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Frequency of Adjusting Asset Allocations in the Life-Cycle Pension Model: When Doing More Is Not Necessarily Better

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Abstract

In the present study, we make an effort to enhance practical advantages of the life-cycle pension model and hypothesize that the pension funds and their members may be made better off if the funds adjust their asset allocations on a less frequent basis, in order to better exploit the return potential of more risky assets. We consider a hypothetical Israeli employee and analyze a number of pension savings glide-paths with different frequency of switches between the major asset classes. We compare the performance of the glide-paths by employing an estimation-based and a simulation-based technique. The results demonstrate that by decreasing the frequency of switches in the framework of the life-cycle model, pension funds can achieve: (i) higher estimated annualized real returns and accumulated savings; (ii) higher expected risk-adjusted performance measures; and (iii) significantly higher simulated mean and median values of real accumulated savings. Moreover, we document that, though decreasing the frequency of switches slightly increases the standard deviation of the employee's terminal wealth, it does not lead to critically low pension savings levels even for relatively unfavorable sequences of financial assets' returns. On the other hand, both empirical techniques prove that keeping the initial asset allocation proportions constant throughout the employees' working career (life-style approach) significantly increases the pension funds' risk levels without significantly increasing their pension portfolio returns.

JEL classification numbers: E21; E37; G11; G17; G23
Keywords: Capital Market; Investment Profitability and Risk; Life-Cycle Pension Model; Pension Funds' Investment Policy; Retirement Savings.

1 Introduction

In recent decades, in most of the developed countries, including Israel, the structure of pension arrangements has moved from the defined benefit systems to various types of

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defined contribution arrangements in which the provision of pensions depends on total assets accumulated by an employee. This change has been initiated by governments seeking to decrease the fiscal impact of aging populations and to diversify the sources of retirement income. This system increasingly links retirement incomes to the performance of the assets in which employees' savings are invested.

Many pension funds now offer their members investment options that do not require them to make investment decisions. One such innovation in the financial services marketplace refers to the life-cycle or target-date funds. The main approach of the life-cycle model of investing, which stands behind this type of funds, is that one’s portfolio should become increasingly conservative with age (e.g., Malkiel, 2003). The idea is that younger investors whose expected investment horizons are much longer are often willing to bear more market risk hoping to receive higher expected returns. As workers age and approach their retirement, every fall in the accumulated value becomes more critical for the total amount of their expected savings, so that many of them are willing to reduce risk in their portfolios (e.g., Viceira, 2009).

In retirement plans, this approach is implemented by gradually switching investments from more volatile assets (like stocks) to less volatile assets (fixed interest securities like bonds and cash) as the participant approaches retirement. While life-cycle funds offered by different investment companies differ from one another with respect to how and when they switch assets, the the general direction of the switch is similar – from stocks to bonds and cash. These funds are one of the most rapidly growing financial products of the last decade, since they offer investors the opportunity to exploit time-varying investment rules. Life-cycle investment strategies are also said to reduce the volatility of wealth outcomes making them desirable to investors who seek a reliable estimate of final pension a few years before retirement (e.g., Blake et al., 2001). On the other hand, some researchers note that these benefits come at a substantial cost to the investor - giving up significant upside potential of wealth accumulation offered by more aggressive strategies (Booth and Yakoubov, 2000; Byrne et al., 2007).

The growing popularity of the life-cycle pension funds makes the definition of their optimal investment strategies an issue of major practical importance. The general direction of the age-based switch of funds to the less risky assets is a matter of rather broad consensus, but the question of when and how exactly this switch needs to be made remains open. A continuously increasing number of studies make efforts to establish the optimal asset allocation for pension funds based on the principles of the life-cycle savings and risk management (e.g., Poterba et al., 2006; Gomes et al., 2008; Bridges et al., 2010; Berstein et al., 2013; Dahlquist et al., 2016). These studies consider a wide variety of potential glide-paths over the pension fund members' life cycle and analyze a number of factors that may affect both the final investment outcomes, including capital market returns, human capital risk and labor income shocks, and the subjective utility the members attribute to these outcomes, including investor's risk preferences, habit formation and liquidity constraints. General conclusion arising from these studies is that there is no universal design of the pension fund that would be optimal for all its members.

Yet, to our best knowledge, previous studies do not explicitly pose the following general question: "Given that a pension fund adopts the life-cycle approach and given the asset allocation proportions at the beginning and towards the end of the members' working career, is it better to adjust the asset allocations on a more frequent or more rare basis?" This is the question our study focuses on. In other words, we ask if from the point of view of an employee whose savings are managed by a pension fund, which invests according to the life-cycle approach and switches its members' savings to less risky assets once in five years , it might be recommended to decrease the frequency of switches.

In order to answer our research question, as a case study which may potentially have broader implications, we consider a hypothetical Israeli employee who works for 40 years earning an average inflation-indexed salary for his age group and contributes a mandatory proportion of his gross salary to a pension fund that charges management fees at the average rates accepted in Israel. We consider two alternative "initial" glide-paths, one more aggressive and another more conservative, based on the 5-year asset redistribution frequency, and for each one of them generate three additional "matching" glide-paths, two of them based on the same allocation proportions at the beginning and towards the end of the employee's working career, but with less frequent switches, and the third one taking the same allocation proportions at the beginning and leaving them constant for the rest of the employee's working career. In order to compare the performance of the eight resulting glide-paths, we employ two alternative techniques: (i) for all the glide-paths, based on historical returns and return volatilities of major asset classes and correlations between their returns, estimate the expected real returns, return volatilities and the employee's total accumulated savings at retirement; and (ii) perform 10,000 simulations of monthly returns for all the asset classes over the employee's working career by randomly drawing respective (for the given asset class) observations from our sample of real historical returns, and as a bottom line of each simulation, obtain the employee's real accumulated savings, according to all the glide-paths.

The results of the analysis demonstrate the advantages of decreasing the frequency of switches between the asset classes in the framework of the life-cycle model. First, according to the estimation-based technique, for both aggressive and conservative asset allocations, the expected annualized real returns and real accumulated savings are higher the lower the frequency of switches, while the differences in the expected annualized standard deviations are relatively moderate, resulting in significantly higher Sharpe ratios for the glide-paths with lower frequency of switches. Second, according to the simulation-based technique, given the initial allocation, if a pension fund which follows the life-cycle approach decreases the frequency of asset switches, the mean and the median values of real accumulated savings are significantly increased. Moreover, though decreasing the frequency of switches increases the volatility of pension portfolio returns, the Value at Risk analysis of the accumulated retirement savings' distributions allows us to conclude that it does not lead to critically low pension wealth levels even if relatively unfavorable sequences of financial assets' returns take place over the employee's working career. Thus, the results produced by both techniques are consistent and allow us to conclude that decreasing the frequency of switches in the framework of the life-cycle model extends the period of holding the maximal acceptable proportion of assets in equity and has a potential to significantly increase pension fund members' total accumulated wealth, without significantly increasing the fund members' risk.

On the other hand, both empirical techniques demonstrate that giving up the life-cycle approach and keeping the initial asset allocation proportions constant throughout the employees' working career increases the pension funds' risk levels so significantly that the increase in the expected return levels fails to provide a sufficient compensation from the members' point of view, as expressed both in significantly lower expected Sharpe ratios and in appreciably weaker performance in case of unfavorable capital market scenarios.

The rest of the paper is structured as follows. In Section 2 briefly reviews the literature dealing with the characteristics and the advantages of the life-cycle pension model. In

Section 3, we formulate and explain our research hypothesis. In Section 4, we describe our research methodology. Section 5 provides the empirical tests and the results. Section 6 concludes and provides a brief discussion.

2 Literature review

In recent decades, the pension fund industry in most of the developed countries is dominated by defined contribution retirement plans. In these plans pension fund members decide how much to contribute, and how to invest their contributions and the contributions that their employers might make on their behalf. Therefore, the amounts of pension payments they receive after retirement depend on their own accumulation and investment decisions. The pension funds are only responsible for the design of pension plans and for their administration. Current regulations grant the funds considerable freedom in their selection of the number and type of investment options available to the fund members.

The model itself of investing the pension savings has experienced a significant change in recent years in many of the countries (Impavido et al., 2010). The trigger for such changes has been in academic studies that have shown that life-cycle investment models, which are based on the change in the allocation of the portfolio of a pension fund as its members approach retirement, have a specific benefit to the members (e.g., Bodie et al., 2009; Viceira, 2009). Life-cycle funds are a variant of life-style funds built on the idea of "age-based investing," or the understanding that investors are better off if they allocate a larger share of their long-term savings to stocks when they are young, have long retirement horizons and are more willing to bear investment risks, and decrease this allocation as their investment horizon decreases, so that they are less likely to compensate for potential losses. Life-cycle funds automatically rebalance their holdings, in order to meet their members' age-based requirements.

A vast body of literature discusses the practical advantages of the life-cycle approach to retirement saving. Fachinger and Mader (2007) suggest that decreasing equity exposure with age is the optimal strategy, regardless of the investor's risk preferences or particular life situation. They bring two arguments supporting this advice: (i) time diversification, and (ii) targeting for large liquidity needs in mid-life. Kovacevic and Latkovic (2015) argue that benefits of implementing life-cycle investments are clearly visible in the total expected amount of accumulated savings from the risk-return perspective. However, those benefits are partially diminished by the fact that the expected risk of a pension fund with the lowest risk profile is not substantially different from the expected risk of a pension fund with a medium risk profile, due to the lack of diversification of the former.

Since the seminal work by Campbell and Viceira (2002), which develops numerical solutions to dynamic models which can be used to study optimal portfolio structure over the life-cycle, many other papers have explored the issue of establishing an optimal asset allocation for pension funds, which is derived from the principles of life-cycle savings and risk management. Gollier and Zeckhauser (2002) derive the conditions under which the option to rebalance a portfolio in the future affects portfolio choice. Their results suggest that under specific assumptions about the structure of utility functions, the optimal portfolio share devoted to equity will decline with age. Cocco et al. (2005) find that a life-cycle investment strategy that reduces the household's equity exposure as it ages may be optimal depending on the shape of the labor income profile. Poterba et al.

(2006) examine how different asset allocation strategies over the course of a worker’s career affect the distribution of retirement wealth and the expected utility of wealth at retirement. They compare a typical life-cycle investment strategy to an age-invariant asset allocation strategy that sets the equity share of the portfolio equal to the average equity share in the life-cycle strategy, and show that the distribution of retirement wealth associated with both strategies is similar. Viceira (2009) argues that the creation of “conservative”, “moderate,” and “aggressive” life-cycle funds can also help investors choose the equity profile that best fits their appetite for risk.

Gomes et al. (2008) compare popular default choices for defined contribution pension plans in terms of welfare costs and show that the life-cycle strategy is the one that results in the smallest welfare loss. Blake et al. (2008) show that a stochastic life-cycle approach, with an initial high weight in equity-type investments and a gradual switch into bond-type investments as the retirement date approaches is an optimal investment strategy. Chai et al. (2009) also show that, in the optimal portfolio, equities are the preferred asset for young workers, with the optimal share of equities generally declining prior to retirement. In particular, they demonstrate that, when both hours of work and retirement ages are endogenous, the optimal share of equities still decreases with age, but equity fractions are considerably higher over the life cycle than reported in studies that do not allow endogenous retirement. Horneff et al. (2008) compare different standardized payout strategies to show how people can optimize their retirement portfolios. They conclude that annuities are attractive as a stand-alone product when the retiree has sufficiently high risk aversion and lacks a bequest motive. Withdrawal plans dominate annuities for low/moderate risk preferences, because the retiree can gain by investing in the capital market. Bridges et al. (2010) argue that life-cycle plans with larger portfolio weights assigned to equities have higher average returns, but those gains come at the cost of increased risk of infrequent bad outcomes.

Antolin et al. (2010) argue that life-cycle strategies that maintain a constant exposure to equities during most of the accumulation period, switching swiftly to bonds in the last decade before retirement, produce better results and are easier to explain. Berstein et al. (2013) evaluate different life-cycle investment strategies for different types of workers. They calibrate a pension risk model for the Chilean economy, including measures of life-cycle income, human capital risk, investment and annuitization risks and document that affiliates can gain around 0.85 percentage points in terms of average replacement rates (ratio of the monthly pension payment to the worker's last wage before retirement) in return for an increase of 1 percentage point in risk, measured as standard deviation of replacement rates.

Generally speaking, a wide variety of factors may affect optimal long-term pension investment from an individual investor’s perspective. These include, but are not limited to, the investor's risk preferences, human capital risk, employee's working ability, habit formation, liquidity constraints and idiosyncratic labor income shocks (e.g, Larraín Rios, 2007; Bodie et al. 2009; Mitchell and Turner, 2010). Consequently, Dahlquist et al. (2016) conclude that there exists no 'one-size-fits-all' design of the pension fund to meet all the participants' needs. They find substantial heterogeneity in the optimal allocation to different asset classes in the defined contribution pension accounts. They also find that the optimal proportion of equity varies substantially with the stock market's past performance. The lack of universal investment strategies may be viewed as a positive result, since it suggests that each type of fund should be attractive for participants with different risk tolerance and other personal characteristics. However, this also means that a more precise definition of the participants’ characteristics must be made in order to find the optimal investment strategy.

3 Research hypothesis

The previous financial literature, as described in the previous Section, theoretically and empirically demonstrates the advantages of the life-cycle approach to retirement savings' investments. Moreover, based on the principles of the life-cycle savings and risk management, a number of studies try to develop an optimal asset allocation for all the pension funds. These studies consider different glide-paths over the pension fund members' life cycle and analyze a number of factors that may affect both the final investment outcomes and the subjective utility the members attribute to these outcomes.

In this respect, we ask another related question, which, to our best knowledge, has not been explicitly addressed by previous literature, namely, "given that a pension fund adopts the life-cycle approach and given the asset allocation proportions at the beginning and in the last years before the end of the fund members' working career, would it be more profitable for the fund and its members to adjust the asset allocations on a more frequent or more rare basis?" We are aware of the fact that because of the differences in pension fund members' risk preferences it is impossible to work out a universal glide-path that would optimize all the members' utility functions, but set a goal for ourselves to provide some aid for the pension funds in establishing at least the general direction of updating their currently established frequency of savings redistributions between the asset classes.

Since decreasing the frequency of switches between the asset classes in the framework of the life-cycle model extends the period of holding the maximal acceptable proportion of assets in equity, we expect that it will significantly increase the pension fund members' total accumulated wealth. Moreover, since decreasing the frequency of the switches does not offset the age-dependent risk reduction of the life-cycle model itself, we hypothesize that the significant increase in returns will not be on account of significant increase in the pension funds' risk levels. On the other hand, we hypothesize that giving up the life-cycle approach and keeping the initial asset allocation proportions constant throughout the members' working career will increase the funds' risk levels so significantly that the increase in the expected return levels will fail to provide a sufficient compensation from the members' point of view.

4 Data description and methodology

Our study is based on the mandatory pension insurance system in Israel. The system operates according to the defined contribution where an employee and his employer make monthly contributions to the employee's pension account, which is managed by a pension fund operated by one of the private investment companies. The employee has a right to choose the pension fund and to transfer his savings to another fund as many times during his working career as he wants. The total wealth which is accumulated in the account by the employee's retirement date determines the amount of the monthly pension payments he receives after retirement.

Realizing the practical advantages of the life-cycle pension model, on February 17, 2015, the Israel Ministry of Finance had passed a resolution establishing that starting with

January 1, 2016 all the pension funds in Israel are obliged to use the programs consistent with the life-cycle model as default options for their members. This important decision is supposed to change the previous state of matters when the employees' pension savings were distributed between asset classes in constant (and quite conservative) proportions and to ensure continuous adjustment of asset allocations towards retirement, and therefore higher expected returns, at least for the majority of Israeli employees.

For the purposes of our research, we analyze a hypothetical employee who is saving for retirement. The retirement age in Israel is 67 for men and 62 for women. For the sake of convenience, we assume that the employee is a man, whose working career lasts 40 years, or 480 months (from the age of 27 till the age of 67[2]). The employee earns an average gross salary for male employees in Israel. The employee's monthly salary changes with his age, according to the data reported by the Israel Central Bureau of Statistics for 2015, as shown in Table 1.

Table 1: Average monthly gross salary for male workers in Israel, by age groups, according to the Israel Central Bureau of Statistics

Age group, years	**Average monthly gross salary per worker, NIS**
25-34	8,459±436.3
35-44	12,950±555.8
45-54	13,588±781.6
55-64	13,904±1,261.6
65+	9,777±1,511.0

We assume that within each age span, the salary continuously grows by the same amount per year. For example, if for the age span of 35-44, the reported monthly gross salary is 12,950±555.8 New Israeli Shekels (NIS)[3], then we assume that at the age of 35, the employee earns 12,950-555.8=12,394.2 NIS per month, while at the age of 44, he earns 12,590+555.8=13,145.8 NIS per month, the monthly salary linearly growing during this 10-year period by 555.8/5=111.2 NIS per year. In addition, the employee's salary is inflation indexed, that is, increases at the same rate as the Consumer Price Index (CPI)[4]. In other words, for each given age, the real (in terms of 2015) salary remains constant over time.

According to the regulation issued by the Israel Ministry of Finance, at the end of each month, the employee contributes 5.5% of his gross salary to his retirement savings account at a pension fund[5], while his employer contributes 6% of the employee's gross

[2] We choose a relatively high age of starting the working career, since after graduating from the higher school,, most of the Israeli men serve for three years in the Israel Defense Forces, and then proceed to three to four years of undergraduate (university/college) studies. We also implicitly assume that the employee's career is continuous, without periods of unemployment.

[3] The official exchange rate for December 31, 2015 was 1 US Dollar=3.902 NIS

[4] Average inflation rate in Israel over years 2000-2015 was 1.6036% per year (or 0.1327% per month)

[5] This was the mandatory contribution proportion in Israel as of December 2015. Starting from July 2016, it was updated to 5.75%, and from January 2017 it is expected to become 6%.

salary to the same account[6]. We assume that the pension fund charges management fees at the average rates that were employed in Israel in 2015, namely, 3.4% on the regular monthly contributions and 0.3% per year on the accumulated wealth.
The employee's savings are invested by the pension fund in four major asset classes:

1. Stocks,
2. Corporate bonds,
3. Government bonds,
4. Pension-Oriented (PO) bonds – A special category of the Israeli government bonds sold only to pension funds and providing a fixed CPI-linked (real) annual yield of about 4.8%. Because of a relatively high risk-free and inflation indexed yield, PO bonds are considered a privilege of the Israeli pension funds, and the latter are allowed to invest 30% of their total portfolio wealth in this category of bonds.

For our empirical analysis, we employ actual monthly returns for the four asset classes on Tel Aviv Stock Exchange (TASE) over years 2000-2015[7]. The benchmark indexes we use for the respective asset classes are as follows:

1. Stocks – We employ the TA-100 Index consisting of the 100 shares with the highest market capitalization. The composition of the index is updated twice a year.
2. Corporate bonds – We construct an equally-weighted portfolio of the two indexes:

- Tel Bond-60 Index consisting of the 60 corporate bonds, fixed-interest and CPI-linked, with the highest market capitalization. As of December 31, 2015 the mean duration of the bonds making up the index was 8.45 years. 48 out of 60 bonds had a high grade credit rating[8], while the rest of 12 bonds had an upper medium grade credit rating.
- Tel Bond-Shekel Index consisting of all corporate fixed-rate (unlinked) bonds. On December 31, 2015 the index consisted of 84 bonds with mean duration of 6.27 years. 42 out of 84 bonds had a high grade credit rating, 36 had an upper medium grade credit rating, and 6 had a lower medium grade credit rating.

3. Government bonds – We employ the Government Bonds General Index which

[6] In practice, in addition to 6% of the employee's gross salary, employers in Israel contribute 8.33% as a "compensation" component. But since the employee may withdraw this savings component after leaving a company, we choose not to consider this additional contribution in our analysis.
[7] This sampling period is chosen, as the official price and return data for all the asset classes are available on TASE website (www.tase.co.il) since 2000. Moreover, the use of these data may be justified by the fact that return and volatility rates we employ (reported in Table 2) are comparable (possibly, slightly higher) to the respective rates usually reported for the developed markets over much longer periods (e.g., Dimson et al., 2014).
[8] According to Maalot credit rating agency estimates.

includes all the government bonds traded on TASE. On December 31, 2015 the index consisted of 13 CPI-linked and 18 unlinked bonds with mean duration of 7.18 years.

Table 2 comprises expected (average historical) annualized real returns and return volatilities (standard deviations) for the asset classes. It should be noted that real returns for stocks and corporate and government bonds are calculated by deducting actual monthly inflation rates from actual nominal monthly returns, while real annual return of 4.8% for PO bonds is provided by the definition of this asset class.

Table 2: Expected returns and return volatilities of major asset classes, annualized percent

Asset class	**Expected real return**	**Expected standard deviation**
Stocks	5.21	17.85
Corporate bonds	2.42	9.47
Government bonds	1.86	7.35
PO bonds	4.80	0.00

Table 3 reports the correlations between the returns of the four major asset classes. Since the returns of PO bonds are fixed and constant, they are uncorrelated with other asset classes' returns. The correlations between stock and bond returns are positive, but quite moderate, leaving some space for portfolio risk diversification.

Table 3: Correlations between the returns of major asset classes

Correlation coefficients	**Stocks**	**Corporate bonds**	**Government bonds**	**PO bonds**
Stocks	1	0.24	0.18	0
Corporate bonds	0.24	1	0.35	0
Government bonds	0.18	0.35	1	0
PO bonds	0	0	0	1

We consider two alternative employee's retirement savings allocations, one relatively aggressive (with relatively high proportions of assets invested in equity) and another relatively conservative (with relatively low proportions of assets invested in equity). For each of the allocations, we consider four alternative glide-paths with different "speed of decreasing the portfolio risk":

1. Life-cycle with frequent switches between asset classes (from stocks to bonds): These are two "classic" glide-paths with switches taking place every five years (overall, seven switches). The more aggressive glide-path in this category is the one which is actually employed by one of the Israeli investment companies.

2. Life-cycle with medium frequency of switches between asset classes: These are two glide-paths with similar asset allocation proportions at the beginning and during the last five years before retirement, but with switches taking place every seven years (overall, five switches).

3. Life-cycle with rare switches between asset classes: These are two glide-paths with similar asset allocation proportions at the beginning and during the last five years before retirement, but with only three switches: at age of 39, 51 and 62.

4. Life-style allocation: We take the same allocation proportions at the beginning and leaving them constant for the rest of the employee's working career.

Table 4 depicts the allocation proportions between the asset classes for the four aggressive glide-paths: Aggressive-Frequent (AF), Aggressive-Medium (AM), Aggressive-Rare (AR) and Aggressive-Constant (AC), while Table 5 does the same thing for the four conservative glide-paths: Conservative-Frequent (CF), Conservative-Medium (CM), Conservative-Rare (CR) and Conservative-Constant (CC)[9].

[9] Note that in all the glide-paths, the proportion of PO bonds remains similar (30%) for all age spans. As mentioned above, due to their relatively high risk-free yield, these bonds are considered a privilege of the Israeli pension funds, so we may assume that the pension funds will hold them in the highest possible proportion, which is 30%.

Table 4: Aggressive investment allocations, by employee's age: Various frequencies of switches between the asset classes

Panel A: Aggressive – Frequent (AF)

Asset class	Proportion invested, by employee's age							
	27-32	**32-37**	**37-42**	**42-47**	**47-52**	**52-57**	**57-62**	**62-67**
Stocks	48%	45%	40%	37%	25%	15%	9%	1%
Corporate bonds	16%	17%	18%	20%	24%	25%	26%	29%
Government bonds	6%	8%	12%	13%	21%	30%	35%	40%
PO bonds	30%	30%	30%	30%	30%	30%	30%	30%

Panel B: Aggressive – Medium (AM)

Asset class	Proportion invested, by employee's age					
	27-34	**34-41**	**41-48**	**48-55**	**55-62**	**62-67**
Stocks	48%	45%	37%	25%	9%	1%
Corporate bonds	16%	17%	20%	24%	26%	29%
Government bonds	6%	8%	13%	21%	35%	40%
PO bonds	30%	30%	30%	30%	30%	30%

Panel C: Aggressive – Rare (AR)

Asset class	Proportion invested, by employee's age			
	27-39	**39-51**	**51-62**	**62-67**
Stocks	48%	40%	15%	1%
Corporate bonds	16%	18%	25%	29%
Government bonds	6%	12%	30%	40%
PO bonds	30%	30%	30%	30%

Panel D: Aggressive – Constant (AC)

Asset class	Proportion invested, by employee's age
	27-67
Stocks	48%
Corporate bonds	16%
Government bonds	6%
PO bonds	30%

Table 5: Conservative investment allocations, by employee's age: Various frequencies of switches between the asset classes

Panel A: Conservative – Frequent (CF)

Asset class	Proportion invested, by employee's age							
	27-32	32-37	37-42	42-47	47-52	52-57	57-62	62-67
Stocks	24%	22%	19%	16%	10%	6%	4%	0%
Corporate bonds	19%	20%	21%	22%	23%	24%	25%	26%
Government bonds	27%	28%	30%	32%	27%	40%	31%	44%
PO bonds	30%	30%	30%	30%	30%	30%	30%	30%

Panel B: Conservative – Medium (CM)

Asset class	Proportion invested, by employee's age					
	27-34	34-41	41-48	48-55	55-62	62-67
Stocks	24%	22%	16%	10%	4%	0%
Corporate bonds	19%	20%	22%	23%	25%	26%
Government bonds	27%	28%	32%	27%	31%	44%
PO bonds	30%	30%	30%	30%	30%	30%

Panel C: Conservative – Rare (CR)

Asset class	Proportion invested, by employee's age			
	27-39	39-51	51-62	62-67
Stocks	24%	19%	6%	0%
Corporate bonds	19%	21%	24%	26%
Government bonds	27%	30%	40%	44%
PO bonds	30%	30%	30%	30%

Panel D: Conservative – Constant (CC)

Asset class	Proportion invested, by employee's age
	27-67
Stocks	24%
Corporate bonds	19%
Government bonds	27%
PO bonds	30%

In order to test our research hypothesis, for all the glide-paths, we calculate the employee's retirement savings. We perform our empirical analysis employing two alternative techniques:

First, we estimate the expected real returns, return volatilities and total accumulated savings based on historical returns and return volatilities of the asset classes and the correlations between their returns. That is, for each given investment portfolio in each given period, we calculate[10]:

$$R_P = \sum_i w_i R_i \quad (1)$$

$$\sigma_P^2 = \sum_{i,j} w_i w_j \sigma_i \sigma_j \rho_{ij} \quad (2)$$

where Rp and σ_p represent the pension assets' expected return and expected volatility, respectively; w_i represents the share of an asset class i in the portfolio; Ri and σ_i are the asset class i's expected return and expected volatility, respectively; and ρ_{ij} is the expected correlation between the asset classes i and j. Furthermore, we estimate expected returns and volatilities for all the glide-paths. The total real accumulated savings are estimated by employing the expected (average historical) real returns, recalculated to monthly terms, on the series of the employee's monthly pension contributions over his whole working career. The results are shown in Subsection 5.1.

Second, we simulate monthly returns for the four asset classes over the employee's 40-year working career by randomly drawing respective (for the given asset class) observations from our sample of historical returns. We perform 10,000 simulations employing actual real monthly returns for each asset class[11]. As a bottom line of each simulation, we obtain the employee's real accumulated savings. The results are analyzed in Subsection 5.2.

5 Results description

5.1 Frequency of asset allocation adjustments: Returns and savings estimation

First, based on historical returns, return volatilities and correlations of the asset classes, by equations (1) and (2), respectively, for all the suggested glide-paths, we estimate the expected real returns and return volatilities over the accumulation period. Furthermore, we estimate total real accumulated savings by applying the expected (average historical) real returns, recalculated to monthly terms, on the series of the employee's monthly pension contributions over his whole working career. Finally, based on the expected returns and their standard deviations, we calculate the expected Sharpe ratios, assuming that the Bank of Israel annualized real rate of interest is 2.16%[12]. Table 6 depicts the estimated measures for all the glide-paths.

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[10] This approach is similar to the one employed by Kovacevic and Latkovic (2015).

[11] For stocks and corporate and government bonds, real monthly returns are obtained by deducting actual monthly inflation rates from actual nominal monthly returns, while for PO bonds, real monthly returns are fixed at the level of 4.8% per year (0.3915% per month).

[12] Over our sampling period of 2000 through 2015, the Bank of Israel average annualized nominal rate of interest was 3.7957%, while average annualized inflation rate in Israel was 1.6036%.

Table 6: Estimated expected real returns, return volatilities, employee's total accumulated savings and Sharpe ratios for the suggested glide-paths

Glide-path	Expected real return, annualized %	Expected standard deviation, annualized %	Expected real accumulated savings, NIS	Expected Sharpe Ratio
AF	3.79	5.32	987,805	0.31
AM	3.95	5.38	1,057,632	0.33
AR	4.17	5.43	1,147,410	0.37
AC	4.32	7.88	1,231,482	0.27
CF	3.41	4.30	895,641	0.29
CM	3.53	4.45	935,181	0.31
CR	3.76	4.68	976,582	0.34
CC	3.94	6.82	1,010,278	0.26

A number of results, corroborating our research hypothesis, may be noted when analyzing the Table:

- Consistently with our hypothesis, for both savings allocations, if the life-cycle approach is adopted, then the expected real returns and accumulated savings amounts are higher the lower the frequency of switches between the asset classes[13]. Moreover, since decreasing the frequency of the switches does not offset the age-dependent risk reduction of the life-cycle model itself, the standard deviations of the expected returns are only slightly higher for the glide-paths with the higher frequency of switches. As a bottom line, the expected Sharpe ratios for the AR (CR) glide-paths are 0.37 (0.34) compared to 0.31 (0.29) for the AF (CF) glide-paths. This makes up a difference of 19.4% (17.2%), representing a significant improvement in the expected risk-adjusted performance of the pension funds that would decide to perform the switches three times during the employee's career, instead of the commonly accepted seven times.
- The glide-paths based on keeping the asset allocation proportions constant throughout the employee's working career are expected to yield higher real returns and accumulated savings. Yet, giving up the advantages of the life-cycle approach results in a significant increase in the expected risk levels. Subsequently, in line with our hypothesis, the expected risk-adjusted performance of the pension funds is deteriorated if they decide to adopt the life-style, instead of the life-cycle approach, as expressed in the relatively low expected Sharpe ratios of 0.27 (0.26) for the AC (CC) glide-paths. Moreover, the CC glide-path performs strictly worth than the AM and AR glide-paths, the latter producing higher expected real returns with lower expected standard deviations.
- The glide-paths based on the aggressive asset allocation yield higher expected

[13] In addition, we might pay attention to the fact that decreasing the frequency of asset switches can potentially decrease the number of transactions the fund performs, and therefore, the transaction costs it pays.

returns, but with higher expected standard deviations, compared to those based on the conservative asset allocations. Overall, the expected Sharpe ratios are slightly higher for the aggressive allocation, yet the choice of the allocation greatly depends on the employee's risk preferences.

5.2 Frequency of asset allocation adjustments: Simulation results

Our second technique of comparison between the suggested glide-paths is based on the simulation. As explained in Section 4, for the employee's 40-year (480-month) working career, we perform 10,000 monthly return simulations by randomly drawing observations from our sample of historical real monthly returns[14]. These simulated returns determine the performance of the employee's pension investment portfolio, so that at the end of each simulation, we obtain the total amount of his real accumulated savings.

Table 7 reports for all the glide-paths, the mean, median and standard deviation of the employee's real accumulated savings over the sample of 10,000 asset return sequence simulations. In addition, the Table presents for both aggressive and conservative asset allocations, the differences in the mean and median values of the accumulated savings between (i) the glide-paths with rare and frequent switches between the asset classes; (ii) the glide-paths with constant asset allocations and those with rare switches.

Table 7: Simulated employee's real accumulated savings

Glide-path	Mean, NIS	Median[a], NIS	Standard deviation, NIS
AF	997,792	984,187	846,837
AM	1,068,051	1,052,665	857,964
AR	1,167,809	1,151,587	863,082
AC	1,242,503	1,228,772	1,587,936
Difference AR-AF (t-statistic)	***170,017 (5.87)	***167,400 (4.96)	
Difference AC-AR (t-statistic)	74,694 (0.95)	77,185 (1.08)	
CF	901,324	893,825	764,287
CM	948,207	938,473	772,057
CR	989,273	976,508	779,768
CC	1,021,311	1,006,432	1,466,980
Difference CR-CF (t-statistic)	***87,949 (3.76)	***82,683 (3.25)	
Difference CC-CR (t-statistic)	32,038 (0.74)	29,924	

[a]We employ Wilcoxon/Mann-Whitney test for median equality.
Asterisks denote two-tailed p-values: ***p<0.001.

[14] Alternatively, in order to preserve correlations between asset classes, we have performed 10,000 monthly return simulations by randomly drawing months, rather than individual observations, from our working sample, and subsequently employing real monthly return rates contemporaneously registered for all the asset classes during the respective months. The results, available upon request from the authors, are qualitatively similar to those reported and discussed in Subsections 5.2 and 5.3.

The results in Table 7 support our research hypothesis demonstrating two major things:

- If the life-cycle approach is adopted, then the mean and the median values of real accumulated savings are higher the lower the frequency of switches between the asset classes. The differences in the mean and median values between the glide-paths with rare and frequent switches are highly statistically significant, once again indicating the superiority of risk-adjusted performance of the pension funds that would decide to decrease the frequency of the switches in the framework of the life-cycle model.
- The glide-paths based on keeping the asset allocation proportions constant throughout the employee's working career yield higher mean and median accumulated savings. Yet, the differences in the mean and median values between the glide-paths with constant asset allocations and those with rare switches are non-significant, demonstrating, similarly to the previous Subsection, that giving up the life-cycle approach in favor of the life-style one increases the fund's risk levels so significantly that the increase in its returns fails to provide a sufficient compensation from the employee's point of view. Moreover, once again, the conservative CC glide-path is strictly inferior than the aggressive AM and AR glide-paths.

5.3 Frequency of asset allocation adjustments: The effect of risk

In the previous Subsections, we have documented that increasing the frequency of switches between the asset classes in the framework of the life-cycle model leads to higher expected values and significantly higher simulated mean and median values of the accumulated retirement savings. Yet another result is that both expected and simulated standard deviation of these values increases, as well. We have already established that the increase in the volatility is relatively moderate, but because of the major importance of the risk component in any analysis concerned with the pension savings, in this Subsection we take a closer look at the downside potential of the employee's accumulated wealth. Adopting the approach used by Scheuenstuhl et al. (2010), we calculate the following measures that deal with the issue of risk from different points of view:

1. Value at Risk of the accumulated savings distribution on a 95% confidence level (VaR5%): This risk-measure describes the result that could happen under very unfavorable circumstances. The measure represents the highest value of the accumulated savings achieved by the 500 (out of 10,000) worst scenarios. Thus, in 95% of the scenarios, the values of the accumulated savings are higher than this risk level. This risk-measure is directly computed by identifying the 5% percentile value of the empirical accumulated savings distribution, that is:

$$VaR_{5\%} = \inf\{x, P(AccSav < x) \geq 5\%\} \qquad (3)$$

Where: *AccSav* stands for the value of real accumulated savings at retirement; and inf{x,…} refers to infimum, so that $VaR_{5\%}$ represents the lowest value x such that the probability of an *AccSav* value to be smaller than *x* is 5%.

It is worth noting that since we seek to maximize the value of the accumulated savings, with this specification of the Value at Risk, the higher the VaR the lower the risk.

2. Conditional Value at Risk of the accumulated savings distribution on a 95% confidence level ($CVaR_{5\%}$): This risk-measure provides the expected value of the accumulated savings in the 5% worst cases, that is:

$$CVaR_{5\%} = E[AccSav \mid AccSav < VAR_{5\%}] \quad (4)$$

Once again, since our goal is to maximize the value of the accumulated savings, we may note that a high $CVaR_{5\%}$ is better than a lower $CVaR_{5\%}$. Obviously, based on the definitions, $CVaR_{5\%} \leq VaR_{5\%}$ holds.

Table 8 reports these risk measures for all the suggested glide-paths.

Table 8: Simulated employee's real accumulated savings risk measures

Glide-path	**$VaR_{5\%}$, NIS**	**$CVaR_{5\%}$, NIS**
AF	875,112	853,648
AM	879,260	852,103
AR	886,361	851,684
AC	821,582	753,996
CF	812,645	798,237
CM	814,692	798,301
CR	821,037	798,128
CC	765,271	713,987

The Table provides additional support for our research hypothesis, demonstrating that:

- Within the life-cycle model, the values of VaR5% are slightly higher, the lower the frequency of switches between the asset classes. This represents an important argument in favor of decreasing the frequency of switches, since it appears that though it leads to certain increase in the return volatility, investment scenarios when it actually leads to a decrease in the final savings' values are relatively rare. Moreover, the values of CVaR5% are almost equal for all the switching frequencies, suggesting that even in extremely unfavorable scenarios the lower frequency of switches is not expected to result in a financial disaster for the employee.
- The glide-paths based on keeping the asset allocation proportions constant yield appreciably lower values of VaR5% and CVaR5%, compared to those based on the life-cycle approach. This result emphasizes once again one of the major advantages of the life-cycle model in general, and namely, the fact that in unfavorable investment scenarios, given the same initial asset allocation, it performs significantly better than the life-style model.

6 Conclusion and Discussion

In the present study, we analyze the life-cycle pension model, which is based on the idea that the exposure of pension fund members' portfolios to risky assets should be gradually decreased with the members' age. We make an effort to enhance the model's practical advantages and hypothesize that the pension funds and their members may be made better off if the funds adjust their asset allocations on a rarer basis, in order to better exploit the return potential of more risky assets.

To empirically test our hypothesis, we consider a hypothetical (average) Israeli employee who works for 40 years earning an average inflation-indexed salary for his age group and contributes a mandatory proportion of his gross salary to a pension fund. We analyze two alternative employee's retirement savings allocations, one relatively aggressive and another relatively conservative, and for each of the allocations, consider four alternative glide-paths with different "speed of decreasing the portfolio risk", from a glide-path with the switches between the asset classes taking place every five years to a glide-path keeping the asset allocation constant throughout the employee's career. We perform the comparison between the suggested glide-paths by employing an estimation-based and a simulation-based technique.

The results of our empirical analysis support our hypothesis and demonstrate the advantages of decreasing the frequency of switches between the asset classes in the framework of the life-cycle model. First, according to the estimation-based technique, for both aggressive and conservative asset allocations, the expected annualized real returns and real accumulated savings are higher the lower the frequency of switches, while the differences in the expected annualized standard deviations are relatively moderate, resulting in significantly higher Sharpe ratios for the glide-paths with lower frequency of switches.

Furthermore, simulation results prove that by decreasing the frequency of asset switches the pension fund can significantly increase the mean and the median values of real accumulated savings. Moreover, the Value at Risk analysis of the accumulated retirement savings' distributions allows us to conclude that, though decreasing the frequency of switches increases the volatility of pension portfolio returns, it does not lead to critically low pension wealth levels even for relatively unfavorable sequences of financial assets' returns.

On the other hand, both empirical techniques demonstrate that keeping the initial asset allocation proportions constant throughout the employees' working career significantly increases the pension funds' risk levels without significantly increasing their pension portfolio returns.

Generally speaking, the goal of our study was obviously not to work out a universal glide-path that would optimize all the members' utility functions, since the differences in pension fund members' risk preferences make it a virtually impossible task. We rather made an effort to provide some aid for the pension funds in determining at least the general direction of updating their currently established frequency of savings switches between the asset classes. In this respect, our findings have a potential to significantly improve the risk-adjusted performance of the pension funds that would decide to perform the switches less frequently than the commonly accepted pattern of once in five years.

After all, the major goal of any economist is to contribute, as far as possible, to the well-being of her country's citizens and to the efficiency of the world economy as a whole. In this respect, we hope that the results of our study have a potential of making at least a modest contribution, and are relevant not only for Israel, but in fact, for any defined contribution pension system. If public sector officials adopt the recommendation to decrease the frequency of pension assets' redistribution, it may bring a number of important (and positive) consequences. The first and the most straightforward effect directly arises from the findings of our study, demonstrating that, all other thing being equal, an employee whose pension savings are redistributed for less times during his working career is expected to take advantage of higher pension payments after retirement. The higher replacement[15] rate he is expected to enjoy may help him to go more smoothly through the transition from the category of an employee to the category of a pensioner.

Yet, there are also important potential indirect effects of following our recommendation. Since, as we have seen, the lower frequency of switches between the asset classes suggests investing a greater overall proportion of pension savings in stocks, adopting it may decrease the cost of capital for public companies and therefore enhance productive investments and create new working places. Moreover, higher pension payments may increase consumption and once again, stimulate the economy as a whole. Finally, following our recommendation may help to decrease the number of people whose retirement savings are not sufficient to ensure a deserved quality of life after retirement and who therefore stand in need of income transfers from working people. This result may be of serious help for the economic policy makers who are now heavily concerned with the problem of forced wealth redistribution when facing the reality of a continuously increasing life expectancy without increasing the retirement age.

[15] Defined as a ratio of a pension fund's member monthly pension payment to his expected last salary.

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