

MAKERERE



UNIVERSITY

COLLEGE OF BUSINESS AND MANAGEMENT SCIENCES

SCHOOL OF STATISTICS AND PLANNING

**A PRICING AND PROFIT TESTING MODEL FOR A UNIT-LINKED TENANT
PROTECTION ENDOWMENT PLAN**

BY

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DECLARATION

I, Nabukenya Glenda Lillian, hereby declare that the information contained in this dissertation is my own authentic work and has not been submitted to any college, university or institute for an academic award.

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APPROVAL

This research project has been submitted for examination with my approval as the student's university supervisor.

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DEDICATION

I dedicate this project to God, who has brought me this far and has made all this possible. I also dedicate this project to my parents, for their unwavering love and support that has kept me focused on pursuing my dream to be an actuary.

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ABSTRACT

Uganda's growing urban population depends heavily on rental housing, yet no existing insurance product protects tenants against the loss of rental income following the death or permanent total disability of a breadwinner. This project designs and evaluates a unit-linked tenant protection endowment insurance product intended to give renting families in Kampala continued rental cover for a period of two years, while also building long-term savings. The main objective was to develop a product that pays a rent-related benefit on death, permanent total disability, surrender or survival to the end of a 10-year policy term, and to assess whether such a product could be priced affordably for renters while remaining profitable for insurers. A pricing and profit-testing model was built in Microsoft Excel for a 30 – year old male and female, using a sum assured of UGX 16,800,000, equivalent to roughly two years of rent at the assumed monthly rent of UGX 700,000, and the model built in Python 3.14 to extend the analysis across a range of ages and policy terms. Assumptions on mortality, disability, expenses, interest rates and surrender were drawn from a combination of Kenyan and Ugandan data, in the absence of published Uganda-specific experience tables. For the base case of a healthy 30 – year old male, the model produced an annual premium of UGX 641,711 and a profit margin of 6.25%. Female results, presented in the appendix, showed a slightly lower annual premium of UGX 629,470 and a higher profit margin of 7.48%. Sensitivity analysis showed the profit margin to be most responsive to changes in inflation, expenses, interest rate and the bid/offer spread, and less responsive to mortality. The results suggest that a unit-linked tenant protection product is feasible for the Ugandan market, though its profitability varies considerably by age and policy term and would require careful pricing and monitoring by insurers.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Insurance serves as an important tool for financial protection against unexpected risks. This project addresses housing and rental risk, specifically focusing on scenarios where dependents are unable to cover rental payments following the death or permanent total disability of a breadwinner. To minimize this risk, this project designed a unit-linked endowment product aimed at securing rental coverage for beneficiaries over a two – year period. This research is especially important given that a significant portion of the Ugandan population relies on rental housing before acquiring or constructing their own homes.

1.2 Background to the project

Kampala and its surrounding urban areas are mostly urban centers characterized by intensive commercial and residential development, creating increasing pressure on land use and urban infrastructure (Mukiibi, 2011). As a result, rising land and housing costs have made rental housing an increasingly important housing option for many urban households (UN - Habitat, 2026). This demand is further intensified by rural–urban migration and continued urban population growth, which increase pressure on housing demand and urban land (Mukiibi, 2011). Furthermore, many urban households, including tenants, obtain income from informal and often unpredictable economic activities (Economic Policy Research Centre, 2025). This financial vulnerability increases the risk of rent overdue rent payments, displacement and housing insecurity among tenant households (Reall, 2021).

Given these vulnerabilities, financial protection mechanisms like insurance can play an important role in helping tenant households manage housing – related risks. However, access to insurance in Uganda remains limited due to low market penetration and other structural challenges (FSD Uganda, 2018). Regionally, Uganda exhibits a low insurance penetration rate, typically falling below 1% of its GDP (Insurance Regulatory Authority of Uganda, 2024). Within this market context, endowment products offer a dual framework by combining insurance protection and long–

term savings. They provide a death benefit if the policyholder dies during the policy term or a maturity benefit if the policyholder survives to the end of the contract (Black & Skipper, 2000; Uganda Insurers Association, 2026). Furthermore, unit – linked products allocate a portion of premium payments to investment funds selected by the policyholder while the remaining portion provides insurance coverage, allowing policyholders to accumulate investment value alongside risk protection (Dickson et al., 2019). The inclusion of unit – linked and endowment features created a flexible model capable of addressing both protection and wealth accumulation objectives.

From an actuarial perspective, such products require careful pricing to ensure that premium income adequately covers expected benefit payments, expenses and investment – related risks while maintaining insurer profitability (Black & Skipper, 2000; Rejda & McNamara, 2014). Therefore, profit testing was carried out to enable insurers to evaluate the long–term financial viability of innovative products under varying assumptions and market conditions.

1.3 Problem Statement

Insurance is designed to safeguard individuals against unforeseen events that result in financial loss (Rejda & McNamara, 2014). Life insurance, specifically, aims to guarantee financial continuity for a policyholder’s beneficiaries, ensuring that households can sustain essential living conditions, such as housing, following the loss of a breadwinner (Black & Skipper, 2000).

In Uganda, however, this safety net is frequently not met for families residing in rental properties (Mukiibi, 2011). Many renting households operate under limited financial conditions and have limited capacity to absorb income shocks (Mukiibi, 2011). Without adequate financial protection, renting households may struggle to meet ongoing housing costs, particularly in an environment characterized by high rental expenses and limited access to affordable housing (Reall, 2021).

Despite growth in the insurance sector, available products are largely concentrated in conventional life, health and property classes, with limited evidence of products specifically designed to address tenant housing vulnerabilities (Insurance Regulatory Authority of Uganda, 2025). Traditional life policies typically distribute benefits as a single lump – sum payment rather than a structured stream of income (Belbase et al., 2015). While lump – sum benefits provide financial relief, they do not inherently ensure that funds are allocated toward maintaining long – term housing stability (Belbase et al., 2015).

This emphasizes a gap in the Ugandan insurance sector; there is a distinct lack of products tailored for tenants that effectively include income protection with dedicated housing – related financial support. Furthermore, current frameworks offer limited options that integrate risk protection with savings vehicles dedicated to long–term housing stability (Insurance Regulatory Authority of Uganda, 2025).

1.4 Objectives of the project

1.4.1 General Objective

To develop a unit-linked endowment rent protection insurance product that provides rent continuity in the event of death, permanent total disability, surrender or on survival to the end of the policy term.

1.4.2 Specific Objectives

1. To design a unit-linked tenant–protection endowment insurance product that is affordable to renter households.
2. To evaluate the profitability and financial sustainability of the proposed product for insurance companies.

1.5 Significance of the project

This project is important to renters because it provides a mechanism that may reduce exposure to housing insecurity and rent – payment difficulties. It combines savings discipline with protection, which can also build a savings habit within the household. Furthermore, this insurance product enables the family or beneficiaries of the policyholder to maintain rental payments after the death of the policyholder, thus reducing their risk of housing insecurity and displacement. It also allows them to build savings over time, which can later be used for housing, such as paying a deposit for a home.

This project is important to insurers because it opens a new, underserved product line and market segment. It also supports growth in a low–penetration market. Furthermore, the product would help insurance companies become more innovative, as it focuses on designing products that are more suited to the actual needs of clients. It can also help them reach a new market of renters, which may ultimately improve insurance penetration.

This project is important to the housing and rental market because it may reduce the financial vulnerabilities associated with the loss of a household breadwinner, thereby supporting housing stability among renting households.

This project is important to policymakers and regulators since it's relevant to financial inclusion goals, and to IRA's interest in expanding insurance penetration and product innovation. For policymakers and regulators, the project can bring to light the need for financial solutions that address real-life problems such as housing insecurity. This can support efforts aimed at improving financial inclusion and social protection.

The project is also significant from an actuarial and academic perspective because it demonstrates the application of pricing and profit – testing techniques in the design of an innovative unit – linked endowment product tailored to a specific need. It contributes to the limited body of literature linking insurance product development with housing – related financial protection in Uganda and may serve as a foundation for future research in actuarial modelling, product innovation and financial inclusion.

CHAPTER TWO

MODEL ASSUMPTIONS

2.1 Introduction

This chapter states the actuarial assumptions used to build the pricing and profit – testing model for the proposed unit – linked tenant – protection endowment product. Since unit – linked endowments combine both insurance cover and investment growth, setting realistic assumptions is key when determining whether the product is profitable and solvent over the policy term.

Since complete historical data for this specific product is limited in the Ugandan market, the assumptions have been chosen using a mix of Kenyan and Ugandan data. The model includes assumptions on rent, interest rates, mortality, disability, expenses and surrender rates.

Table 2.1 Assumptions of the model

Assumption	Value
Sum assured	16,800,000
Monthly rent	700,000
Death Benefit	Varies, max (Sum assured, Fund Value)
Disability benefit	8,400,000
Maturity benefit	Max (Sum Assured, Fund Value)
Surrender benefit	90% of Fund Value
Term	10 years

Entry age	30
Interest rate	15.5%
Inflation	3%
Initial expenses	20% of premium
Claims expense	100,000
Renewal expenses	5% of premium
Initial commission	25% of premium
Renewal commission	5% of premium
Mortality basis	Kenyan tables where Male $q_x >$ Female q_x
Disability rates	Kenyan tables
Surrender rates (all years except the first and last)	10%
Allocation in first year	60%
Allocation in other years	95%
Bid-offer spread	5%
Unit fund interest rate	15.5%

Non-unit fund interest rate	11.5%
Management charge	2%
Risk discount rate	18.5%

2.2 Explanation of assumptions

- Monthly rent: It was taken as a representative of the average monthly rent for a family – sized housing unit in areas around Kampala, and forms the basis for the sum assured calculation.
- Sum assured: Derived by multiplying the average monthly rent for a family – sized home in areas around Kampala by 24 months, giving a sum assured intended to cover roughly two years of housing costs for the policyholder’s dependents.
- Death benefit: It is the higher of the sum assured and the fund value at the date of death.
- Disability benefit: It’s set at half the sum assured, reflecting partial protection benefit relative to the full death benefit.
- Maturity benefit: On survival to the end of the 10 – year term, the policyholder receives the full fund value accumulated under the policy.
- Surrender benefit: A surrendering policyholder receives 90% of the fund value. The 10% deduction acts as a surrender penalty, discouraging early surrender and partly recovering the initial expenses and commission the insurer has not yet recovered.
- Term: A 10 – year term was chosen as a reasonable length of time for the policyholder to build up savings towards a housing – related goal.
- Inflation rate: The long – term inflation of 3% was used. This is consistent with Uganda’s recent inflation experience and mainly in line with the Bank of Uganda’s outlook, which projects inflation to remain slightly below its 5% medium target throughout 2026.
- Mortality basis: Due to the absence of a published Uganda – specific table, Kenyan life tables were used as a regional proxy, with male mortality rates inflated by 20% and female mortality rates inflated by 10%.

- Disability rates: As with the mortality basis, disability incidence rates were sourced from Kenyan tables, used as a regional proxy for Uganda in the absence of Uganda – specific disability incidence data.
- Unit – fund interest rate: Since this is a 10 – year term, a 10 – year government bond yield was used to reflect the mix of assets backing the units. since the policy term is 10 years, the 10 – year T – bond yield (15.5%) is a natural duration matched anchor for a bond – heavy unit fund
- Non – unit fund interest rate: the non – unit reserve needs to stay liquid to cover claims and expenses as they fall due, so it's typically rolled over in T – bills. The 91 – day (10.38%) and 364 – day (12.00%) rates are a reasonable range. Insurers hold their non – unit reserves in short – dated liquid instruments, so this is anchored to T – bill yields, lying between the 91 – day and 364 – day rates.
- Risk discount rate: This is the shareholders' required return, set above the risk – free rate with a margin for the insurance risk being taken on, the risk premium in this case is 3%, i.e. $15.5\% + 3\% = 18.5\%$
- Management charge: An annual management charge of 2% of fund value was assumed, in line with typical fees on unit-linked funds in Uganda. (around 1.5% - 2.5% p.a)
- Initial expenses: An initial expense of 20% of the first premium was assumed to cover the cost of setting up a new policy, i.e. underwriting, policy documentation, and administrative onboarding.
- Expenses: They were calculated as a percentage of the premium paid based on IRA reports

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the software, various formulae and techniques used in the pricing and profit testing models.

3.2 Software

Microsoft Excel was initially used to develop a pricing and profit testing model for a single life, a 30 – year old male and female with a policy term of 10 years. The same procedure was then carried out in Python 3.14 thereby writing a program that performs the pricing and profit testing as the excel model for the given ages and policy terms, depending on the output.

3.3 Formulae

The table below shows the formulae used in the model, defining all the terms and symbols.

Table 3.1: Multiple decrements

Output	Formula
$(aq)_x^d$	$q_x^d \left[1 - \frac{1}{2}(q_x^{dis} + q_x^{su}) + \frac{1}{3}(q_x^{dis} q_x^{su}) \right]$
$(aq)_x^{dis}$	$q_x^{dis} \left[1 - \frac{1}{2}(q_x^d + q_x^{su}) + \frac{1}{3}(q_x^d q_x^{su}) \right]$
$(aq)_x^{su}$	$q_x^{su} \left[1 - \frac{1}{2}(q_x^{dis} + q_x^d) + \frac{1}{3}(q_x^{dis} q_x^d) \right]$
$(ap)_x$	$1 - [(aq)_x^d + (aq)_x^{dis} + (aq)_x^{su}]$
tp_x	$(ap)_x *_{t-1} (ap)_x$

Table 3.2: Pricing Formulae

Output	Formula
Discount factor	$\frac{1}{1+i}$
Death benefit	Sum assured
EPV Death benefit	$S * \sum_{k=0}^{n-1} v^{k+1} * {}_k(ap)_x * (aq)_{x+k}^d$
Survival benefit	Fund value in final policy year
EPV Survival benefit	$S * v^n * {}_n(ap)_x$
Disability benefit	8,400,000
EPV Disability benefit	$\text{Disability benefit} * \sum_{k=0}^{n-1} v^{k+1} * {}_k(ap)_x * (aq)_{x+k}^d$
Surrender benefit	90% * Fund at year end
EPV Surrender benefit	$\text{Surrender benefit} * \sum_{k=0}^{n-1} v^{k+1} * {}_k(ap)_x * (aq)_{x+k}^d$
EPV Benefits	EPV Death Benefit + EPV Survival Benefit + EPV Disability Benefit + EPV Surrender Benefit
EPV Expenses	$I + \sum_{k=0}^{n-1} e_k * v^k * {}_k(ap)_x$

EPV Commission	Initial commission + $\sum_{k=0}^{n-1} v^k \cdot {}_k(ap)_x$
EPV Total Expenses	EPV Expenses + EPV Commission
Premium	Assumed premium (Before Goal Seek)
EPV Premium	$p \cdot \sum_{k=0}^{n-1} v^k \cdot {}_k p_x$
Equation of value	EPV Premium – EPV Benefits + EPV Total Expenses

Table 3.3: Profit testing formulae

Output	Formula
Premium allocated	60% * Premium in the first year for the first-year allocation 95% * subsequent premiums in remaining years
Bid/Offer spread	5% * Allocated premium
Cost of allocation	Premium allocated – Bid/Offer spread
Fund after allocation	Fund at end of year for previous year + Cost of allocation
Fund before management charge	Fund after allocation * (1+Unit fund interest rate)
Management charge	2% * Fund before management charge
Fund at year end	Fund before management charge – Management charge
Premium less Cost of allocation	(Premium received – Premium allocated) + Bid/Offer spread
Initial expenses	20% of premium
Renewal expenses	5% of premium
Initial commission	25% of premium
Renewal commission	5% of premium

Interest gained in Non – unit fund	Non unit interest rate * (Premium less Cost of Allocation – Expenses – Commission)
Extra Death cost	$\max [(aq)_x^d * (Sum\ Assured - Fund\ at\ year\ end), 0]$
Extra Disability cost	$\max [(aq)_x^{dis} * (Disability\ benefit - Fund\ at\ year\ end), 0]$
Profit vector	(Unallocated premium + Bid/Offer Spread + Interest + Management charge) – (Expenses + Commission + Extra Death Cost + Extra Disability Cost)
Discount factor (profits)	$\left(\frac{1}{1 + risk\ discount\ rate} \right)^t$
Discount factor (premiums)	$\left(\frac{1}{1 + risk\ discount\ rate} \right)^{t-1}$
Profit Signature	Profit vector $*_{t-1} (ap)_x$
Discounted profits	Profit Signature * Discount factor(profits)
Discounted premiums	Premium * (t – 1)(ap) _x * Discount factor(premiums)
NPV of profits	Sum of discounted profits
NPV of premiums	Sum of discounted premiums
Profit margin	$\frac{NPV\ of\ profits}{NPV\ of\ premiums}$

3.4 Description of symbols

- $(aq)_x^d$ = Dependent death probability
- $(aq)_x^{dis}$ = Dependent disability probability
- $(aq)_x^{su}$ = Dependent surrender probability
- $(ap)_x$ = Dependent survival probability
- q_x^d = Independent death probability
- q_x^{dis} = Independent disability probability
- q_x^{su} = Independent surrender probability
- ${}_t(ap)_x$ = In-force probability after t years
- ${}_{t-1}(ap)_x$ = cumulative probability of being in force at the start of each year

CHAPTER FOUR

PRESENTATION AND JUSTIFICATION OF RESULTS

4.1 Introduction

In this chapter, the results from both the pricing and profit testing model are presented. Sensitivity analysis is also included to show how the profit margin can be affected by changes in some of the assumptions such as interest rates and expenses.

4.2 Results from the model

The results presented in this chapter are based on a healthy 30 – year old male, with a policy term of 10 years and a sum assured of UGX 16,800,000.

4.2.1 Multiple decrements

Under this section, the multiple decrement tables for both genders are presented. In these tables, the dependent and independent probability rates are included.

Table 4.1 Multiple decrements for male life

Male					Male deaths probabilities inflated by 20%				Male					
Age	lx	qx ^d	qx ^{dis}	qx ^{su}	Age	qx ^d	qx ^{dis}	qx ^{su}	t	(aq)x ^d	(aq)x ^{dis}	(aq)x ^{sur}	(ap)x	t-1(ap)x
30	98215	0.00189	0.00061	0	30	0.002268	0.00061	0	1	0.0022673083	0.0006093	0	0.9971234	1
31	98029	0.00184	0.00063	0.1	31	0.002208	0.00063	0.1	2	0.0020969508	0.0005979	0.09986	0.8974471	0.99712
32	97849	0.0018	0.00065	0.1	32	0.00216	0.00065	0.1	3	0.0020513448	0.0006168	0.09986	0.8974723	0.89487
33	97673	0.00178	0.00069	0.1	33	0.002136	0.00069	0.1	4	0.0020285122	0.0006548	0.09986	0.8974579	0.80312
34	97499	0.00179	0.00073	0.1	34	0.002148	0.00073	0.1	5	0.0020398682	0.0006928	0.09986	0.8974112	0.72076
35	97324	0.00182	0.00078	0.1	35	0.002184	0.00078	0.1	6	0.0020740050	0.0007402	0.09985	0.8973339	0.64682
36	97147	0.00188	0.00083	0.1	36	0.002256	0.00083	0.1	7	0.0021423262	0.0007876	0.09985	0.8972243	0.58041
37	96964	0.00197	0.00088	0.1	37	0.002364	0.00088	0.1	8	0.0022448292	0.0008350	0.09984	0.8970823	0.52076
38	96773	0.00207	0.00094	0.1	38	0.002484	0.00094	0.1	9	0.0023587104	0.0008919	0.09983	0.8969205	0.46717
39	96572	0.00219	0.00099	0	39	0.002628	0.00099	0	10	0.0026266991	0.0009887	0	0.9963846	0.41901

The 20% mortality loading increased expected claim costs, thereby producing a more conservative premium estimate and reducing the risk of underpricing.

Table 4.2 Multiple decrements for female life

Female					Female deaths inflated by 10%				Female					
Age	lx	qx ^{ad}	qx ^{adis}	qx ^{asu}	Age	qx ^{ad}	qx ^{adis}	qx ^{asu}	t	(aq)x ^{ad}	(aq)x ^{adis}	(aq)x ^{asu}	(ap)x	t-1(ap)x
30	98323	0.00153	0.00047	0	30	0.001683	0.00047	0	1	0.0016826045	0.0004696	0	0.9978478	1
31	98172	0.00146	0.00048	0.1	31	0.001606	0.00048	0.1	2	0.0015253403	0.0004556	0.0999	0.8981233	0.99785
32	98029	0.00139	0.0005	0.1	32	0.001529	0.0005	0.1	3	0.0014521932	0.0004746	0.0999	0.8981746	0.89619
33	97893	0.00133	0.00053	0.1	33	0.001463	0.00053	0.1	4	0.0013894882	0.0005031	0.0999	0.8982070	0.80494
34	97763	0.00129	0.00056	0.1	34	0.001419	0.00056	0.1	5	0.0013476792	0.0005316	0.0999	0.8982196	0.723
35	97637	0.00128	0.00059	0.1	35	0.001408	0.00059	0.1	6	0.0013372123	0.0005601	0.0999	0.8982025	0.64941
36	97511	0.0013	0.00063	0.1	36	0.00143	0.00063	0.1	7	0.0013580796	0.0005981	0.0999	0.8981468	0.5833
37	97385	0.00133	0.00067	0.1	37	0.001463	0.00067	0.1	8	0.0013893926	0.0006360	0.09989	0.8980812	0.52389
38	97255	0.00138	0.00071	0.1	38	0.001518	0.00071	0.1	9	0.0014415970	0.0006740	0.09989	0.8979958	0.4705
39	97121	0.00145	0.00075	0	39	0.001595	0.00075	0	10	0.0015944019	0.0007494	0	0.9976562	0.4225

4.2.2 Pricing model

The basic principle used in pricing is the principle of equivalence, EPV income = EPV Outgo.

Outgo includes the expenses, commissions and the claims paid by the insurer while income is the premium paid by the policyholder.

Treatment of the death benefit

Although the death benefit was defined as the higher of the sum assured and the fund value, the projected fund value remained below the sum assured throughout the 10 – year policy term under the assumptions adopted. Therefore, the death benefit valued in the pricing model was effectively the sum assured. Consequently, the expected present value of death benefits was calculated using a fixed death claim amount equal to the sum assured plus the claims expense.

The pricing results presented are for the 30 – year old male only.

Table 4.3 Expected Present Value of Death and Survival Benefits

kx	Amount(s+f)	Discount	Probability	EPV(for each year)
0	16,900,000	0.87	0.00226731	33,175.33
1	16,900,000	0.75	0.00209092	26,488.65
2	16,900,000	0.65	0.00183568	20,134.33
3	16,900,000	0.56	0.00162913	15,470.89
4	16,900,000	0.49	0.00147026	12,088.48
5	16,900,000	0.42	0.00134151	9,549.68
6	16,900,000	0.36	0.00124344	7,663.67
7	16,900,000	0.32	0.00116902	6,238.12
8	16,900,000	0.27	0.00110191	5,090.91
9	16,900,000	0.24	0.00110062	4,402.54
			Total	140,302.60

SURVIVAL BENEFIT

t	Amount	Discount	Probability	EPV
10	16800000	0.236690135	0.417496371	1,660,130.18

Table 4.4 Expected Present value of Disability benefits

t	Amount	Discount	Probabilites	EPV
1	8400000	0.865800866	0.000609308	4,431.33
2	8400000	0.749611139	0.000596131	3,753.68
3	8400000	0.649013973	0.000551993	3,009.31
4	8400000	0.56191686	0.000525891	2,482.26
5	8400000	0.486508104	0.000499322	2,040.56
6	8400000	0.421219138	0.00047878	1,694.04
7	8400000	0.364691894	0.00045715	1,400.44
8	8400000	0.315750558	0.000434852	1,153.36
9	8400000	0.273377106	0.000416671	956.83
10	8400000	0.236690135	0.000414276	823.66
			Total	21,745.47

Table 4.5 Expected Present Value of Surrender benefits

t	Amount	Discount	Probability	EPV
1	0	0.865800866	0	0
2	0	0.749611139	0.0995709	0
3	0	0.649013973	0.0893609	0
4	2310160.897	0.56191686	0.0801983	104,106.82
5	2887701.121	0.486508104	0.0719727	101,113.70
6	3465241.345	0.421219138	0.0645863	94,271.86
7	4042781.57	0.364691894	0.057952	85,442.60
8	4620321.794	0.315750558	0.0519918	75,849.22
9	5197862.018	0.273377106	0.0466367	66,269.67
10	5775402.242	0.236690135	0	0
			Total	527,053.88

Table 4.6 Expected Present Value of Initial and Renewal expenses

kx	Amount	Discount	Probability	EPV(for each year)
0	128,342.27	1.00	1.00	128,342.27
1	32,085.57	0.87	1.00	27,699.80
2	33,048.14	0.75	0.89	22,168.73
3	34,039.58	0.65	0.80	17,742.59
4	35,060.77	0.56	0.72	14,199.93
5	36,112.59	0.49	0.65	11,364.05
6	37,195.97	0.42	0.58	9,093.74
7	38,311.85	0.36	0.52	7,276.10
8	39,461.20	0.32	0.47	5,820.85
9	40,645.04	0.27	0.42	4,655.81
			Total	248,363.87

Table 4.7 Expected Present Value of Initial and Renewal commission

kx	Amount	Discount	Probability	EPV(for each year)
0	160427.8401	1	1	160,427.84
1	32085.56801	0.865800866	0.997123383	27,699.80
2	32085.56801	0.749611139	0.894865441	21,523.03
3	32085.56801	0.649013973	0.803116913	16,724.09
4	32085.56801	0.56191686	0.720763639	12,994.95
5	32085.56801	0.486508104	0.646821371	10,096.81
6	32085.56801	0.421219138	0.580414765	7,844.34
7	32085.56801	0.364691894	0.520762222	6,093.62
8	32085.56801	0.315750558	0.467166558	4,732.88
9	32085.56801	0.273377106	0.419011263	3,675.34
			Total	271,812.71

Table 4.8 Expected Present Value of Premiums

kx	Amount	Discount	Probability	EPV(for each year)
0	641711.3602	1	1	641,711.36
1	641711.3602	0.865800866	0.9971234	553,996.02
2	641711.3602	0.749611139	0.8948654	430,460.69
3	641711.3602	0.649013973	0.8031169	334,481.84
4	641711.3602	0.56191686	0.7207636	259,899.03
5	641711.3602	0.486508104	0.6468214	201,936.19
6	641711.3602	0.421219138	0.5804148	156,886.75
7	641711.3602	0.364691894	0.5207622	121,872.38
8	641711.3602	0.315750558	0.4671666	94,657.62
9	641711.3602	0.273377106	0.4190113	73,506.81
			Total	2,869,408.71

As discussed previously, the equation of value does balance. The EPV income and EPV outgo are both UGX 2,869,408.71. However, to get the actual premium, an assumed premium is initially used in the model, and all the computations are made based on that. Using Goal Seek, the premium was iteratively adjusted until the equivalence condition was satisfied.

The equality between EPV income and EPV outgo confirms that the premium of UGX 641,711 derived through the equivalence principle is actuarially fair under the assumptions adopted in the model. At this premium level, the insurer is expected to collect sufficient revenue to meet expected benefit payments and expenses.

4.2.3 Profit testing

To determine whether the product designed will be profitable for the insurance company, in a way that makes business sense, a profit testing model is developed. This included a unit fund, non – unit fund and discounted cash flows as shown in the tables that follow.

Table 4.9 Unit Fund

Year	Age	Allocated	Bid/Offer spread	Cost of allocation	Fund before growth	Fund after growth	Maintenance charge	Bid value of units
1	30	385,026.82	19,251.34	365,775.48	365,775.48	422,470.67	8,449.41	414,021.26
2	31	609,625.79	30,481.29	579,144.50	993,165.76	1,147,106.46	22,942.13	1,124,164.33
3	32	609,625.79	30,481.29	579,144.50	1,703,308.83	1,967,321.70	39,346.43	1,927,975.26
4	33	609,625.79	30,481.29	579,144.50	2,507,119.77	2,895,723.33	57,914.47	2,837,808.86
5	34	609,625.79	30,481.29	579,144.50	3,416,953.37	3,946,581.14	78,931.62	3,867,649.52
6	35	609,625.79	30,481.29	579,144.50	4,446,794.02	5,136,047.09	102,720.94	5,033,326.15
7	36	609,625.79	30,481.29	579,144.50	5,612,470.65	6,482,403.60	129,648.07	6,352,755.53
8	37	609,625.79	30,481.29	579,144.50	6,931,900.03	8,006,344.54	160,126.89	7,846,217.65
9	38	609,625.79	30,481.29	579,144.50	8,425,362.15	9,731,293.28	194,625.87	9,536,667.42
10	39	609,625.79	30,481.29	579,144.50	10,115,811.92	11,683,762.77	233,675.26	11,450,087.51

Table 4.10 Non – unit Fund

Year	Age	Unallocated	Bid/Offer spread	Expenses	Interest	Management charge	Extra death benefit	Extra disability benefit	Surrender penalty	Profit
1	30	256,684.54	19,251.34	(288,770.11)	(1,475.94)	8,449.41	(37,152.06)	(4,865.92)	-	(47,878.74)
2	31	32,085.57	30,481.29	(65,133.70)	(295.19)	22,942.13	(32,871.46)	(4,349.86)	41,224.47	24,083.24
3	32	32,085.57	30,481.29	(66,125.15)	(409.20)	39,346.43	(30,507.65)	(3,992.23)	100,456.29	101,335.34
4	33	32,085.57	30,481.29	(67,146.33)	(526.64)	57,914.47	(28,322.48)	(3,642.19)	15,462.02	36,305.71
5	34	32,085.57	30,481.29	(68,198.16)	(647.60)	78,931.62	(26,380.29)	(3,139.87)	20,424.47	63,557.04
6	35	32,085.57	30,481.29	(69,281.54)	(772.19)	102,720.94	(24,404.14)	(2,492.03)	24,979.72	93,317.63
7	36	32,085.57	30,481.29	(70,397.41)	(900.51)	129,648.07	(22,381.41)	(1,612.46)	29,169.11	126,092.24
8	37	32,085.57	30,481.29	(71,546.77)	(1,032.69)	160,126.89	(20,099.71)	(462.42)	33,029.11	162,581.27
9	38	32,085.57	30,481.29	(72,730.61)	(1,168.83)	194,625.87	(17,132.10)	0	36,592.18	202,753.37
10	39	32,085.57	30,481.29	(73,949.96)	(1,309.06)	233,675.26	(14,052.61)	0	-	206,930.49

Table 4.11 Net Present Value of Profit and Premium

Year	Age	t-1Px	Present value profits	Premium	Discounting factor	t-1Px	Present Value of premiums
1	30	1.00	(40,404.00)	641,711.36	1.00	1.00	641,711.36
2	31	1.00	17,101.22	641,711.36	0.84	1.00	539,970.80
3	32	0.89	54,495.88	641,711.36	0.71	0.89	408,941.10
4	33	0.80	14,787.01	641,711.36	0.60	0.80	309,715.86
5	34	0.72	19,604.91	641,711.36	0.51	0.72	234,562.83
6	35	0.65	21,799.07	641,711.36	0.43	0.65	177,636.55
7	36	0.58	22,304.80	641,711.36	0.36	0.58	134,514.18
8	37	0.52	21,775.25	641,711.36	0.30	0.52	101,847.59
9	38	0.47	20,557.71	641,711.36	0.26	0.47	77,101.83
10	39	0.42	15,880.59	641,711.36	0.22	0.42	58,357.98
			167,902.43				2,684,360.09

Table 4.12 Profit margin

profit margin	6.25%
---------------	-------

When premium is paid, a portion is allocated to the unit fund. The client is then assigned units equivalent to the value of the money that has been allocated, which is then invested in relatively safe assets to generate a return. The other portion is allocated to the non – unit fund, which reflects the profit to be earned from the policy, taking into consideration the expenses and income associated with each policy year. The results are presented in Table 4.9 and Table 4.10 respectively.

Finally, the profit margin is determined from the quotient of the NPV of profit and NPV of premium and for this model under consideration, the margin is 6.25% as shown in Table 4.12. This is then compared to the benchmark profit margin set by the insurer to determine whether the policy is a viable one or not.

The positive profit margin indicates that the product is commercially viable under the base assumptions. However, the margin is relatively modest, implying that profitability may be sensitive to adverse changes in expenses, investment performance or decrement experience.

4.2.4 Analysis of the results

Under this section, the premiums and profit margins are analyzed to get an understanding of how the two vary across all age groups and policy terms. This supports decision making as the insurer can determine which ages or policy terms are most or least profitable.

4.2.4.1 Premiums

This policy is designed for renting families, and the breadwinner is expected to be the policyholder. It was designed with affordability as one of the key objectives and as a result, the annual premiums across all ages and policy terms under consideration range between UGX 416,855.68 and UGX 677,919.72. This is for the basic policy with a sum assured of UGX 16,800,000.

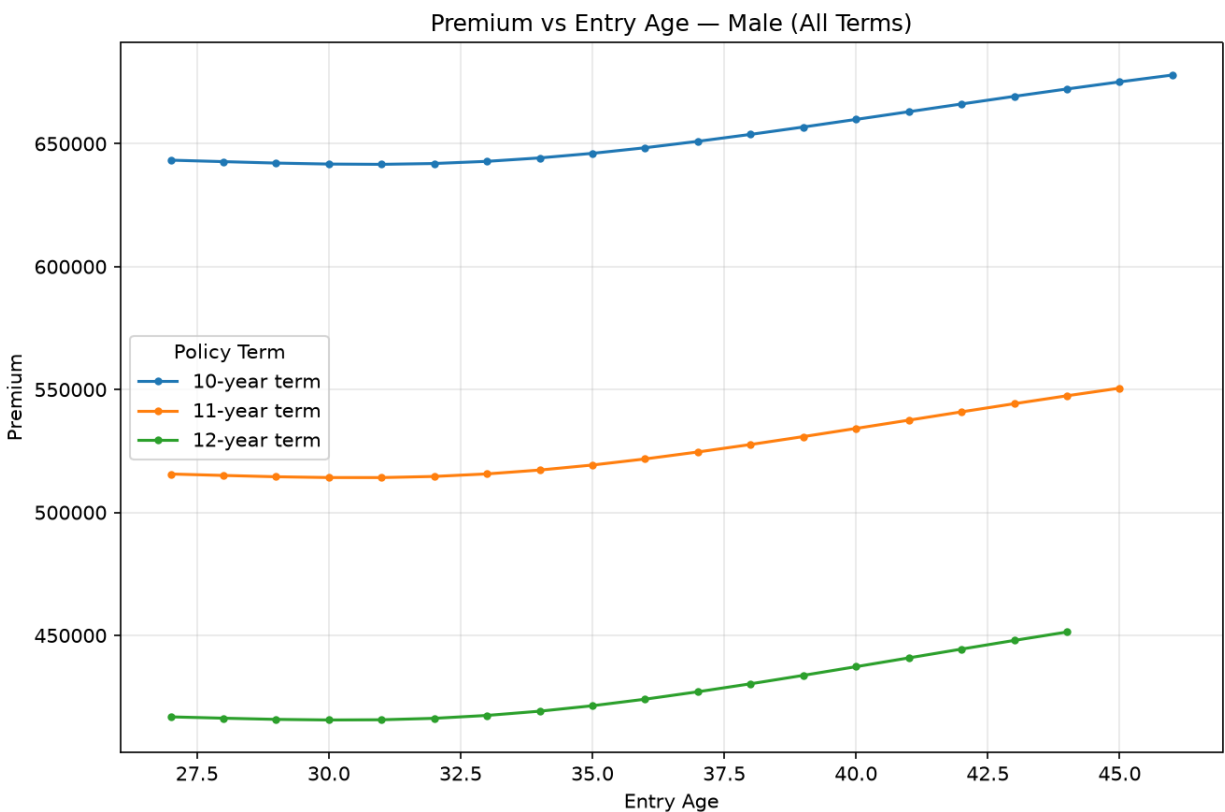


Figure 4.1: Premiums across all ages and terms under consideration

Premiums generally increase as the age at entry increases because older policy holders are exposed to higher mortality and disability risks. The highest premiums are observed among older entrants taking shorter policy terms.

Table 4.13: Profit margins across all ages and policy terms for males

Age	Term		
	Profit Margin (%)		
	10yr	11yr	12yr
27	6.13	5.34	4.21
28	6.18	5.39	4.27
29	6.23	5.44	4.32
30	6.25	5.46	4.34
31	6.26	5.45	4.32
32	6.21	5.39	4.24
33	6.12	5.27	4.08
34	5.98	5.08	3.85
35	5.79	4.85	3.56
36	5.57	4.57	3.21
37	5.32	4.25	2.83
38	5.05	3.92	2.43
39	4.77	3.58	2.01
40	4.48	3.22	1.59
41	4.19	2.87	1.17
42	3.91	2.52	0.76
43	3.63	2.18	0.35
44	3.36	1.85	-0.03

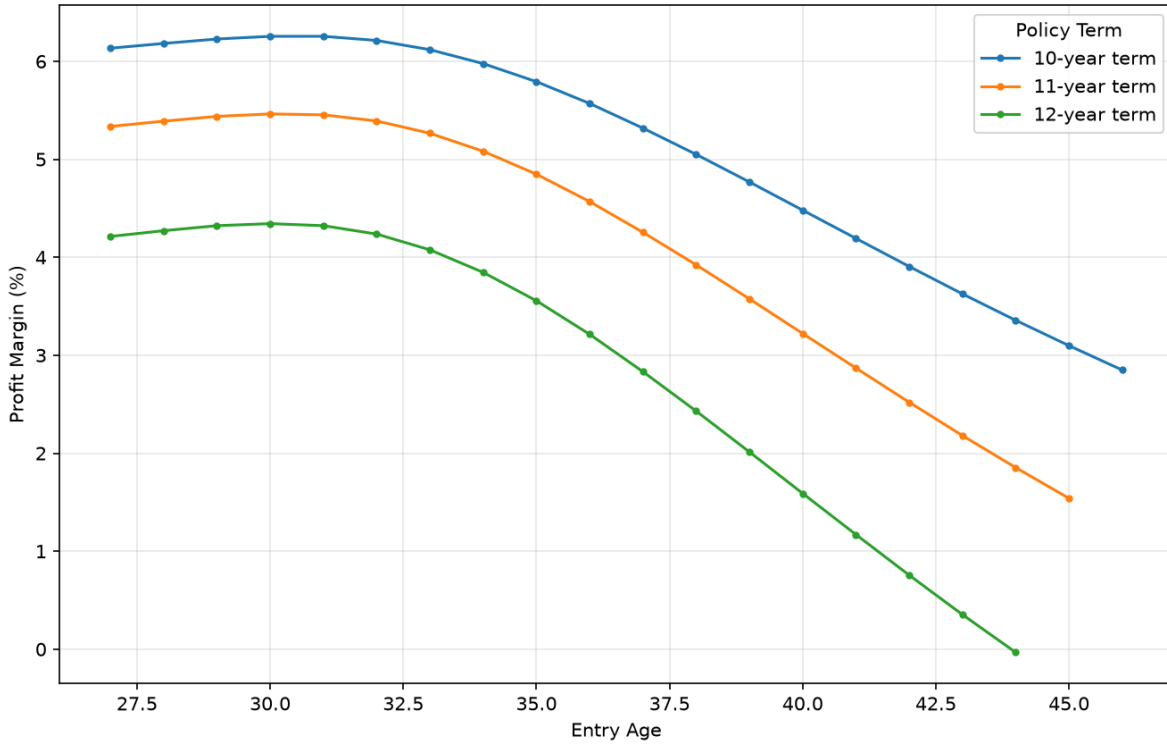


Figure 4.2: Profit margins for males across all ages and terms under consideration

As illustrated in Figure 4.2 above, the 10-year policy has the highest profit margin across all ages as compared to the other policy terms. This implies that the shorter the policy term, the higher the profit margin and vice versa. However, profit margins also tend to decrease over the long term as the client's age increases implying higher expected claim costs for older lives. Young policyholders provide more profitable business for the insurer due to their relatively lower mortality and disability risks.

4.3 Sensitivity analysis

Sensitivity analysis aims to test the responsiveness of the results of the model to changes in certain variables used. This is particularly important because some variables such as interest rates, expenses among others have been assumed and are likely to change frequently, which would then affect the profit margin of the product. The results shown in Table 4.14 below are for a 10 – year policy taken out by a 30 – year old male with an overall profit margin of 6.25%

Table 4.14 Sensitivity Analysis

Assumption	Change	Profit margin	Comment
Inflation rate	+5%	5.57%	A 5% increase in inflation leads to a 0.68% decrease in the profit margin.
	–2%	6.49%	A 2% decrease in the inflation rate leads to a 0.31% increase in the profit margin.
Initial expenses	+10%	4.20%	A 10% increase in initial expenses leads to a 2.05% decrease in the profit margin.
	–10%	8.31%	A 10% decrease in initial expenses leads to a 2.06% increase in the profit margin.
Renewal expenses	+3%	4.09%	A 3% increase in renewal expenses leads to a 2.16% decrease in the profit margin.
	–3%	8.42%	A 3% decrease in renewal expenses leads to a 2.17% increase in the profit margin.

Risk discount rate	+10%	4.41%	A 10% increase in the risk discount rate leads to a 1.84% decrease in the profit margin
	-10%	8.88%	A 10% decrease in the risk discount rate leads to a 2.61% increase in the profit margin
Interest rate	+10%	5.55%	A 10% increase in the interest rate leads to a 0.70% decrease in the profit margin
	-10%	6.08%	A 10% decrease in the interest rate leads to a 0.17% decrease in the profit margin
Bid/Offer spread	+3%	8.3%	A 3% increase in the Bid/Offer spread leads to a 2.05% increase in the profit margin
	-3%	4.21%	A 3% decrease in the Bid/Offer spread leads to a 2.04% decrease in the profit margin
Mortality	+10%	5.94%	A 10% increase in the mortality leads to a 0.3% decrease in the profit margin
	-10%	6.56%	A 10% decrease in the mortality leads to a 0.31% increase in the profit margin

Table 4.14 above shows the results of the sensitivity analysis where one variable is changed while keeping the remaining variables constant to see the effect on the profit margin.

The profit margin was generally observed to decrease with increase in inflation, expenses, mortality and the risk discount rate. Changes in the interest rate produced a mixed effect on profitability, suggesting that the relationship between interest rates and profit margin is influenced by various components of the model.

CHAPTER FIVE

SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This final chapter draws together the findings presented, summarizes the key results obtained from the pricing and profit-testing model, presents the conclusions drawn from these results in relation to the project's objectives, offers recommendations to insurers, regulators and future researchers.

5.2 Summary of results

The general objective of this project was to develop a unit-linked endowment tenant – protection insurance product that provides rent continuity on death, permanent total disability, surrender or survival to the end of the policy term, while remaining affordable to renter households and profitable for insurers. A pricing and profit-testing model was built in Microsoft Excel and replicated in Python for a 30 – year old male and female over a 10 – year term, based on a sum assured of UGX 16,800,000, equivalent to roughly two years of rent at the assumed monthly rent of UGX 700,000.

For the base case of a healthy 30 – year old male, the equation of value balanced when the annual premium was set at UGX 641,711, meaning the expected present value of premium income equaled the expected present value of benefits, expenses and commission (Table 4.8). This premium level suggests that the product can provide meaningful housing protection while remaining within the affordability range considered during the product design. Profit testing of this policy produced a profit margin of 6.25% (Table 4.13), calculated as the ratio of the net present value of profit to the net present value of premiums.

The sensitivity analysis in Section 4.3 showed that increases in the risk discount rate and mortality reduced profitability. Profitability was also sensitive to changes in inflation, expenses, interest rates and the bid offer spread.

The positive profit margin indicates that the product is actuarially and commercially viable under the base assumptions adopted in the study.

5.3 Recommendations

Based on the findings of this project, the following recommendations are made:

Insurers considering offering this product should price it by age band and policy term rather than applying a single flat rate, given the wide variation in profit margins observed across the ages and terms tested in this study.

Insurers should also pay close attention to the interest rate and bid/offer spread assumptions when setting policy terms, since the profit margin proved most sensitive to changes in these two variables.

The Insurance Regulatory Authority of Uganda and other industry stakeholders should support the development of Uganda-specific mortality and disability tables, since this and similar actuarial work in the local market currently relies on Kenyan tables adjusted by assumption rather than on Ugandan experience data.

Future studies could extend this model to joint-life or family policies, incorporate more detailed rent data across different regions of Uganda, and test the product against real market data once Uganda-specific mortality, disability and lapse experience becomes available.

Further research could also explore alternative benefit structures, such as paying the death benefit as a series of rent instalments rather than a lump sum, to test whether these better addresses the housing-security objective identified in Chapter One.

5.4 Conclusion

Based on the results obtained, the project met its two specific objectives. A unit-linked rent-protection product was designed, priced and profit-tested for a Ugandan tenant seeking to protect roughly two years of rental payments for their dependents, at a premium level designed with affordability considerations for low – and - variable income renter house funds. The product was also shown to be capable of generating a positive profit margin for the insurer under the base assumptions used, satisfying the second objective of evaluating its profitability and financial sustainability.

Overall, the project demonstrates that it is actuarially feasible to design a unit-linked endowment product that combines rent protection with long-term savings for the Ugandan market, addressing the gap identified in Chapter One between existing life insurance products and the specific needs of tenant households.

REFERENCES

- Belbase, A., Coe, N. B., & Wu, A. Y. (2015). *Overcoming Barriers to Life Insurance Coverage: A Behavioral Approach*. <https://doi.org/10.2139>
- Black, K., & Skipper, H. D. (2000). *Life and Health Insurance*. Prentice Hall.
- Dickson, D. C. M., Hardy, M. R., & Waters, H. R. (2019). *Actuarial Mathematics for Life Contingent Risks* (3rd edn). Cambridge University Press.
- <https://doi.org/10.1017/9781108784184>
- Economic Policy Research Centre. (2025). *An Assessment of the Informal Sector in Uganda: A consolidated Report*. Ministry of Finance, Planning and Economic Development.
- FSD Uganda. (2018). *Report on Uptake of Insurance Services in Uganda*.
- Insurance Regulatory Authority of Uganda. (2025). *2024 Annual Insurance Industry Market Report*. <https://ira.go.ug/wp-content/uploads/2025/10/2024-Insurance-Industry-market-report-2.pdf>
- Insurance Regulatory Authority of Uganda (IRA). (2024). *Annual Insurance Market Performance Report*.
- Investopedia. (2022). *Understanding ULIPs: Benefits, Risks, and How They Work*. Investopedia.
- <https://www.investopedia.com/terms/u/unit-linked-insurance-plan.asp>
- Mukiibi, S. (2011). *The Effect of Urbanisation on the Housing Conditions of the Urban Poor in Kampala*.
- Reall. (2021). *Uganda Market Profile: Market Shaping Indicators*. <https://reall.net/wp-content/uploads/2021/05/Uganda-MSI-Country-Profile.pdf>
- Rejda, G. E., & McNamara, M. J. (2014). *Principles of Risk Management and Insurance* (12th edn). Pearson. https://business.ucdenver.edu/sites/default/files/attached-files/rejda_12th_edition_textbook_principles_of_risk_management_and_insurance.pdf

Uganda Insurers Association. (2026). *Life Insurance*. Uganda Insurers Association.

<https://uia.co.ug/page/life-insurance>

UN - Habitat. (2026). The Global Housing Crisis. In *World Cities Report 2026: The Global Housing Crisis: Pathways to Action*.

APPENDIX

APPENDIX A: Variation in premiums across various policy terms

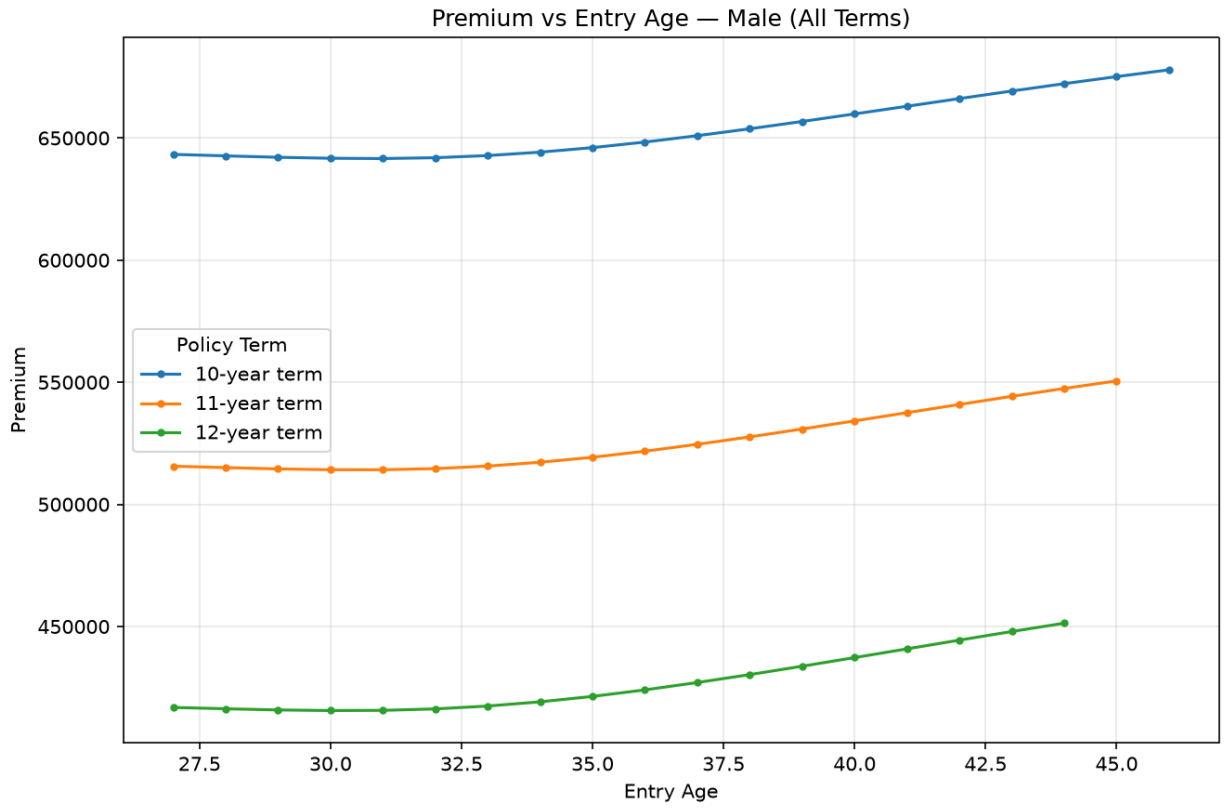


Figure A.1: Premiums across all policy terms for males

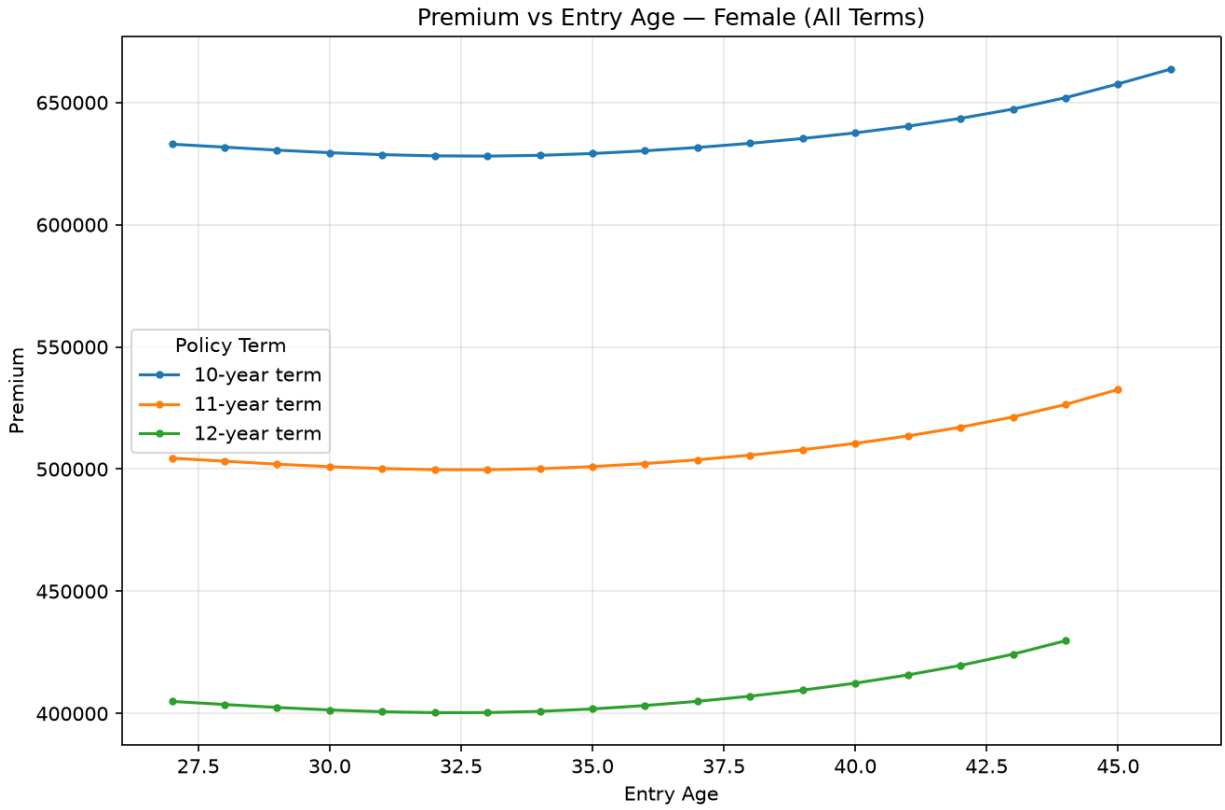


Figure A.2: Premiums across all policy terms for females

APPENDIX B: Variation in profit margins across various policy terms

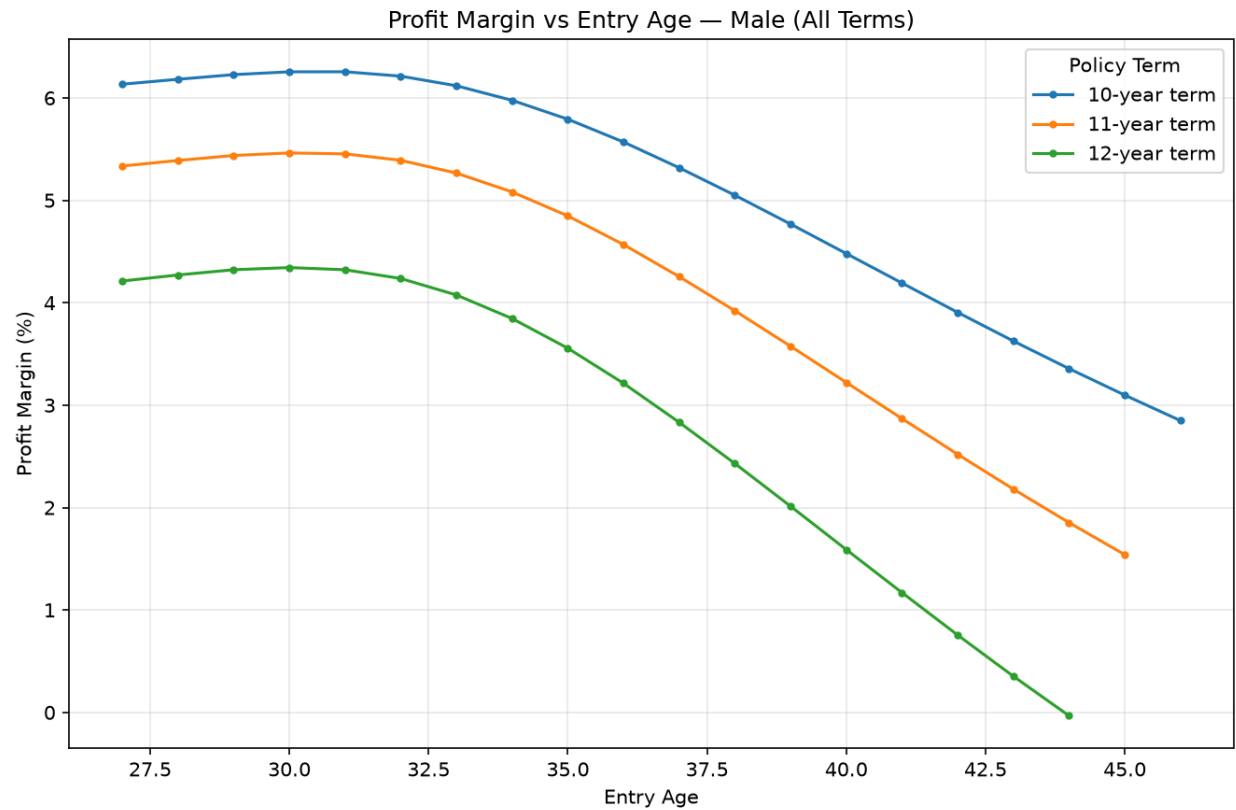


Figure B.1: Profit margins across all policy terms for males

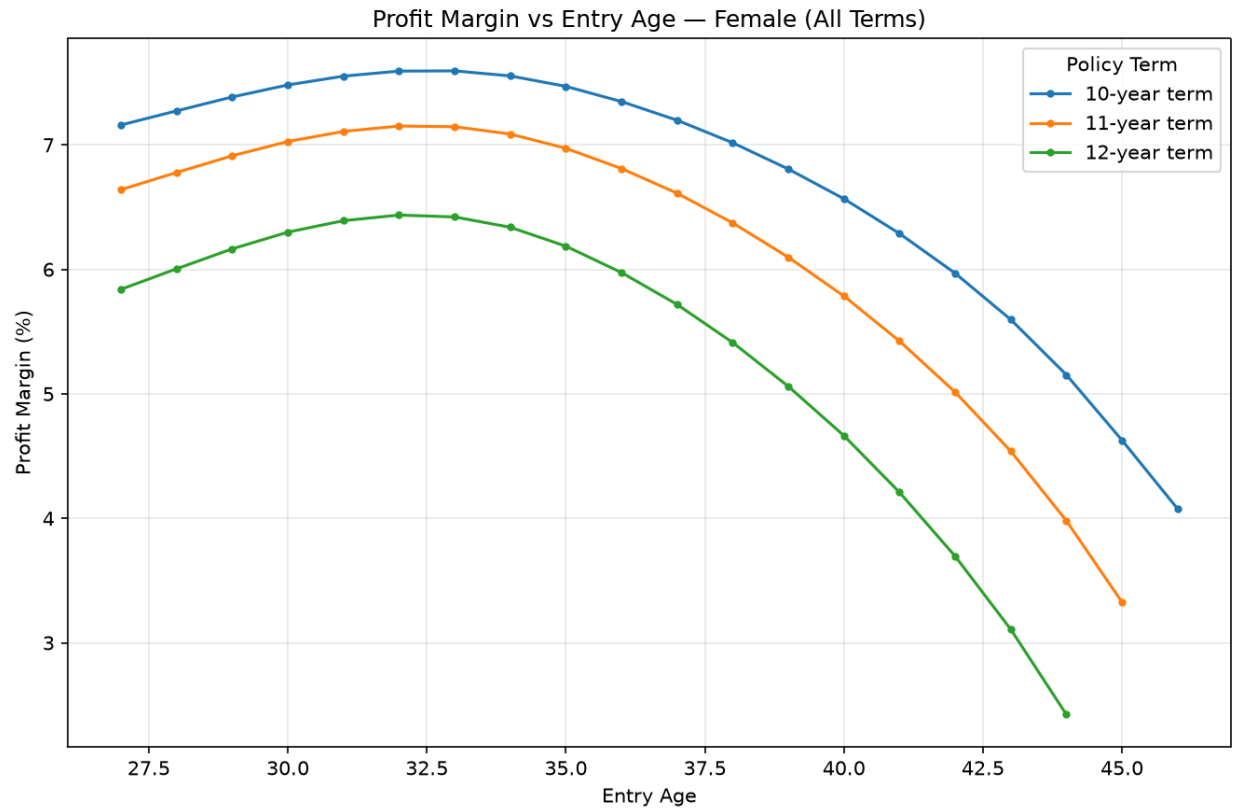


Figure B.2: Profit margins across all policy terms for females

APPENDIX C: Python program output

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=====
UNIT-LINKED TERM PRODUCT PRICING TOOL
=====

1. Single age/gender/term - FULL detailed breakdown
2. Profit margins across ALL ages - Male & Female (one term)
3. Premiums across ALL ages - Male & Female (one term)
4. Export Excel file (Premiums + Profit Margins sheets)
5. View / customize pricing assumptions
6. Generate charts (Premium / Profit Margin vs Age)
0. Exit
=====

Choose an option: 1

Available terms: [10, 11, 12]
Enter term (10/11/12): 10
Valid ages for 10-year term: 27-46
Enter entry age (27-46): 30
Gender (M/F): M

=====
UNIT-LINKED TERM PRODUCT - MALE, ENTRY AGE 30, 10-YEAR TERM
=====
Sum Assured: 16,800,000.00   Disability Benefit: 8,400,000.00   Pricing Interest Rate: 15.5%   v=0.8658008658

--- LIFE DECREMENT TABLE (Male) ---
Yr  Age  qx      qx_di    qd      qdi      qw      (aq)d      (aq)di      (aq)w      ap      t-1(ap)x
-----
1   30   0.00189  0.00061  0.002268  0.000610  0.00   0.00226731  0.00060931  0.000000  0.99712338  1.00000000
2   31   0.00184  0.00063  0.002208  0.000630  0.10   0.00209695  0.00059785  0.099858  0.89744705  0.99712338
3   32   0.00180  0.00065  0.002160  0.000650  0.10   0.00205134  0.00061684  0.099860  0.89747226  0.89486544
4   33   0.00178  0.00069  0.002136  0.000690  0.10   0.00202851  0.00065481  0.099859  0.89745793  0.80311691
5   34   0.00179  0.00073  0.002148  0.000730  0.10   0.00203987  0.00069277  0.099856  0.89741121  0.72076364
6   35   0.00182  0.00078  0.002184  0.000780  0.10   0.00207401  0.00074021  0.099852  0.89733393  0.64682137
7   36   0.00188  0.00083  0.002256  0.000830  0.10   0.00214233  0.00078763  0.099846  0.89722429  0.58041476
8   37   0.00197  0.00088  0.002364  0.000880  0.10   0.00224483  0.00083503  0.099838  0.89708227  0.52076222
9   38   0.00207  0.00094  0.002484  0.000940  0.10   0.00235871  0.00089191  0.099829  0.89692050  0.46716656
10  39   0.00219  0.00099  0.002628  0.000990  0.00   0.00262670  0.00098870  0.000000  0.99638460  0.41901126

--- UNIT FUND (Male) ---   Premium = 641,711.36
Yr  Alloc.Prem  B/O Spread  Cost of Alloc  Fund@Growth  Mgmt Charge  Bid Value
-----
1   385,026.82  19,251.34  365,775.48  422,470.67  8,449.41  414,021.26
2   609,625.79  30,481.29  579,144.50  1,147,106.46  22,942.13  1,124,164.33
3   609,625.79  30,481.29  579,144.50  1,967,321.70  39,346.43  1,927,975.26
4   609,625.79  30,481.29  579,144.50  2,895,723.33  57,914.47  2,837,808.86
5   609,625.79  30,481.29  579,144.50  3,946,581.14  78,931.62  3,867,649.52
6   609,625.79  30,481.29  579,144.50  5,136,047.09  102,720.94  5,033,326.15
7   609,625.79  30,481.29  579,144.50  6,482,403.60  129,648.07  6,352,755.53
8   609,625.79  30,481.29  579,144.50  8,006,344.54  160,126.89  7,846,217.65
9   609,625.79  30,481.29  579,144.50  9,731,293.28  194,625.87  9,536,667.42
10  609,625.79  30,481.29  579,144.50  11,683,762.77  233,675.26  11,450,087.51
```

--- EPV DEATH CLAIMS (Sum Assured + Claims Expense) ---

t	Amount	Discount	Probability	EPV
1	16,900,000.00	0.86580087	0.0022673083	33,175.33
2	16,900,000.00	0.74961114	0.0020909187	26,488.65
3	16,900,000.00	0.64901397	0.0018356776	20,134.33
4	16,900,000.00	0.56191686	0.0016291325	15,470.89
5	16,900,000.00	0.48650810	0.0014702629	12,088.48
6	16,900,000.00	0.42121914	0.0013415108	9,549.68
7	16,900,000.00	0.36469189	0.0012434377	7,663.67
8	16,900,000.00	0.31575056	0.0011690222	6,238.12
9	16,900,000.00	0.27337711	0.0011019106	5,090.91
10	16,900,000.00	0.23669014	0.0011006165	4,402.54

Total EPV Death Claims: 140,302.60

--- EPV DISABILITY BENEFIT ---

t	Amount	Discount	Probability	EPV
1	8,400,000.00	0.86580087	0.0006093083	4,431.33
2	8,400,000.00	0.74961114	0.0005961311	3,753.68
3	8,400,000.00	0.64901397	0.0005519931	3,009.31
4	8,400,000.00	0.56191686	0.0005258908	2,482.26
5	8,400,000.00	0.48650810	0.0004993222	2,040.56
6	8,400,000.00	0.42121914	0.0004787804	1,694.04
7	8,400,000.00	0.36469189	0.0004571499	1,400.44
8	8,400,000.00	0.31575056	0.0004348517	1,153.36
9	8,400,000.00	0.27337711	0.0004166707	956.83
10	8,400,000.00	0.23669014	0.0004142761	823.66

Total EPV Disability: 21,745.47

--- EPV SURRENDER BENEFIT ---

t	Amount	Discount	Probability	EPV
1	0.00	0.86580087	0.0000000000	0.00
2	0.00	0.74961114	0.0995708928	0.00
3	0.00	0.64901397	0.0893608574	0.00
4	2,310,160.90	0.56191686	0.0801982503	104,106.82
5	2,887,701.12	0.48650810	0.0719726837	101,113.70
6	3,465,241.35	0.42121914	0.0645863149	94,271.86
7	4,042,781.57	0.36469189	0.0579519547	85,442.60
8	4,620,321.79	0.31575056	0.0519917907	75,849.22
9	5,197,862.02	0.27337711	0.0466367132	66,269.67
10	5,775,402.24	0.23669014	0.0000000000	0.00

Total EPV Surrender: 527,053.88

--- EPV SURVIVAL BENEFIT (end of term) ---

Amount=16,800,000.00 Discount=0.23669014 Probability=0.4174963706 EPV=1,660,130.18

--- EPV EXPENSES ---

k	Amount	Discount	Probability	EPV
0	128,342.27	1.00000000	1.0000000000	128,342.27
1	32,085.57	0.86580087	0.9971233835	27,699.80
2	33,048.14	0.74961114	0.8948654409	22,168.73
3	34,039.58	0.64901397	0.8031169129	17,742.59
4	35,060.77	0.56191686	0.7207636393	14,199.93
5	36,112.59	0.48650810	0.6468213706	11,364.05
6	37,195.97	0.42121914	0.5804147645	9,093.74
7	38,311.85	0.36469189	0.5207622222	7,276.10
8	39,461.20	0.31575056	0.4671665577	5,820.85
9	40,645.04	0.27337711	0.4190112632	4,655.81

Total EPV Expenses: 248,363.87

--- EPV COMMISSION ---

k	Amount	Discount	Probability	EPV
0	160,427.84	1.00000000	1.0000000000	160,427.84
1	32,085.57	0.86580087	0.9971233835	27,699.80
2	32,085.57	0.74961114	0.8948654409	21,523.03
3	32,085.57	0.64901397	0.8031169129	16,724.09
4	32,085.57	0.56191686	0.7207636393	12,994.95
5	32,085.57	0.48650810	0.6468213706	10,096.81
6	32,085.57	0.42121914	0.5804147645	7,844.34
7	32,085.57	0.36469189	0.5207622222	6,093.62
8	32,085.57	0.31575056	0.4671665577	4,732.88
9	32,085.57	0.27337711	0.4190112632	3,675.34

Total EPV Commission: 271,812.71

--- EPV PREMIUM ---

k	Amount	Discount	Probability	EPV
0	641,711.36	1.00000000	1.0000000000	641,711.36
1	641,711.36	0.86580087	0.9971233835	553,996.02
2	641,711.36	0.74961114	0.8948654409	430,460.69
3	641,711.36	0.64901397	0.8031169129	334,481.84
4	641,711.36	0.56191686	0.7207636393	259,899.03
5	641,711.36	0.48650810	0.6468213706	201,936.19
6	641,711.36	0.42121914	0.5804147645	156,886.75
7	641,711.36	0.36469189	0.5207622222	121,872.38
8	641,711.36	0.31575056	0.4671665577	94,657.62
9	641,711.36	0.27337711	0.4190112632	73,506.81
Total EPV Premium: 2,869,408.71				

--- EQUIVALENCE PRINCIPLE CHECK ---

Total Income (EPV Premium) = 2,869,408.71
 Total Outgo (Death+Disability+Surrender+Survival+Exp+Comm) = 2,869,408.71
 Difference (should be ~0, solved via Goal Seek) = 0.000000
 >>> PREMIUM = 641,711.36 <<<

--- NON-UNIT FUND (PROFIT TEST) ---

Yr	Unalloc.	B/O	Expenses	Interest	MgmtChg	XDeath	XDisab	SurrPen	Profit
1	256,684.54	19,251.34	-288,770.11	-1,475.94	8,449.41	-37,152.06	-4,865.92	0.00	-47,878.74
2	32,085.57	30,481.29	-65,133.70	-295.19	22,942.13	-32,871.46	-4,349.86	41,224.47	24,083.24
3	32,085.57	30,481.29	-66,125.15	-409.20	39,346.43	-30,507.65	-3,992.23	100,456.29	101,335.34
4	32,085.57	30,481.29	-67,146.33	-526.64	57,914.47	-28,322.48	-3,642.19	15,462.02	36,305.71
5	32,085.57	30,481.29	-68,198.16	-647.60	78,931.62	-26,380.29	-3,139.87	20,424.47	63,557.04
6	32,085.57	30,481.29	-69,281.54	-772.19	102,720.94	-24,404.14	-2,492.03	24,979.72	93,317.63
7	32,085.57	30,481.29	-70,397.41	-900.51	129,648.07	-22,381.41	-1,612.46	29,169.11	126,092.24
8	32,085.57	30,481.29	-71,546.77	-1,032.69	160,126.89	-20,099.71	-462.42	33,029.11	162,581.27
9	32,085.57	30,481.29	-72,730.61	-1,168.83	194,625.87	-17,132.10	-0.00	36,592.18	202,753.37
10	32,085.57	30,481.29	-73,949.96	-1,309.06	233,675.26	-14,052.61	-0.00	0.00	206,930.49

--- PROFIT SIGNATURE & DISCOUNTED PROFIT (v2=0.84388186, risk discount rate 18.5%) ---

Yr	Profit	t-1(ap)x	Profit Sig.	Discount	Disc.Profit
1	-47,878.74	1.00000000	-47,878.74	0.84388186	-40,404.00
2	24,083.24	0.99712338	24,013.96	0.71213659	17,101.22
3	101,335.34	0.89486544	90,681.50	0.60095915	54,495.88
4	36,305.71	0.80311691	29,157.73	0.50713852	14,787.01
5	63,557.04	0.72076364	45,809.60	0.42796500	19,604.91
6	93,317.63	0.64682137	60,359.84	0.36115189	21,799.07
7	126,092.24	0.58041476	73,185.80	0.30476953	22,304.80
8	162,581.27	0.52076222	84,666.18	0.25718948	21,775.25
9	202,753.37	0.46716656	94,719.59	0.21703753	20,557.71
10	206,930.49	0.41901126	86,706.21	0.18315404	15,880.59
Total Discounted Profit = 167,902.43					

--- DISCOUNTED PREMIUM ---

Yr	Premium	$t-1(ap)x$	Discount	Disc.Premium

1	641,711.36	1.00000000	1.00000000	641,711.36
2	641,711.36	0.99712338	0.84388186	539,970.80
3	641,711.36	0.89486544	0.71213659	408,941.10
4	641,711.36	0.80311691	0.60095915	309,715.86
5	641,711.36	0.72076364	0.50713852	234,562.83
6	641,711.36	0.64682137	0.42796500	177,636.55
7	641,711.36	0.58041476	0.36115189	134,514.18
8	641,711.36	0.52076222	0.30476953	101,847.59
9	641,711.36	0.46716656	0.25718948	77,101.83
10	641,711.36	0.41901126	0.21703753	58,357.98

Total Discounted Premium = 2,684,360.09

```

=====
>>> PREMIUM          = 641,711.36 <<<
>>> PROFIT MARGIN = 6.254840% <<<
=====

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APPENDIX D: Microsoft Excel Pricing output for Women

EPV Benefits and claims for women

kx	Amounts(s+f)	Discount	Probability	EPV (for each year)
0	16,900,000	0.87	0.00168260	24,619.93
1	16,900,000	0.75	0.00152206	19,282.08
2	16,900,000	0.65	0.00130144	14,274.65
3	16,900,000	0.56	0.00111845	10,621.23
4	16,900,000	0.49	0.00097437	8,011.26
5	16,900,000	0.42	0.00086840	6,181.80
6	16,900,000	0.36	0.00079217	4,882.39
7	16,900,000	0.32	0.00072789	3,884.16
8	16,900,000	0.27	0.00067827	3,133.65
9	16,900,000	0.24	0.00067364	2,694.61
Total EPV				97,585.75

EPV Expenses

kx	Amount	Discount	Probability	EPV (for each year)
0	125,894.06	1.00	1.00	125,894.06
1	31,473.51	0.87	1.00	27,191.15
2	32,417.72	0.75	0.90	21,778.04
3	33,390.25	0.65	0.80	17,443.55
4	34,391.96	0.56	0.72	13,972.25
5	35,423.72	0.49	0.65	11,191.91
6	36,486.43	0.42	0.58	8,964.66
7	37,581.02	0.36	0.52	7,180.20
8	38,708.45	0.32	0.47	5,750.52
9	39,869.71	0.27	0.42	4,605.07
Total EPV				243,971.40

EPV Commission

kx	Amount	Discount	Probability	EPV(for each year)
0	157,367.57	1.00	1.00	157,367.57
1	31,473.51	0.87	1.00	27,191.15
2	31,473.51	0.75	0.90	21,143.73
3	31,473.51	0.65	0.80	16,442.21
4	31,473.51	0.56	0.72	12,786.59
5	31,473.51	0.49	0.65	9,943.87
6	31,473.51	0.42	0.58	7,732.99
7	31,473.51	0.36	0.52	6,013.30
8	31,473.51	0.32	0.47	4,675.70
9	31,473.51	0.27	0.42	3,635.29
Total EPV				266,932.40

EPV Premium

kx	Amount	Discount	Probability	EPV(for each year)
0	629,470.28	1.00	1.00	629,470.28
1	629,470.28	0.87	1.00	543,822.97
2	629,470.28	0.75	0.90	422,874.53
3	629,470.28	0.65	0.80	328,844.29
4	629,470.28	0.56	0.72	255,731.81
5	629,470.28	0.49	0.65	198,877.34
6	629,470.28	0.42	0.58	154,659.86
7	629,470.28	0.36	0.52	120,266.02
8	629,470.28	0.32	0.47	93,513.98
9	629,470.28	0.27	0.42	72,705.77
Total EPV				2,820,766.86

Disability Benefit

t	Amount	Discount	Probability	EPV
1	8,400,000.00	0.87	0.0004696	3,415.31
2	8,400,000.00	0.75	0.0004547	2,862.87
3	8,400,000.00	0.65	0.0004254	2,319.00
4	8,400,000.00	0.56	0.0004050	1,911.61
5	8,400,000.00	0.49	0.0003844	1,570.78
6	8,400,000.00	0.42	0.0003637	1,287.01
7	8,400,000.00	0.36	0.0003489	1,068.71
8	8,400,000.00	0.32	0.0003332	883.79
9	8,400,000.00	0.27	0.0003171	728.21
10	8,400,000.00	0.24	0.0003166	629.51
Total				16,676.81

Surrender Benefit

t	Amount	Discount	Probability	EPV
1	0.00	0.87	0.00	0.00
2	0.00	0.75	0.10	0.00
3	0.00	0.65	0.09	0.00
4	2266093.02	0.56	0.08	102394.81
5	2832616.28	0.49	0.07	99537.21
6	3399139.54	0.42	0.06	92888.75
7	3965662.79	0.36	0.06	84273.06
8	4532186.05	0.32	0.05	74891.10
9	5098709.30	0.27	0.05	65508.2022029
10	5665232.56	0.24	0.00	0.00
Total				519,493.12

Survival Benefit

t	Amount	Discount	Probability	EPV
10.0	16,800,000.00	0.24	0.42	1,676,107.38

APPENDIX E: Microsoft Excel Profit testing output for Women

Unit fund								
Year	Age	Allocated	Bid/Offer spread	Cost of allocat	Fund before growth	Fund after growth	Management charge	Bid value of Units
1	30	377,682.17	18,884.11	358,798.06	358,798.06	414,411.76	8,288.24	406,123.53
2	31	597,996.77	29,899.84	568,096.93	974,220.46	1,125,224.63	22,504.49	1,102,720.14
3	32	597,996.77	29,899.84	568,096.93	1,670,817.07	1,929,793.71	38,595.87	1,891,197.84
4	33	597,996.77	29,899.84	568,096.93	2,459,294.77	2,840,485.46	56,809.71	2,783,675.75
5	34	597,996.77	29,899.84	568,096.93	3,351,772.68	3,871,297.45	77,425.95	3,793,871.50
6	35	597,996.77	29,899.84	568,096.93	4,361,968.43	5,038,073.54	100,761.47	4,937,312.07
7	36	597,996.77	29,899.84	568,096.93	5,505,409.00	6,358,747.39	127,174.95	6,231,572.45
8	37	597,996.77	29,899.84	568,096.93	6,799,669.38	7,853,618.13	157,072.36	7,696,545.77
9	38	597,996.77	29,899.84	568,096.93	8,264,642.70	9,545,662.32	190,913.25	9,354,749.07
10	39	597,996.77	29,899.84	568,096.93	9,922,846.01	11,460,887.14	229,217.74	11,231,669.39

Non unit fund										
Year	Age	Unallocated	Bid/Offer spread	Expenses	Interest	Management charge	Extra death benefit	Extra disability benefit	Surrender penalty	Profit
1	30	251,788.11	18,884.11	(283,261.63)	(1,447.78)	8,288.24	(27,584.41)	(3,753.96)	0.00	(37,087.32)
2	31	31,473.51	29,899.84	(63,891.23)	(289.56)	22,504.49	(23,943.69)	(3,324.93)	40,482.69	32,911.12
3	32	31,473.51	29,899.84	(64,863.77)	(401.40)	38,595.87	(21,650.46)	(3,089.36)	98,724.48	108,688.73
4	33	31,473.51	29,899.84	(65,865.47)	(516.59)	56,809.71	(19,475.52)	(2,825.79)	15,207.76	44,707.45
5	34	31,473.51	29,899.84	(66,897.23)	(635.25)	77,425.95	(17,528.09)	(2,448.75)	20,106.03	71,396.01
6	35	31,473.51	29,899.84	(67,959.94)	(757.46)	100,761.47	(15,862.93)	(1,939.49)	24,613.23	100,228.23
7	36	31,473.51	29,899.84	(69,054.54)	(883.34)	127,174.95	(14,352.77)	(1,296.89)	28,769.84	131,730.61
8	37	31,473.51	29,899.84	(70,181.97)	(1,012.99)	157,072.36	(12,648.27)	(447.43)	32,611.89	166,766.95
9	38	31,473.51	29,899.84	(71,343.22)	(1,146.53)	190,913.25	(10,733.05)	0.00	36,171.72	205,235.51
10	39	31,473.51	29,899.84	(72,539.31)	(1,284.09)	229,217.74	(8,878.16)	0.00	0.00	207,889.54

Year	Age	t-1Px	Present value profits	Premium	Discounting factor	t-1Px	Present value of premium
1	30	1	(31,297.32)	629,470.28	1	1	629,470.28
2	31	0.99784779	23,386.77	629,470.28	0.843881857	0.997847791	530,055.30
3	32	0.89619034	58,536.90	629,470.28	0.712136588	0.896190345	401,734.19
4	33	0.80493539	18,250.19	629,470.28	0.600959146	0.804935394	304,495.73
5	34	0.7229986	22,091.22	629,470.28	0.50713852	0.722998603	230,801.85
6	35	0.64941153	23,507.15	629,470.28	0.427964996	0.649411527	174,945.78
7	36	0.58330309	23,418.15	629,470.28	0.361151895	0.583303088	132,604.85
8	37	0.52389181	22,470.09	629,470.28	0.304769532	0.523891809	100,505.17
9	38	0.47049737	20,957.75	629,470.28	0.257189478	0.470497375	76,170.29
10	39	0.42250465	16,087.21	629,470.28	0.217037534	0.422504652	57,722.03
			197,408.10				2,638,505.48

Profit margin	7.48%
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