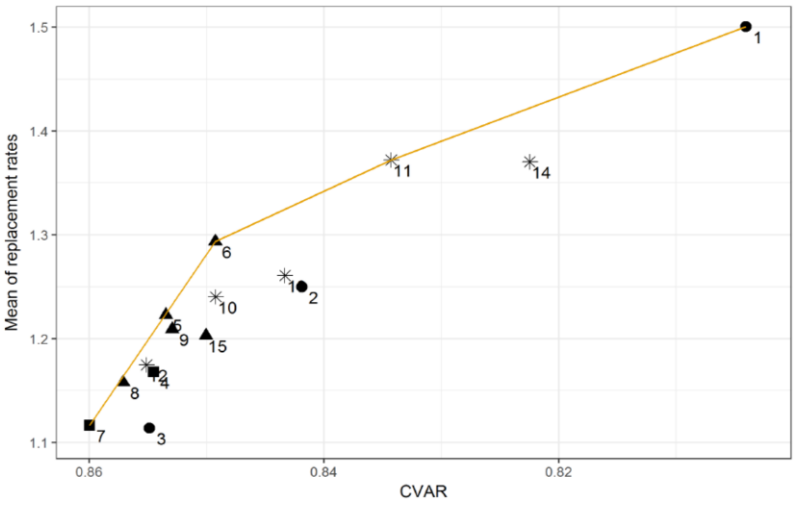
Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 21. Efficiency line of replacement rate: a female with salary of 15,000 NIS

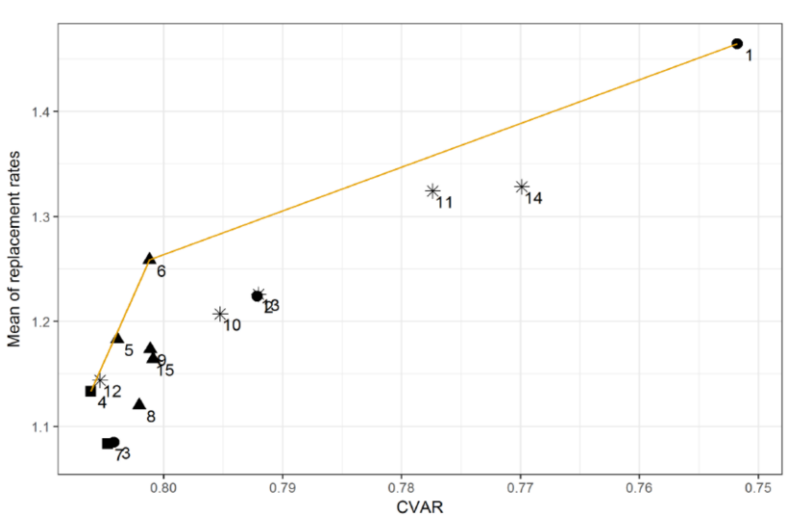
Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3-Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 22. Efficiency line of replacement rate: a male with salary of 6,000 NIS.

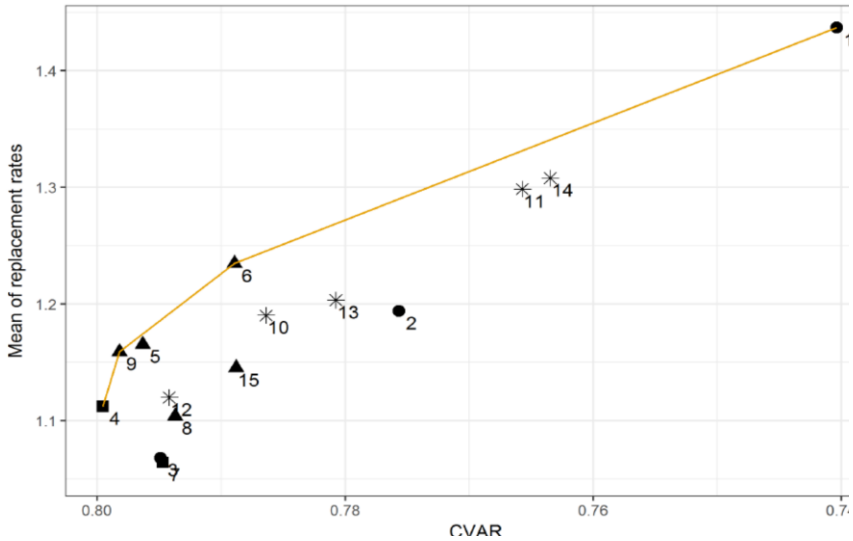
Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 23. Efficiency line of replacement rate: a male with salary of 9,000 NIS

Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3-Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 24. Efficiency line of replacement rate: a male with salary of 15,000 NIS

Source: Author's simulations.

4.3.2 Analysis of the results

As expected, the efficiency lines of replacement rates were similar to the efficiency line of IRR, and the same strategies continued to dominate. The changes were not in the shape of the efficiency line or the winning strategy, but in the values on both axes.

Another small change is that the earlier strategy 11, which was on the line, is now a little below the line, but very close to it. The line continues and connects strategy 6 to 1, which is constant 80% equities and has a high risk. Strategy 1 does not match the needs, since the target is to reduce the risk of losing accumulation close to retirement, while strategy 1 is a fixed strategy where the rate of equities remains constant and high. Ignoring strategy 1 leads to an efficiency line connecting strategy 6 with strategy 11, that is considered efficient, and will be examined compared to strategy 6.

Determining the best investment strategy, as was done in the previous subchapter, produced a change, that the strategy 11, which is riskier, became the best choice for all biographies as can be seen in Table 23. Strategy 11 has a starting point of 100% equities, remains fixed for 20 years and then the share of equities declines linearly to no equities on retirement point. This result is the same as Antolin at al. had in similar research on a global portfolio [Antolin et al. 2010, p. 88].

The results show that for low earners taking a riskier strategy is more profitable than for high earners, since the ratio of added mean to reduced CVaR is greater for low earners. The highest replacement rates were, as expected, for low earners in both strategies.

The explanation is that the income after retirement is based on three components: the accumulation of the risky part; the accumulation of the risk-free part and the flat rate National Institute old age pension, which is also risk-free.

The risky part can be 50%-70% of the annuity, depending on the salary. Hence, taking more risk to get a better replacement rate is reasonable, considering that a significant portion of the income after retirement is risk-free.

Table 23. Relative added mean replacement rate compared to reduced CVaR of replacement rate

Biography	Strategy	Mean replacement rate	CVaR of replacement rate	Change of mean	Change of CVaR	$factor$ relative additional mean / additional risk
F 6000	6	1.14	0.77			
	11	1.20	0.76	6.55%	-1.53%	4.28
F 9000	6	1.10	0.71			
	11	1.16	0.70	6.35%	-1.66%	3.83
F 15000	6	1.08	0.69			
	11	1.14	0.67	6.10%	-1.87%	3.26
M 6000	6	1.28	0.84			
	11	1.35	0.82	6.84%	-1.67%	4.09
M 9000	6	1.24	0.79			
	11	1.31	0.77	6.51%	-1.82%	3.59
M 15000	6	1.22	0.78			
	11	1.29	0.76	6.35%	-2.02%	3.14

Source: Author's calculations.

The replacement rates in this research are much higher than the Israeli rates of 0.75 M/0.67 F according to OECD research [2017]. The target replacement rate in the literature is around 0.8 due to the retirement consumption puzzle that was discussed in the first chapter. The results of this research are around 1.1 for females and 1.25-1.3 for males. One of the major reasons is the assumption of continued work and that severance pay is not withdrawn. This assumption will be changed in the next simulation, and the other reasons will be discussed.

4.4 Replacement rates – scenario with temporary joblessness and withdrawal of severance pay

4.4.1 The scenario

The model assumes a continuous employment period, continuous contributions and that the employee does not withdraw the severance pay at any time. These assumptions are not a reality for part of the population that is sometimes jobless, and hence the

replacement rate for them is lower than the theoretical model. A lifetime job still exists for government employees and in big corporations, but most employees in the private sector change their employer more than once.

The unemployment rate in Israel in 2016 was low, only 4.6%. Data on unemployment [CBS 2016] suggests that around 200,000 were jobless. Out of the jobless 62% were laid off and 24% resigned. Out of the jobless 53% were over 45 years of age. The difficulty for those above 55 in finding employment is especially true for the uneducated population, with much higher unemployment rates, and for females who have higher unemployment rate than males at all educational levels [Kimhi and Shraberman 2013, p. 161].

The unemployed mostly tend to withdraw the severance pay. No official data exists, but newspaper articles, based on data from pension providers, suggest that around 40% of the severance pay accumulation is withdrawn. Those who are young or have a low salary tend to fully withdraw the severance pay. The mid-high earners at older ages tend to partially withdraw the severance pay and withdraw other savings first [Amstradamsky 2012b].

Based on strategy 11, the simulation will assume an unemployment period of three months after 13 years of employment (age of 40 for males, 39 for females). In the unemployment period, no contribution is made, and all severance pay accumulation are withdrawn. After 28 years of employment (age of 55 for males, 54 for females) the unemployment period is six months, no contribution is made, and the withdrawals of severance pay is equal to an amount of a yearly last net salary before the unemployment period of six months. The withdrawal is higher than six months net salary since the decision must be made when becoming unemployed, to get tax benefits, and at this point, it is not certain when one will be hired again. A new job is at the same salary level as before the unemployment period. Severance pay accumulation is 40% of the accumulation and will be divided in such a way: 71% from the risky portfolio and 29% from the risk-free portfolio.

4.4.2 Results

The results show, as expected, a sharp decline in replacement rates, and the high theoretical replacement rates move closer to the actual replacement rates. The decline is mostly around 23% in the mean and CVaR, as can be seen in Table 24.

Table 24. Replacement rates: scenario of temporary joblessness and withdrawal of severance pay based on strategy 11

Biography	Mean replacement rates		CVaR of replacement rates	
	Continues work. No withdrawals	Temporary joblessness. Two withdrawals	Continues work. No withdrawals	Temporary joblessness. Two withdrawals
F 6000	1.20	0.92	0.76	0.61
F 9000	1.16	0.88	0.70	0.55
F 15000	1.14	0.88	0.67	0.52
M 6000	1.35	1.05	0.82	0.68
M 9000	1.31	1.01	0.77	0.61
M 15000	1.29	1.00	0.76	0.59

Source: Author's calculations.

The results show that the change in this scenario is not dependent on the biography. All biographies have the same change in replacement rates. The results of this scenario are still higher than the replacement rates for Israel, 0.75 males and 0.67 females, found by OECD research [2017].

There are the following reasons for the gap:

- The mandatory pension was established in Israel in 2008. Until then part of the population had only the National Institute old age pension. The real replacement rate in Israel today takes into account also this part of the population.
- The pension portfolio in Israel is conservatively invested. The average portion of equities is around 30%-35% in the last decade, and in the past used to be around 20%. Since 93% of the pension accumulation is in the general fund, which has a

fixed investment policy, the strategy that reflects the current portfolio is no. 3: fixed 30% equities. Replacement rates simulated by strategy 11, which is the most efficient, compared to the replacement rates according to strategy 3, which is the most common in Israel, are represented in Table 25.

Table 25. Replacement rate according to strategy

Biography	Mean replacement rates		CVaR of replacement	
	strategy 11	Strategy 3	strategy 11	Strategy 3
F 6000	0.92	0.78	0.61	0.63
F 9000	0.88	0.73	0.55	0.57
F 15000	0.88	0.72	0.52	0.54
M 6000	1.05	0.87	0.68	0.69
M 9000	1.01	0.83	0.61	0.63
M 15000	1.00	0.83	0.59	0.61

Source: Author's calculations.

As can be seen, the current investment strategy is much inferior to the recommended one. Using a different strategy can raise the replacement rates by 20%-25% with the same risk. This explains the high rates that were found in this research, and the gap to the current replacement rates according to the OECD report. The average real annual return in years 1993-2016 was 3.95% of the general fund, while the annual return according to the simulation of strategy 11 is 5.47%.

- The contribution rates rose in 2016 and 2017 and are now 20.83% of the salary compared to 18.33% before. Compared to the average contribution rates of the OECD countries, the contribution rates of the model are much higher as demonstrated in Table 26 that also includes the contributions for pensions in public plans, and in Israel includes the rates for pensions included in the National Insurance Institute fees.

Table 26. Contribution rates in OECD countries

Country	Contribution rates - public pension plan	Contribution rates - private pension plan	Total contribution rates
Australia	9.50%		9.50%
Belgium	16.36%		16.36%
Canada	9.90%		9.90%
Chile		12.30%	12.30%
Denmark	1.36%	12.00%	13.36%
Finland	24.80%		24.80%
France	15.25%	6.00%	21.25%
Germany	18.90%		18.90%
Iceland	7.80%	12.00%	19.80%
Japan	17.50%		17.50%
Korea	9.00%		9.00%
Luxemburg	16.00%		16.00%
Mexico		6.28%	6.28%
Netherland	4.90%	16.00%	20.90%
New		6.00%	6.00%
Poland	19.50%		19.50%
Sweden	18.40%	4.50%	22.90%
Switzerland	8.40%	18.10%	26.50%
Turkey	20.00%		20.00%
Average	**13.60%**	**10.35%**	**16.36%**
Israel 2017	**7.50%**	**14.58%**[21]	**22.08%**

Source: OECD 2015, p. 177.

On the other hand, in reality, part of the population, including the middle class, saves for a pension by buying real estate with a mortgage during the work period then renting it. In the pension period they have income from rental fees, free of tax, without a mortgage that they have already paid. It makes the real replacement rates higher than the model, and partly balances the other factors that make the replacement rates of the model higher than the reality.

[21] 20.83%·70%=14.58%.

4.5 Replacement rates – scenario of early retirement

4.5.1 The scenario

This scenario is based on the former scenario which includes two leaves and partial withdrawal of severance pay and is based on the efficient strategy 11. Early retirement, especially during the four to five years before the official retirement age is not rare. According to research [Ahdut and Gharrah 2008], about 12.4% of females and 29.5% of males defined themselves as retirees in the period of five years prior to the official retirement age.

This scenario examines the influences of early retirement of four years on the replacement rates and the chosen investment strategy.

It is expected that early retirement will reduce the replacement rates since : (a) the work period is shorter and the retirement period is longer; (b) accumulation is not growing since no contributions are made and no return is added to the portfolio from retirement point.

Early retirement has an extra problem for retirees during the early retirement period. In this period, regular tax is paid, and tax benefits to annuity are not given. National Institute insurance fees must be paid, and the National Institute old age pension is not paid. Hence, during this period the replacement rates started to sharply decline, especially for low earners.

4.5.2 Results

As can be expected, the replacement rates declined in the scenario of early retirement. The mean replacement rates declined by 0.1-0.14, which is about 10%-15% of the normal retirement replacement rates. As can be seen in Table 27, the low earners have better replacement rates than the high earners due to tax on annuity and the flat rate old age pension. The replacement rates are still high, due to high contributions in the work period, and are still more than needed according to pension theory for males, and a little lower than needed for females.

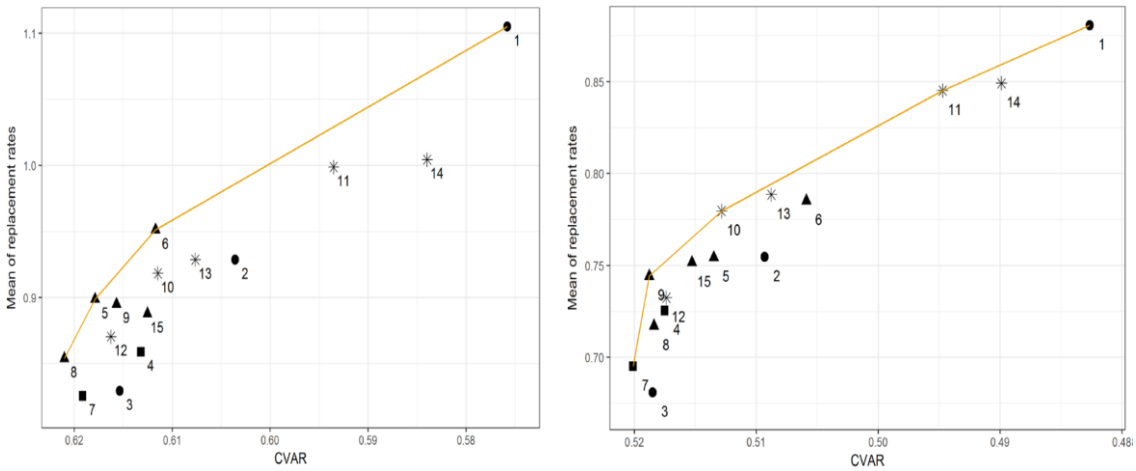
Table 27. Replacement rates of early retirement scenario- strategy 11

Biography	Mean replacement rates			CVaR of replacement rates		
	Retirement at retirement age	Early retirement of four years – at the retirement age	Early retirement of four years – during four years	Retirement at retirement age	Early retirement of four years –at retirement age	Early retirement of four years – during four years
F 6000	0.92	0.82	0.45	0.61	0.55	0.19
F 9000	0.88	0.77	0.49	0.55	0.47	0.22
F 15000	0.88	0.75	0.52	0.52	0.43	0.25
M 6000	1.05	0.91	0.53	0.68	0.60	0.25
M 9000	1.01	0.89	0.59	061	0.52	0.26
M 15000	1.00	0.88	0.62	0.59	0.48	0.30

Source: Authors' simulations.

The replacement rates in the period between early retirement and the official retirement age declined sharply to very low levels below 0.5. The reasons are that tax is fully paid without any benefits, National Institute fees are paid, and the old age pension is not paid. If the retirees received any funds for early retirement, such as is done in big corporations and in government for low rated employees, then these funds help them overcome the four years period without a sharp decline in their living standards. Otherwise, they must work in a different occupation during this period and finding a new job at the age of 60 is usually difficult.

The CVaR replacement rate is around 0.3 lower than the mean. During the four years of early retirement till the official retirement age, the CVaR is very low and has a critical value of 0.2-0.3. Comparing the CVaR with the mean, it can be seen that the risk is relatively higher than at other periods, and the retirees might find themselves with an income of 20%-30% of their previous income before retirement. With a replacement rate of 0.5-0.6 one might get used to a lower standard of living, but it is not likely to be able to live with an income of 20%-30% of the income before retirement, where the risk becomes a reality.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 25.Comparison of efficiency line of replacement rate, regular retirement (left) and early retirement (right): a male with salary of 15,000 NIS

Source: Author's simulations

The winning strategies were not changed, and the piecewise strategies remained dominant. However, as can be seen in Figure 25, strategy 11 is now on the efficiency line, with a higher mean of return and a lower CVaR. which means it is now more dangerous than in the scenario of normal retirement at retirement age. The conclusion is that the best strategies are riskier on early retirement. The main reason is that early retirement is not planned in advance but is a sudden change for a strategy that was built for normal retirement. The portfolio still contains equities, and on average for all the contribution period it is riskier than the portfolio of normal retirement.

4.6 Replacement rates – scenario of different allocation of government earmarked bonds

Earmarked government bonds are issued only to pension funds, and not for provident funds and executive life insurance that have no government support or subsidy. These bonds are linked to the consumer price index and bear a 4.8% interest rate. In reality, where the interest rates are low it reflects an annual subsidy of 4.3billion NIS [MOF Accountant General 2017b, p. 16].

The earmarked bonds are flatly allocated to pension funds, in a way that 30% of each portfolio is allocated in earmarked bonds, regardless of age of a person (including current pensioners).

The calculation of annuity is based on an assumption that the future real return on the part of the pensioners' portfolios that is not allowed to be invested in equities will be 3.74%. The low returns on government bonds (0.1% yield to maturity for short bonds till 1.6% for 10-year bonds in December 2017) make it impossible to reach the target, and hence the current contributors have to subsidy the pensioners. The number of pensioners in pension funds is expected to increase in the future, and the problem is expected to be more significant.

To solve the problem, the Ministry of Finance [MOF 2017] decided to change the allocation. According to the new allocation, the pensioners' portfolios will include 60% of earmarked bonds, portfolios of those aged 50 till retirement will have 30% earmarked bonds out of portfolios, and the portfolios of contributors up to the age of 50 will not have any earmarked bonds at all. The idea is that young contributors can invest more in equities to create returns, while pensioners are limited to solid investments in order not to lose the accumulation.

4.6.1 The scenario

This scenario is based on the former scenario which includes two leaves and partial withdrawal of severance pay and is based on strategy 11. The scenario will examine the

effects of the change on replacement rates. According to the scenario, contributors to pension funds only until the age of 50 will have 0% earmarked bonds and from the age of 50 till retirement – 30% earmarked bonds. Contributors to provident funds and executive life insurance are not entitled to any earmarked bonds at all. According to the scenario and the portfolios of all pension providers in Israel, the portfolios of persons below the age of 50 will have a risk-free portion of only 6% of the portfolio, mainly cash and deposits, bearing a return of only 0.1% quarterly and the rest of the portfolios will be invested in capital markets according to the strategies of this research. From age 50 till retirement the allocation will change to 29% risk-free portion with 0.95% quarterly return, and the rest invested in capital markets according to the strategies.

This means that the portfolios will have a much lower risk-free portion than before the change. It is expected that the mean replacement rate will be higher, but the risk should be higher as well. It might cause the leading strategy to change to less risky, since a greater portion of the portfolio is invested in risky assets.

4.6.2 Results

Table 28 compares the results of this scenario with the basic scenario, both according to strategy 11, in which for all contributors to pension funds, regardless of their age, 30% of the portfolio is in earmarked bonds. As expected, the replacement rates were higher in this scenario than in the former one, and so was with the risk. The change of mean replacement rates was from 0.04 to 0.06 and the decline of CVaR replacement rates was also from 0.04 to 0.06.

Table 28. Replacement rates of different allocation of earmarked bonds

Biography	Mean of replacement rates		CVaR of replacement rates	
	30% all ages	No allocation till age of 50. Allocation of 30% of portfolio in ages 50-retirement	30% all ages	No allocation till age of 50. Allocation of 30% of portfolio in ages 50-retirement
F 6000	0.92	0.97	0.61	0.57
F 9000	0.88	0.94	0.55	0.51
F 15000	0.88	0.93	0.52	0.47
M 6000	1.05	1.11	0.68	0.63
M 9000	1.01	1.07	061	0.56
M 15000	1.00	1.06	0.59	0.54

Source: Authors' simulations.

Replacement rates are, as in the former scenario, higher for low earners than high earners due to the flat rate old age pension and tax-free annuity. Comparing strategies 6 and 11 suggests that moving to strategy 6 will increase the CVaR by 0.01 to 0.02 but will reduce the mean replacement rate by 0.05 to 0.07 base points. This means that there is no change in the winning strategy, and strategy 1 is still superior.

4.7 Replacement rates – scenario of temporary joblessness, withdrawal of severance pay and a different change in wages per age and gender

Redistribution, to reduce gaps in the pension period, is considered one of the most important objectives of the pension system according to pension theory. The next two scenarios will examine the gap between genders, and the influence of redistributive elements on this subject. The winning strategy will be examined too, but since no change is expected in the winning strategy the focus from now on will be on the gap between genders. The gap will be examined in absolute pensions and salaries in NIS and in the relative factors of replacement rates. The main question is whether the system, during

the retirement phase, reduces the gaps that were created during the work period or whether the gaps continue to grow.

All the scenarios considered here are based on the former ones that include two leaves and withdrawals of severance pay.

4.7.1 The scenario

Research by the National Insurance Institute [Rozenberg 2015, p. 194] suggests that the changes in wages are not constant over the employment period but different by age group and gender. It is very high for the first 10 years, much lower in the next 10 years and very low or frozen in last 10 years, as can be seen in Table 29. The table is based on the average salary of 2013 by gender and age group.

Table 29. Growth rates of wages by age group and gender (percentages)

Age group	Males	Females
25-34	69.04	41.19
35-44	9.74	6.29
45-54	3.89	0.19
55-64	3.45	0.19

Source: Rozenberg 2015, p. 194.

Out of this data the quarterly growth rates are calculated as follows in Table 30.

Table 30. Quarterly growth rates of wages by age group and gender (percentages)

Age group	Males	Females
First 10 years	1.32	0.87
Nest 10 years	0.23	0.15
Nest 10 years	0.10	0.005
Nest 10 years	0.08	0.005
Average	0.43	0.26

Source: Author calculations

These rates of 2013 data present a gap of 69% in the average growth rate. A cross check on the same data from 2003 [National Insurance Institute 2003] was made and calculations showed that the average quarterly wage growth of males is 57% higher than

females, which shows that the gender gap of growth rates of salaries is continues. These are different than the growth rates of average salaries of the whole period of 1989-2014 of 0.17% quarterly, but they reflect the difference in growth rates of salaries per age and gender.

The aim of this scenario is to examine the influence of different growth rates of salaries per age and gender on replacement rates. The scenario includes higher growth rates in the first period of employment, and a much higher growth rate for males compared to females. The result is higher salaries at retirement compared to the previous scenario. It is expected that pensions will improve absolutely for all biographies, but much more for males than females. It is also expected that the winning strategies on efficiency lines will not change.

4.7.2 Results

As expected, the pensions of all biographies according to strategy 11 improved, and those of males improved much more than females as demonstrated in Table 31. This means that the gap between genders expanded and reflected the higher improvement rate of the males' incomes compared to the females' income. The gap that was 14% when salaries growth rate was identical, and with the change of the basic assumption grew to 29%.

Table 31. Change of total pension in NIS including National Institute old age pension

	Constant growth rate of salaries. Same rate for males and	Variable growth rate of salaries. Different rate for males and females	Rate of change	Gap (%)- same growth rate	Gap (%)- different growth rate
Biography	**Total pension**	**Total pension**			
F 6000	6,220	7,115	14%		
F 9000	8,242	9,503	15%		
F 15000	12,121	14,011	16%		
M 6000	7,046	9,146	30%	13%	29%
M 9000	9,404	12,293	31%	14%	29%
M 15000	13,763	18,110	32%	14%	29%

Source: Author's calculations.

Replacement rates were higher for females and smaller for males. The reason is that pensions above 11,000 NIS are taxable, and the last salary for males grew more than the pensions due to tax on pensions. Based on strategy 11, females had a small increase in replacement rates as demonstrated in Table 32.

Table 32. Replacement rates

Bi	Mean replacement rates		CVaR of replacement rates	
	Constant growth rate of salaries. Same rate for males and females	Variable growth rate of salaries. Different rate for males and females	Constant growth rate of salaries. Same rate for males and females	Variable growth rate of salaries. Different rate for males and females
F	0.92	0.93	0.61	0.61
F	0.88	0.90	0.55	0.55
F	0.88	0.91	0.52	0.55
M	1.05	0.97	0.68	0.61
M	1.01	0.97	0.61	0.59
M	1.00	0.96	0.59	0.59

Source: Author's calculations.

The strategies on the efficiency lines were the same as in the previous simulations. Strategy 11 is still the preferred one.

4.8 Replacement rates - scenario of different change in wages and a different starting wage by gender, including leave and withdrawal of severance pay.

4.8.1 The scenario

This scenario follows the previous one and concentrates on gender differences. It is calculated according to strategy 11.Till now this research assumed that starting wages for males and females are the same. The statistical data for 2016 [CBS 2016] and the research [Rozenberg 2015, p. 21] approve that the wages of females are 67% of male wages. Most of the gap is due to the increased working hours of males, and per hour the males' wages are 20% more than females' wages.

The scenario will assume no change in the starting wages of 6,000, 9,000 and 15,000 NIS for males, but only 5,000, 6,000 and 10,000 NIS for females. The 5,000 NIS wage for low earner females is higher than the 67% proportion since the minimum wage is 5,000 NIS. The increase in wages is according to the previous scenario demonstrated in Table 30.

Research of National Institute [Rozenberg 2015, p. 188] suggests that 76% of females earn less than the average gross salary, and 56% of them earn less than median gross salary. According to the assumptions in this scenario the gender gross salary gap after 38 years of work for average and above earners will be 94%, and for median salary earners 55%, which means that total gender gap of last salary in 72%. Net gap is smaller due to higher taxes and National Institute fees. Calculation of the gender gap of last net salary suggests that the gap for average earners is 66% and for median earners 50%. The total gender net gap of last salaries is 57%. It is assumed that the gap will grow more during pension phase.

4.8.2 Results

The lower beginning salary of females reduced much of their pension while the males' pension was not changed. The gap between the genders, based on strategy 11, grew as can be seen in Table 33.

Table 33. Total pension of all biographies in all scenarios in NIS

Biography	The same growth rate and same starting salary	Different growth rate and same starting salary	Different growth rate and different starting salary	Gap (%)- same growth rate	Gap (%)- different growth rate	Gap (%)- different growth rate and different starting salaries
F 6000/5000	6,220	7,115	6,401			
F 9000/6000	8,242	9,503	7,459			
F 15000/10000	12,121	14,011	10,956			
M 6000	7,046	9,146	9,146	13%	29%	43%
M 9000	9,404	12,293	12,293	14%	29%	65%
M 15000	13,763	18,110	18,110	14%	29%	65%

Source: Author's calculations.

For most females' biographies the pensions in this scenario are lower than the pensions of the basic scenario (equal starting salaries, equal and constant growth rates of salaries), besides the lower level of salary that was reduced a little due to the minimum salary. The results prove that the beginning salary is crucial and is more important than the growth of salary during the employment period. Females suffer from both parameters: the females' starting salary is lower than males' one, and the rate of growth of salaries is half of the males' rate. The gender gap few more during pension phase compared to work phase.

Replacement rates were not changed much from previous scenarios, as can be seen in Table 34.

Table 34. Replacement rates in all scenarios

Biography	Mean			CVaR		
	The same growth rate and starting	Different growth rate and same starting salary	Different growth rate and starting salary	The same growth rate and starting salary	Different growth rate and same starting salary	Different growth rate and different starting salary
F 6000/5000	0.92	0.93	0.95	0.61	0.61	0.64
F 9000/6000	0.88	0.90	0.93	0.55	0.55	0.61
F 15000/10000	0.88	0.91	0.90	0.52	0.55	0.55
M 6000	1.05	0.97	0.97	0.68	0.61	0.61
M 9000	1.01	0.97	0.97	0.61	0.59	0.59
M 15000	1.00	0.96	0.96	0.59	0.59	0.59

Source: Author's calculations.

It is clear that the replacement rates of males are higher than females' in all scenarios. The high growth of males' salaries in the last two scenarios reduces the replacement rates, even though the pension is higher. Since the females' pension in this scenario is lower than the scenario with equal starting salary and equal growth of salaries, replacement rates were a little higher than the first scenario.

5. Conclusions

Defined contribution (DC) pension funds invested in capital markets are one of the major pension instruments. Much research in the pension field is aimed at solving the scientific problem of finding the efficient investment strategies in DC plans in order to obtain better mean replacement rates and at the same time to reduce the risk to portfolios, especially of the elderly, from an extreme market crash. This research issue is at the heart of pension theory that seeks to improve replacement rates and bring them as close as possible to the desired replacement rates according to pension theory. Researchers have tried to find the recommended strategies in different countries, using simulations as the main research method. Research of this kind was never conducted before in Israel. The aim of this research is to solve the main scientific problem: what are the efficient investment strategies that will lead to a better mean of net replacement rates in Israel and at the same time protect the elderly's portfolios from a market crash?

This thesis solved the scientific problem by using the advanced scientific method of Monte Carlo simulations, and by using CVaR as the risk factor, a technique that is quite new in this research field. CVaR and VaR are better measures of risk than standard deviation for non-normal distribution and are better fitted to measure the risk of extreme crashes. CVaR is better in assessing the risk of heavy tail distribution since it also takes into account the values left to the VaR and it is a coherent measure of risk. Most researchers have chosen to work with VaR and choosing CVaR in this work is a relatively new approach to this kind of research.

The method was to run 10,000-time Monte Carlo simulations for each of six biographies, using 15 different strategies: fix allocation, stepwise strategies, linear strategies and piecewise strategies. The biographies were males and females with starting salaries of the median salary, the average salary and the typical starting salary for the high-tech industry. A minimum salary biography was not simulated, due to the reasons that were explained in the introduction and in chapter four.

Israel adopted the age-based default model in 2016 and pension providers had to determine the strategy for reducing the portion of equities so that at the retirement age no equities were left in the portfolio.

The first question was to find the efficient strategies for managing a risky portfolio. The outcome was a distribution of returns (IRR) and the efficient line was drawn using mean return versus CVaR of returns. The results were that fixed strategies were ranked very low, while the best strategy was dynamic, starting with a high portion of equities and reducing the portion of equities by steps every ten years.

The second question was to find the efficient strategies to manage the risky portfolio according to the net replacement rates (net total pension divided into net salary before retirement). The replacement rate is considered as one of the major factors in the pension field and measures the standard of living after retirement compared to the employment phase. It combines all sources of income after retirement compared to the income before and relates to the risky fund, the risk-free fund and the first pillar of the flat rate National Insurance old age pension.

The results clearly proved that static strategies with a fixed portion of equities are not efficient. Dynamic strategies that changed the portion of equities every few years produced a higher mean of replacement rates with basically the same risk, measured by CVaR. The most efficient strategy was to start with 100% invested in equities, maintain the same portion for 20 years and then decline to no equities at retirement point. This strategy is riskier than the previous one of step reductions every ten years but considering the other risk-free elements it is logical to increase the risk of the risky accumulation. This conclusion of the research matches the results and conclusions achieved by other researchers in other countries, like Antolin et al. [2010].

Compared to the popular investment strategy in Israel with the constant fraction of 30% of a portfolio invested in equities, the efficient strategy, which is the result of this dissertation, can increase replacement rates by 20%-25%, with a little more risk. This is a very important conclusion that enables an improvement of the pension system in Israel.

The replacement rates that were simulated were extremely high. Replacement rates for males can obtain values from 1.30 to 1.35 and for females 1.14 to 1.20, compared to the replacement rate of 0.8 required by the consumption puzzle [Blanchett 2014]. The main reason for such high numbers was that in the basic model we assumed continuous employment and the keeping of severance pay. In reality, people are sometimes not employed and withdraw about 40% of the severance pay.

The next step was to remove the assumptions of continuous work and lack of withdrawals of severance pay and to adopt more realistic assumptions. According to the new assumptions, there are two periods of leave: the first one of three months after 13 years of employment and the second one of six months after 28 years of employment. During the leave period, no contribution is made. Severance pay is fully withdrawn in the first leave, and an amount of a net yearly salary is withdrawn in the second leave. After 13 years the employees are at an age where there are many household expenses, need the severance pay and are less aware of the meaning of the withdrawal. At the second period of leave they mostly have financial resources to cover part of the expenses and they are more aware of the importance of pension accumulation, so they withdraw only a part of their severance pay. Under the new assumptions, the question was what the replacement rates would be, and would there be any change in the efficient strategies.

The results showed no change in the efficient strategy. Replacement rate values dropped to around 0.90 for females and around 1.00 for males. These results are reasonable for the following reasons: (a) the high contribution rates in Israel of 22% compared to average OECD countries' contribution rate of 16.4%, (b) the full coverage assumed in the model, while part of the population has no pension savings at all since the mandatory pension has fully operated only in the last few years, (c) in practice most accumulation is invested in an inefficient fixed strategy while this model is based on an efficient dynamic strategy. The results emphasize how crucial it is to keep the accumulation and avoid withdrawing the severance pay that comprises 40% of the accumulation.

Based on the last scenario, two more cases of changing the basic assumptions were analyzed: an early retirement scenario and a different allocation of government earmarked bonds.

Early retirement of four years, which actually takes place for 12.4% of females and 29.5% of males, produced a decline in replacement rates of 0.1-0.14, from 1.0-1.05 to 0.88-0.91 for males, and from 0.88-0.92 to 0.75-0.82 for females. During the period between actual retirement and the official retirement age, the drop was very sharp - 0.36-0.52. The meaning is that an early retirement period of four years must be backed by other funds or by other work to keep the same living standards, especially in the period between retirement and the official retirement age. The conclusion is that early retirement only suits those who have the means to support it; otherwise the standard of living cannot be maintained. The dominant strategy was unchanged.

Allocation of earmarked bonds to retirees, partially to those aged from 50 till retirement and no allocation at all to younger contributors, as was decided by the Ministry of Finance, did not change the winning strategy. The replacement rates increased due to higher returns on equities. On the other hand, it reduces the CVaR of replacement rates, which means a higher risk for the contributors. Reducing the extra risk for young contributors to pension funds can be achieved by a guarantee from the government to cover the losses in the case of an extreme collapse in financial markets for contributors that are almost at the age of 50 and can gain only part of the recovery after the collapse. This step can correct the rise in the risk that is caused due to government action.

The last two stages of the research questions are about the gender gap, since the salaries of males are 50% higher than of females. At first, only a difference in growth rates was simulated and after that the starting salaries were also changed. The analysis included the influence of investment strategies on the absolute annuity and on replacement rates.

The results show that the dominant strategies are the same as before and had no effect neither on the gap between genders, nor on the replacement rates. On the other hand,

the high gap in net salaries between males and females during the employment period expanded in the retirement period. Replacement rates were not changed in the first scenario and went up a little for females in the second scenario. Before changing the assumptions, males' annuity was 14% higher than females'. When assuming only different growth rates of salaries, the gap jumped to 29%, and when adding different starting salaries, the gap is 65%. The conclusion is that the gap in salaries during the employment period expands in the retirement period. Part of this is due to the shorter employment period of females and longer life expectancy.

The conclusion is that if reducing the gap is desirable, then it can be achieved through three actions: (1) reducing the wages gap by taking steps that will help females work full-time and obtain promotions during the period of birth and raising small children, (2) raising the retirement age for females to 67 as it is for males, (3) raising the flat rate first pillar. Increases in the National Institute old age pension, which would partly be financed by the high contribution rates, can have a redistributive effect that will reduce the gap between genders and between high to low income earners as well. Today, the old age pension is low compared to European countries and contribution rates are higher, hence it is reasonable to take this action.

To summarize the conclusions:

- Life cycle, dynamic investment strategies are superior to static fixed strategies. The most efficient strategies were those with a high starting portion of equities, which keep a high portion of equities for 10-20 years and then gradually reduce the portion of equities, till at retirement no equities are left in the portfolio. These strategies produce 20%-25% higher replacement rates than the 30% equities fixed strategy that is common in Israel, with a little more risk measured by CVaR.
- Withdrawal of severance pay during the employment period reduces the replacement rates significantly. Tax policy today encourages people who were laid off to withdraw the severance pay, instead of encouraging them to keep it for future annuity.

- Contribution rates for the funded second pillar are too high. This creates replacement rates of 1.00-1.05 for males and 0.88-0.92 for females, after taking into consideration the withdrawal of severance pay. Compared to the replacement rate 0.8, which is required by pension theory due to the consumption puzzle, these replacement rates are too high. The contribution rates are 21% higher than the average contribution rates of OECD countries, as was presented in Table 26, and should be reduced.
- Early retirement reduces replacement rates and is affordable only to those who have other funds in old age. Otherwise, the standard of living will decline compared to the pension level at the official retirement age.
- A different allocation of earmarked bonds, which removes government protection from contributors under the age of 50, increases the replacement rates and risk a little. It is a reasonable step to secure the retirees' accumulation where there are no equities at all and allows them to achieve the desired return in a world of low interest rates.
- Another conclusion is that the system is not redistributive enough to reduce the gap between low earners and high earners. The gap also relates to the differences between genders. For males, initial salaries and rates of growth are much higher than for females. The gap expands in the retirement phase: the annuity of males is much higher than that of females, and males' replacement rates are higher than females'.

The solutions to the gender gap are to raise the retirement age of females to 67, as it is for males. An additional solution that is also suitable for the gap between low and high earners is raising the flat rate old age pension, which is only 17%-24% of the average salary and is much lower than in European countries. This can be partly financed by reducing the contribution rates to the second pillar fund and turning the

contribution to the first flat rate pillar. This step will have a redistributive affect and will reduce both the gap between genders and between low and high earners.

Future research can also be done for minimum earners after data is collected. More future research is needed to simulate the solution that was discussed in the last paragraph and find the balance between increasing the replacement rates of low earners and decreasing the replacement rates of high earners. It could also examine other scenarios of government support and not only in cases where the addition to the flat rate old age pension is fully financed by a reduction in contribution rates to the second pillar which is funded and invested in capital markets.

Further study could also be conducted with regard to the implications of the age-based default model in Israel. Such research could examine the decision-making process of implementing the model, the time and procedures necessary until it is fully adopted, regulation of the model in Israel compared to other countries that have adopted the model, and the penetration process: what portion of accumulation is run according to the model and returns, and the risk compared to static strategies.

Appendixes

Appendix 1. Real growth of salaries 1989-2014

Year	Average Salary	Consumer Price Index[22]
1989	2,051	25.88
1990	2,328	30.32
1991	2,723	36.09
1992	3,085	40.40
1993	3,412	44.82
1994	3,912	50.35
1995	4,355	55.41
1996	4,915	61.65
1997	5,493	67.20
1998	5,914	70.86
1999	6,377	74.54
2000	6,835	75.38
2001	7,079	76.22
2002	7,147	80.55
2003	6,972	81.09
2004	7,099	80.76
2005	7,324	81.83
2006	7,576	83.55
2007	7,749	83.98
2008	8,075	87.84
2009	8,131	90.76
2010	8,414	93.20
2011	8,741	96.42
2012	8,971	98.06
2013	9,212	99.56
2014	9,373	100.03
Change of salary 2014 vs. 1989		4.57
Change of CPI 2014 vs. 1989		3.87
Real growth of salary 2014 vs. 1989		1.18
Compounded quarterly real growth		0.17%

Source: Author's calculations based on CSB data [CSB 2015b].

[22] Average 2014 = 100

Appendix 2. Return of investment groups January 1990-March 2015

Quarter ending in	General Equities	Standard and Poor 500	Government Bonds	Non-Government Bonds
31 Mar 90	-6.53%	-5.02%	-1.92%	-4.86%
30 Jun 90	20.47%	2.77%	2.55%	3.83%
30 Sep 90	-16.26%	-19.00%	0.22%	0.19%
31 Dec 90	2.32%	5.21%	-6.81%	-3.93%
31 Mar 91	28.17%	20.06%	0.52%	1.39%
30 Jun 91	9.90%	-1.30%	-1.07%	1.25%
30 Sep 91	4.98%	-2.22%	4.34%	6.94%
31 Dec 91	-11.32%	1.39%	-5.01%	-3.77%
31 Mar 92	19.33%	0.23%	0.34%	0.73%
30 Jun 92	15.07%	0.88%	5.04%	6.86%
30 Sep 92	13.17%	1.11%	-0.58%	-1.91%
31 Dec 92	12.76%	12.30%	2.02%	4.04%
31 Mar 93	2.27%	1.71%	-4.39%	-3.89%
30 Jun 93	-1.04%	-1.03%	-2.09%	-2.38%
30 Sep 93	12.92%	1.74%	2.62%	1.78%
31 Dec 93	10.88%	2.42%	1.87%	3.95%
31 Mar 94	-21.12%	-7.25%	-1.77%	-2.67%
30 Jun 94	-31.94%	-2.06%	-1.64%	-2.40%
30 Sep 94	13.37%	0.32%	1.92%	2.31%
31 Dec 94	-12.97%	-3.80%	-3.05%	-2.51%
31 Mar 95	-6.86%	6.71%	-0.15%	-0.42%
30 Jun 95	10.02%	5.87%	-0.69%	-0.07%
30 Sep 95	3.71%	5.88%	0.76%	0.11%
31 Dec 95	-0.79%	7.26%	1.23%	1.02%
31 Mar 96	-10.67%	1.61%	0.46%	0.98%
30 Jun 96	-3.37%	2.00%	-0.89%	-0.16%
30 Sep 96	-6.98%	1.04%	1.56%	-0.38%
31 Dec 96	11.51%	7.72%	1.16%	2.07%
31 Mar 97	14.19%	2.69%	1.95%	2.29%
30 Jun 97	12.63%	22.12%	1.21%	0.78%
30 Sep 97	2.21%	3.03%	1.72%	2.62%
31 Dec 97	-3.88%	2.71%	0.12%	-1.10%
31 Mar 98	3.42%	15.10%	-1.33%	-3.55%
30 Jun 98	2.55%	3.13%	-0.74%	-1.81%
30 Sep 98	-11.91%	-7.68%	3.51%	4.84%
31 Dec 98	1.59%	25.72%	-0.78%	-0.39%

31 Mar 99	16.99%	3.10%	1.73%	0.65%
30 Jun 99	18.99%	6.43%	0.28%	0.58%
30 Sep 99	-3.89%	-3.39%	2.10%	1.32%
31 Dec 99	21.24%	10.38%	0.91%	0.34%
31 Mar 00	10.73%	-0.48%	2.79%	1.84%
30 Jun 00	1.32%	-2.06%	-0.30%	0.60%
30 Sep 00	3.43%	-2.08%	0.95%	0.57%
31 Dec 00	-13.56%	-7.93%	1.13%	0.06%
31 Mar 01	-20.02%	-8.15%	4.00%	2.89%
30 Jun 01	5.52%	2.74%	2.22%	2.83%
30 Sep 01	-9.76%	-11.93%	0.94%	0.62%
31 Dec 01	20.88%	11.71%	4.09%	3.35%
31 Mar 02	-14.72%	3.93%	-2.41%	-0.15%
30 Jun 02	-6.99%	-15.13%	-5.53%	-6.01%
30 Sep 02	-5.40%	-16.83%	-0.94%	-2.76%
31 Dec 02	0.27%	7.16%	3.05%	0.89%
31 Mar 03	3.36%	-5.96%	2.80%	1.96%
30 Jun 03	32.30%	7.04%	6.88%	6.86%
30 Sep 03	-2.44%	6.13%	2.58%	2.68%
31 Dec 03	18.70%	9.88%	2.78%	3.22%
31 Mar 04	9.46%	4.99%	0.55%	2.47%
30 Jun 04	4.20%	-0.72%	-0.30%	-0.89%
30 Sep 04	-9.37%	-2.50%	2.00%	1.76%
31 Dec 04	12.39%	5.34%	1.85%	0.76%
31 Mar 05	7.24%	-1.64%	2.88%	3.30%
30 Jun 05	-2.33%	4.65%	0.52%	1.16%
30 Sep 05	11.58%	2.00%	1.47%	1.89%
31 Dec 05	11.02%	1.36%	-1.40%	-2.58%
31 Mar 06	1.24%	5.24%	0.00%	1.65%
30 Jun 06	-9.01%	-7.16%	0.05%	-1.33%
30 Sep 06	5.93%	1.72%	2.30%	1.20%
31 Dec 06	8.52%	4.86%	3.03%	1.73%
31 Mar 07	10.31%	-0.25%	2.03%	2.17%
30 Jun 07	9.60%	6.49%	0.71%	1.47%
30 Sep 07	-2.14%	-5.49%	-1.46%	-3.26%
31 Dec 07	0.48%	-8.56%	-0.18%	-0.22%
31 Mar 08	-16.75%	-17.89%	2.55%	-0.07%
30 Jun 08	3.12%	-9.14%	-0.23%	0.25%
30 Sep 08	-19.43%	-9.53%	-1.96%	-8.53%
31 Dec 08	-25.36%	-11.83%	5.16%	-9.64%
31 Mar 09	20.48%	-4.17%	4.11%	14.86%
30 Jun 09	15.67%	6.67%	-2.73%	6.70%

30 Sep 09	8.97%	7.76%	1.04%	1.56%
31 Dec 09	13.29%	5.63%	-0.38%	2.47%
31 Mar 10	11.38%	4.58%	2.64%	4.71%
30 Jun 10	-15.04%	-10.00%	1.72%	0.17%
30 Sep 10	9.42%	3.44%	-0.08%	2.39%
31 Dec 10	5.94%	6.20%	-0.79%	0.61%
31 Mar 11	-3.22%	3.81%	-1.85%	1.15%
30 Jun 11	-9.91%	-3.96%	0.03%	-2.25%
30 Sep 11	-15.67%	-8.17%	3.09%	-2.56%
31 Dec 11	3.72%	13.67%	1.55%	0.35%
31 Mar 12	4.33%	9.45%	0.43%	3.45%
30 Jun 12	-7.53%	1.79%	1.35%	-3.04%
30 Sep 12	5.65%	3.77%	1.01%	2.66%
31 Dec 12	0.92%	-5.19%	3.27%	5.33%
31 Mar 13	6.35%	7.61%	-0.20%	1.84%
30 Jun 13	-2.92%	0.23%	-0.08%	0.79%
30 Sep 13	4.22%	2.82%	0.51%	2.61%
31 Dec 13	5.24%	7.49%	1.42%	1.59%
31 Mar 14	9.56%	1.97%	2.46%	2.88%
30 Jun 14	-1.96%	2.28%	1.97%	0.00%
30 Sep 14	4.39%	7.49%	1.97%	1.65%
31 Dec 14	-1.05%	11.45%	0.23%	-2.73%
31 Mar 15	10.47%	1.58%	3.54%	1.43%

Source: Author's calculations based on Tel Aviv stock exchange website; Yahoo Finance website and Central Bureau of Statistics in Israel.

Appendix 3. Time series autocorrelation- ACF and Ljung-Box test

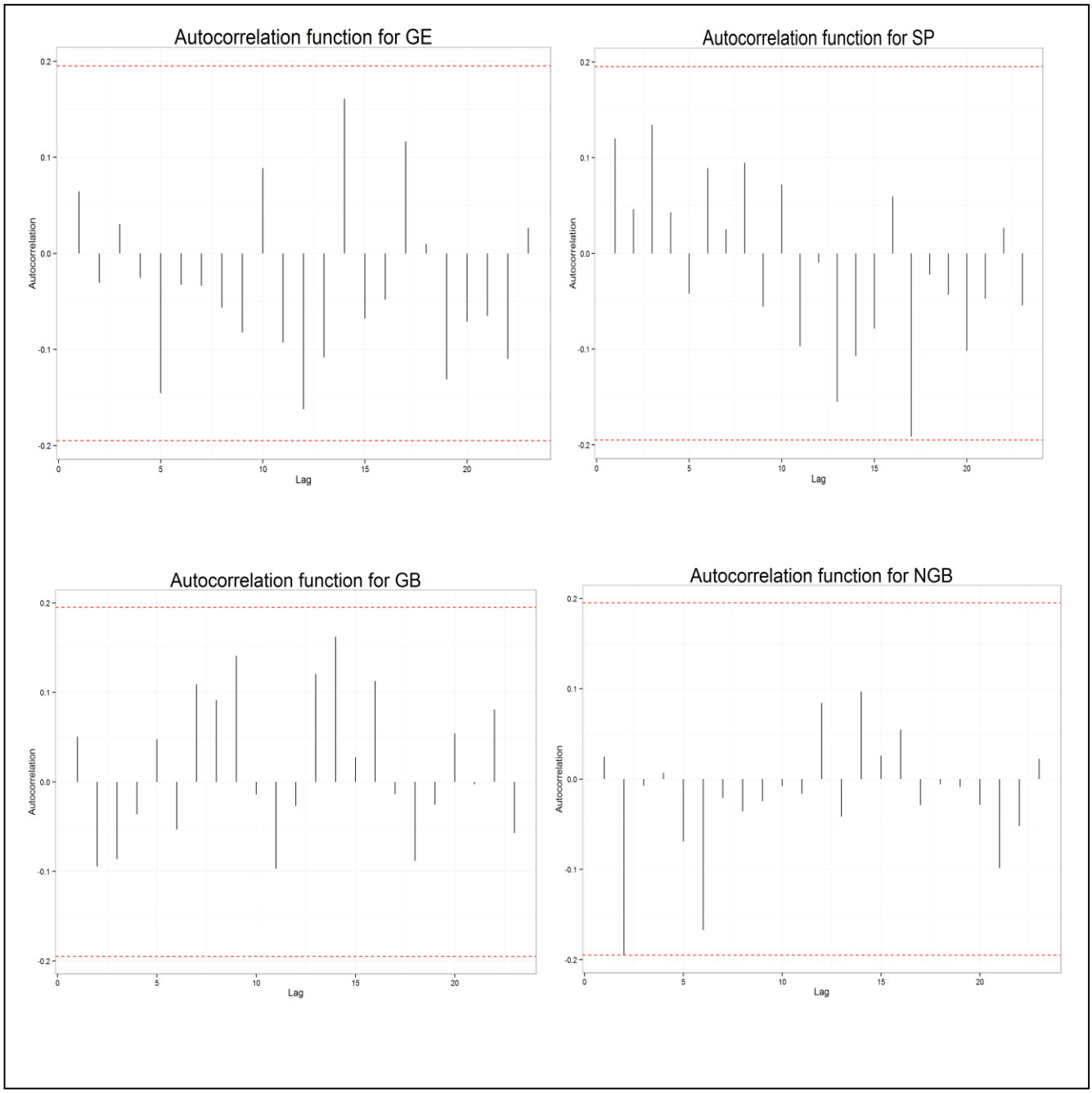
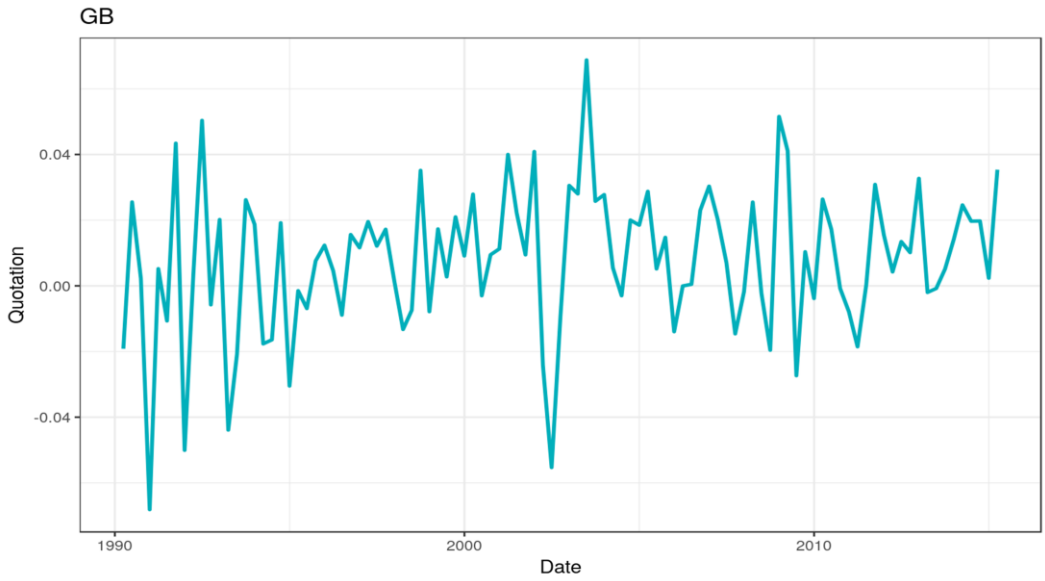
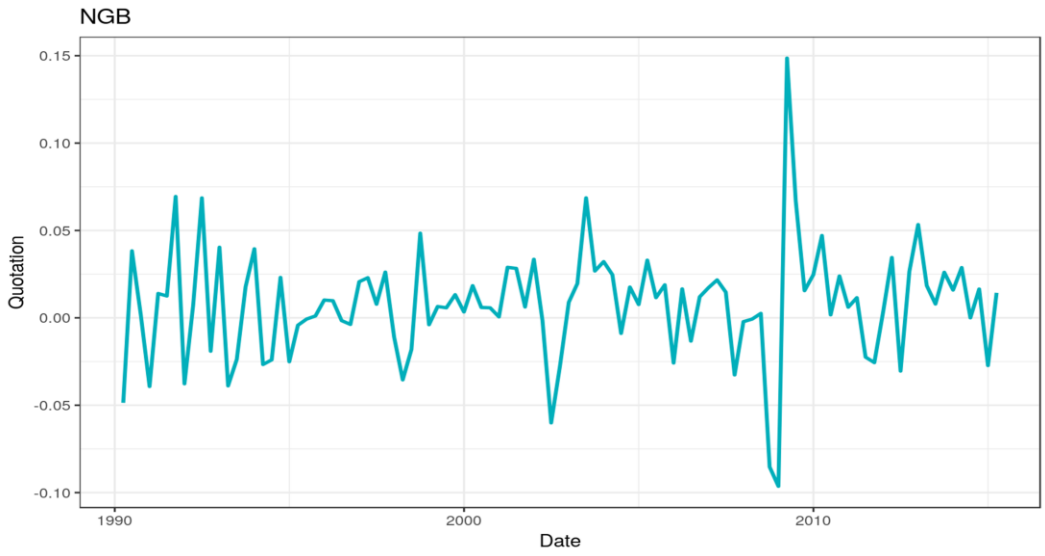


Figure 26: ACF for local equities (GE), foreign equities (SP), government bonds (GB) and non-government bonds (NGB)

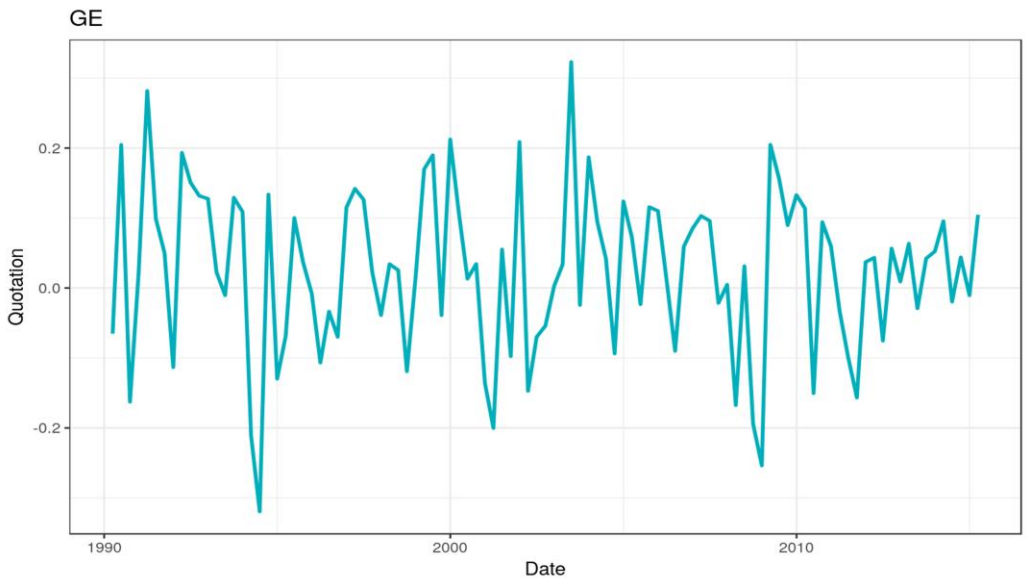
Source: Author's calculations.



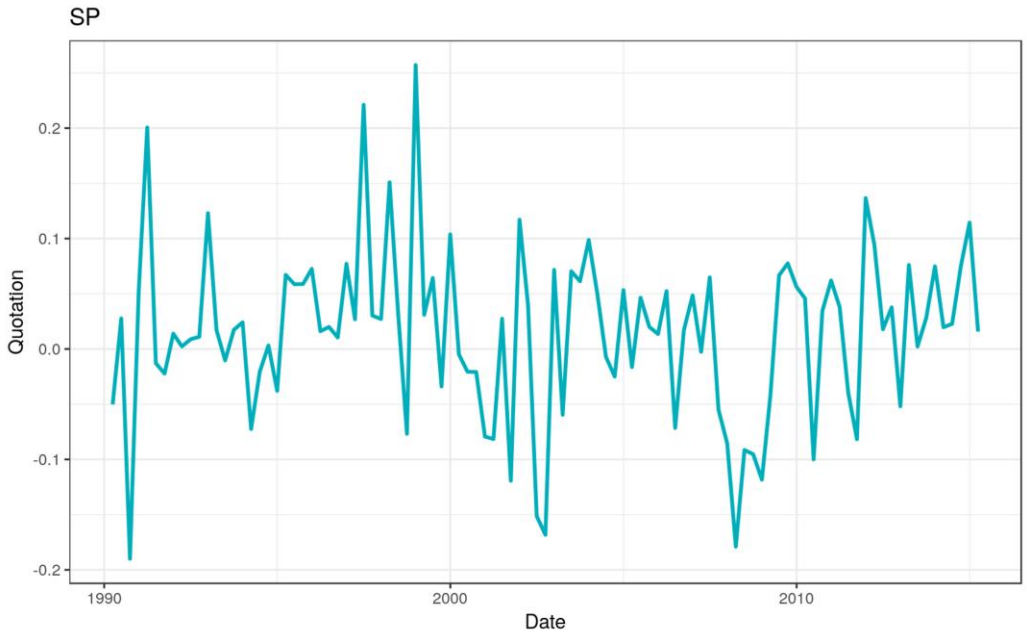
Box-Ljung test data: ts_ = 0.26656, df = 1, p-value = 0.6056



Box-Ljung test data: ts_ = 0.064033 df = 1, p-value = 0.8002



Box-Ljung test data: ts_ X-squared = 0.43361, df = 1, p-value = 0.5102

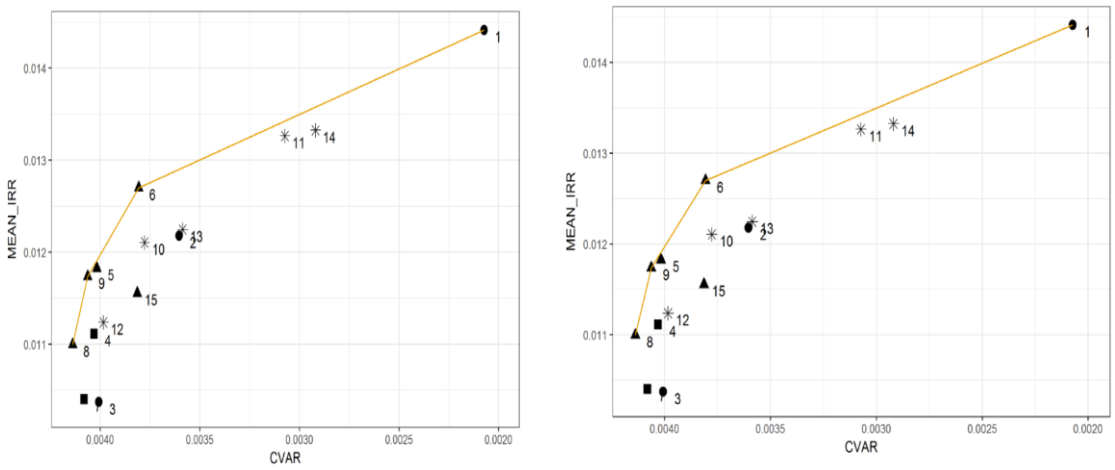


Box-Ljung test data: ts_ X-squared = 1.5004, df = 1, p-value = 0.2206

Figure 27: Ljung-Box test for local equities (GE), foreign equities (SP), government bonds (GB) and non-government bonds (NGB)

Source: Author's calculations.

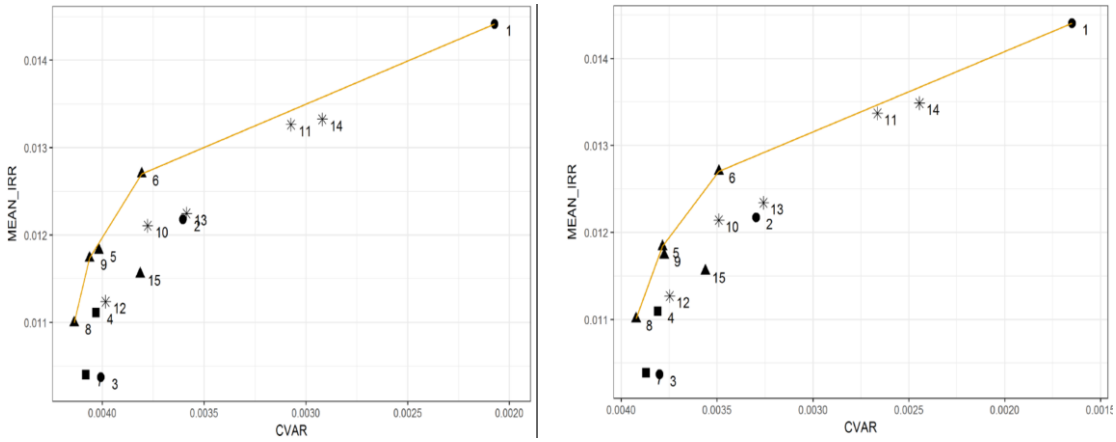
Appendix 4. Efficiency line for investment strategies



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 28. Efficiency line for male, starting salary 6,000 NIS (left) and 9,000NIS (right)

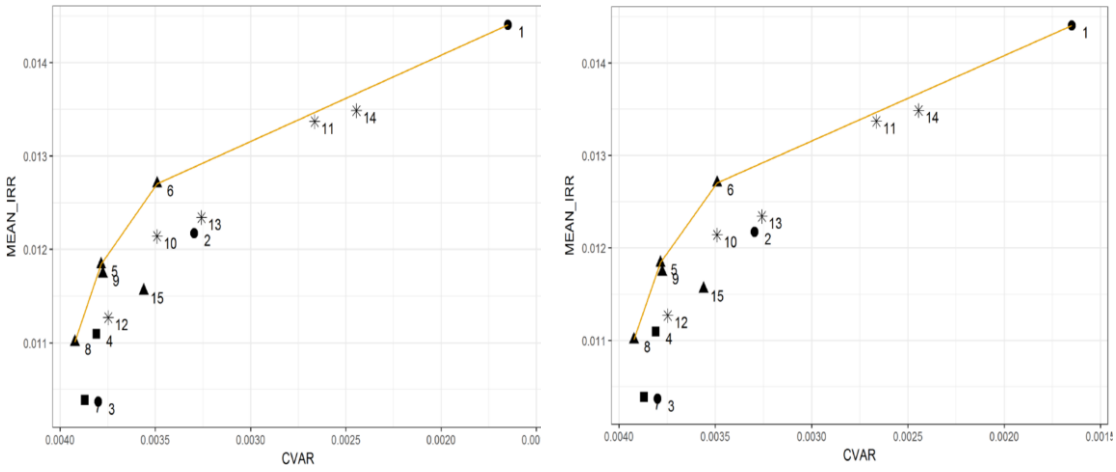
Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 29. Efficiency line for male, starting salary 15,000 NIS (left) and female 6,000NIS (right)

Source: Author's simulations.



1-Fixed 80%, 2-Fixed 50%, 3- Fixed 30%, 4- Linear 100%, 5-Stepwise 100% 5 years, 6-Stepwise 100% 10 years, 7-Linear 80%, 8-Stepwise 80% 5 years, 9-Stepwise 80% 10 years, 10-Piecewise 100% 10 years, 11-Piecewise 100% 20 years, 12-Piecewise 80% 10 years, 13-Piecewise 80% 20 years, 14-Piecewise 80% 30 years, 15-Stepwise-shorter 5 years till 5 years before retirement.

Figure 30. Efficiency line for female, starting salary 9,000 NIS (left) and 15,000NIS (right)

Source: Author's simulations.

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