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Efficient life cycle investment strategies in defined contribution pension plans in Israel

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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) pension arrangements that invest their assets in the capital market. There is an increasing consensus that the risk of a pension plan's investment portfolio should be decreased towards the retirement age, but the strategies to implement 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. Therefore, the purpose of this paper is to present the results and conclusions of research that is focused on finding the most efficient strategies for implementation in Israel's pension system, according to mean vs. risk of returns and net replacement rates.

Risk measurement was carried out using CVaR, which is superior for the measurement of extreme risk, while most of the former research has used 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 and for each of six representative agents. Based on the data of different growth rates for the salaries of males and females, and the higher salaries of males, the research also investigates the influence of these factors on the gender gap, by examining whether the pension system is reducing or expanding the gender gap.

The first conclusion derived from the study is that a life cycle of dynamic strategies with a high portion of equities, switching gradually to a full bonds portfolio at retirement, produced the highest returns and replacement rates for a given risk. Withdrawals of parts of severance pays significantly reduced the replacement rates. The second conclusion is that the gap between genders during the working 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. Another redistributive act can be a raise of the flat rate old age pension (the first pillar) and financing it by reducing contribution rates of the second pillar that were found to be too high.

Keywords: pension, portfolio, strategy, replacement rates, simulation, pension gender gap.
JEL Codes: D63, E21, G11, G17, J16, J32.

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1. Introduction

During the past 30 years, many countries have expanded the portion of defined contributions (DC) pension arrangements that invest their assets in the capital market. However, such pension portfolios are exposed to the risk of market volatility. In recent decades, a much more significant risk has threatened the pension portfolio: the risk of extreme market crashes, as occurred in 1998, 2000 and 2008. There is an increasing international consensus that life cycle strategies with a high portion of equities at the start and a decreasing portion towards retirement are desirable when managing the pension accumulation phase [Antolin, Payet, Yermo 2010, p. 2].

Researchers agree that a well-designed default scheme is essential since pensions are a complicated subject and most of the population cannot make good choices. Saving for retirement requires expertise, continued monitoring and changes of decisions from time to time – a mission that most of the population cannot handle [Barr, Diamond 2010, p. 9]. An important move towards a default system that takes care of the extreme market risk of pension portfolios was made in Chile, which created the first age-based default model. According to it, pension portfolios of young contributors are invested primarily in equities, which gives them a potential for high returns, though they are also exposed to high risk. The contributors are automatically transferred to a fund with a lower portion of equities at the age of 35, then again at 55, and again on retirement to a fund that has no equities at all [Berstein, Fuentes, Torrealba 2010, p. 17]. This allows them to gain high returns during their employment period, and reduces the risk close to retirement in order to safeguard the accumulation.

Although researchers agree that a life cycle default pension program with decreasing risk towards retirement is desirable, the actual portfolio allocation and the strategies to be implemented are still under debate [Antolin, Payet, Yermo 2010, p. 2]. Research has been done worldwide to determine which strategies will bring higher replacement rates with lower exposure to risk, but such research has not been conducted in Israel.

Israel has made significant reforms to its pension system over the last 27 years [Manor 2015]. The main reform reduced the portion of earmarked, non-traded government bonds in pension portfolios, and since then, most pension portfolios have been invested in capital markets. Other reforms included: (a) closing the old funded defined benefits plans to new joiners, who were directed towards a funded defined contribution system; (b) closing the PAYG defined benefits plans to new joiners, who were directed towards a defined contribution system; (c) mandatory pensions for all employees; (d) actions to reduce management fees and (e) adopting an age-based default model in 2016 for new joiners, by creating a multi-funds system with automatically decreasing risk per age for each pension provider. Despite the abovementioned reform, most of the accumulation in Israel is still invested in line with the fixed investment strategy of 30-35% equities [Manor 2015].

The total income after retirement in Israel is split between the flat rate first pillar national insurance old age pension, and the second pillar lifetime annuity based on funded accumulation, invested 30% in risk-free, non-traded earmarked government bonds, and 70% in capital markets. It is important to know which strategies are the best for managing the risky accumulation, invested in capital markets, according to the return on investment, and which strategies are the best when the criteria are the total replacement rates that include all elements.

The contribution rates in Israel as of 2017 are: 6% from employees for pensions, 6.5% from employers for pensions and 8.33% from the employer for severance pays [Ministry of Economy 2016]. Hence, severance pays constitute 40% of the accumulation, but can be withdrawn free of tax if one is laid off. In reality, around 40% of severance pays are withdrawn [Amstradamsky 2012]. It has been assumed that withdrawals of severance pays reduce the annuity significantly, but its influence on net replacement rates is presented in this work for the first time.

The purpose of this paper is to present the results and conclusions of research that is focused on the following issues:

– what are the most efficient strategies in terms of mean returns on investment versus risk, measured by CVaR?
– what are the most efficient strategies in terms of mean replacement rates versus risk measured by CVaR, for different genders and salaries?
– what is the effect of partial withdrawal of severance pays on replacement rates, for different genders and salaries?

The research was carried out by running Monte Carlo simulations 10,000 times, and drawing the efficiency frontiers of 15 investment strategies of four types: fixed, linear, stepwise and piecewise, and for each of six representative agents: males and females with median salary, average salary and a typical salary of high tech employees.

The first section is based on the literature and discusses the theoretical aspects of the measurement of extreme risk; previous papers that tried to find efficient investment strategies for pension portfolios in DC plans in other countries; as well as the reforms in the pension field in Israel in the last 27 years. The second section describes the model used in this research, based on the data and structure of the Israeli pension system. The third section provides the results and the last section summarises the work and concludes it.

2. Literature review

2.1. Measurement of extreme risk

There are several indicators for measuring risk. Among the most important are standard deviation, VaR and CVaR. VaR is defined as "*an estimate of the loss from a fixed set of trading positions over a fixed time horizon that would be equalled or exceeded with a specified probability*" [Dowd, Rowe 2004, p. 909]. The idea of VaR

is that if all possible returns are arranged in a decreasing order, then VaR will be the value of return according to the chosen α. The main problem with 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 levels α [Lleo 2009, p. 10].

To overcome the potential weakness of VaR, Conditional Value at Risk (CVaR) can be used. CVaR is defined as the "*(equal-weighted) average of all the possible outcomes in the left-tail of the profit and loss distribution of an asset or a portfolio*" [Lleo 2009, p. 12]. While VaR only estimates the point of loss at each confidence level, CVaR also estimates the expected loss behind that point. CVaR is superior to VaR for non-normal distributions, in measuring the potential loss of derivatives and asymmetrical risk profile [Kido 2012, p. 3], and satisfying the demand for a coherent measure of risks [Rockafellar, Uryasev 2002, p. 1445]

2.2. Simulations of pension portfolios

Most papers in the last decade have used stochastic models, while some have used utility models and the minority have used deterministic models. The deterministic simulation uses known variables and leaves no room for random variation, and thus each repetition of a simulation will lead to the same result. The deterministic method is not so common, and seems to be inadequate when exploring capital market returns over a long period [Gomez-Hernandez, Perez-Sosa 2014, p. 50].

Shiller [2005, pp. 7-11] used a deterministic model for his research. He set 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. A more appropriate method is the stochastic simulation that enables random variables and generates various ranges of outcomes under basic assumptions of contribution period, contribution rate and salary [Gomez-Hernandez, Perez-Sosa 2014, p. 51].

A few researchers, like Chai et al. [2009], favoured the utility function approach to replacement rates or accumulation on retirement. 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. presented research regarding investment strategies for Chile, and they expanded the research to examine differences in contributors' profiles [Berstein, Fuentes, Villatoro 2013, pp. 381, 384]. They ran simulations of the replacement rate probability function 10,000 times and measured the median replacement rate versus the standard deviation for risk measurement. They found no dominant strategy, and that an increase of one percent of risk is equal to a gain of 0.85 points in the replacement rate [Berstein, Fuentes, Villatoro 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 Monte Carlo bootstrap simulation

5,000 times, using the CVaR for measuring risk and wealth after retirement compared to income before retirement as the target factor, which is quite like the replacement rate idea [Basu, 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 rates but also proved to be less risky [Basu, Drew 2009, p. 31].

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

- fixed strategies in which the allocation does not change;
- dynamic lifecycle strategies where the portion of equities out of the pension portfolio decreases to the point that at retirement the portfolio does not contain equities at all:
  - a linear decrease;
  - a stepwise decrease in which the portfolio allocation is changed every few years;
  - a piecewise linear approach where the allocation does not change for the first period (from five up to twenty years) and only then does it decrease in a linear or step way;
  - multi-shape strategies that minimise the expected shortfall after retirement.

The research aims to create a probability distribution function of the replacement rate and from that distribution to derive the efficient frontier of the median replacement rate versus risk, which is measured as the left VaR of the 5th percentile of the replacement rate [Antolin, Payet, Yermo 2010, p. 96]. The results show that life cycle strategies with a high portion of equities in most of the accumulation phase, switching gradually 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, Payet, Yermo 2010, p. 88].

Cannon and Tonks [2013, p. 115] ran a simulation based on international data regarding four strategies: all equity, all bonds, 50% equity and a life cycle strategy where the equities portion gradually falls as the participant ages. They calculated the median replacement rate vs. the risk which was represented by the left 5% VaR of the distribution. They found that this life cycle strategy was superior to fixed allocation strategies.

A simulation for Mexican data was made in 2014 [Gomez-Hernandez, Perez-Sosa 2014, p. 58]. They used the Mexican fund asset allocation as strategies and ran the Monte Carlo simulation on returns for each investment group 10,000 times, calculating the mean 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 assets allocation policy should be more diversified and less conservative and that investment in international equities should be expanded.

The main conclusion, as it appears in the literature, is that efficient strategies are life cycle dynamic strategies that start with a high portion of equities, and reduce the risk during the contribution period, mainly towards the retirement period.

2.3. Pension reforms in Israel[2]

The system up to 1986 was based on three pillars [Ahdut, Spivak 2010]:
- The National Insurance Institute flat rate old age pension, financed by obligatory National Insurance fees;
- The Partly Mandatory pension: defined benefits, PAYG government plans for government employees; defined benefits pension funds, provident funds and „*executive life insurance*" – life insurance that contains insurance and savings for the pension period. Pension funds, provident funds and executive life insurance invested only in non-traded earmarked government bonds;
- The Voluntary Pillar: provident funds and executive life insurance.

The salary in Israel was divided between the insured salary for pensions that was around 70% of the total salary, and 30% unpensionable salary, mostly reimbursement of expenses [Spivak 2013, p. 25].

The Israeli pension system has been through many reforms since 1990, accelerated particularly since 2003. The main directions of the reforms were: reducing government involvement in the pension field; expanding the second pillar defined contribution, invested in capital markets plans; ensuring minimum annuity at the second pillar and steps to increase future annuity [Manor 2015].

The first goal was achieved with a few major steps: for new government employees the PAYG defined benefits program was shut down, and they were directed towards the funded, privately managed, defined contribution, invested in capital markets system [Manor 2015]. Employees who were not government employees used to contribute to defined benefits pension funds. These funds were closed to new joiners in 1995. The new members were directed towards new, defined contribution, actuary balanced, privately managed funds and invested most of their accumulations in capital markets. The old deficit pension funds were nationalised, and the government supported their balancing through the budget [Ahdut, Spivak 2010].

Another major step in developing capital markets and reducing government involvement in the pension field was eliminating the issue of new earmarked bonds to provident funds and executive life insurance and reducing the portion of earmarked bonds for old and new pension funds to only 30% of their assets. The rest of the accumulation must be invested in capital markets, loans and real estate [Ahdut, Spivak 2010].

[2] The Israeli pension system and the reforms made in the last 27 years were discussed in detail in the author's last article from 2015 [Manor 2015]. Here we provide only a brief description of the system and a few new reforms to understand the models' assumptions.

The steps to ensure a minimum annuity of the second pillar were achieved with a few steps [Manor 2015]. In 2008, a new regulation for a mandatory pension for all employees was operated. Up until then, about 40% of the population did not have any pension arrangement besides the first pillar. The regulation expanded pension coverage significantly, and according to the Ministry of Finance, between 2008 and 2013, 1.3 million employees, about 30% of the labour force, joined the program [Manor 2015].

The second step from 2008 prohibited lump-sum withdrawals of pension accumulations before retirement age, and at retirement age, accumulation must be kept for a life annuity, and cannot be withdrawn in a lump-sum, unless the minimum level of annuity income is achieved. The minimum is linked to the consumer price index, and is about 50% of the average salary. This step made a lump-sum withdrawal only possible for mid-high and high classes, and only at retirement [Ahdut, Spivak, 2010].

The third step from 2016-2017 was a reduction in management fees. In 2005, the pension funds and provident funds were sold to insurance companies and investment houses, which immediately raised management fees. Public pressure reduced the managing fees by lowering the maximum fees by legislation [Manor 2015]. The second step by the Ministry of Finance was to choose two small pension funds as default funds that offered very low management fees, suggesting them to the public in 2016 to create competition, and enforcing employers from 2019 to join their employees to these funds, unless they make a bid and can justify a different choice. The factor of management fees in that bid must be at least 50% [Ministry of Finance 2016].

Other reforms included raising the retirement age to 67 for males and 64 for females (currently equal to 62 and to rise to 64 in 2018) to address the increasing life expectancy [Ahdut, Spivak 2010], and the full adoption of the age-based default model from 2016 for new joiners by default, and for current contributors by an active demand of the contributor [Ministry of Finance 2015]. The model is a multi-funds system for each pension provider that included: the fund till the age of 50; the fund for ages 50-60; the fund for ages 60 through retirement and a retirees' fund that has no equities at all. Each pension provider had to decide on the risk reduction strategy: what is the portion of equities at the starting point, and in what way should they reduce the portion of equities. No research has been made regarding these questions. In 2016[3], 93% of accumulations, in all instruments, was still invested in the General Fund[4], with only 30-35% as a fixed portion of equities out of accumulation.

[3] According to the author's calculations based on the annual data published by the Ministry of Finance.

[4] Each pension provider has operated few funds, differed by investment policy such as: all equities; all bonds; international securities and a General Fund that has a flexible investment policy according to the pension provider's decision. The new age based funds were added in 2016 to pension providers' portfolio.

3. The model

3.1. Data and representative agents

The model is based on running a Monte-Carlo simulation of returns 10,000 times according to investment groups. The simulations are performed for each representative agent out of six representative agents of participants differentiated by gender and income. For each gender, three levels of monthly income in New Israeli Shekels (NIS) were chosen: the median salary in Israel (NIS 6,000), the average salary (NIS 9,000) and the higher beginner salary, which is a typical value for high tech employees (NIS 15,000). The salaries were increased according to the real average growth of salaries 1989-2014 published by the Central Bureau of Statistics (CBS).

The starting work age is 27 for males, and 26 for females. The work start age was determined as follows: males serve three years in the army, and females two years. After the service, it is common to work for 12-18 months to save money for a 6 months tour around the world, and for higher education studies, and then three to four years of studies. Retirement at 67 for males and 64 for females is according to the regulations. The contributions of employee and employers are 20.83% out of the insured salary, which is 70% of the salary, as described in the former section. Each contribution is divided according to the distribution of all pension instruments' assets in Israel in 2014[5]: 71% is invested in capital markets, and 29% is invested in cash, deposits and non-traded earmarked bonds bearing a real fixed annual return of 4.86%.

A risky pension portfolio of all instruments: pension funds, provident funds and executive life insurance at the end of 2014 was combined with four major investment groups:

- government bonds: this group is 32% of the portfolio, and the relevant index for the group is the general government bonds index in the Tel Aviv stock exchange;
- fixed income instruments and non-government bonds: this group is 32% of the portfolio, and the appropriate index for the group is the general non-government bonds index in the Tel Aviv stock exchange;
- equities in Israel: this group is 14% of the portfolio, and the appropriate index for the group is the general equities index in the Tel Aviv stock exchange;
- foreign equities: most foreign equities are traded in Nasdaq and the New York Stock Exchange (NYSE). This group is 22% of the portfolio, and the appropriate index for the group is the Standard and Poor 500 (S&P).

The data for the simulations were the actual real returns, after reducing for inflation according to the consumer price index (CPI), on the above indices that occurred during the period January 1990-March 2015 on a quarterly base. Calculations of the real

[5] Authors' calculations based on Ministry of Finance publications.

return on the S&P index were made by multiplying the index in the USD currency rate to obtain the values in NIS, and dividing the quarterly change in the CPI index change to arrive at the real return in NIS. The nominal indices data was collected from the Tel Aviv stock exchange publications and from the American financial websites. Data of CPI was collected from the Central Bureau of Statistics website, and USD exchange rates from the Bank of Israel website.

3.2. Strategies

At the starting point of the work period, the portfolios have a high portion of equities to achieve high returns. The portion of equities is reduced during the work period, and at retirement, no equities are left in the portfolio. The strategies should define the starting portion of equities and the way this is reduced during the work period.

Table 1. Summary of all investment strategies

Strategy No.	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
5	Stepwise decrease	100	Five years	Step every five years
6	Stepwise decrease	100	Ten years	Step every ten years
7	Linear	80	-	Linear from starting point
8	Stepwise decrease	80	Five years	Step every five years
9	Stepwise decrease	80	Ten years	Step every ten years
10	Piecewise decrease	100	Ten years	Linear
11	Piecewise decrease	100	Twenty years	Linear
12	Piecewise decrease	80	Ten years	Linear
13	Piecewise decrease	80	Twenty years	Linear
14	Piecewise decrease	80	Thirty years	Linear
15	Stepwise	80	Five years	Step every five years. No equities five years before retirement.

Source: Author's own elaboration.
Note: Chosen strategies presented.

The research considered fifteen different strategies based on four different groups of strategies (Table 1) proposed in the literature:[6]

- fixed strategies that the allocation does not change – three strategies with different portions of equities at the starting point;
- dynamic lifecycle strategies with linear decreases and different starting portions of equities – two strategies;
- a stepwise decrease in which the portfolio allocation is changed every few years – five strategies differentiated by the starting portion of equities and the number of years that the allocation is not changed;
- a piecewise decrease with the linear approach: the allocation does not change for the first period and only then decreases in a linear way – five strategies differentiated by the starting portion of equities and the number of years of the first period.

3.3. Pension calculations: IRR and replacement rates

For each representative agent, the following calculations were performed:

- calculating the quarterly salary net of income tax, national insurance fees and an employee contribution rate of 6%. The salary was increased quarterly by 0.17%, according to the real growth rate of salaries in 1989-2014 published by the CBS;
- the total contribution of 20.83% of the insured salary (70% of salary) was divided: 71% to the risky fund, 29% to the risk-free fund. A contribution fee rate of 3% was subtracted from the contribution;
- the quarterly return was added to the fund value. For the risk-free fund, it was 0.95% quarterly, but for the risky one, there were 10,000 outcomes for each strategy and for each representative agent;
- quarterly management fees of 0.0625% (0.25% annually) were deducted from the fund value;
- the result was a distribution of 10,000 accumulations for each strategy and representative agent. For each one, the internal rate of return (IRR) was calculated. Out of the 10,000 values, the mean and CVaR were calculated, and the efficiency frontier was drawn;
- the value of the funds at retirement was combined and the total accumulation was divided by the pension factor for retirees 40 years from now to obtain the pensions after retirement. The factors used were 197.67 for males and 223.12 for females. The result was the monthly life annuity. Tax calculations were made to achieve the net annuity;
- the flat rate national insurance old age pension was added to calculate total life annuity. The total annuity was divided by the last monthly net salary to get the replacement rate.

[6] In the graphs fixed strategies are marked in round, linear in square, stepwise in triangle and piecewise in star.

The basic model assumed continuous employment and contributions, and severance pays were not withdrawn. In reality, people switch employers or might be laid off and withdraw their severance pays. The first scenario ran calculations of replacement rates under the assumption of two periods of unemployment and withdrawals of part of severance pays.

3.4. Gap between genders

The different representative agents of males and females also allowed for examination of the gap that had opened between genders, and related only to the shorter accumulation period and longer life expectancy of females compared to males. According to CBS [2016] and the National Insurance Institute [Rozenberg 2015], males' salaries are 50% higher than females', and the growth rate for males is higher than for females, and is different for each decade. The first assumption that was changed was the different quarterly salary growth for each ten-year period as depicted in Table 2.

Table 2. Quarterly real growth rates of salaries by period and gender (in %)

Period	Males	Females
First 10 years	1.32	0.87
Next 10 years	0.23	0.15
Next 10 years	0.10	0.00
Next 10 years	0.08	0.00

Source: [Rozenberg 2015].

The last change introduced was that the starting salaries of males and females will vary. Males' salaries are 50% higher than females', 20% more per hour and 30% more due to increased working hours. This scenario will reflect the differences. Starting salaries for females are 5,000 (minimum), 6,000 and 10,000.

4. Results

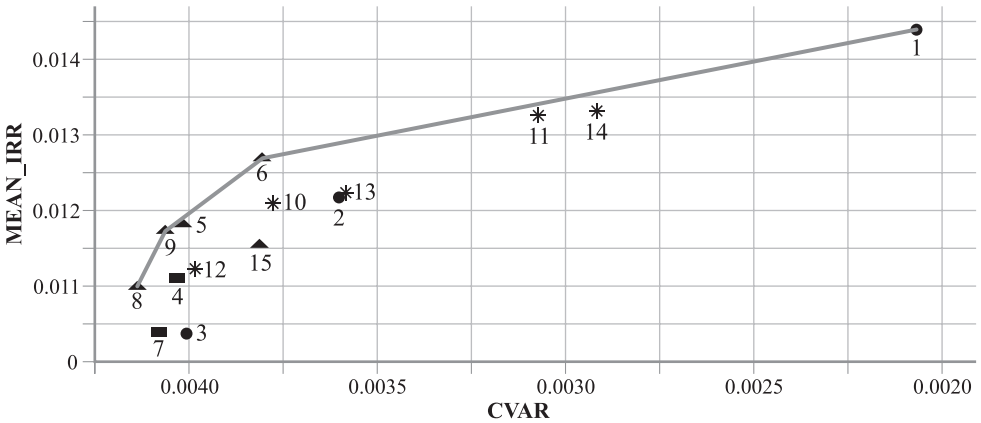
4.1 Efficient strategies for the risky portfolio

The analysis of the results, as shown in Figure 1, suggests that the efficient strategies are stepwise and piecewise[7], where equities are kept in high proportions for a long time and then reduced towards the end; or strategies that reduce

[7] Strategies: 8, 9, 5, 6, 11, 14.

the portion of equities every ten years. Fixed allocation strategies were found to be inefficient.

Figure 1. Efficient frontier of IRR for fifteen investment strategies



Legend: 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 5 years till 5 years before retirement.

Source: Author's own simulations.

Strategy 11 is a little below the efficiency frontier, which connects strategy 6 to 1. Strategy 1 is a fixed strategy with 80% equities, and does not fulfil the objective of reducing the risk towards retirement. Hence, strategy 11 will be considered as efficient. Further calculations based on the marginal added return compared to the marginal added risk suggest that strategy 6 (100% equities at the starting point, step every ten years) is preferred to strategy 11 (100% equities for 20 years and linear decline till retirement age). Strategy 6 has a mean return of 1.33% and CVaR of 0.38% compared to strategy 11 with 1.27% mean and 0.31% CVaR.

4.2. Efficient strategies for replacement rates

The efficiency frontiers supplied the same superior strategies. Further analysis comparing added return with the added risk of strategy 11 and strategy 6 suggest that the best strategy is 11. It makes sense to increase the risk profile of the risky accumulation since there are risk-free elements in the calculations of replacement rates: the risk-free accumulation and the flat rate old age pension. The results for Israel, produced for the first time, match the results of former research in other countries regarding the efficient strategies for DC plans.

The results for replacement rates were much higher than expected. Strategy 11 supplied a mean replacement rate of 1.29-1.35 for males, and 1.14-1.20 for females compared to Israel's replacement rates of 0.83 for males and 0.75 for females according to OECD research [OECD 2015]. The main reason for the high replacement rate is the assumption of continuous work without any withdrawal of severance pays. This assumption was changed in the next simulation.

4.3. Scenario with a leave and withdrawal

The model assumes a continuous employment period, continuous contributions and that the employee does not withdraw the severance pays at any time. These assumptions are not realistic for most of the population. Jobs for life still exist, mainly in the public sector, which is around 18% of the labour market, but most employees in the private sector change their employer more than once. Young employees find a new job quickly, but for ages of 40 and higher, it is more difficult to find a new job.

Unemployment data for 2016 [CBS 2016] suggests that about 4.6% of the workforce was jobless. Out of the jobless, 53% were at an age over 45. The difficulty for those to find a new job is especially relevant for the uneducated population. Females have higher unemployment rates than males in all education levels [Kimhi, Shraberman 2013 p. 161]. According to research by the Israeli Employment Service, which is part of the Ministry of Economy, 50.4% of the unemployed aged 45 and older found a new job in three months, compared to 59.6% of the younger unemployed, 20.2% found a new job within 4-12 months, and for 29.5% of them it took more than a year [Hakohen 2014]. This suggests that a three-month period of unemployment is reasonable at ages below 45, but for those who are older, the unemployment period should be longer.

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

The scenario includes an unemployment period of three months after 13 years of work (age of 40 for males, 39 for females). In the unemployment period, no contributions are made, and all severance pay are withdrawn. After 28 years of work (age of 55 for males, 54 for females), the unemployment period is six months, no contributions are made, and the withdrawal of severance pays is an amount equivalent to the last yearly net salary before the unemployment period of six months.

Periods of three and six months of unemployment are given by the Ministry of Economic research. The ages of unemployment period are exemplary, but reflect the reality, since the younger unemployed are much more likely to find a new job quickly, and most do not really have an unemployment period. These assumptions

lead to a withdrawal of 40% of severance pays. The results, presented in Table 3, clearly show the sharp decline in replacement rates, as was expected.

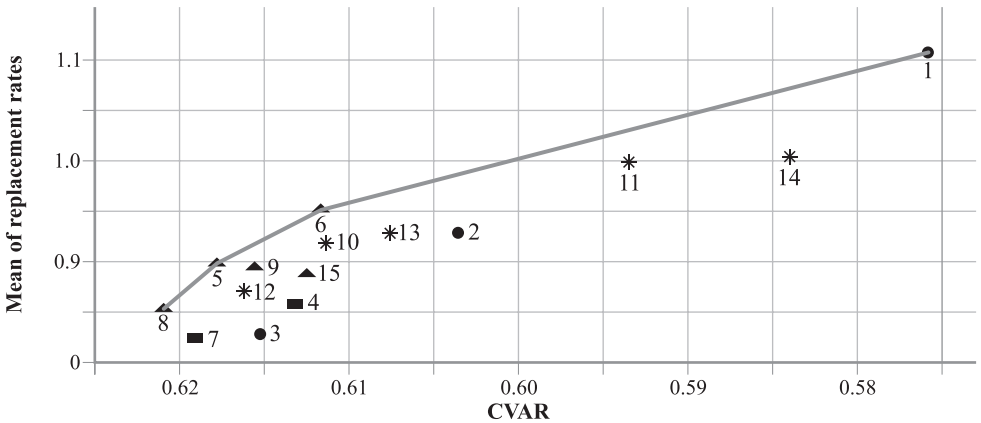
Table 3. Replacement rates with withdrawal of severance pay

Representative agent	Mean		CVaR	
	No withdrawal	With withdrawal	No withdrawal	With withdrawal
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 own calculations.

The strategies for an efficient frontier were not changed, and strategy 11 is still the dominant one, as in the former simulation, what can be seen in Figures 2 and 3:

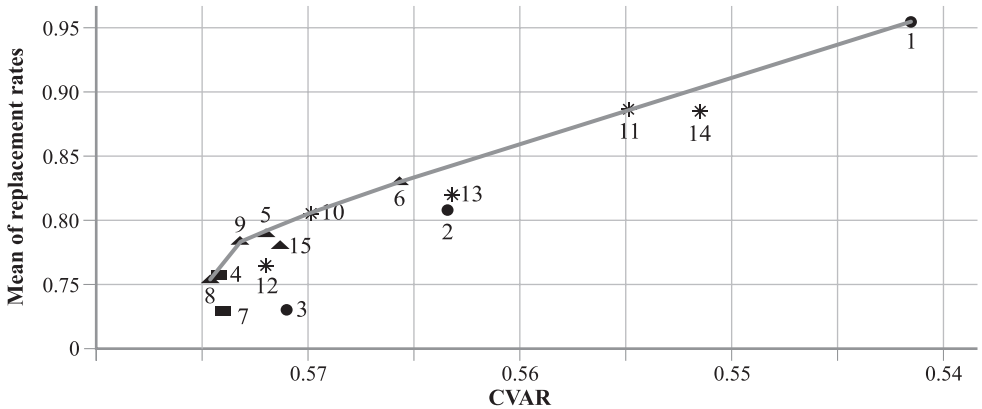
Figure 2. Efficiency frontier of replacement rate: a male with a salary of NIS 15,000



Legend: 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 5 years till 5 years before retirement.

Source: Author's own simulations.

Figure 3. Efficiency line of replacement rate: a female with a salary of NIS 9,000



Legend: 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 5 years till 5 years before retirement.

Source: Author's own simulations.

These results are still higher than the OECD findings and the 0.8 replacement rate that is considered to be optimal in pension theory due to the consumption puzzle. The possible reasons for higher replacement rates found in this research compared to reality are:

– according to the authors' calculations, based on the Ministry of Finance data, 93% of accumulation is currently invested in line with strategy 3 (fix 30% equities), which proved to be inefficient. The replacement rates for strategy 11 are 1.0-1.05 for males and 0.88-0.92 for females compared to replacement rates for strategy 3 of 0.83-0.87 for males and 0.72-0.78 for females. The CVaR of strategy 11 was a little lower, by 0.02 points than strategy 3. The meaning of these results is that changing the investment strategy can significantly improve the replacement rates with a little higher risk;
– contribution rates in Israel are much higher than in other OECD countries. The contribution rate, according to the National Insurance Institute for pensions, is 20.83% on 70% of the salary +7.5% on all the salary, which, in total, is 22.1% compared to the 16.4% average rate of OECD countries excluding Israel [OECD 2015];
– these reasons explain a bigger gap than the one that was found. Another factor that balances this is that 24.4% of females and 11.8% of males continue to work after retirement [Ahdut, Gharrah 2008].

The conclusion is that adopting the dominant investment strategy will improve replacement rates, and will enable a reduction in the contribution rates of the second pillar.

4.4. Gap between genders: different growth rates of salaries

In this scenario, the growth rate of salaries is not constant but varies according to age and gender as described in Table 2. Replacement rates for males declined slightly, and they increased slightly for females. The important result is the growing gap in the absolute annuity in NIS. Since the growth rate was higher than before, the levels of annuities improved. While females' annuity grew by 14-16%, males' annuity grew by 30-32%. The conclusion is that the gap during the employment period was expanded and continued into the retirement period.

4.5. Gap between genders: different growth rate of salaries and different starting salaries

This scenario is the same as the former one, but with 50% higher starting salaries of males compared to females', with the exception of the low salary band, which is the minimum for females. The results of replacement rates are presented in Table 4.

Table 4. Replacement rates in all scenarios

Representative agent	Mean			CVaR		
	The same growth rate and starting salary	Different growth rate and same starting salary	Different growth rate and different 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	0.92	0.93	0.95	0.61	0.61	0.64
F 9000	0.88	0.90	0.93	0.55	0.55	0.61
F 15000	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 own calculations.

The replacement rates for males were the same, while for females they mostly increased a little. The real change was in the total pension in NIS combined with the flat rate old age pension and the annuity of the second pillar. This was reduced significantly for females, with no change for males as can be seen in Table 5.

Table 5. Total pension of all representative agents according to scenario (in NIS)

Representative agent	Scenario		
	The same growth rate and starting salary	**Different growth rate and same starting salary**	**Different growth rate and starting salary**
F 6000	6,220	7,115	6,401
F 9000	8,242	9,503	7,459
F 15000	12,121	14,011	10,956
M 6000	7,046	9,146	9,146
M 9000	9,404	12,293	12,293
M 15000	13,763	18,110	18,110

Source: Author's own calculations.

5. Conclusions

This paper examines, for the first time, the efficiency of lifecycle investment strategies in defined contribution plans in Israel. The model used is an advanced measurement of risk, CVaR, that was proved to be better than a standard deviation or VaR, which have been the most common methods used for risk measurement in this kind of research. The model ran the Monte Carlo simulation for each of six representative agents 10,000 times, using 15 different strategies. The representative agents were males and females with starting salaries of the median salary, the average salary and typical starting salary in a high-tech industry. The efficiency of strategies was tested for the risky portfolio and for the net replacement rate.

The basic model assumed the same starting salaries for both genders, and the same growth rate of salaries. Males' salaries are 50% higher than females' and the growth rate of males' salaries is higher than females'. The second issue to be examined was the gap between genders when the growth rate of salaries is different, and when also adding different starting salaries.

The first conclusion from the research is that life cycle, dynamic investment strategies are superior to statically fixed strategies and to linear strategies. The strategies that lay on the efficient frontier had a high portion of equities at the starting point, which was gradually reduced every 5 or 10 years, or kept the same portion of equities for 20 years, and then gradually reduced it until no equities were left in the portfolio at retirement.

The second conclusion is that a high portion of equities during the accumulation phase is essential for achieving high returns and high replacement rates. On the other hand, in the last period of the work phase, the portion of equities must be minimised to reduce the high risk of losing the accumulation. Another important conclusion is that the static investment policy, which is commonly used in Israel, with fixed

30-35% equities, should be changed to a dynamic, lifecycle strategy that can produce significantly higher replacement rates than the statically fixed strategy with a slightly higher risk.

Withdrawal of severance pays during the employment period reduces the replacement rates significantly. Tax policy today encourages people who have been laid off to withdraw their severance pays, instead of encouraging them to keep these resources for their future annuity. The rules should be changed to allow gradual, tax-free withdrawals during the leave period, and improve the public understanding of the consequences of severance pays withdrawals on the future annuity.

Contribution rates for the funded second pillar are 21% higher than the average for OECD countries. 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 pays. Compared to the 0.8 replacement rate needed according to pension theory and the consumption puzzle, these replacement rates are higher. The rates can be reduced or can be used to raise old age pensions. The differences in replacement rates between low earners and high earners for each gender category are only 0.04-0.05. The conclusion is that the system is not redistributive enough to correct the high gap that was created during the work period.

There is also a gender gap during the work period and after retirement. Males' starting salaries and rates of growth are much higher than females'. The gap expands in the retirement phase: the annuity of males is much higher than females', and males' replacement rates are higher than females'. Part of this is due to the shorter employment period of females and longer life expectancy, and can be solved by equalising the retirement age of females to 67, as it is for males.

An additional solution to both the gender gap and low to high earners can be achieved by 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 of the second pillar fund, and redirecting the contribution to the first flat rate pillar. This step will have a redistributive effect and will reduce both the gap between genders and between low and high earners.

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. A further study could also be conducted regarding 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.

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References

Ahdut L., Gharrah R., 2008, *Work and Retirement Among Israelis Aged 50 and over*, "Social Security", 76, pp. 43-71, http://www.jstor.org/stable/23279285 (in Hebrew).

Ahdut L., Spivak A., 2010, *The Pension System in Israel After 15 Years of Reforms*, Program of economic and society, Policy Studies, 8, Van Leer Institute, Jerusalem (in Hebrew).

Amstradamsky S., 2012, *Taking responsibility on pension,* Calcalist, 26 August, http://www.calcalist.co.il/Ext/Comp/ArticleLayout/CdaArticlePrint1280/0,16492,3581066,00.html (access: 29.01.2017; in Hebrew).

Antolin P., Payet S., Yermo J., 2010, *Assessing default investment strategies in defined contribution pension plan,* OECD Journal: Financial Market Trends, 1, pp. 87-115.

Basu A., Drew A., 2009, *The Appropriateness of Default Investment Options in Defined Contribution Plans: Australian Evidence*, Griffith University Business School Discussion Paper Finance, 2009-3, Nathan, Australia.

Barr N., Diamond P., 2010, *Reforming Pensions: Lessons from Economic Theory and Some Policy Directions*, [in:] Bernal R., Panizza U., Rigobón R., Soares R. (eds.), Economia, 11(1), pp. 1-15.

Berstein S., Fuentes O., Torrealba N., 2010, *In an Individually Funded Pension System: How Can Risks Be Mitigated?*, Working Papers Series, 36, Superintendencia de Pensiones Santiago, Chile.

Berstein S., Fuentes O., Villatoro F., 2013, *Default investment strategies in a defined contribution pension system: a pension risk model application for the Chilean case*, "Journal of Pension, Economics and Finance", 12(4), pp. 379-414.

Cannon E., Tonks I., 2013, *The value and risk of defined contribution pension schemes: international evidence*, "Journal of Risk and Insurance", 80(1), pp. 95-119.

Central Bureau of Statistics (CBS), 2016, *Statistical Abstract of Israel 2016,* http://www.cbs.gov.il/reader/shnaton/shnatone_new.htm?CYear=2016&Vol=67&CSubject=12 (access: 30.01.2017).

Chai J., Horneff W., Maurer R., Mitchel O.S., 2009, *Extending Life Cycle Models of Optimal Portfolio Choice: Integrating Flexible Work, Endogenous Retirement, and Investment Decisions with Lifetime Payouts,* NBER Working Paper Series, 15079.

Dowd K., Rowe D., 2004, *Introduction to Value at Risk Models*, [in:] Alexander C., Sheedy E. (eds.) The Professional Risk Managers' Handbook, PRMIA Publications, Wilmington, pp. 907-946.

Gómez-Hernández D., Pérez-Sosa F. A., 2014, *A Stochastic Approach to Increase Replacement Rates in Defined Contributions Pension Schemes*, "International Review of Business Research Papers", 10(1), pp. 49-64.

Hakohan R., 2014, *Employment among elders in Israel*, Policy Paper. Israeli employment service, https://www.taasuka.gov.il/he/InfoAndPublications/Documents/adultsemployment0214.pdf (in Hebrew).

Kido D., 2012, *Value at Risk and Conditional Value at Risk: A Comparison*, "Investment Risk and Performance Feature Articles", 2012(1), CFA Institute.

Kimhi A., Shraberman K., 2013, *Employment and income trends among elder Israelia*, Policy Paper, 2013.07, Taub centre (in Hebrew).

Lleo, S., 2009, *Risk Management: A Review*, "Risk Management, Foundations for a Changing Financial World", Research Foundation of CFA Institute, 4(1), pp. 73-111.

Manor M., 2015, *Reforms to Israeli pension system*, [in:] New trends in economics, management and finance, Poznan University of Economic, Doctorals seminars in English, 1st edition 2015, pp. 89-108.

Ministry of Economic (MOE), 2016, *Mandatory pension expansion order,* Government of Israel, Jerusalem*,* http://economy.gov.il/Employment/WorkRights/EmploymentTermination/Pages/PensionPlan.aspx (access: 25.06.2016; in Hebrew).

Ministry of Finance-Director of Capital Markets and Insurance, 2015, *Multi-Funds system in provident funds*, Regulation 2015-9-7, Government of Israel, Jerusalem (in Hebrew).

Ministry of Finance-Director of Capital Markets and Insurance, 2016, *Process of choosing Default Funds*, Regulation 2016-6446, Government of Israel, Jerusalem (in Hebrew).

OECD, 2015, *Pensions at a Glance 2015: OECD and G20 indicators*, OECD Publishing, Paris.

Rockafellar R. T., Uryasev S., 2002, *Conditional value-at-risk for general loss distributions,* "Journal of Banking and Finance", 26(7), pp.1443-1471.

Rozenberg M., 2015, *Wages and income from work by locality and various economic variables 2013,* Periodic Survey, 272, National Insurance Institute, Jerusalem (in Hebrew).

Shiller R. J., 2005, *The life-cycle personal accounts proposal for social security: A review*, NBER Working Paper, 11300, National Bureau of Economic Research, Cambridge, MA.

Spivak A., 2013, *Pension in Israel and Abroad: Major Developments, Approaches and Ideological Influences*, Van Leer Institute, Disputes in Economics – Second Series, 4, Jerusalem (in Hebrew).

Abbreviation

CBS – Central Bureau of Statistics; CPI – consumer price index; CVaR – Conditional Value at Risk; DC – Defined Contribution; NIS – New Israeli Shekels; NYSE – New York Stock Exchange; PAYG – Pay-As-You-Go; S&P – Standard and Poor 500; VaR – Value at Risk; USD – US Dollar.