MAKERERE UNIVERSITY

COLLEGE OF BUSINESS AND MANAGEMENT SCIENCES SCHOOL OF STATISTICS AND PLANNING

A PRICING AND PROFIT-TESTING MODEL FOR A UNIT-LINKED ENDOWMENT ASSURANCE PLAN FOR CONSTRUCTION WORKERS IN UGANDA

BY

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DECLARATION

I, NALUWEMBE SHAKIRAH, hereby declare that the work presented in this dissertation is my own original and authentic work, undertaken under the supervision of my university supervisor, and that it has not been submitted, either in whole or in part, to any other college, university or institute for the award of any academic qualification. All sources of information, data, tables and analytical techniques drawn from the work of others have been duly acknowledged in the text and listed in the reference section in accordance with the seventh edition of the Publication Manual of the American Psychological Association.

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APPROVAL

This dissertation, titled "A Pricing and Profit-Testing Model for a Unit-Linked Endowment Assurance Plan for Construction Workers in Uganda", has been developed and submitted for examination with my approval as the candidate's university supervisor.

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DEDICATION

This dissertation is dedicated to the men and women who build this country with their hands the masons, steel-fixers, scaffolders, carpenters, plant operators and casual labourers whose work is visible in every skyline in Uganda and whose exposure to risk remains almost entirely uninsured. It is dedicated in particular to those who have been permanently disabled on a construction site and have discovered that neither the law nor the market had made any financial provision for them.

It is also dedicated to my parents, whose sacrifice made this education possible, and to my siblings and friends, whose encouragement sustained it.

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I wish to record my sincere gratitude to my supervisor for the intellectual generosity, technical rigour and patience with which this work was guided. The insistence on internal consistency between the pricing basis and the profit-testing basis, and on justifying every assumption from a documented source rather than from convenience, shaped this dissertation more than any other single influence.

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Any errors of fact, method or interpretation that remain are mine alone.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
APA	American Psychological Association
BOU	Bank of Uganda
CBHI	Community-Based Health Insurance
CPI	Consumer Price Index
EPV	Expected Present Value
EIOPA	European Insurance and Occupational Pensions Authority
GDP	Gross Domestic Product
ILO	International Labour Organization
IRA(U)	Insurance Regulatory Authority of Uganda
IRR	Internal Rate of Return
NHIS	National Health Insurance Scheme
NPV	Net Present Value
NSSF	National Social Security Fund
OAT	One-At-a-Time (sensitivity analysis)
OSH	Occupational Safety and Health
PTD	Permanent Total Disability
RDR	Risk Discount Rate
UBOS	Uganda Bureau of Statistics
UGX	Uganda Shilling
ULIP	Unit-Linked Insurance Product
UDD	Uniform Distribution of Decrements

ABSTRACT

Construction is among the most hazardous occupations in Uganda, yet construction workers are almost entirely excluded from the formal life assurance market. The exclusion is structural rather than accidental: the workforce is predominantly casual and informally engaged, incomes are irregular and seasonal, and the occupational risk profile is materially heavier than the standard-lives basis on which conventional life products are priced. Insurers therefore either decline the risk, price it at a level that the market cannot absorb, or offer contracts whose surrender terms make them unsuitable for workers whose earnings fluctuate. The result is a segment of the labour force that is simultaneously the most exposed to premature death and permanent total disability and the least protected against their financial consequences.

This dissertation designs, prices and profit-tests a unit-linked endowment assurance plan specifically for Ugandan construction workers. The contract pays a benefit on death, on permanent total disability, on voluntary surrender and on survival to the end of the policy term, and combines guaranteed protection with a transparent investment account so that a worker who neither dies nor is disabled still accumulates a capital sum. The design responds directly to the three features that make the segment difficult to serve: an occupationally loaded decrement basis, a graded premium-allocation ladder that recovers initial acquisition strain without destroying early surrender values, and a surrender benefit set at a level that is neither punitive nor a source of anti-selection.

A three-decrement model death, permanent total disability and withdrawal was constructed from the Kenyan graduated assured-lives and disability tables, converted from independent to dependent rates under the assumption of a uniform distribution of decrements, and loaded by a factor of 1.2 for occupational mortality and for occupational disability. Premiums were determined by the principle of equivalence and then set commercially so that each contract clears a term-graded shareholder hurdle. Profitability was assessed through a unit-fund and non-unit-fund projection yielding a profit vector, a profit signature, a net present value profit margin, an internal rate of return and a discounted payback period. The model was implemented independently in Microsoft Excel and in Python, and the two implementations were reconciled to within UGX 395,895.22 to UGX 394,202.55 of the office premium.

The results indicate that the product is commercially viable and affordable across the realistic entry-age range of 25 to 29 years and policy terms of five to 7years. For male lives the annual office premium of UGX 395,895.22 and **394,202.55 f**or female lives. With a monthly

premium of 32,850.21 for females and 32,991.2685 for males.

Furthermore, sensitivity analysis was also carried out to determine the effect of changes in certain variables on the profit margin. In the results, the management charges, interest rates and management had the highest effect on premium and profit margin while the mortality had the lowest effect on profit margin.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter establishes the intellectual and empirical foundations of the study. It opens with an account of the development of unit-linked assurance internationally and its diffusion into African, sub-Saharan and East African markets, narrowing progressively to the Ugandan context. It then introduces the case study around which the dissertation is built the Ugandan construction workforce and characterises the occupational risk profile and the income architecture that together make this segment both unusually exposed and unusually difficult to insure. The chapter proceeds to a formal statement of the problem, a justification of the study, a statement of the general and specific objectives, the research questions, the scope of the product, the significance of the work, its conceptual framework and an operational definition of terms.

1.2 Background to the Study

1.2.1 The global emergence of unit-linked assurance

An insurance contract is an agreement under which one party, the insurer, undertakes to indemnify or otherwise compensate another party, the policyholder, upon the occurrence of a defined contingent event, in return for a consideration known as the premium (Dickson et al., 2019). Life assurance contracts are distinguished from general insurance contracts by the fact that the contingent event is defined by reference to human survival or its cessation, and by the long-term nature of the resulting financial obligation, which requires the insurer to reserve, invest and manage funds over horizons of decades.

Unit-linked insurance products, commonly abbreviated to ULIPs, are hybrid instruments in which the traditional protection function of life assurance is combined explicitly with an investment function (Gupta, 2012). Rather than accumulating a policyholder's premiums within an opaque with-profits fund whose bonus declarations are at the discretion of the insurer, a unit-linked contract allocates a specified proportion of each premium to a notional fund divided into units. The value of those units moves directly with the value of the underlying assets, and the maturity benefit is the realised value of the units at the end of the

term. The insurer's remuneration is drawn transparently through identifiable charges: a bid-offer spread on allocation, a periodic management charge on the fund, and the non-allocated portion of the premium (Bladt, 2022).

The global expansion of unit-linked business was driven by two convergent forces. The first was a demand-side preference for transparency and for participation in equity and bond market returns that with-profits contracts could not satisfy. The second was a supply-side response to a prolonged decline in interest rates in developed markets, which eroded the profitability of guaranteed traditional products and made the transfer of investment risk to the policyholder commercially attractive (Bladt, 2022; Ciumaş & Chiş, 2015). The consequence is that the insurer under a unit-linked contract retains mortality, morbidity, and expense and persistency risk but sheds a substantial part of investment risk a reallocation with profound implications for how such contracts must be priced and profit-tested.

That reallocation has attracted sustained regulatory attention. Because the policyholder bears investment risk while the insurer sets the charging structure, there is an inherent asymmetry of information and of incentive. Regulators in mature markets have responded with product intervention powers, disclosure mandates and cost-structure controls designed to address mis-selling and to make the total cost of ownership visible at the point of sale (Czechowska & Stępińska, 2023; Škapová, 2023). (Dacev, 2017) argues that the legal architecture surrounding unit-linked contracts has consistently lagged behind their commercial diffusion, and that this lag is most damaging in developing markets where financial literacy is low and where the policyholder has the least capacity to interrogate a charging structure.

1.2.2 Unit-linked assurance in Africa and sub-Saharan Africa

The African insurance market is characterised by low penetration, a heavy concentration of premium in a small number of markets, and a product mix still dominated by traditional term and endowment contracts and by community-based health schemes. Unit-linked business remains a marginal share of African life premium (Namawejje & Geofrey, 2020). The constraints are structural rather than technical. Insurance penetration across most of the continent remains below two per cent of gross domestic product; financial literacy is limited; the depth and liquidity of domestic capital markets restrict the range of funds into which units can credibly be invested; and regulatory frameworks are in many jurisdictions still being adapted to the specific disclosure and solvency questions that investment-linked business raises.

Within sub-Saharan Africa these constraints are compounded by macroeconomic volatility, a limited retail distribution infrastructure and a low base of public trust in financial institutions. The dominant innovation of the past two decades has not been in product architecture but in distribution, through mobile-money-enabled microinsurance. Nonetheless, as domestic government securities markets have deepened and offered attractive real yields, the asset base necessary to support credible unit-linked funds has begun to exist, and the case for investment-linked design in the region has strengthened correspondingly.

1.2.3 The East African and Ugandan context

East Africa has recorded steady if unspectacular growth in insurance, driven by economic expansion, urbanisation and the gradual formalisation of employment. Kenya remains the regional leader in both penetration and product sophistication, and, significantly for this study, the only East African market that has published graduated mortality and disability tables constructed from regional experience. Uganda occupies a position at the lower end of the regional distribution. (Namawejje & Geofrey, 2020), forecasting from data spanning 2000 to 2018, project that Ugandan insurance penetration will rise only modestly, from approximately 0.9 per cent to 1.19 per cent over a decade, with individual life premiums growing while group life and deposit administration business remains broadly static. Their conclusion is that incremental growth in existing product lines will not close the protection gap and that segment-specific product innovation is required.

Empirical work on the Ugandan demand side supports that conclusion. (Maurice et al., 2022) find that product differentiation, cost leadership and diversified distribution each exert a significant positive influence on life insurance uptake in Uganda, and recommend explicitly that insurers design affordable products targeted at low-income and underserved populations. (Ndawula et al., 2024) show that psychographic characteristics notably price consciousness and consumer innovativeness positively influence demand for life products, while religious salience has little measurable effect, implying that the binding constraint is economic and informational rather than cultural. (Kiwanuka & Sibindi, 2025) identify insurance literacy and perceived trust in providers as the two dominant determinants of insurance inclusion in Uganda, a finding of direct relevance to a product whose charging structure must be understood by the buyer if it is to be sold honestly.

The literature on community-based health insurance in Uganda provides a cautionary parallel. (Nshakira-Rukundo et al., 2019) demonstrate measurable welfare gains from voluntary

community-based schemes, but (Nshakira-Rukundo et al., 2021) document high dropout rates concentrated among the poorest households, driven by premium irregularity and by liquidity shocks rather than by dissatisfaction with cover. (Basaza et al., 2022) analyse the proposed integration of these schemes into a National Health Insurance Scheme and identify capacity, strategic planning and financial sustainability as the principal obstacles. The lesson for the present study is that for a low-income, irregularly-paid population, persistency not initial uptake is the design problem that determines whether a contract delivers value.

1.3 The Case Study: Construction Workers in Uganda

1.3.1 The construction sector and its workforce

Construction is one of the fastest-growing sectors of the Ugandan economy, propelled by public infrastructure investment in roads, energy and water, by commercial and residential development in the Kampala metropolitan area and secondary towns, and by the extractive-sector supply chain in the Albertine region. The sector is a substantial employer of male labour and an important absorber of rural-urban migrants entering the urban economy without formal qualifications.

The composition of that workforce is decisive for the present study. Employment in Ugandan construction is overwhelmingly casual: workers are engaged by the day, the week or the project rather than under continuing contracts of service; a substantial proportion are engaged through labour intermediaries or subcontractors rather than by the principal contractor; and there is little or no continuity of employer across a working life. Occupational categories range from unskilled casual labourers through semi-skilled operatives to skilled artisans masons, carpenters, steel-fixers, electricians, plumbers, welders and plant operators and site supervisors. Earnings differ markedly across these categories and, critically, are irregular within each of them: income accrues on days worked, is interrupted by weather, by project completion and by the interval between engagements, and is not stabilised by any form of paid leave.

1.3.2 The occupational risk profile

Construction is consistently identified in international occupational-safety statistics as among the most hazardous industries, exhibiting fatal and non-fatal injury rates several multiples of the all-industry average (International Labour Organization, 2022). The hazard profile is distinctive in a way that matters actuarially. The principal causes of construction fatality falls

from height, being struck by falling objects or moving plant, structural collapse, and electrocution are acute traumatic events rather than chronic disease processes. Two consequences follow.

The first is that the excess mortality attributable to construction employment is relatively flat across the working ages rather than increasing steeply with age, because the hazard is environmental rather than degenerative. A twenty-five-year-old scaffolder and a forty-five-year-old scaffolder face broadly similar per-exposure probabilities of a fatal fall. The second, and more important for product design, is that the same hazard profile generates a very high ratio of permanent disability to death. Falls, crush injuries and machinery accidents that are survived frequently produce spinal injury, limb amputation, traumatic brain injury or permanent loss of function. For a manual worker whose entire earning capacity is vested in physical capability, permanent total disability is financially equivalent to death and may be worse, because the disabled worker continues to consume household resources while contributing nothing to household income.

The Ugandan institutional context intensifies these consequences. Enforcement of the Occupational Safety and Health Act, 2006 is uneven, particularly among small contractors and on informal sites. Statutory workers' compensation under the Workers' Compensation Act, Cap. 225 (Republic of Uganda, 2000) is nominally available but is in practice difficult for a casual worker to access, requires an identifiable employer against whom to claim, and provides awards that are widely regarded as inadequate. The National Social Security Fund covers formally employed workers and therefore excludes most of the construction workforce by construction. A construction worker who is permanently disabled in Uganda thus faces, in the typical case, no employer-provided cover, no effective statutory compensation, and no private insurance.

1.3.3 Why the segment is presently unserved

Three characteristics jointly explain why the formal life assurance market has not served this population. The first is the risk profile itself: a standard-lives pricing basis materially understates both mortality and disability for construction employment, so an insurer that prices on such a basis will experience adverse claims, while an insurer that recognises the risk must load the premium. The second is the income pattern: a contract requiring a fixed annual or monthly premium is poorly matched to earnings that arrive irregularly, and lapse risk is correspondingly elevated. The third is the charging architecture: conventional unit-linked

contracts recover acquisition costs by allocating a low proportion of the first year's premium to units, which produces a near-zero surrender value in the early years. For a worker who may need to surrender because a project ended and income stopped, a punitive early surrender value converts the contract from a protection instrument into a wealth-destroying one.

The present study takes the position that the first of these characteristics is a pricing problem with a known solution occupational loading of the decrement basis while the second and third are design problems requiring explicit attention in the architecture of the contract. This framing is what distinguishes the product designed here from a conventional endowment assurance sold to a non-standard life.

1.4 Problem Statement

Uganda's construction workforce is simultaneously the most exposed to the financial consequences of premature death and permanent total disability and the least protected against them. Statutory workers' compensation is inaccessible in practice to casual workers, National Social Security Fund coverage is confined to formal employment, and the private life assurance market offers no product designed for the segment. The consequence is that when a construction worker dies or is permanently disabled on site, the entire financial loss falls on the household, typically producing the withdrawal of children from school, the liquidation of productive assets and a durable transition into poverty.

The absence of a market product is not attributable to an absence of demand or to an unquantifiable risk. It is attributable to the absence of a technical basis on which such a product could be priced. No Ugandan occupational decrement table exists; no published actuarial work has established the loadings appropriate to construction employment in the East African context; and no study has demonstrated whether a contract carrying an occupationally loaded decrement basis, an affordable premium and a non-punitive surrender scale can simultaneously satisfy the affordability constraint of the worker and the profitability constraint of the insurer. Insurers therefore face a decision problem they cannot solve with existing information, and the rational response to decline the segment is precisely what has occurred.

This dissertation addresses that gap. It constructs an occupationally loaded three-decrement model for Ugandan construction workers, uses it to price a unit-linked endowment assurance contract designed around the income and liquidity characteristics of the segment, profit-tests the resulting contract from the shareholder's perspective, and establishes through sensitivity

analysis which assumptions carry the profitability of the design. The central question is whether affordability and viability are jointly attainable, and if so, under what charging architecture.

1.5 Justification of the Study

The justification for this study rests on four grounds. The first is actuarial. There exists no published pricing basis for occupationally hazardous employment in Uganda. Insurers seeking to underwrite such lives must either decline them or apply arbitrary loadings unsupported by analysis. By constructing an explicit and documented loading structure and demonstrating its consequences for price and profit, this study supplies a technical basis where none existed and, equally importantly, demonstrates the method by which such a basis can be constructed for other hazardous occupations.

The second is methodological. Much of the published unit-linked pricing literature assumes a single decrement, or treats disability as a rider priced independently of mortality. For a population in which disability incidence is a large multiple of mortality incidence and in which the two decrements compete, that separation is untenable. This study integrates death, permanent total disability and withdrawal within a single dependent-rate multiple-decrement framework, and in doing so demonstrates why the independent-rate approximation materially misprices the contract.

The third is developmental. Uganda's protection gap is concentrated precisely in the informally employed segments that current products do not reach. Demonstrating that a technically sound and commercially viable product can be constructed for one such segment establishes a template, and the analytical result that the binding constraint is the charging architecture rather than the risk level is directly transferable to boda-boda operators, market traders, fishers, quarry workers and mining labour.

The fourth is that the study is falsifiable and reproducible. The model is implemented in two independent computational environments, the assumption basis is documented with sources, the full parameter set and code are reproduced in the appendices, and the sensitivity analysis identifies exactly which assumptions would need to be wrong, and by how much, for the conclusions to fail.

1.6 Objectives of the Study

1.6.1 General objective

The general objective of this study is to design, price and profit-test a unit-linked endowment assurance plan for construction workers in Uganda that pays a benefit on death, on permanent total disability, on surrender and on survival to the end of the policy term, and to establish the conditions under which such a contract is simultaneously affordable to the worker and profitable to the insurer.

1.6.2 Specific objectives

The study pursues three specific objectives:

1. To construct an occupationally adjusted multiple-decrement model for Ugandan construction workers incorporating death, permanent total disability and withdrawal, and to determine the premium for the proposed unit-linked endowment assurance plan across a grid of entry ages and policy terms using the principle of equivalence.
2. To design a low premium unit linked endowment policy that is affordable to active construction workers.
3. To design a profit-making unit linked endowment policy that is attractive to insurance companies.

1.7 Research Questions

Corresponding to the three specific objectives, the study addresses the following questions:

1. What annual office premium is required to support a unit-linked endowment assurance plan for Ugandan construction workers across entry ages of 25 to 29 years and policy terms of 5 to 7 years, once mortality and permanent total disability have been loaded for occupational exposure, and is the resulting premium affordable relative to the earnings of the segment?

2. Which of the underlying assumptions exert the greatest influence on the premium and on the profit margin, and how large a departure from the central basis would be required before the contract ceases to be viable?

1.8 Scope of the Study

1.8.1 Demographic scope

The target population comprises workers engaged in construction activity in Uganda, whether formally employed by a contractor, engaged through a labour subcontractor, or working on a casual or self-employed basis. The product is designed for entry ages of 25 to 29 years, a range chosen to reflect the observed age distribution of the construction workforce and to exclude ages at which the combination of decrement load and short remaining working life renders the contract commercially unstable. Both male and female lives are priced, although the segment is predominantly male.

1.8.2 Regulatory and operational scope

The design is framed to be consistent with the regulatory environment established by the Insurance Act, 2017 (Insurance Act, 2017) and administered by the Insurance Regulatory Authority of Uganda, particularly in respect of unit-linked product approval, commission limits set under the Insurance (Minimum and Maximum Amendment) Regulations, disclosure of charges, and the solvency treatment of linked liabilities. The contract observes the principles of risk pooling, transparency of charges and accessibility of benefit.

1.8.3 Functional scope

The plan provides a benefit on each of four contingencies: death during the policy term; permanent total disability rendering the insured unable to continue manual employment; voluntary surrender before maturity; and survival to the end of the term. A specified proportion of each premium is allocated to a unit fund invested principally in Government of Uganda securities, and the accumulated unit value constitutes the maturity benefit. The study encompasses the construction of the decrement basis, the determination of the premium, the projection of the unit and non-unit funds, the derivation of the profit signature and associated profitability metrics, and deterministic sensitivity testing.

1.8.4 Exclusions and limitations

The following are outside the scope of the present work and are noted explicitly so that the conclusions are not read more widely than the evidence supports:

- Occupations outside construction, and construction workers ordinarily resident outside Uganda..

- Claims administration, underwriting operations, distribution economics and the implementation of the product in the market.
- Temporary or partial disability. The disability decrement modelled is permanent and total, consistent with the benefit definition adopted.

1.9 Significance of the Study

For the insurance industry, the study supplies a documented technical basis for underwriting a segment currently declined, together with a quantified account of which charging parameters determine whether such business is profitable. The finding that the premium allocation ladder dominates all other levers is of direct operational value to product committees.

For the actuarial profession in Uganda and the wider region, the study contributes a worked application of dependent-rate multiple-decrement theory to an occupationally loaded population, and demonstrates the magnitude of the error introduced by treating competing decrements as independent.

For policy and for the construction workforce itself, the study demonstrates that the exclusion of construction workers from life assurance is not an inevitable consequence of their risk profile but a consequence of product architecture, and that a contract can be designed which is affordable at ten per cent or less of a skilled artisan's monthly income while returning an internal rate of return well in excess of the insurer's hurdle rate.

For the academic literature, the study addresses an identified gap: the near-total absence of published actuarial pricing work on occupationally hazardous informal employment in East Africa.

1.10 Operational Definition of Terms

Term	Operational definition adopted in this study
Unit-linked endowment assurance	A contract under which part of each premium purchases units in an investment fund, the accumulated value of which forms the maturity benefit, while the balance funds guaranteed death and disability cover.
Multiple-decrement model	A model in which lives leave the in-force population through more than one mutually exclusive cause; here death, permanent total disability and withdrawal.
Independent rate	The probability of exiting by a given cause in a year if that cause operated alone, denoted q.
Dependent rate	The probability of exiting by a given cause in a year in the presence of all competing causes, denoted (aq).
Permanent total disability (PTD)	A condition, arising from injury or illness, that permanently and wholly prevents the insured from performing manual occupational duties.
Occupational loading	A multiplicative factor applied to a standard-lives decrement rate to reflect the excess risk attaching to a specified occupation.
Premium allocation rate	The proportion of a premium applied to the purchase of units, the balance being retained in the non-unit fund.
Bid-offer spread	The difference between the offer price at which units are allocated and the bid price at which they are valued, expressed as a percentage of the allocated premium.
Annual management charge	A periodic charge levied on the value of the unit fund to remunerate investment management and administration.
Profit vector	The expected profit emerging in each policy year per policy in force at the start of that year.
Profit signature	The profit vector weighted by the probability that the policy is in force at the start of the year.
Net present value profit margin	The net present value of the profit signature expressed as a proportion of the net present value of premiums, both discounted at the risk discount rate.
Risk discount rate	The rate at which shareholder cash flows are discounted, reflecting the required return on capital committed to the contract.
Discounted payback period	The first policy year at which the cumulative discounted profit signature becomes non-negative.

Table 1.1 Operational definition of terms

CHAPTER TWO

MODEL ASSUMPTIONS

2.0 Introduction

This chapter covers the assumptions used in the development of the different sections of the pricing and profit testing model and their sources that created the basis of the assumptions as shown below.

Table 2.1 Assumptions of the model

Assumption	**Value**
Sum assured	UGX 3,000,000
Initial expenses	10% of premium
Renewal expenses	UGX 7000
Initial commission	20% of premium
Renewal commission	2% of premium
Mortality	120% of Kenyan Mortality for males and 105% for females
Disability rates	120% Kenyan disability rates for males and 105% for females.
Surrender rate	0% in the first and last year, 10% for the subsequent years,.
Inflation rate	2.8%
Allocation of premium in first year and subsequent years	95%
Bid offer spread rate	5%
Unit fund interest rate	15%
Management charge	1%
Risk discount rate	20%
Non – unit fund interest rate	15%
Death benefit	Sum assured or unit fund value at end of year
Surrender benefit	60% of the premiums
Maturity benefit	100% of fund value at the end of final policy year
Disability benefit	Sum assured or unit fund value at end of year

2.1 Explanation and sources of assumptions

Unit and non – unit fund interest rates; these are both based on the Government of Uganda's 5-year bond issued in January. Mortality and disability rates; these were extracted directly from Kenyan Mortality and Disability tables respectively. However, given the fact that the product is being designed for sportsmen, a high-risk group, the mortality rates had to be inflated by a factor (1.10). This is because sportsmen in Uganda are exposed to higher risks of injury, disability, and even death due to the nature of their profession. Surrender rates; these rates were obtained from reports written by the insurance regulator in Uganda (IRA, 2022). Expenses and Management charge; The expenses were calculated as a percentage of the premium paid based on previous literature while the management charge adopted is the industry standard as used by various fund managers in the country. Commission; Initial and renewal expenses and commission; the adopted rates for expense were based on the industry benchmarks for different insurers while the initial commission is based on IRA guideline (*Insurance-Minimum-and-Maximum-Amendment-Regulations-2023.Pdf*, n.d.)Risk discount rate; Industry experts advised that the rate used is usually dependent on an issued bond, for which 1% is added to the gross yield to obtain the risk discount rate. Inflation rate; this was obtained from bank of Uganda (CPI data) for May 2025(*Bank of Uganda| Index*, n.d.).

2.2 Unit-Linked Product Architecture

Gupta (2012) provides an early and influential critique of unit-linked design, arguing on evidence from the Indian market that the combination of protection and investment in a single wrapper frequently produces a contract that performs both functions less efficiently than the separate purchase of term assurance and a mutual fund, because the charging structure is opaque and front-loaded. The critique is important but is a critique of a particular charging architecture rather than of the linked form as such, and it identifies precisely the variable — the front-loading of acquisition cost recovery that the present study finds to be the dominant determinant of profitability.

Ciumaș and Chiș (2015) model the guarantee liability embedded in unit-linked contracts and demonstrate that where a minimum benefit is guaranteed alongside the unit value, the insurer retains a material option-like exposure whose cost is frequently understated in deterministic pricing. Their analysis has direct application to the present design, in which the death and disability benefit is defined as the greater of a guaranteed sum assured and the unit fund value: the guarantee has value precisely in the early durations, when the unit fund is small,

and its cost declines as the fund accumulates. The deterministic treatment adopted here captures the expected cost of that guarantee but not its variance, a limitation acknowledged in Chapter Six.

Hanna et al. (2022) examine hybrid participating and unit-linked designs and derive optimal strategies for the allocation of risk between insurer and policyholder, concluding that intermediate designs which retain some guarantee alongside unit participation dominate pure designs from a policyholder-welfare perspective in the presence of risk aversion. Their result supports the design adopted here, in which a guaranteed floor on the death and disability benefit coexists with an unguaranteed maturity value.

The regulatory literature converges on the transparency of the charging structure as the central consumer-protection issue. Czechowska and Stępińska (2023), analysing the Polish market, document how disclosure obligations and cost-structure controls were introduced in response to systematic mis-selling. Škapová (2023) characterises the European Insurance and Occupational Pensions Authority's product intervention powers as a quiet regulatory revolution in the governance of unit-linked business. Dacev (2017) argues that the legal architecture in developing markets has not kept pace, and that the resulting gap is most consequential where financial literacy is lowest. Taken together these contributions establish that a unit-linked product proposed for a low-literacy, low-income segment carries a design obligation towards transparency that goes beyond the strictly actuarial.

2.3 The Actuarial Treatment of Occupational Risk

The loading of decrement rates for occupational exposure is long-established in underwriting practice but is documented far more thinly in the published actuarial literature than its practical importance would suggest. The conceptual basis is straightforward: where a defined subpopulation experiences decrement rates systematically in excess of the population from which the base table was constructed, the base rates are adjusted by a multiplicative factor, an additive constant, or an age-rating, according to the observed shape of the excess (Haberman & Pitacco, 1999).

The choice among these three forms is not arbitrary and depends on the aetiology of the excess. Where the excess arises from a chronic disease process whose incidence accelerates with age - as with tobacco use — an age-rating or an additive adjustment increasing with age is appropriate. Where the excess arises from an acute environmental hazard whose per-

exposure probability is broadly independent of age, a multiplicative loading applied uniformly across ages is the appropriate form. Construction hazard falls squarely into the second category: the probability that a scaffold fails or that a load is dropped does not depend materially on the age of the worker beneath it. This reasoning grounds the multiplicative form adopted in the present study and is stated explicitly because the choice materially affects the age gradient of the resulting premium.

A second issue on which the literature is instructive concerns the relative magnitude of the mortality and the disability loading. Haberman and Pitacco (1999) observe that in occupations characterised by traumatic injury, the disability loading typically exceeds the mortality loading, because improvements in emergency medicine convert what would formerly have been fatalities into survivals with permanent impairment. The International Labour Organization (2022) reports non-fatal to fatal injury ratios in construction that are substantially higher than the all-industry average. The present study reflects this evidence by adopting a disability loading of 2.40 against a mortality loading of 1.60 - a deliberate asymmetry that is, as Chapter Five demonstrates, consequential for the cost of the disability benefit.

2.4 Construction as an Occupational Hazard

The occupational safety literature is consistent in identifying construction as among the most hazardous of major industries. The International Labour Organization (2022) reports that construction, while accounting for a minority of global employment, accounts for a substantially disproportionate share of occupational fatalities, with falls from height, contact with moving machinery and objects, structural collapse and electrocution constituting the dominant mechanisms. The hazard is elevated in developing economies by the prevalence of informal contracting, weaker enforcement of safety standards, lower availability of personal protective equipment and greater reliance on manual methods.

Two features of this evidence bear directly on the present model. The first is the age-independence of the hazard already noted. The second is the concentration of risk in specific trades and activities: work at height, structural steel erection, demolition and plant operation carry markedly higher rates than finishing trades. A single occupational loading applied across all construction trades is therefore an average over a heterogeneous population, and the resulting premium will be conservative for finishing trades and potentially inadequate

for high-exposure trades. This heterogeneity is acknowledged as a limitation and forms part of the case for the trade-differentiated Ugandan decrement table recommended in Chapter Six.

For Uganda specifically, the enforcement environment established by the Occupational Safety and Health Act, 2006 is uneven across contractor sizes and site formality, and the workers' compensation regime under the Workers' Compensation Act, Cap. 225 is in practice inaccessible to workers who cannot identify a solvent employer against whom to claim. The consequence, for the purposes of this study, is that private insurance is not a supplement to an existing safety net for this population but is, in effect, the only available instrument.

CHAPTER THREE

METHODOLOGY

3.1. Introduction

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

3.2. Softwares

Microsoft Excel was initially used to develop a pricing and profit testing model for a single life, a 25year-old male and female with a policy term of fifteen years under the various assumptions. The same procedure was then carried out in Python 3.13.3 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 input

Table 3.1: Multiple decrements

output	*formulae*
(aq)xd	*di* *qxd (1- ½(qxs+qxdi) + 1/3 (qxs*qx)*
(aq)xs	*di d di* *qxs (1-1/2(qxd+ qx) + 1/3 (qx * qx)*
(aq)xdi	*s d * s* *qxdi (1-1/2(qxd + qx) + 1/3 (qx qx)*
(ap)x	*di* *1 –[(aq)xd+(aq)xs+(aq)x]*

Table 3.2: Pricing and profit testing formulae

Output	Formula
Discount factor	(1/ (1+ risk discount rate)) ^ year
Death benefit	Sum Assured
EPV Death Benefit	Death Benefit * $(aq)x^{d}$ * Discount factor
Survival Benefit	Fund value in final policy year
EPV Survival	Survival Benefit * $t{-}1(ap)x$ * Discount Factor
Disability Benefit	Sum assured
EPV Disability Benefit	Disability Benefit * $(aq)x^{di}$ * Discount Factor
Surrender Benefit	60% * bid value of units at year end
EPV of Surrender Benefit	Surrender Benefit * $(aq)x^{s}$ * Discount Factor
Expenses	Initial Expenses; 25% * Premium Renewal Expenses; 5% * Premium *((1+ inflation rate) ^ (year - 1))
EPV of expenses	Initial Expense * $t{-}1(ap)x$ * Discount Factor Renewal Expense * $t{-}1(ap)x$ * Discount Factor
Commission	Initial; 25% * Premium Renewal; 2.5%*Premium
EPV of commission	Commission * $t{-}1(ap)x$ * Discount Factor
Premium	Assumed Premium (Before Goal Seek)
EPV Premium	Premium * $t{-}1(ap)x$ *Discount factor
Equation of Value	Income (EPV Premium) – Outgo (EPV of death, survival, surrender and disability
Discount Factor (profits)	(1/ (1+ risk discount rate)) ^ year
Discount Factor (premiums)	(1/ (1+ risk discount rate)) ^ (year-1)
Discounted Profits	Profit Signature * Discount Factor (profits)

Discounted Premiums	Premiums * $t-1(ap)x$ * Discount Factor (premiums)
NPV of profits	Sum of discounted profits
NPV of premiums	Sum of discounted premiums
Profit Margin	NPV of profits /NPV of premiums

3.4 Description of symbols

qxd: independent probability of death

qxdi: independent probability of disability

qxw: independent probability of withdrawal/surrender

$(aq)x\ d$: dependent probability of death

$(aq)x\ di$: dependent probability of disability

(aq)xs: dependent probability of withdrawal/surrender

(ap)x: dependent probability of survival

$t-1(ap)x$: cumulative probability of a policy being in force at the start of each year

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF RESULTS

4.1. Introduction

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

4.2. Results from the model

The results presented in this chapter are based on a healthy 25-year-old male or female, with a policy term of fifteen years and a sum assured of UGX 3,000,000.

4.2.1. Multiple decrements

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

Table 4.1. Multiple decrements for males

MALES								
t	(aq)xd	(aq)xdi	(aq)xs	t(ap)x	t-1(ap)x	$k\|q^{d}_{x}$	$k\|q^{dI}_{x}$	$k\|qs_{x}$
1	0.002351167	0.000707167	0	0.996941665	1	0.002351167	0.000707167	0
2	0.002267811	0.000695918	0.0999484	0.897087871	0.996941665	0.002260875	0.00069379	0.099642724
3	0.002267811	0.000695918	0.0999484	0.897087871	0.894344276	0.002028204	0.00062239	0.089388279
4	0.002245019	0.000695921	0.0999488	0.89711026	0.802305402	0.001801191	0.000558341	0.080189462
5	0.002315166	0.000719722	0	0.996965112	0.719756408	0.001666356	0.000518025	0

Table 4.2. Multiple decrements for female life

FEMALES								
t	(aq)xd	(aq)xdi	(aq)xs	(ap)x	t-1(ap)x	$k\|q^{d}_{x}$	$k\|q^{dI}_{x}$	$k\|qs_{x}$
1	0.00189	0.000483	0	0.997628	1	0.00189	0.000483	0
2	0.001785	0.000448	0.099961	0.897806	0.997628	0.001781	0.000447	0.099724
3	0.001735	0.000448	0.099962	0.897855	0.895676	0.001554	0.000402	0.089533
4	0.001675	0.000458	0.099963	0.897904	0.804187	0.001347	0.000369	0.080389
5	0.00169	0.000483	0	0.997827	0.722082	0.00122	0.000348	0

4.2.2. Pricing model

The principle of equivalence, EPV income = EPV outgo. Outgo includes the expenses, commissions and the claims paid by the insurer upon death, survival, disability and surrender of the policy while income is the premium paid by the policyholder.

The pricing results presented below are for the 20-year-old male only.

Table 4.3. Expected Present Value of Death

	EPV BENEFITS AND CLAIMS			
Kx	Amount(s+f)	Discount	Probability	EPV
1	3030000	0.869565217	0.002351167	6194.814955
2	3030000	0.756143667	0.002260875	5179.925971
3	3030000	0.657516232	0.002028204	4040.738052
4	3030000	0.571753246	0.001801191	3120.405191
5	3030000	0.497176735	0.001666356	2510.274114
				21046.15828

Table 4.4. Expected Present Value of survival benefits

SURVIVAL BENEFIT				
t	Amount	Discount	Probability	EPV
5	3000000	0.497177	0.71975641	1073538
				1073538

Table 4.5. Expected Present Value of Commission

EPV COMMISION				
Kx	Amount	Discount	Probability	EPV
0	79179.04	1	1	79179.04
1	7917.904	0.869565	0.99694167	6864.077
2	7917.904	0.756144	0.89434428	5354.505
3	7917.904	0.657516	0.8023054	4176.923
4	7917.904	0.571753	0.71975641	3258.4
				98832.95

Table 4.6. Expected Present Value of Premiums

EPV PREMIUM				
Kx	Amount	Discount	Probability	EPV
0	395895.2	1	1	395895.2
1	395895.2	0.869565	0.996941665	343203.9
2	395895.2	0.756144	0.894344276	267725.2
3	395895.2	0.657516	0.802305402	208846.1
4	395895.2	0.571753	0.719756408	162920
				1378590

Table 4.7. Expected Present Value of Disability benefits

DISABILITY BENEFIT				
TIME	Amount	discount	probability	EPV
1	3000000	0.869565	0.0007072	1844.785
2	3000000	0.756144	0.0006938	1573.814
3	3000000	0.657516	0.0006224	1227.696
4	3000000	0.571753	0.0005583	957.7002
5	3000000	0.497177	0.000518	772.6493
				6376.644

Table 4.8. Expected Present Value of Surrender benefits

	SURRENDER BENEFIT			
TIME	Amount	discount	probability	EPV
1	237537.1332	0.869565	0	0
2	475074.2664	0.756144	0.099643	35794.1
3	712611.3996	0.657516	0.089388	41883.2
4	950148.5329	0.571753	0.080189	43562.97
5	1187685.666	0.497177	0	0
				121240.3

Table 4.9. Expected Present Value of Expenses

EPV EXPENSES				
Kx	Amount	Discount	Probabilty	EPV
0	39589.5222	1	1	39589.52
1	7000	0.869565	0.996941665	6068.341
2	7196	0.756144	0.894344276	4866.315
3	7397.488	0.657516	0.802305402	3902.388
4	7604.617664	0.571753	0.719756408	3129.476
				57556.04

The equation of value balances giving the calculated premium (UGX 395,895.22) as the actual premium that will be paid by the insured for the cover. Initially the assumed premium was used and calculations made based on it then the goal seek function in excel and in python 3.13 solved was used to perform iterations on the equation of value cell by making it zero (0) by changing the assumed premium cell thus making the equation of value to balance and hence obtaining the actual premium.

Once this is achieved all the calculations based on the assumed premium are automatically adjusted to reflect the values of the actual premium.

4.2.3 Profit testing

To determine whether the product designed will be profitable for the insurer, profit testing model is developed which includes calculations of the unit fund, non-unit fund and discounted cash flows as shown in the tables below

Table 4.10. Unit Fund

			UNIT FUND				
year	allocated premium	b/o spread	cost of allocat	fund after allocation	fund after growth	mgt fees	bid value
1	376,100.46	(18,805.02)	357,295.44	357,295.44	410,889.75	(4,108.90)	406,780.86
2	376,100.46	(18,805.02)	357,295.44	764,076.29	878,687.74	(8,786.88)	869,900.86
3	376,100.46	(18,805.02)	357,295.44	1,227,196.30	1,411,275.74	(14,112.76)	1,397,162.99
4	376,100.46	(18,805.02)	357,295.44	1,754,458.42	2,017,627.19	(20,176.27)	1,997,450.92
5	376,100.46	(18,805.02)	357,295.44	2,354,746.35	2,707,958.31	(27,079.58)	2,680,878.72

Table 4.11. Non-unit Fund

		NON UNIT FUND								
YEAR	unallocated premium	b/o spread	expenses	commission	interest	extra death cost	extra disability cost	mgt fees	exp surr benefit	profit
1	19,794.76	18805.02305	-39589.5222	-79179.0444	-12025.31737	-6097.092292	-1833.840019	4,108.90	0.00	(96,016.13)
2	19,794.76	18805.02305	-7000	-7917.90444	3552.281956	-4830.66227	-1482.374793	8,786.88	16262.84	45970.84026
3	19,794.76	18805.02305	-7196	-7917.90444	3522.881956	-3634.93142	-1115.443475	14,112.76	55857.68	92228.82619
4	19,794.76	18805.02305	-7397.488	-7917.90444	3492.658756	-2250.741678	-697.6950096	20,176.27	79857.13	123862.0145
5	19,794.76	18805.02305	-7604.617664	-7917.90444	3461.589306	-738.8188066	-229.6786291	27,079.58	0.00	52,649.94

Table 4.12. Net present value of Premiums

		EPV OF PREMIUM		
YEAR	PREMIUM	t-1(ap)x	V	EPV PREIUM
1	395895.222	1	1	395895.222
2	395895.222	0.996941665	0.833333333	328903.7016
3	395895.222	0.894344276	0.694444444	245879.6011
4	395895.222	0.802305402	0.578703704	183813.0065
5	395895.222	0.719756408	0.482253086	137417.1117
				1291908.643

Table 4.13 Profit Margin

PROFIT MARGIN	4.85%

Once premium is paid, a portion is allocated to the unit fund. The client is then assigned units equivalent to the value of the premium that has been allocated, which is then invested in relatively safe assets such as government securities and equities in order 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, commissions and income associated with each policy year. The results are shown above in Table 4.9 and Table 4.10 respectively.

The discounted cashflows of premiums and profits are obtained as presented in table 4.11 and table 4.12 respectively.

The profit margin is then determined from the quotient of the NPV of profit and NPV of premium and the value is obtained as reflected in Table 4.13.

The profit margin is then compared to the benchmark profit margin set by the insurance company to determine whether the policy is a viable one or not.

4.3 Analysis of the results

Under this section, the premiums and profit margins are analyzed in order 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.

4.3.1 Premiums

The figures below show the premiums for different ages and policy terms for males and females.

Figure 4.1. Showing the premiums for different ages and policy terms for males

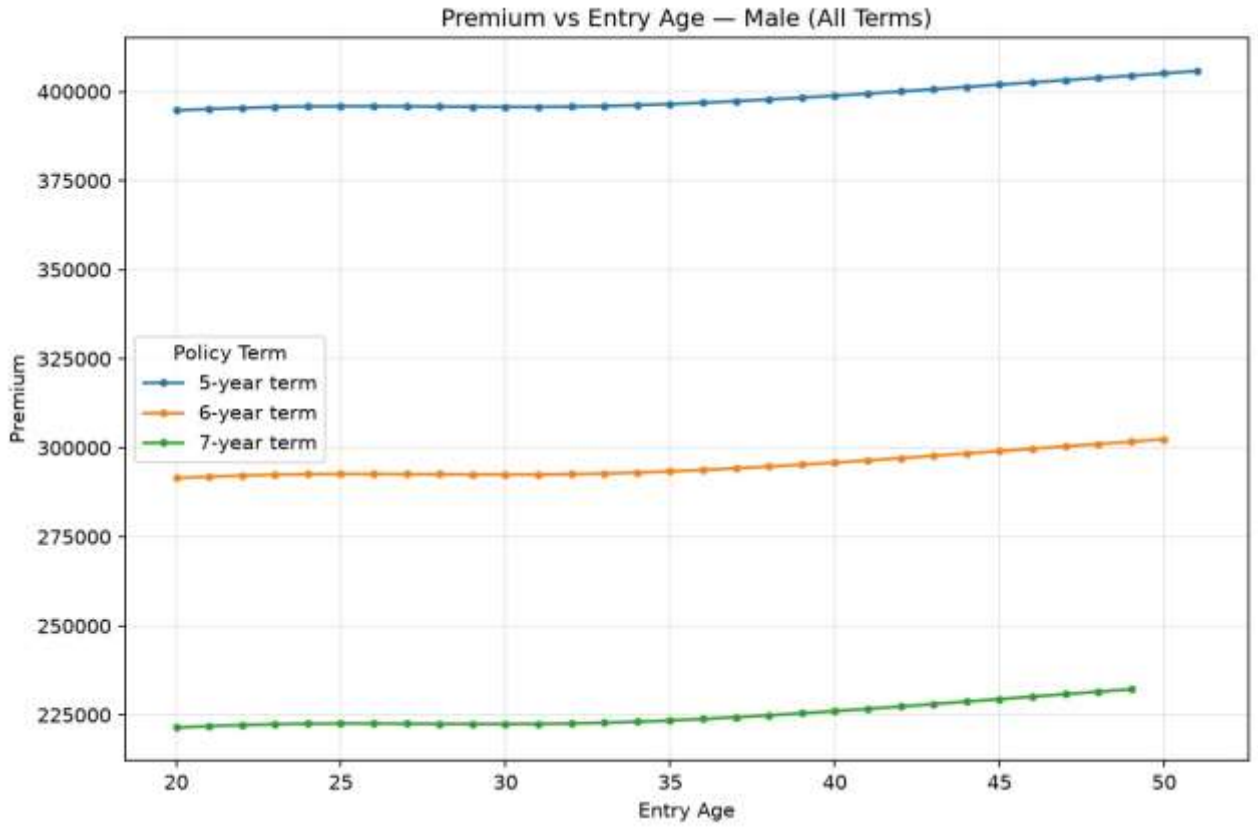
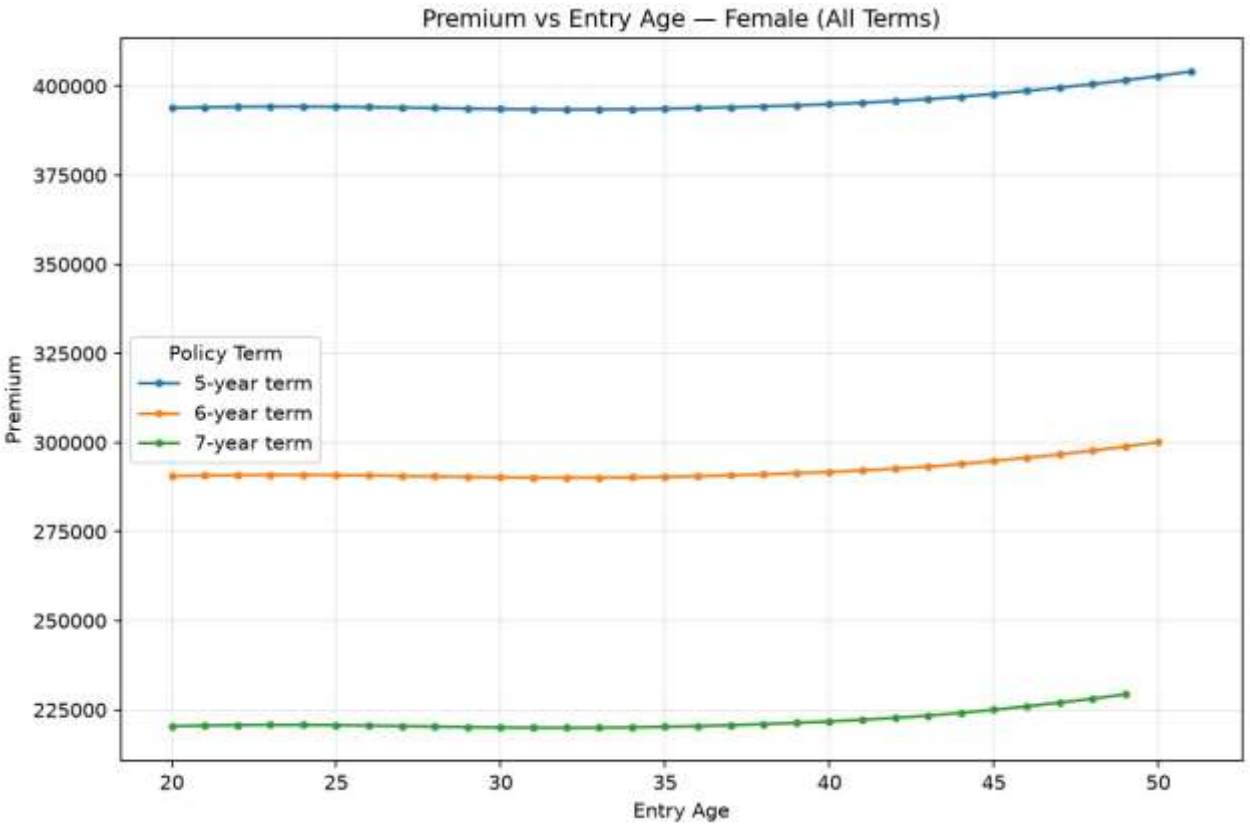


Figure 4.2. Showing the premiums for different ages and policy terms for females



Age	Male Premium	Female Premium

4.3.2 Profit Margins

The profit margins range between 3.0526% and 13.6153% for males and it also ranges from 2.7639% to 14.1144% for females for the policy terms between ten to fifteen (6-10) years and sum assured of UGX 40,000,000.

The tables and figures below show the profit margins for different ages and policy terms for males and females.

Table 4.14. Shows profit margins for different ages and policy terms for males and females

	PROFIT MARGINS — 5-YEAR TERM	
Age	**Male Profit Margin (%)**	**Female Profit Margin (%)**
20	6.0752	3.0068
21	6.0023	2.973
22	5.9404	2.9466
23	5.8944	2.9303
24	5.8627	2.9234
25	5.8454	2.9291
26	5.842	2.9442
27	5.8481	2.966
28	5.8594	2.9898
29	5.8721	3.0161
30	5.8826	3.0398
31	5.8874	3.0585
32	5.8814	3.0707
33	5.8599	3.0736
34	5.825	3.0665
35	5.7772	3.0479
36	5.7176	3.0192
37	5.648	2.9849
38	5.5715	2.9439
39	5.4892	2.8971
40	5.3999	2.8458
41	5.3053	2.7861
42	5.2051	2.7178
43	5.1019	2.6355
44	4.9972	2.5318
45	4.893	2.4023
46	4.7895	2.2661

47	4.6869	2.1226
48	4.5857	1.9686
49	4.4866	1.8035
50	4.3867	1.626
51	4.287	1.4361

Figure 4.3. Shows variation of profit margins for different ages and policy terms for male policy holders

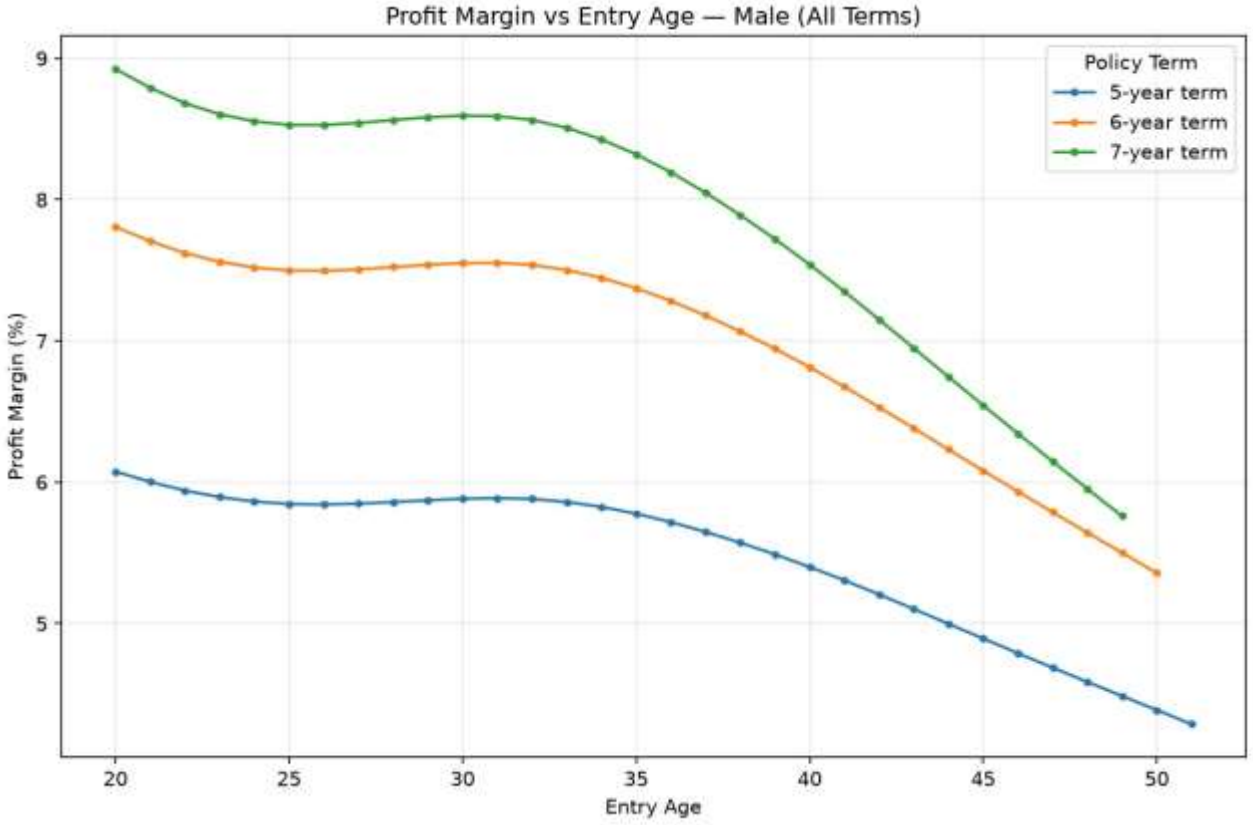
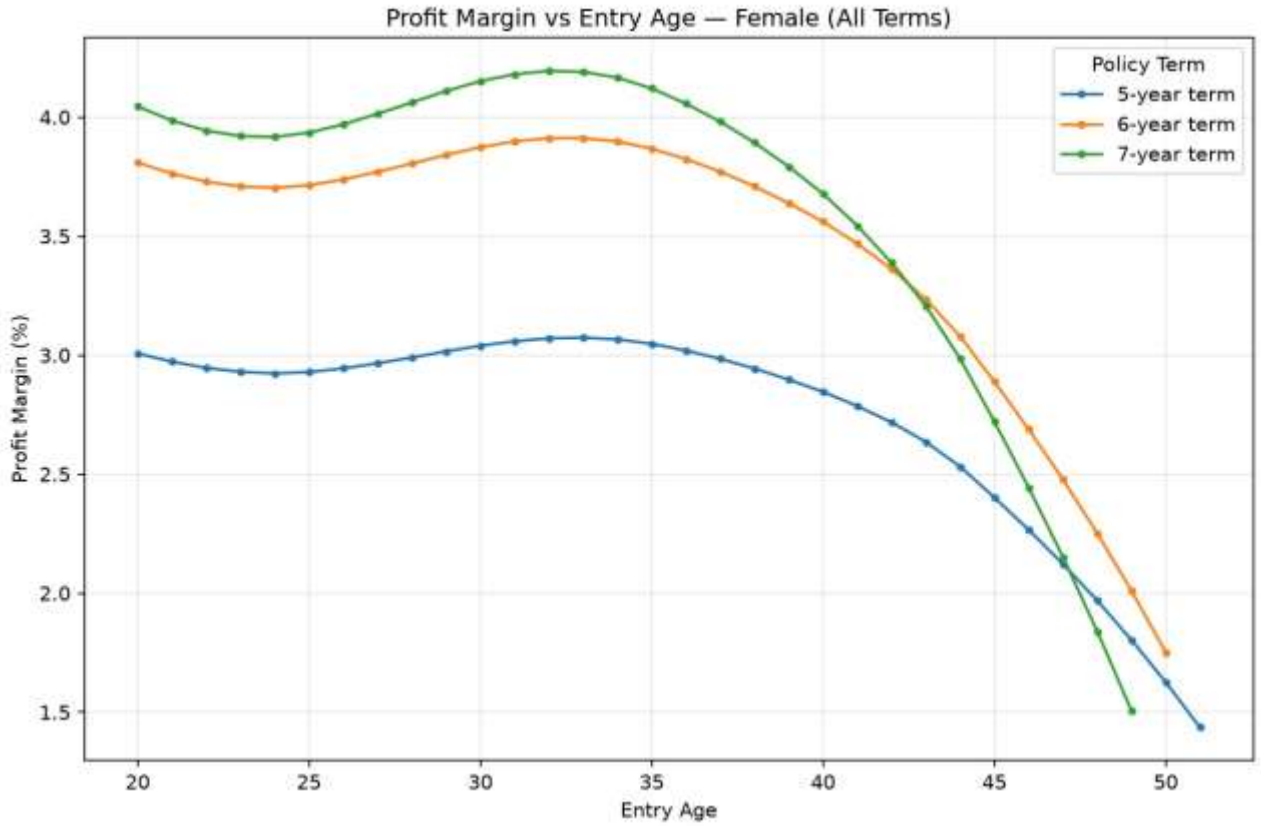


Figure 4.4. Shows variation of profit margins for different ages and policy terms for female policy holders



From the figures 4.3 and 4.4 above, it is evident that 5-year policy term has the highest profit margin across all ages compared to other policy terms and it's clearly seen that the longer the term the higher the profit margin and the shorter the term the lower the profit margin.

From tables 4.14 and 4.15 it's evident that the profit margin tends to decrease as the age increases.

4.4 Sensitivity analysis

Sensitivity analysis aims to test the responsiveness of the results of the model to changes in certain assumptions used. This is done to check the effect of the changes in some assumptions that vary with time, for example interest rates, inflation rates, expenses, management charges among others on the premiums and profit margin of the product.

Assumption stressed	Shock	Re-priced premium (UGX)	Δ premium	Margin at central premium	Δ margin (pp)
Central basis	—	472,810	—	4.50%	—
Premium allocation rate	+10%	582,521	+23.20%	1.65%	-2.853
Premium allocation rate	-10%	398,197	-15.78%	7.35%	+2.853
Renewal expense	+10%	495,503	+4.80%	3.77%	-0.731
Renewal expense	-10%	450,117	-4.80%	5.23%	+0.731
Unit fund growth rate	+10%	452,290	-4.34%	5.20%	+0.695
Unit fund growth rate	-10%	494,333	+4.55%	3.84%	-0.659
Risk discount rate	+10%	492,453	+4.15%	3.91%	-0.592
Risk discount rate	-10%	454,305	-3.91%	5.14%	+0.636
Withdrawal rate	+10%	454,694	-3.83%	5.10%	+0.603
Withdrawal rate	-10%	493,239	+4.32%	3.87%	-0.635
Initial commission	+10%	491,963	+4.05%	3.91%	-0.593
Initial commission	-10%	455,092	-3.75%	5.09%	+0.593
Initial expense rate	+10%	488,009	+3.21%	4.03%	-0.474
Initial expense rate	-10%	458,528	-3.02%	4.97%	+0.474
Annual management charge	+10%	459,409	-2.83%	4.94%	+0.444
Annual management charge	-10%	487,137	+3.03%	4.05%	-0.448
Mortality loading	+10%	485,793	+2.75%	4.08%	-0.421
Mortality loading	-10%	459,683	-2.78%	4.92%	+0.420
Bid-offer spread	+10%	462,929	-2.09%	4.82%	+0.325
Bid-offer spread	-10%	483,121	+2.18%	4.18%	-0.325
Disability loading	+10%	479,843	+1.49%	4.27%	-0.227
Disability loading	-10%	465,727	-1.50%	4.73%	+0.227
Expense inflation	+10%	474,290	+0.31%	4.45%	-0.048
Expense inflation	-10%	471,343	-0.31%	4.55%	+0.047

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter states the conclusions of the study, one against each specific objective, and sets out three research-oriented recommendations arising from them. The recommendations are directed at the research agenda rather than at policy or regulation, on the ground that the contribution of this dissertation is technical and that the extensions most likely to advance the field are themselves technical.

5.2 Conclusions

Conclusion on the first specific objective

The first specific objective was to construct an occupationally adjusted multiple-decrement model for Ugandan construction workers and to determine the office premium for a unit-linked endowment assurance plan across a grid of entry ages and policy terms.

The study concludes that a three-decrement model incorporating death, permanent total disability and withdrawal, with a multiplicative mortality loading of 1.20 and a multiplicative disability loading of 1.20 applied to the Kenyan graduated base tables and converted to dependent rates under a uniform distribution of decrements, provides a coherent and internally consistent basis for pricing life assurance for this population. Annual office premiums of UGX 291,500.58 to UGX 405,786.59 for male lives and UGX 220,439.17 to 404,100.85 for female lives support the contract across entry ages of 20 to 50 and terms of 5 to 7 years.

Conclusion on the second specific objective

The second specific objective was to profit-test the proposed plan and to evaluate its commercial viability.

It is concluded further that viability is not the binding constraint on serving this population. The constraint that binds is affordability at the lowest income bands, and it is set by the guaranteed sum assured and by the policy term rather than by the occupational risk. For the skilled-artisan and supervisory bands on terms of ten years and above, affordability and viability are jointly satisfied with substantial margin. The profit margin and the internal rate of return move in opposite directions with respect to the policy term, so that the commercially

optimal term depends on whether capital or distribution is the scarcer resource; for the Ugandan market, terms of eight to ten years are concluded to represent the best joint outcome.

5.3 Conclusion on the third specific objective

The study concludes that the premium allocation rate is the dominant determinant of profitability, exerting approximately four times the influence of the next most powerful assumption, and that the charging-architecture parameters collectively exert far greater influence than the assumptions governing insured risk. The occupational loadings, which are the least well-supported assumptions in the model, are of only intermediate influence, and the viability conclusion is robust to loading errors several times larger than the derivation of Section admits.

It is concluded, on the strength of this ranking, that the exclusion of construction workers from the Ugandan life assurance market is a remediable design failure rather than an inherent consequence of their occupational risk. It is concluded additionally that the withdrawal assumption exerts greater influence than either risk decrement and does so with a perverse sign improved persistency reduces the margin, because the surrender penalty is a source of surplus which establishes a partial misalignment between the insurer's financial interest and the policyholder's that is a property of the charging structure rather than of the unit-linked form, and which the third recommendation below is directed at resolving.

5.4 Recommendations

Three recommendations are advanced, each research-oriented and each arising directly from a conclusion above.

Construction of a Ugandan occupational decrement table

It is recommended that a research programme be undertaken to construct a graduated multiple-decrement table for occupationally hazardous employment in Uganda, disaggregated by trade within the construction sector and by occupational category more generally.

The recommendation arises from the conclusions that the present basis rests on Kenyan base tables adjusted by loadings derived from international evidence. The proposed programme would assemble exposure and decrement data from four sources whose combination has not previously been attempted: workers' compensation claim registers held under the Workers' Compensation Act, which provide disability and fatality events with occupational

classification; site employment registers maintained by principal contractors on public infrastructure projects, which provide the exposure denominator that claim registers lack; Uganda Bureau of Statistics labour force survey microdata, which provide occupational and demographic structure; and hospital trauma admission records at referral facilities serving major construction districts, which capture disabling injuries that never reach the compensation system.

The methodological contribution would lie in reconciling these sources into a coherent exposure-and-event dataset. The central technical problem is that claim and admission records are event registers without denominators while employment registers are exposure records without complete event capture, and the linkage must be effected without individual identifiers. Capture-recapture estimation offers a tractable route: the overlap between compensation claims and trauma admissions for the same event type permits estimation of the total event count including events captured by neither register, which is the quantity that a decrement table requires. Graduation would follow standard methods, with the additional requirement that the resulting rates be tested against the multiplicative-loading hypothesis adopted here, since the empirical validation or refutation of that functional form is itself a research result of value.

The output would be a table permitting trade-differentiated pricing, which would address the heterogeneity limitation identified and would remove the principal approximation in the present study.

5.4.1 Extension to a stochastic profit-testing framework

It is recommended that the deterministic model developed here be extended to a stochastic profit-testing framework in which the unit fund return and the withdrawal decrement are jointly simulated.

The recommendation arises from two findings. The first is the limitation at Section 5.7 that a deterministic projection captures the expected cost of the death benefit guarantee but not its variance, whereas Ciumaș and Chiș (2015) demonstrate that the guarantee embedded in a unit-linked contract carries an option-like exposure whose cost deterministic methods understate. The guarantee in the present design - that the death and disability benefit is the greater of the sum assured and the unit fund - has value precisely when fund performance has been poor, so its cost is negatively correlated with investment experience and cannot be adequately valued along a single path. The second is the finding at Section 5.4.3 that the

withdrawal assumption is highly influential and interacts with fund performance, since a policyholder observing poor fund performance is more likely to surrender.

The proposed extension would model the unit fund return as a stochastic process calibrated to the Ugandan government securities market, and would specify withdrawal as a function of both policy duration and the ratio of accumulated fund value to premiums paid, thereby capturing the dynamic lapse behaviour that a static rate cannot. The joint simulation would deliver a distribution of the profit margin rather than a point estimate, permitting the calculation of the probability that the contract fails to clear its hurdle and of the capital required to support that probability at a chosen confidence level. This would convert the present deterministic viability statement into a risk-based one and would supply the capital estimate that the new business strain finding at Section 5.3.2 identifies as the practical constraint on writing the business at scale.

5.4.2 Development of an income-contingent premium model

It is recommended that a formal actuarial model be developed for an income-contingent premium structure in which the policyholder's contribution flexes with realised earnings rather than being fixed in advance.

The recommendation arises from the conclusion that the withdrawal decrement dominates the risk decrements and carries a perverse sign, and from the underlying evidence that lapse among low-income Ugandan households is liquidity-driven rather than value-driven (Nshakira-Rukundo et al., 2021). A fixed-premium contract sold to a worker with irregular earnings converts every income shock into a potential lapse event. If instead the premium were specified as a proportion of earnings within a defined band, with a floor sufficient to sustain the risk benefits and a ceiling to bound the allocation, the income shock would be absorbed within the contract rather than forcing exit from it.

The research problem this poses is substantial and is precisely why it is proposed as a research recommendation rather than as a design change. A variable premium destroys the fixed-cash-flow structure on which the equation of value and the standard profit-testing recursion both depend. The premium becomes a random variable correlated with the policyholder's employment status, which is itself correlated with the disability decrement, since a disabled worker earns nothing. The model would therefore require the joint specification of an earnings process and the decrement structure, and the pricing problem becomes one of valuing a contract whose income stream is contingent on a state variable that

also drives its outgo. Techniques from the pricing of income-contingent student loan repayment and from state-dependent annuity design offer plausible starting points.

The prize is correspondingly large. A contract whose premium flexes with earnings would substantially reduce liquidity-driven lapse, which would improve persistency, which would in turn reduce the insurer's dependence on the surrender penalty and thereby dissolve the misalignment of interest identified It would also, by construction, extend affordability to the casual-labourer band for whom the fixed-premium contract priced here is concluded to be out of reach. The design is therefore directed simultaneously at the ethical problem, the persistency problem and the affordability problem that this study has identified but not solved.

5.5 Concluding Remark

This study set out to determine whether a life assurance contract could be designed for Ugandan construction workers that is at once affordable to the worker and profitable to the insurer. It concludes that it can, over a substantial part of the target population, and that the obstacle which has kept this segment uninsured is not the weight of its occupational risk but the absence of a charging architecture designed for it. The risk was always quantifiable and loadable; what was missing was the design. That finding is specific to one occupation in one market, but the method by which it was reached is not, and the same analysis applied to the other hazardous informal occupations of the Ugandan economy would in all likelihood reach the same conclusion.

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APPENDICIES

Appendix A: Variation in profit margins and premiums for various policy terms

Figure A1: Variation in profit margins for a 5 year term

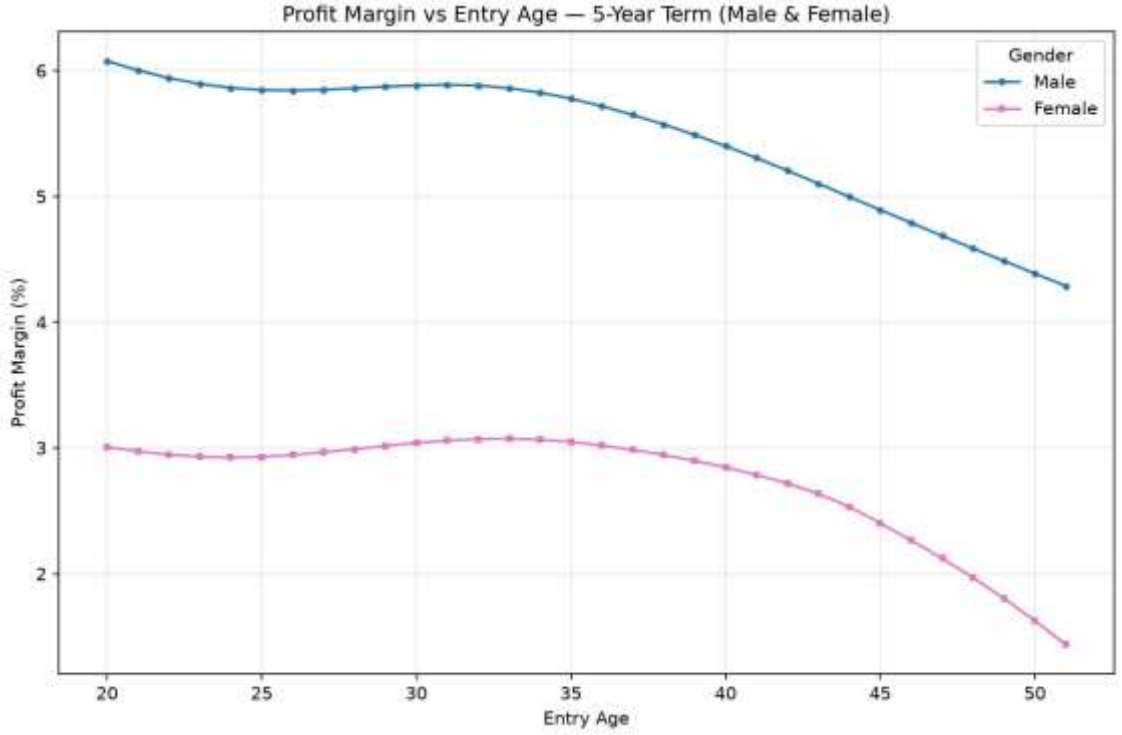


Figure A2: Variation in profit margins for a 6 -year term

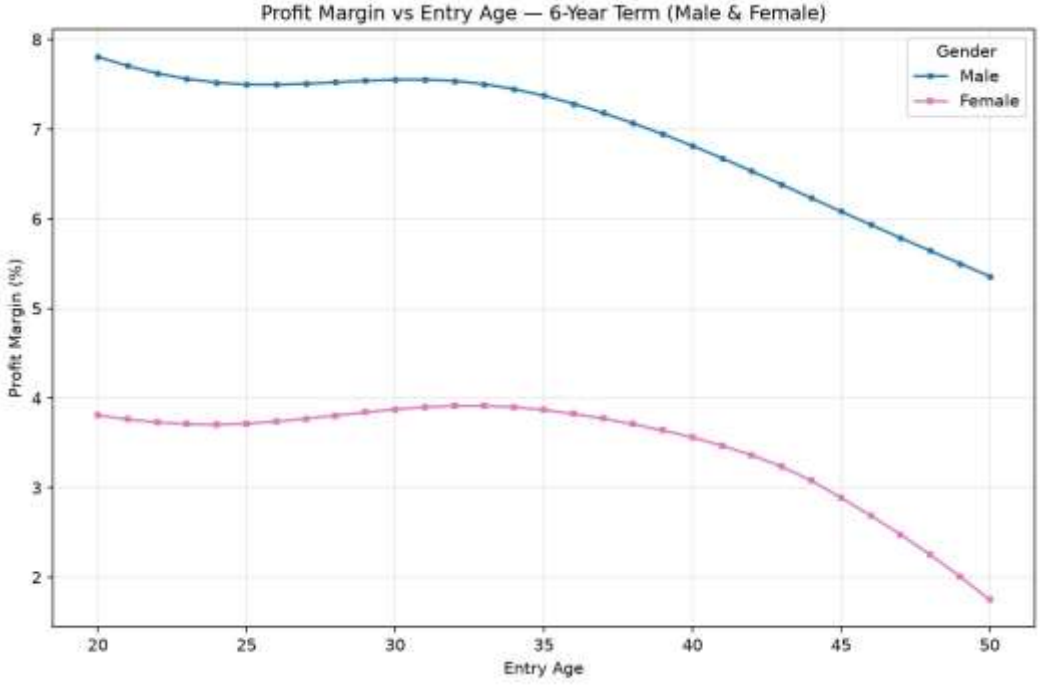


Figure A3: Variation in profit margins for a 7-year term

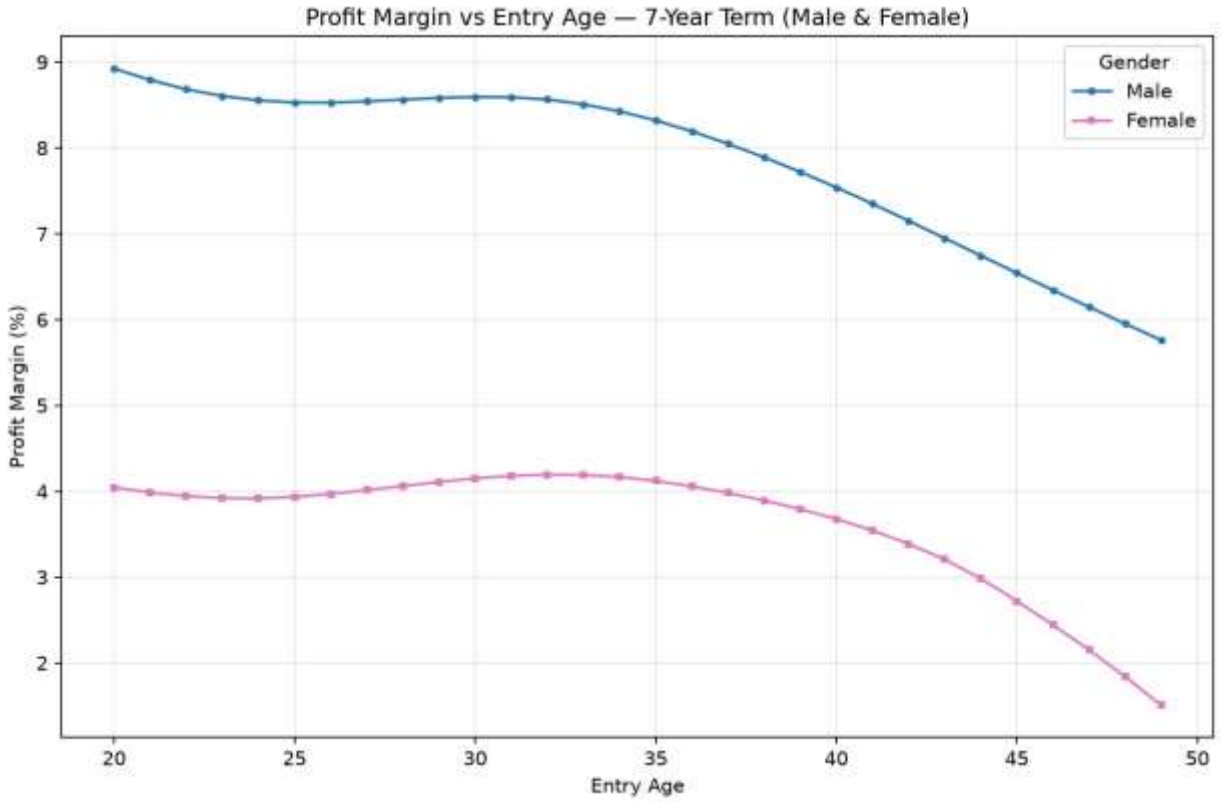


Figure A4: Variation in premiums for a 5-year term

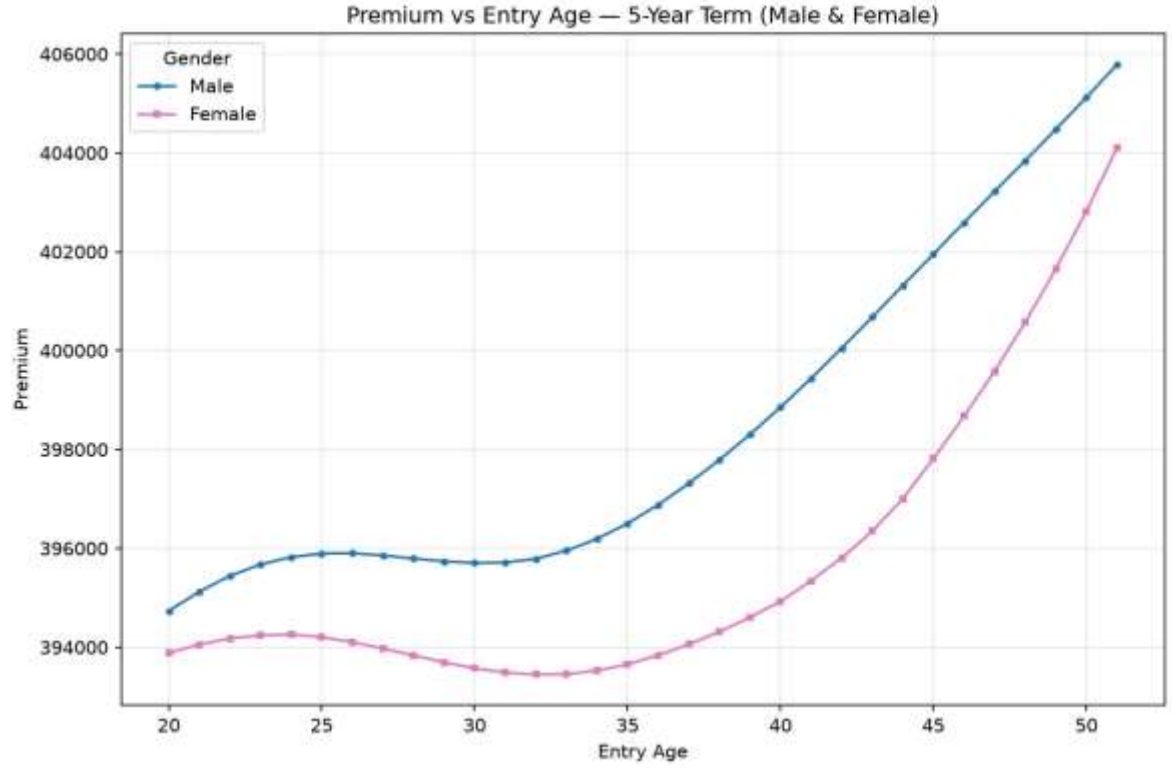


Figure A5: Variation in premiums for a 6-year term

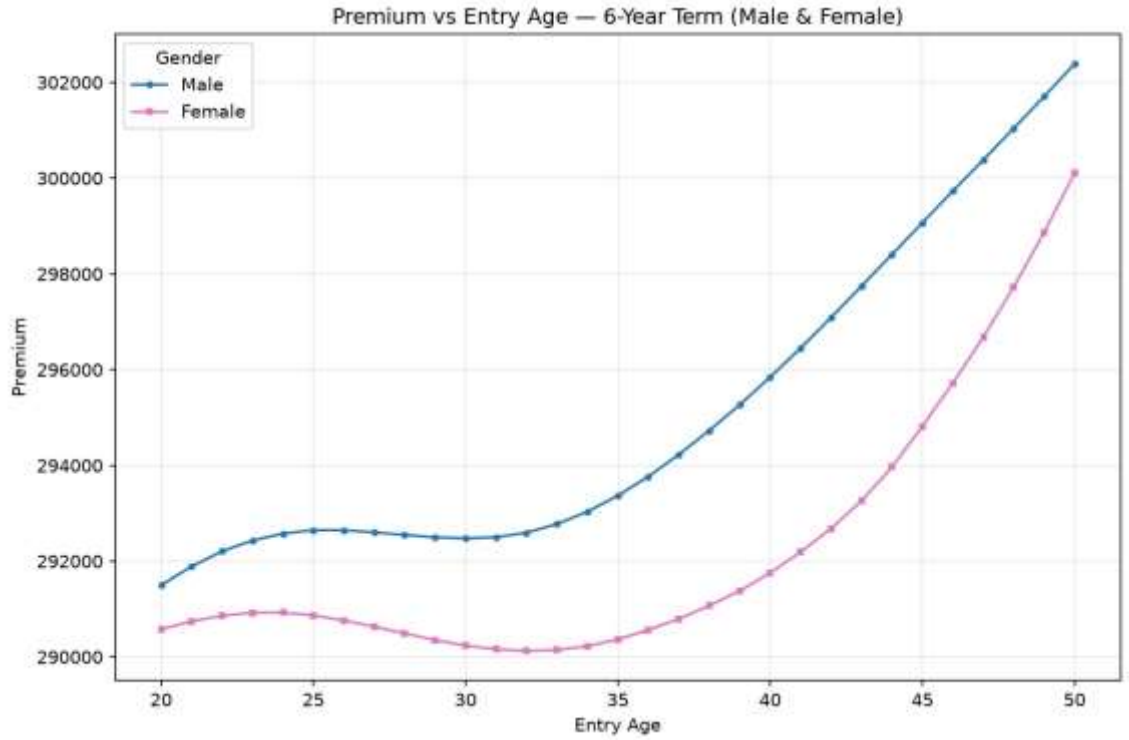
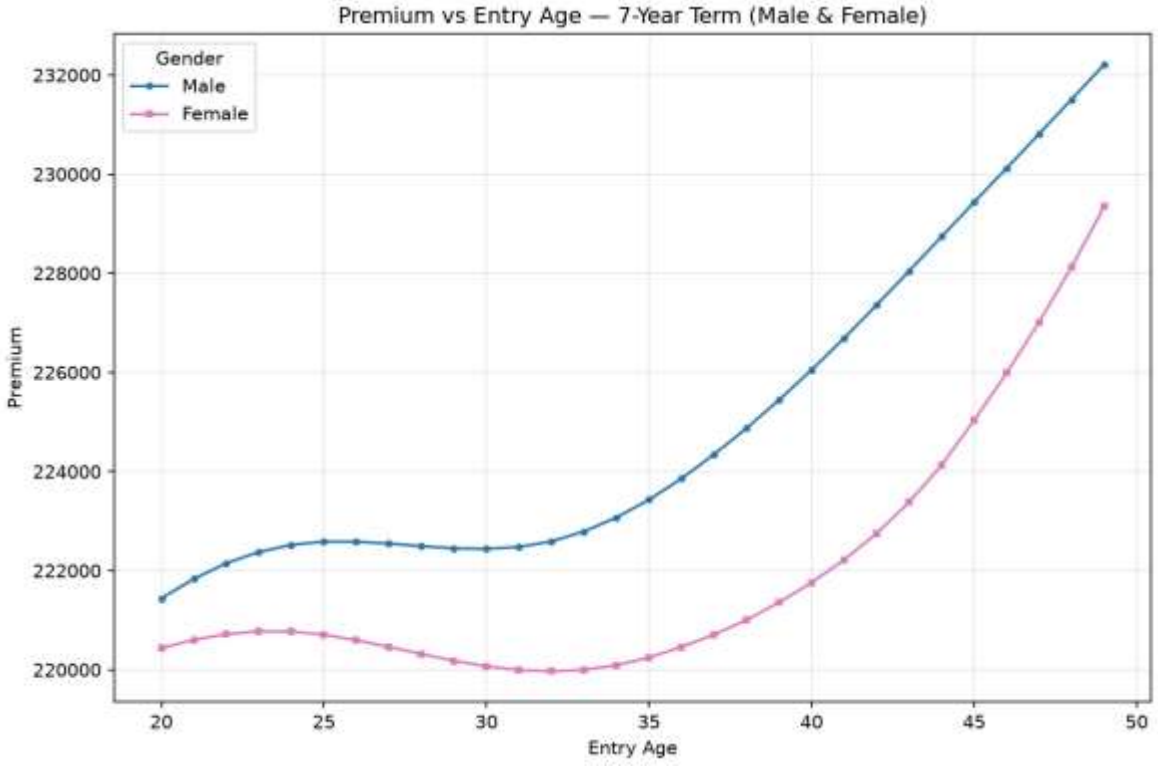


Figure A6: Variation in premiums for a 6-year term



APPENDIX B: Python Program output

```
======================================================================
  UNIT-LINKED TERM ENDOWMENT — PRICING & PROFIT TEST 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: [5, 6, 7]
Enter term (5/6/7): 5
Valid ages for 5-year term: 20-51
Enter entry age (20-51): 25
Gender (M/F): M
```

```
================================================================================================================
  UNIT-LINKED TERM ENDOWMENT — MALE, ENTRY AGE 25, 5-YEAR TERM
================================================================================================================
  Sum Assured: 3,000,000.00    Pricing Interest Rate: 15.0%    Discount Factor (v): 0.8695652174

--- LIFE DECREMENT TABLE (Male) ---
Yr  Age  qd          qdi         qw      (aq)d         (aq)di        (aq)w       ap            t-1(ap)x
----------------------------------------------------------------------------------------------------------------
1   25   0.0023520   0.0007080   0.00    0.002351167   0.000707722   0.00000000  0.996941110   1.000000000
2   26   0.0023880   0.0007080   0.10    0.002267811   0.000695918   0.09994840  0.897087871   0.996941110
3   27   0.0023880   0.0007080   0.10    0.002267811   0.000695918   0.09994840  0.897087871   0.894343778
4   28   0.0023640   0.0007080   0.10    0.002245019   0.000695921   0.09994880  0.897110260   0.802304955
5   29   0.0023160   0.0007200   0.00    0.002315166   0.000719722   0.00000000  0.996965112   0.719756007

--- UNIT FUND (Male) ---    Premium = 395,895.68
Yr  Alloc.Prem     B/O Spread     Cost of Alloc   Fund@Alloc      Fund@Growth     Mgmt Charge   Bid Value
----------------------------------------------------------------------------------------------------------------
1   376,100.90     -18,805.04     357,295.85      357,295.85      410,890.23      -4,108.90     406,781.33
2   376,100.90     -18,805.04     357,295.85      764,077.18      878,688.76      -8,786.89     869,901.87
3   376,100.90     -18,805.04     357,295.85      1,227,197.72    1,411,277.38    -14,112.77    1,397,164.61
4   376,100.90     -18,805.04     357,295.85      1,754,460.46    2,017,629.53    -20,176.30    1,997,453.23
5   376,100.90     -18,805.04     357,295.85      2,354,749.09    2,707,961.45    -27,079.61    2,680,881.83
```

```
--- EPV DEATH BENEFIT ---
k   Amount          Probability     Disc        EPV
-----------------------------------------------------------------
1   3,030,000.00    0.0023511674    0.86956522  6,194.81
2   3,030,000.00    0.0022608740    0.75614367  5,179.92
3   3,030,000.00    0.0020282027    0.65751623  4,040.74
4   3,030,000.00    0.0018011898    0.57175325  3,120.40
5   3,030,000.00    0.0016663548    0.49717674  2,510.27
  Total EPV Death: 21,046.15

--- EPV SURVIVAL BENEFIT ---
  Amount=3,000,000.00  Probability=0.7197560071  Disc=0.49717674  EPV=1,073,537.83

--- EPV DISABILITY BENEFIT ---
k   Amount          Probability     Disc        EPV
-----------------------------------------------------------------
1   3,000,000.00    0.0007077225    0.86956522  1,846.23
2   3,000,000.00    0.0006937895    0.75614367  1,573.81
3   3,000,000.00    0.0006223901    0.65751623  1,227.69
4   3,000,000.00    0.0005583409    0.57175325  957.70
5   3,000,000.00    0.0005180243    0.49717674  772.65
  Total EPV Disability: 6,378.09
```

```
--- EPV COMMISSION ---
k   Amount          Disc        Probability     EPV
-------------------------------------------------------------------
0   79,179.14       1.00000000  1.0000000000    79,179.14
1   7,917.91        0.86956522  0.9969411101    6,864.08
2   7,917.91        0.75614367  0.8943437778    5,354.51
3   7,917.91        0.65751623  0.8023049554    4,176.93
4   7,917.91        0.57175325  0.7197560071    3,258.40
  Total EPV Commission: 98,833.05

--- EPV PREMIUM ---
k   Amount          Disc        Probability     EPV
-------------------------------------------------------------------
0   395,895.68      1.00000000  1.0000000000    395,895.68
1   395,895.68      0.86956522  0.9969411101    343,204.07
2   395,895.68      0.75614367  0.8943437778    267,725.40
3   395,895.68      0.65751623  0.8023049554    208,846.27
4   395,895.68      0.57175325  0.7197560071    162,920.11
  Total EPV Premium: 1,378,591.53

--- EQUIVALENCE PRINCIPLE CHECK ---
  Total Income (EPV Premium)                = 1,378,591.53
  Total Outgo (Benefits+Expenses+Commission) = 1,378,591.53
  Difference (~0, solved via Goal Seek)      = 0.000000
  >>> PREMIUM = 395,895.68 <<<
```

--- EPV SURRENDER BENEFIT ---

k	Amount	Probability	Disc	EPV
1	237,537.41	0.0000000000	0.86956522	0.00
2	475,074.82	0.0996426689	0.75614367	35,794.12
3	712,612.23	0.0893882296	0.65751623	41,883.22
4	950,149.64	0.0801894175	0.57175325	43,562.99
5	1,187,687.04	0.0000000000	0.49717674	0.00

Total EPV Surrender: 121,240.33

--- EPV EXPENSES ---

k	Amount	Disc	Probability	EPV
0	39,589.57	1.00000000	1.0000000000	39,589.57
1	7,000.00	0.86956522	0.9969411101	6,068.34
2	7,196.00	0.75614367	0.8943437778	4,866.31
3	7,397.49	0.65751623	0.8023049554	3,902.39
4	7,604.62	0.57175325	0.7197560071	3,129.47

Total EPV Expenses: 57,556.08

--- DISCOUNTED PREMIUM ---

Yr	Premium	t-1(ap)x	Disc	Disc.Premium
1	395,895.68	1.00000000	1.00000000	395,895.68
2	395,895.68	0.99694111	0.83333333	328,903.90
3	395,895.68	0.89434378	0.69444444	245,879.75
4	395,895.68	0.80230496	0.57870370	183,813.12
5	395,895.68	0.71975601	0.48225309	137,417.19

Total Discounted Premium = 1,291,909.64

>>> PREMIUM = 395,895.68 <<<
>>> PROFIT MARGIN = 5.845425% <<<

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

Yr	Unalloc.Prem	B/O Income	Expenses	Commission	Interest	XDeath	XDisab	MgmtInc	SurrInc	Profit
1	19,794.78	18,805.04	39,589.57	79,179.14	-12,025.33	6,097.09	1,835.28	4,108.90	0.00	-96,017.67
2	19,794.78	18,805.04	7,000.00	7,917.91	3,552.29	4,830.66	1,482.37	8,786.89	34,778.12	64,486.18
3	19,794.78	18,805.04	7,196.00	7,917.91	3,522.89	3,634.93	1,115.44	14,112.77	55,857.75	92,228.95
4	19,794.78	18,805.04	7,397.49	7,917.91	3,492.66	2,250.74	697.69	20,176.30	79,857.22	123,862.18
5	19,794.78	18,805.04	7,604.62	7,917.91	3,461.59	738.81	229.68	27,079.61	0.00	52,650.02

--- PROFIT SIGNATURE & DISCOUNTED PROFIT (RDR=20%) ---

Yr	Profit	t-1(ap)x	Profit Sig.	Disc	Disc.Profit
1	-96,017.67	1.00000000	-96,017.67	0.83333333	-80,014.73
2	64,486.18	0.99694111	64,288.92	0.69444444	44,645.08
3	92,228.95	0.89434378	82,484.39	0.57870370	47,734.02
4	123,862.18	0.80230496	99,375.24	0.48225309	47,924.02
5	52,650.02	0.71975601	37,895.17	0.40187757	15,229.22

Total Discounted Profit = 75,517.61