Simulating pension outcomes using penCalc

Renuka Sane
National Institute of Public Finance and Policy

Presented at the IGIDR Household Finance Workshop, Mumbai

24 February, 2018

Context

- Modeling pension outcomes is a critical part of good policy design for a pension system.
- Historically, those running Defined Benefit funds have been significant users of modeling
- The shift to Defined Contribution pensions puts a much higher premium on understanding the likely outcomes from a given path of contributions and investments
- Useful for members as well as policy makers

This paper

- Sets out a new model for pension outcomes called penCalc
- The use of the model is illustrated for India's National Pension

penCalc

- library in R
- Calculates the expected monthly pension payments
- The package may be installed as follows `devtools::install_github("renukasane/penCalc")`.

Structure of the talk

- Drivers of pension performance
- Overview of the model
- Results

Part I

Drivers of pension performance

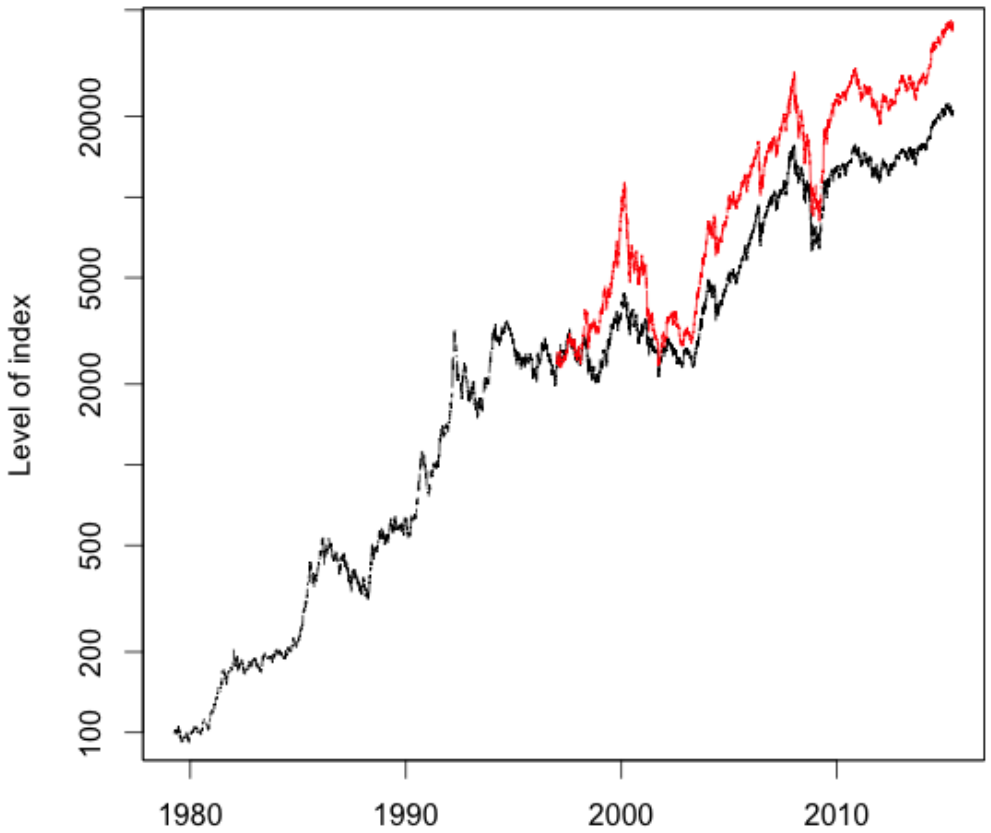
Drivers of pension performance

- Macroeconomic environment
  - Inflation
  - Bond returns
  - Equity premium
- Annuity prices

Inflation

- We have had very high volatility in inflation
- August 2016, the GOI backed the inflation strategy of the Reserve Bank of India (RBI)
- We expect that inflation will have a tight distribution around the mean of 4%.

Equity premium



- Over the span of 36 years, equity has given returns of 16%.
- The annualised standard deviation is 24.9%

Bond returns

- If we do assume a 4% inflation rate, government bonds at the short end should be around 6%, and on the long end should be around 9%.
- Assume that average nominal return for government bonds of 7%
- Assume a 3% premium on corporate bonds. Hence, a nominal return of 10%.

Annuity prices

The prices for an annuity (Jeevan Akshay VI) which begins at age 60 and pays Rs.1 for life works out to be

- Rs.4087 for a nominal annuity
- Rs.4440 for a nominal annuity with a provision of 50% of the annuity payable to spouse (for life) on death of the annuitant.
- Rs.5589 for an annuity with a provision of 100% of the annuity payable to spouse (for life) on death of annuitant, and return of purchase price on the death of last survivor

Part II

Overview of penCalc

Inputs

- Age at entry, age at exit
- Wages
  - Single number, and a growth rate in wages
  - Vector of different values
- Contribution rate
- Inflation
- Investment weights
  - Life cycle weights
  - Constant wegihts

Inputs (contd)

- Returns
  - Mean returns for the three asset classes
  - Standard deviation of returns for the three asset classes
- Fees and expenses
  - Monthly fees (% AUM)
  - Annual flat fee (Rs.)
- Annuities
  - Percent to be annuitised
  - Price of annuity

Assumptions

Age	
Age of entry	25
Age of exit	60
Wages and contributions	
Starting wage	Rs.25,000 (US$386) per month.
Wage growth (nominal)	8% per anum
Contribution rate	20% of wage
Inflation (mean, sd)	(4%, 0)
Investment portfolio	Lifecyle
Returns (nominal)	
GOI bonds (mean, sd)	(7%, 0)
Corporate bonds (mean, sd)	(10%, 0)
Equities (mean, sd)	(16%, 25%)
Fees	
AUM	0.01% per anum
Flat fee	Rs.100 (US$1.5) per anum
Annuities	
Percent to be annuitised	40%
Annuity price (for Rs.1 per day nominal annuity)	Rs.4,087 (US$63)

Structure of the code

```
x <- pencalc(age=list(age.entry=25
                ,age.exit=60),
             wage=list(25000
                ,0.08
                ,0.2
                ,initial.amount=0),
             inflation=list(c(0.04,0)
                            ,real=TRUE),
             inv.weights=list("lc"),
             returns=list(data.frame(mean=c(0.07, 0.10, 0.16),
                                     sd=c(0, 0, 0.25)),
                          c(monthly.fees.expenses=0.01, 100)),
             annuity=list(perc.annuitised=0.4,
                          value=4087))
```

The working of the model

- Starting wage and the yearly growth rate in wages are used to generate a vector of wages for the years the subscriber is expected to be in the system
- The wages are expected to stay the same in each month of the year.
- The default number of years is 60-25+1, that is 36 years.
- The contribution rate is then used on this vector of wages to arrive at the rupee value of contributions
- The mean and standard deviations of the underlying instruments (bonds and equity) are used to simulate returns on the investment each year as a draw from a normal distribution.
- The returns are annualized figures, and are converted to monthly returns.

The working of the model

- Starting wage and the yearly growth rate in wages are used to generate a vector of wages for the years the subscriber is expected to be in the system
- The wages are expected to stay the same in each month of the year.
- The default number of years is 60-25+1, that is 36 years.
- The contribution rate is then used on this vector of wages to arrive at the rupee value of contributions
- The mean and standard deviations of the underlying instruments (bonds and equity) are used to simulate returns on the investment each year as a draw from a normal distribution.
- The returns are annualized figures, and are converted to monthly returns.

The working of the model

- Starting wage and the yearly growth rate in wages are used to generate a vector of wages for the years the subscriber is expected to be in the system
- The wages are expected to stay the same in each month of the year.
- The default number of years is 60-25+1, that is 36 years.
- The contribution rate is then used on this vector of wages to arrive at the rupee value of contributions
- The mean and standard deviations of the underlying instruments (bonds and equity) are used to simulate returns on the investment each year as a draw from a normal distribution.
- The returns are annualized figures, and are converted to monthly returns.

The working of the model (contd)

- The investment weights and returns are used to arrive at a portfolio return.
- The monthly fees and expenses are deducted from the portfolio returns.
- The contributions and returns are accumulated over each year in the system, and give us the total expected accumulation in the pension account.
- If the user has entered the "real" option, then the rate of inflation is subtracted from the wages, and returns assumptions.
- This simulation is done 1,000 times, and thus generates a distribution of the expected accumulated amounts in the NPS account.
- The amount to be annuitized is subtracted from this accumulation and used to arrive at the monthly expected pension using the annuity price.

The working of the model (contd)

- The investment weights and returns are used to arrive at a portfolio return.
- The monthly fees and expenses are deducted from the portfolio returns.
- The contributions and returns are accumulated over each year in the system, and give us the total expected accumulation in the pension account.
- If the user has entered the "real" option, then the rate of inflation is subtracted from the wages, and returns assumptions.
- This simulation is done 1,000 times, and thus generates a distribution of the expected accumulated amounts in the NPS account.
- The amount to be annuitized is subtracted from this accumulation and used to arrive at the monthly expected pension using the annuity price.

The working of the model (contd)

- The investment weights and returns are used to arrive at a portfolio return.
- The monthly fees and expenses are deducted from the portfolio returns.
- The contributions and returns are accumulated over each year in the system, and give us the total expected accumulation in the pension account.
- If the user has entered the "real" option, then the rate of inflation is subtracted from the wages, and returns assumptions.
- This simulation is done 1,000 times, and thus generates a distribution of the expected accumulated amounts in the NPS account.
- The amount to be annuitized is subtracted from this accumulation and used to arrive at the monthly expected pension using the annuity price.

The working of the model (contd)

- The investment weights and returns are used to arrive at a portfolio return.
- The monthly fees and expenses are deducted from the portfolio returns.
- The contributions and returns are accumulated over each year in the system, and give us the total expected accumulation in the pension account.
- If the user has entered the "real" option, then the rate of inflation is subtracted from the wages, and returns assumptions.
- This simulation is done 1,000 times, and thus generates a distribution of the expected accumulated amounts in the NPS account.
- The amount to be annuitized is subtracted from this accumulation and used to arrive at the monthly expected pension using the annuity price.

The working of the model (contd)

- The investment weights and returns are used to arrive at a portfolio return.
- The monthly fees and expenses are deducted from the portfolio returns.
- The contributions and returns are accumulated over each year in the system, and give us the total expected accumulation in the pension account.
- If the user has entered the "real" option, then the rate of inflation is subtracted from the wages, and returns assumptions.
- This simulation is done 1,000 times, and thus generates a distribution of the expected accumulated amounts in the NPS account.
- The amount to be annuitized is subtracted from this accumulation and used to arrive at the monthly expected pension using the annuity price.

Outcomes

- In hand accumulation
- Monthly pension
- Replacement rate

Part III

Results

GOI bonds portfolio: 85% bonds, 15% equity

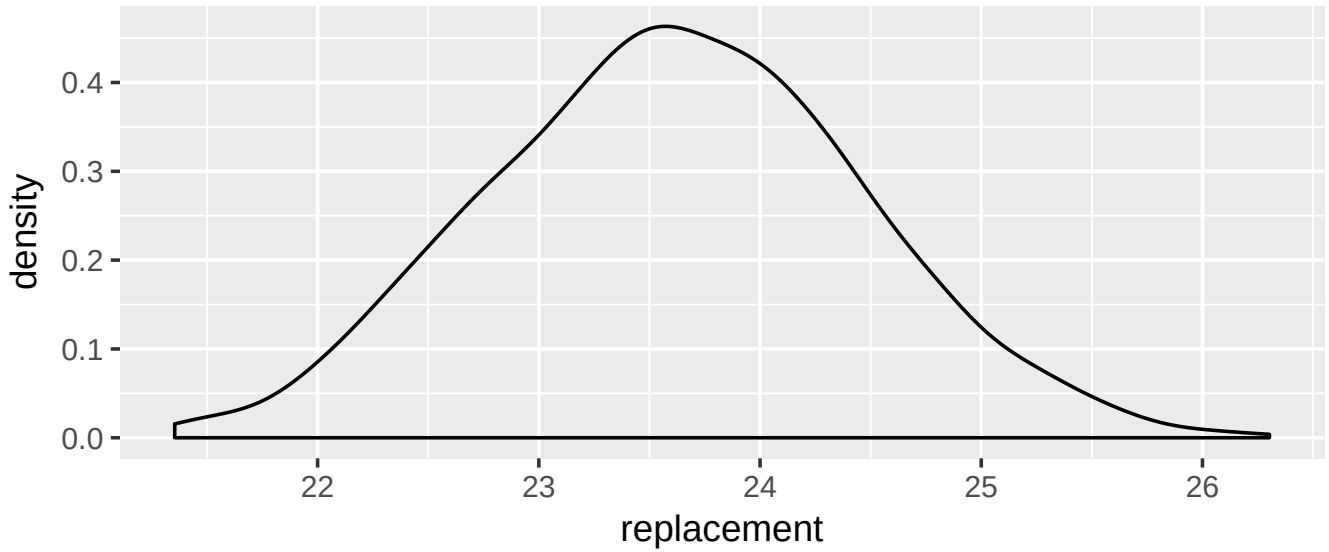
```
library(penCalc)
weightmatrix <- data.frame(goi_bonds=rep(0.85, 36), corp_bonds=rep(0,36),
                           equity=rep(0.15,36))
set.seed(111)
# 40% annuity
x <- pencalc(inflation=list(c(0.04,0)
                           ,real=TRUE),
                           inv.weights=list(weightmatrix))

# 100% annuity
y <- pencalc(inflation=list(c(0.04,0)
                           ,real=TRUE),
             inv.weights=list(weightmatrix),
             annuity=list(perc.annuitised=1,
             value=4087))
y
```

Results: GOI bonds portfolio

	40%		100%	
	Mean	SD	Mean	SD
In hand accumulation (In million)	4.70	0.17	0.00	0.00
Monthly Pension (In Rs.)	23,297	828	58,242	2,072
Replacement Rate (In%)	23.60	0.80	59.00	2.10

Distribution of replacement rates



Life cycle weights

```
library(penCalc)
set.seed(111)
# 40% annuity
set.seed(111)
x <- pencalc(inflation=list(c(0.04,0)
                            ,real=TRUE),
             inv.weights=list("lc"))
x

# 100% annuity
set.seed(111)
y <- pencalc(inflation=list(c(0.04,0)
                            ,real=TRUE),
             inv.weights=list("lc"),
             annuity=list(perc.annuitised=1,
                          value=4087))
y
```

Results: Life cycle weights

	40%		100%	
	Mean	SD	Mean	SD
In hand accumulation (In Rs.million)	7.41	0.75	0.00	0.00
Monthly Pension (In Rs.)	36744.3	3702.4	92034.2	9520.09
Replacement Rate (In%)	37.20	3.80	93.10	9.40

Results: Lower equity returns

1. We assume a 12% rate of return and a 20% standard deviation. This amounts to an equity premium of 5%.
2. We assume a 10% rate of return and a 18% standard deviation. This amounts to an equity premium of 3%.

	12% return		10% return	
	Mean	SD	Mean	SD
In hand accumulation (In Rs. million)	6.64	0.68	5.51	0.49
Monthly Pension (In Rs.)	32,952.0	3,398.3	27,321.2	2,429.1
Replacement Rate (In%)	33.40	3.40	27.70	2.50

Results: Different annuity prices

	Nominal	50 % spouse	100 % spouse	WB price
In hand accumulation (In Rs. million)	7.41	7.41	7.41	7.41
Accumulation std. dev	(0.75)	(0.75)	(0.75)	(0.75)
Monthly Pension (In Rs.)	36,744.3	34,130.4	26,869.5	22,524.9
Pension SD	(3702.4)	(3439.1)	(2,707.4)	(2269.7)
Replacement Rate (In %)	37.2	34.6	27.2	22.8
RR SD	(3.8)	(3.5)	(2.7)	(2.3)

Varying contribution rates

```
library(penCalc)
wage = round(rnorm(36, 3000, 100),0)
set.seed(111)
x <- pencalc(wage=list(wage
                ,0
                ,1
                ,initial.amount=0),
             inflation=list(c(0.04,0)
                ,real=TRUE))
x

#100 %

set.seed(111)
y <- pencalc(wage=list(wage
                ,0
                ,1
                ,initial.amount=0),
             inflation=list(c(0.04,0)
                            ,real=TRUE),
             annuity=list(perc.annuitised=1,
                          value=4087))
y
```

Results: Varying contribution rates

	40%		100%	
	Mean	SD	Mean	SD
In hand accumulation (In Rs. million)	2.71	0.34	0.00	0.00
Monthly Pension (In Rs.)	13,454.1	1,698.3	33,635.2	4,245.9

Part IV

Way forward

Future work

- A GUI based front-end
- Build more functionalities. For example:
  - Possibility of premature withdrawals
  - Asset correlations
- Impact of international diversification for pension funds (such as the EPFO).

Thank you