MAKERERE UNIVERSITY

COLLEGE OF BUSINESS AND MANAGEMENT SCIENCES

SCHOOL OF STATISTICS AND PLANNING

A PRICING AND PROFIT TESTING MODEL FOR A UNIT-LINKED ENDOWMENT MICROINSURANCE PLAN FOR FACTORY & INDUSTRIAL WORKERS

BY

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DECLARATION

I, Kabba Misulamu Joshua, declare that the work presented in this dissertation is my original and independent intellectual effort, carried out under the guidance of my supervisor where applicable, and has not been submitted to any college, university, or institution for the award of any academic qualification. All information, data, ideas, and references derived from other sources have been properly acknowledged and cited in accordance with the required academic standards and ethical guidelines.

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APPROVAL

This dissertation product & report has been submitted with my approval as the student's university supervisor

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DEDICATION

I dedicate this dissertation to my parents, Mr. Peter Simon Kabba and Mrs. Rebecca Mudondo Kabba, for raising and providing for my brothers and me, and above all, for instilling in us a dependence on God and the value of hard work.

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Above all, I give thanks to the Almighty God. None of this would have been possible without His grace, and whatever strength carried me through the difficult moments of this journey came from Him. For that, all glory belongs to Him.

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LIST ACRONYMS

AKI Association of Kenya Insurers

BOU Bank of Uganda

NSSF (U) National Social Security Fund Uganda

ILO International Labour Organisation

IRA (U) Insurance Regulatory Authority of Uganda

NPV Net Present Value

UBOS Uganda Bureau of Statistics

MTN Momo Mobile Telephone Network mobile money

URTU Uganda Road Transport Workers' Union

pp percentage points

ABSTRACT

This study develops, prices, and profit-tests a unit-linked endowment micro insurance product for factory and industrial workers in Uganda. A formal-sector workforce whose exposure to machinery, hazardous materials, and shift-based labour leaves it carrying meaningful occupational risk. The plan combines a death, disability and survival benefit with an investment-linked endowment component, priced using the principle of equivalence and assessed for insurer profitability through unit-fund and non-unit-fund profit testing. Assumptions were calibrated to Uganda's regulatory and macroeconomic environment, including Kenyan mortality and disability tables adjusted upward for occupational risk, a 2026 Government of Uganda Treasury bond-linked discount rate, and Uganda Bureau of Statistics inflation data. Models were built first in Microsoft Excel for a 27-year-old male and female policyholder on a 5-year term, then generalized in Python 3.12.4 across ages 20 to 51 and terms of 5, 6, and 7 years, with a sum assured of UGX 2,000,000. For the baseline profile, the model produced an annual premium of UGX 278,558.90 and a 7.94% profit margin for the male life, and UGX 277,828.51 and 8.09% for the female life. Across the full range of ages and terms, annual premiums ran from roughly UGX 147,300 to UGX 285,000, and profit margins from about 7% to 19%, rising with policy term and falling with entry age, with female policyholders consistently posting marginally higher margins than males. Sensitivity testing identified renewal commission, the risk discount rate, and initial expenses as the strongest drivers of profitability, with the product remaining profitable under every scenario tested. The study concludes that an actuarially sound, affordable micro insurance product for this segment is achievable, and recommends mobile-money premium collection, employer-facilitated payroll deduction, and closer collaboration with the Insurance Regulatory Authority of Uganda to support its rollout.

CHAPTER ONE: INTRODUCTION

This chapter sets out the background to the study, the problem it addresses, and the objectives that guide it. It situates the study within the broader insurance and micro insurance landscape in Africa and Uganda, before narrowing in on factory and industrial workers, an occupational group that is central to Uganda's manufacturing and industrialization drive yet remains largely outside the reach of affordable, tailored insurance products. The chapter further outlines the problem motivating the research, namely the absence of a unit-linked endowment micro insurance product priced and tested specifically for this group that is affordable, and closes by stating the study's objectives and its significance to policymakers, insurers, and factory and industrial workers themselves.

1.1 Background to the Study

At its core, insurance is a contract. A policyholder pays a premium, and in exchange, the insurer promises to pay out a defined benefit, or provide indemnification, if something insured happens: death, disability, illness, damage to property. What makes this work is pooling. Insurers collect premiums from a large number of people, which spreads the cost of any one person's loss widely enough that cover stays affordable. But for a claim to actually hold up, it has to satisfy a set of long-established principles: insurable interest, utmost good faith, indemnity, contribution, subrogation, proximate cause. These exist for a reason, to keep the contract fair and enforceable on both sides. In Uganda, the Insurance Act, Cap. 191, splits the industry into two: life business, which covers policies paying out on death or maturity, and general business, covering accident, property, and liability risks.

Across Africa, insurance markets have historically trailed behind other regions, and that gap is especially wide for low-income earners working outside formal employment. Things are shifting, though, as economies grow, mobile technology spreads, and distribution gets easier. The continent's insurance market was worth around USD 98.5 billion in 2025, and it's projected to reach about USD 166.1 billion by 2034, growing at close to 5.79% a year (IMARC Group 2026).

Uganda's own insurance penetration, gross premiums measured against GDP, is still among the lowest in East Africa, even as the sector keeps expanding in absolute terms. Gross written premiums across the industry rose from UGX 1.76 trillion in 2024 to roughly UGX 2 trillion in 2025, and the first quarter of 2026 alone brought in UGX 603.86 billion, a 5.75% jump over the

same period the year before (Insurance Regulatory Authority of Uganda 2026). Penetration, though, stayed under 1% of GDP through 2025; it stood at 0.883% in 2024, the most recent year with a published figure. Deepening this is now written into the IRA's five-year strategic plan for 2025/26 to 2029/30 (Insurance Regulatory Authority of Uganda 2026).

Micro insurance is one of the more promising answers to this gap. Internationally, insurance supervisors define it as insurance accessed by low-income populations, offered by a range of providers, but still run according to accepted insurance practice (International Association of Insurance Supervisors 2007). Uganda's regulator has pushed this along, issuing a 2023 circular that eased compliance requirements for micro insurance providers and encouraged mobile-based distribution along with flexible premium collection (Insurance Regulatory Authority of Uganda 2023). And the growth shows it: micro insurance premiums jumped 131.42% in 2024, from UGX 700 million in 2023 to UGX 1.64 billion, the fastest-growing line in the entire industry (Insurance Regulatory Authority of Uganda 2026). The National Social Security Fund's 2024 launch of Smart Life Flexi, a voluntary, goal-based savings product open to both formal and informal workers, points in a similar direction. By early 2026, it had drawn more than 68,000 voluntary savers and roughly UGX 114 billion in savings, disproportionately from lower-income savers (National Social Security Fund 2026).

Factory and industrial workers sit in a particular kind of gap here. Manufacturing is a recognized pillar of Uganda's industrialization plans and a major formal-sector employer, but the work carries real hazards: heavy machinery, hazardous materials, repetitive strain, and long shifts. A systematic review of small-scale industrial workers across sub-Saharan Africa found a pooled occupational injury prevalence of 53.23%, ranging from 31.2% to 86.5% depending on the country (Atalay, Gebeyehu et al. 2024). Uganda's own numbers sit toward the top of that range. A study of welders in small-scale metal workshops in Wakiso District recorded an injury prevalence of 87.8%, among the highest reported anywhere in the region (Itiakorit Zziwa & Osuret 2021).

Uganda's Workers' Compensation Act already requires employers to insure against liability for injuries their employees suffer on the job (Parliament of Uganda 2000). That's a real protection, but it's built around employer liability, not the worker's own financial planning. It doesn't give a factory or industrial worker any personal savings component, any maturity benefit, or anything they can carry with them if they change employers. NSSF contributions play a similar role for

retirement, and they're mandatory, but they were never designed to combine life cover with the kind of flexible, near-term savings a younger worker, supporting a family on a modest wage, might actually want.

This study responds to that gap. It develops, prices, and profit tests a unit-linked endowment micro insurance plan built specifically for factory and industrial workers, one that combines a death and disability benefit with an investment-linked savings component, priced with assumptions that reflect this group's occupational risk profile, and tested for whether it would actually be profitable and sustainable from an insurer's side.

1.2 Problem Statement

Uganda's formal economy runs, in large, on the backs of its factory and industrial workers. Yet the work itself is dangerous, and the financial protection available to these workers rarely matches the risk. Injuries from machinery, constant exposure to dust, fumes, and chemicals, the physical wear of shift work and repetitive tasks, all of it adds up to a higher chance of disability, long illness, or death well before retirement age. Among small-scale industrial workers in Uganda, one study put injury prevalence as high as 76.6% (Itiakorit, Zziwa & Osuret, 2021). Roughly 2,000 work-related accidents get reported across the country each year, most of them concentrated in factories, construction, transport, security, and commercial agriculture (Lawyer Issue, 2016). The Ministry of Gender, Labour and Social Development has gone as far as estimating that these accidents and related diseases cost Uganda about 4% of GDP annually (Insurance Regulatory Authority of Uganda, 2023).

Legally, employers are required to carry Workers' Compensation insurance. In practice, though, a lot of them don't. Where labour is casual, outsourced, or subcontracted, compliance tends to break down, and injured workers are left to cover their own medical bills and lost wages (Lawyer Issue, 2016). Even employers who do comply are only protecting themselves against liability, not building any savings for the worker, and that protection disappears the day the worker leaves the job. NSSF is mandatory too, and useful for retirement, but it was never built to pay out for disability on the kind of timeline a young worker actually needs, and it doesn't have the flexible, goal-based design that products like Smart Life Flexi have shown people want (National Social Security Fund, 2026).

A review of existing Ugandan micro insurance offerings did not identify any product combining a death and disability benefit with an investment-linked endowment component priced specifically for factory and industrial workers. That leaves the workforce with two bad options: informal safety nets that aren't really adequate, or insurance products priced for a different kind of risk altogether. Insurers, meanwhile, don't have the actuarial groundwork to confidently price cover for this group even if they wanted to. This study tries to close that gap, by building, pricing, and profit-testing a unit-linked endowment micro insurance plan designed specifically for factory and industrial workers.

1.3 Objectives of the Study

1.3.1 Main objective of the study

To develop a pricing and profit testing model for a unit-linked endowment micro insurance plan designed for factory and industrial workers, providing financial protection in the event of death, permanent disability, policy surrender, or survival to the end of the policy term, while assessing the product's profitability and sustainability from the insurer's perspective.

1.3.2 Specific objectives

- To design and develop a low-cost, unit-linked endowment micro insurance policy structured around the irregular income flows and demanding working conditions of long-distance truck drivers, ensuring the product remains affordable and accessible to them.
- To evaluate the profitability and long-term sustainability of the proposed product from an insurer's standpoint, building a case attractive enough to encourage providers to extend coverage to this currently underserved segment.

1.4 Significance of the Study

By demonstrating that a unit-linked endowment micro insurance product can be priced affordably for factory and industrial workers while remaining profitable for insurers, this study supports the wider push by the IRA and the insurance industry to deepen micro insurance penetration and financial inclusion in Uganda, an effort placed at the Centre of the regulator's five-year strategic

plan for 2025/26 to 2029/30, themed “Insurance for All: Building Resilience, Inclusion and Growth” (Insurance Regulatory Authority of Uganda, 2026).

For factory and industrial workers and their households, the product modelled in this study offers a practical source of resilience: a death or disability payout to cushion the financial shock of losing an income earner, and a savings component that builds value over the policy term and can support future goals such as education or business capital, in much the same way Uganda’s NSSF Smart life Flexi has shown demand for among lower-income savers (National Social Security Fund, 2026).

More broadly, extending affordable insurance to the manufacturing and industrial workforce reinforces the resilience of a sector that Uganda has identified as a pillar of its industrialization drive; protecting the people who keep factories running is, in that sense, also a way of protecting the sector itself, an alignment the IRA’s current strategic plan explicitly draws between the insurance industry and the country’s wider development priorities (Insurance Regulatory Authority of Uganda, 2026).

CHAPTER TWO: BASIS AND ASSUMPTIONS OF THE MODEL

2.0 Introduction

This chapter outlines the key assumptions used and their basis used in developing the unit-linked endowment micro insurance model. These assumptions which include factors such as income patterns, risk exposure, life expectancy and claim probabilities, form the foundation for pricing, benefit design and sustainability of the product. The exact figures, data sources, and their references are presented to support the model`s design and ensure its relevance to the Manufacturing and Industrial workers.

Table 2.1: Assumptions and basis of the model

Assumption	Amounts & Percentages
Sum assured	UGX 2,000,000
Initial commission	25% of first premium
Renewal commission	7.5% of subsequent premiums
Initial Expenses	15% of first premium
Renewal Expenses	5% of subsequent premiums
Mortality	120% of Kenyan Mortality (KE 2007-2010 mortality tables for assured lives)
Disability Rates	150% of Kenyan Disability rates
Surrender rate(all years except the first and last year)	15%
Inflation rate	3.1%
Allocation in first year	95%
Allocation in other years	85%
Bid-offer spread	5%
Unit fund interest rate	14.9%
Non-unit fund interest rate	14.9%
Management charge	1.5%
Risk discount rate	15.9%

Death benefit	Sum assured or unit fund value at year end whichever is higher
Disability Benefit	110% of unit fund value at year end
Surrender Benefit	60% of unit fund value at year end
Survival/Maturity Benefit	Sum assured or 100% of fund value at the end of the final policy whichever is higher

2.2 Explanation of Assumptions and Basis of the model.

This section outlines the key assumptions underpinning the design of a unit-linked endowment micro insurance model for Manufacturing & Industrial workers in Uganda. These assumptions serve as the actuarial and operational basis for premium pricing, benefit structure, and the long term sustainability of the product.

- **Term:** Factory & Industrial workers in Uganda work for an average of 5 years in a Factory before switching jobs/careers. That is why a 5 year term is used for the product.
- **Sum Assured (UGX 2,000,000):** This is the guaranteed amount paid in case of (death or survival) if the bid value of the unit's doesn`t exceed it. It is set to provide meaningful protection for Manufacturing & Industrial workers families while keeping premiums affordable.
- **Initial Commission (25% of premium):** This accounts for the commission paid to agents at policy inception. The percentage is consistent with industry practice for micro insurance distribution.
- **Renewal Commission (7.5% of premium**): This reflects ongoing agent commissions for maintaining the policy after the first year, in line with common insurance practice.
- **Initial Expenses (15% of premium):** This accounts for the expenses paid in the first year in order to facilitate the policy. The percentage is consistent with industry practice for micro insurance products.

- **Renewal Expenses (5% of premium**): This accounts for the expenses paid in the subsequent years in order to facilitate the policy. The percentage is consistent with industry practice for micro insurance products.

- **Mortality Rates (120% of Kenyan mortality tables):** Mortality assumptions are based on Kenyan life tables but increased by 20% to reflect the higher risk profile of Manufacturing & Industrial workers, who face occupational hazards.

- **Disability Rates (150% of Kenyan disability tables):** Similarly, disability rates are inflated by 50% to account for greater exposure to accidents and work-related injuries among workers.

- **Surrender Rates (15%)**: These assumptions are based on the industry standard for Manufacturing & Industrial workers.

- **Inflation Rate (3.1%):** As of the first quarter of 2026. Based on UBOS data

- **Allocation Rates**: 95% in the first year and 85% in subsequent years. This means most of the premium is invested, while a portion is reserved for expenses and reserves.

- **Bid-Offer Spread (5%):** Reflects the difference between unit buying and selling prices, covering transaction costs.

- **Unit Fund Interest Rate (14.9%):** Based on the yield of the Government of Uganda's 5-year Treasury bond issued in March 2026. This represents expected long-term investment returns.

- **Non-Unit Fund Interest Rate (14.9%):** Applied to reserves and cash balances, consistent with the government bond yield (Based on the yield of Government of Uganda).

- **Management Charge (1.5%):** Deducted annually to cover fund management costs, consistent with typical fund manager fees in Uganda.

- **Risk Discount Rate (15.9%):** Calculated as the gross government bond yield plus 1%, used to discount future cash flows for profitability testing.

- **Death Benefit:** Pays either the sum assured (UGX 2,000,000) or the unit fund value, whichever is higher.
- **Maturity Benefit:** At the end of the term, the policyholder receives 100% of the accumulated unit fund value or the sum assured whichever is higher.
- **Surrender Benefit:** If the policy is surrendered early, the policyholder receives 60% of the fund value at the end of the final policy.
- **Disability Benefit:** In case of permanent disability, the policyholder receives 110% of unit fund value at year end.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter describes the tools, models, and techniques used to develop a unit-linked endowment micro insurance product tailored specifically for factory and industrial workers. It covers the software used, the mathematical formulae applied, and the overall approach taken in pricing and profit testing the product. The aim of the methodology was to design a product that is both financially accessible to factory and industrial workers and economically viable for insurers, while incorporating realistic assumptions that reflect the distinct risk profile of this occupational group.

3.1 Software Used

The pricing and profit testing model was developed using Microsoft Excel 2013 as an initial prototype, built for a single life of a male and female manufacturing and industrial worker aged 27, with a policy term of 5 years. Excel provided a clear and flexible environment for calculating and adjusting key variables such as mortality rates, disability rates, and investment returns.

Once the Excel model had been validated, the same logic was translated into Python 3.12.4 to automate calculations and improve scalability. The Python program performs pricing and profit testing across a range of inputs, including age, policy term, and sum assured, making it possible to apply the model to a broad spectrum of worker profiles. The use of Python significantly enhanced both efficiency and accuracy, particularly when running multiple scenarios for the sensitivity analysis.

3.2 Description of symbols

q_x^d : Independent probability of death at age x

q_x^{di} : Independent probability of disability at age x

q_x^w : Independent probability of withdrawal/surrender at age x

$(aq)_x^d$: Dependent probability of death at age x

$(aq)_x^{di}$: Dependent probability of disability at age x

$(aq)^{w}_{x}$: Dependent probability of withdrawal/surrender at age x

$(ap)_{x}$: Dependent probability of surviving the year at age x

t-1$(ap)_{x}$: Cumulative probability of being in force at the start of each year

k|q^{d}_{x} : Dependent deferred probability of death between age (x + k) and (x + k + 1)

k|q^{dI}_{x} : Dependent deferred probability of disability between age (x + k) and (x + k + 1)

k|q^{w}_{x} : Dependent deferred probability of withdrawal between age (x + k) and (x + k + 1)

3.3 Formulae Used

The table below presents the key formulae applied in the pricing and profit testing model. These equations define how premiums are calculated, how benefits are determined, and how profits are projected over the policy term.

Table 3:1: Multiple decrements

Output	Formula
$(aq)^{d}_{x}$	$q^{d}_{x}[1-\frac{1}{2}(q^{w}_{x}+q^{di}_{x})+\frac{1}{3}(q^{w}_{x}\cdot q^{di}_{x})]$
$(aq)^{di}_{x}$	$q^{di}_{x}[1-\frac{1}{2}(q^{w}_{x}+q^{d}_{x})+\frac{1}{3}(q^{w}_{x}\cdot q^{d}_{x})]$
$(aq)^{w}_{x}$	$q^{w}_{x}[1-\frac{1}{2}(q^{d}_{x}+q^{di}_{x})+\frac{1}{3}(q^{d}_{x}\cdot q^{di}_{x})]$
$(ap)_{x}$	$1-[(aq)^{d}_{x}+(aq)^{di}_{x}+(aq)^{w}_{x}]$
t-1$(ap)_{x}$	$(ap)_{x} \times$ t-1$(ap)_{x}$ *1 in first year*
$k\|q^{d}_{x}$	$(aq)^{d}_{x} \times$ t-1$(ap)_{x}$
$k\|q^{dI}_{x}$	$(aq)^{di}_{x} \times$ t-1$(ap)_{x}$
$k\|q^{w}_{x}$	$(aq)^{w}_{x} \times$ t-1$(ap)_{x}$

Table 3.2: Pricing Formulae

Output	Formula
Discount factor	(1/ (1+ risk discount rate)) ^ year
Death benefit	Sum Assured
EPV Death Benefit	Death Benefit × $k\|q^{d}_{x}$× Discount factor
Survival Benefit	Fund value in final policy year
EPV Survival	Survival Benefit × $t\text{-}1(ap)_{x}$ × Discount Factor
Disability Benefit	110% × Fund at year end
EPV Disability Benefit	Disability Benefit ×$k\|q^{dI}_{x}$× Discount Factor
Surrender Benefit	60% × Fund at year end
EPV Surrender Benefit	Surrender Benefit × $k\|q^{w}_{x}$ × Discount Factor
EPV Benefits	EPV Death Benefit + EPV Survival Benefit + EPV Disability Benefit + EPV Surrender Benefit
Expenses (Initial)	15% × Premium
Expenses (Renewal)	5% × Premium × ((1+ inflation rate) ^ (year − 1))
EPV Expenses	Initial Expense × $t\text{-}1(ap)_{x}$ × Discount Factor Renewal Expense × $t\text{-}1(ap)_{x}$ × Discount Factor
Commission (Initial)	25% × Premium
Commission (Renewal)	7.5% × Premium
EPV Commission	Commission × $t\text{-}1(ap)_{x}$ × Discount Factor
EPV Total Expenses	EPV Expenses + EPV Commission
Premium	Assumed Premium (Before Goal Seek)
EPV Premium	Premium × $t\text{-}1(ap)_{x}$ × Discount factor
Equation of Value	EPV Premium − EPV Benefits − EPV Total Expenses

Table 3.3: Profit Testing Formulae

Output	Formula
Premium Allocated	95% × Premium in the first year for the first-year allocation 85% × subsequent premiums in other years
Bid/Offer spread	5% × Allocated Premium
Cost of Allocation	Premium Allocated − Bid/Offer spread
Fund after allocation	Fund at the end of year for previous year + Cost of allocation
Fund before management charge	Fund after allocation × (1 + Unit Fund interest rate)
Management Charge	1.5% × 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	15% × Premium
Renewal Expenses	5% × Premium × ((1 + inflation rate) ^ (year − 1))
Initial Commission	25% × Premium
Renewal Commission	7.5% × Premium
Interest gained in Non-unit Fund	Non unit interest rate × (Premium less Cost of Allocation − Expenses − Commission)
Extra Death cost	max $\left[(aq)_x^d \times (\text{Sum Assured - Fund at year end}), 0\right]$
Extra Disability Cost	max $\left[(aq)_x^{di} \times (\text{Disability Benefit - Fund at year end}), 0\right]$
Expected Surrender Penalty	40% × Fund value at year end × $(aq)_x^w$
Profit vector	(Premium less cost of Allocation + Interest + Management charge + Expected Surrender Penalty) − (Expenses + Commission + Extra Death Cost + Extra Disability Cost)
Discount Factor (profits)	(1/ (1+ risk discount rate)) ^ year
Discount Factor (premiums)	(1/ (1+ risk discount rate)) ^ (year−1)
Profit Signature	Profit vector × t-1$(ap)_x$

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	$\frac{\text{NPV of profits}}{\text{NPV of premiums}}$

CHAPTER FOUR: PRESENTATION AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter presents the findings obtained from the pricing and profit testing model for a unit-linked endowment micro insurance product specifically designed for factory & industrial workers. The results include the estimated premiums, benefit levels, and an assessment of the product's financial viability from the insurer's perspective.

In addition, a sensitivity analysis is conducted to evaluate how changes in key variables such as interest rates, expense levels, and risk assumptions affect the overall profitability and sustainability of the product. This analysis provides insight into how the product may perform under varying economic and operational conditions.

4.1 Output from the model

The results presented in this chapter are based on a model developed for a factory and industrial worker aged 27 (male & female), with a policy term of 5 years and a sum assured of UGX 2,000,000. This profile and benefit level were selected to reflect the typical demographic characteristics and financial needs of factory and industrial workers in Uganda.

The model generated key outputs, including annual premium estimates, projected investment growth, and expected benefit payouts in the event of death, disability, or policy maturity. These outputs were used to evaluate both the affordability of the product for the policyholder and its profitability for the insurer.

The pricing structure was designed to ensure that premiums remain affordable and manageable. At the same time, the profit testing results indicate that the product can be financially sustainable for insurers, especially when distributed on a larger scale.

Overall, these findings provide a strong basis for the introduction of a unit-linked endowment micro insurance product tailored to the specific risks and lifestyle of long-distance truck drivers, while also promoting increased access to formal insurance services.

4.2 Multiple Decrements

This section presents the multiple decrement tables developed for factory and industrial workers, illustrating the probabilities of various risks occurring over the policy term. These tables provide a structured view of the different ways in which a policy may terminate before maturity.

The analysis incorporates both independent probabilities representing the likelihood of a specific event occurring in isolation and dependent probabilities, which account for the presence of competing risks such as death, disability, or policy withdrawal. This approach ensures a more realistic representation of the risk environment faced by policyholders.

The probabilities were derived based on the occupational risk profile of factory and industrial workers, who may be exposed to workplace accidents, health-related challenges, and income uncertainties. As a result, the model captures the likelihood of claim events such as death or disability, as well as the possibility of policy surrender before maturity.

By incorporating multiple decrement analysis, the model ensures that the unit-linked endowment micro insurance product accurately reflects the real-life risks faced by factory and industrial workers. This enhances the reliability of premium pricing and supports effective risk management for insurers.

Table 4.11: Multiple decrements for the male life

MULTIPLE LIFE DECREMENT TABLE (MALES)											
Age (x)	q^{d}_{x}	q^{dI}_{x}	q^{w}_{x}	$(aq)^{d}_{x}$	$(aq)^{dI}_{x}$	$(aq)^{w}_{x}$	$(ap)_{x}$	$_{t-1}(ap)_{x}$	$k\|q^{d}_{x}$	$k\|q^{dI}_{x}$	$k\|q^{w}_{x}$
27	0.002388	0.000885	0.00	0.002386943	0.000883943	0	0.996729113	1.000000000	0.002386943	0.000883943	0
28	0.002364	0.000885	0.15	0.002185759	0.000817684	0.14975643	0.847240128	0.996729113	0.002178609	0.000815009	0.149266593
29	0.002316	0.0009	0.15	0.002141362	0.000831562	0.14975890	0.847268172	0.844468902	0.001808314	0.000702228	0.126466737
30	0.002268	0.000915	0.15	0.002096966	0.000845441	0.14976137	0.847296214	0.715491623	0.001500362	0.000604906	0.107153012
31	0.002208	0.000945	0.00	0.002206957	0.000943957	0	0.996849087	0.606233343	0.001337931	0.000572258	0

Table 4.12: Multiple decrements for the female life

MULTIPLE LIFE DECREMENT TABLE (FEMALES)											
Age (x)	q^{d}_{x}	q^{dI}_{x}	q^{w}_{x}	$(aq)^{d}_{x}$	$(aq)^{dI}_{x}$	$(aq)^{w}_{x}$	$(ap)_{x}$	$_{t-1}(ap)_{x}$	$k\|q^{d}_{x}$	$k\|q^{dI}_{x}$	$k\|q^{w}_{x}$
27	0.002088	0.000675	0.00	0.002087295	0.000674295	0	0.997238409	1.000000000	0.002087295	0.000674295	0
28	0.002016	0.00069	0.15	0.001864174	0.000637624	0.14979712	0.847701082	0.997238409	0.001859026	0.000635863	0.149383344
29	0.001932	0.00069	0.15	0.001786 5	0.000637 6	0.14980341	0.847772433	0.845360079	0.001510236	0.000539044	0.126637 83
30	0.001836	0.000705	0.15	0.001697718	0.000651543	0.14980949	0.847841 25	0.716672971	0.001216708	0.000466943	0.107364 41
31	0.001752	0.00072	0.00	0.001751369	0.000719369	0	0.997529261	0.607624908	0.001064176	0.000437107	0

4.3 Pricing Model

The pricing of this product is based on the principle of equivalence, which states that the expected present value (EPV) of future premiums must be equal to the expected present value of future benefits and expenses. This relationship can be expressed as:

EPV (Premiums) = EPV (Benefits) + EPV (Expenses)

This ensures that, on average, the insurer collects sufficient premiums to meet all expected obligations arising from the policy. The outgoings considered in the model include claim payments (such as death and disability benefits), administrative expenses, and agent commissions.

To account for the time value of money, all cash flows are discounted using an assumed interest rate. In addition, probabilities of decrements such as death, disability, and surrender/withdrawal are incorporated into the valuation to reflect the likelihood and timing of future payments.

The pricing results presented in this section are based on a model developed for a 27-year-old (male & female) factory & industrial worker, representing a single individual within this occupational group. The model produces the level premium required over the 5-year policy term to ensure equilibrium between expected income and outgoings, while maintaining affordability for the policyholder.

Overall, this actuarial pricing approach provides a consistent and financially sound basis for determining premiums, ensuring that the product remains both sustainable for insurers and accessible to factory and industrial workers.

Table 4.13: Expected Present Value of Death and Survival benefits for the male life.

EPV DEATH & SURVIVAL BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount factor**	**EPV(each year)**
1	2,000,000.00	0.002386943	0.86281277	4,118.97
2	2,000,000.00	0.002178609	0.744445875	3,243.71
3	2,000,000.00	0.001808314	0.642317408	2323.022651
4	2,000,000.00	0.001500362	0.554199661	1662.999908
5	2,000,000.00	0.001337931	0.478170545	1279.518151
Survival Benefits	2,000,000.00	0.606233343	0.478170545	579,765.86
Sum of EPV				592,394.08

Table 4.14: Expected Present Value of Death and Survival benefits for the female life.

EPV DEATH & SURVIVAL BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount factor**	**EPV(each year)**
1	2,000,000.00	0.002087295	0.86281277	3,601.89
2	2,000,000.00	0.001859026	0.744445875	2767.888396
3	2,000,000.00	0.001510236	0.642317408	1940.101588
4	2,000,000.00	0.001216708	0.554199661	1348.598618
5	2,000,000.00	0.001064176	0.478170545	1017.71485
Survival Benefits	2,000,000.00	0.607624908	0.478170545	581,096.67
Sum of EPV				591,772.86

Table 4.15: Expected Present Value of Disability benefits for the male life.

EPV DISABILITY BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount Factor**	**EPV(each year)**
1	312,977.55	0.000883943	0.86281277	238.70
2	634,249.59	0.000815009	0.744445875	384.8183036
3	997,854.04	0.000702228	0.642317408	450.0854946
4	1,409,368.82	0.000604906	0.554199661	472.4750195
5	1,875,106.85	0.000572258	0.478170545	513.098497
Sum of EPV				2,059.18

Table 4.16: Expected Present Value of Disability benefits for the female life.

EPV DISABILITY BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount Factor**	**EPV(each year)**
1	312,156.92	0.000674295	0.86281277	181.61
2	632,586.57	0.000635863	0.744445875	299.4447942
3	995,237.63	0.000539044	0.642317408	344.5884023
4	1,405,673.41	0.000466943	0.554199661	363.7596137
5	1,870,190.26	0.000437107	0.478170545	390.8913558
Sum of EPV				1,580.29

Table 4.17: Expected Present Value of Surrender Benefits for the male life.

EPV SURRENDER BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount Factor**	**EPV(each year)**
1	170,715.03	0	0.86281277	-
2	345,954.32	0.149266593	0.744445875	38442.7555
3	544,284.02	0.126466737	0.6423157408	44213.16348
4	768,746.63	0.107153012	0.554199661	45651.37509
5	1,022,785.56	0	0.478170545	0
Sum of EPV				128,307.29

Table 4.18: Expected Present Value of Surrender Benefits for the female life.

EPV SURRENDER BENEFITS				
k(future lifetime)	**Amount**	**Probability**	**Discount Factor**	**EPV(each year)**
1	170,267.41	0	0.86281277	-
2	345,047.22	0.149383441	0.744445875	38371.97189
3	542,856.89	0.126637828	0.642317408	44156.89208
4	766,730.95	0.107364412	0.554199661	45621.50423
5	1,020,103.78	0	0.478170545	0
Sum of EPV				128,150.37

Table 4.19: Expected Present Value of Initial and Renewal Expenses for the male life.

EPV EXPENSES				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV(each year)**
0	41,783.83	1	1	41,783.83
1	13927.94495	0.86281277	0.996729113	11,977.90
2	14359.71124	0.744445875	0.844468902	9,027.40
3	14804.86229	0.642317408	0.715491623	6,803.91
4	15263.81302	0.554199661	0.606233343	5,128.25
EPV of Expense				74,721.29

Table 4.20: Expected Present Value of Initial and Renewal Expenses for the female life.

EPV EXPENSES				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV(each year)**
0	41,674.28	1	1	41,674.28
1	13891.42541	0.86281277	0.997238409	11,952.60
2	14322.05959	0.744445875	0.845360079	9,013.23
3	14766.04344	0.642317408	0.716672971	6,797.28
4	15223.79079	0.554199661	0.607624908	5,126.54
EPV of Expense				74,563.92

Table 4.21: Expected Present Value of Commission for the male life.

EPV COMISSION				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV**
0	69,639.72	1	1	69,639.72
1	20,891.92	0.86281277	0.996729113	17,966.85
2	20,891.92	0.744445875	0.844468902	13,133.94
3	20,891.92	0.642317408	0.715491623	9,601.36
4	20,891.92	0.554199661	0.606233343	7,019.15
EPV of Commission				117,361.02

Table 4.22: Expected Present Value of Commission for the female life.

EPV COMISSION				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV**
0	69,457.13	1	1	69,457.13
1	20,837.14	0.86281277	0.997238409	17,928.90
2	20,837.14	0.744445875	0.845360079	13,113.33
3	20,837.14	0.642317408	0.716672971	9,591.99
4	20,837.14	0.554199661	0.607624908	7,016.81
EPV of Commission				117,108.16

Table 4.23: Expected Present Value of Premium for the male life

EPV PREMIUM				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV**
0	278,558.90	1	1	278,558.90
1	278,558.90	0.86281277	0.996729113	239558.0366
2	278,558.90	0.744445875	0.844468902	175119.2249
3	278,558.90	0.642317408	0.715491623	128018.0721
4	278,558.90	0.554199661	0.606233343	93588.63485
EPV of Premium				914,842.87

Table 4.24: Expected Present Value of Premium for the female life

EPV PREMIUM				
k(future lifetime)	**Amount**	**Discount Factor**	**Probability**	**EPV**
0	277,828.51	1	1	277,828.51
1	277,828.51	0.86281277	0.997238409	239051.9927
2	277,828.51	0.744445875	0.845360079	174844.377
3	277,828.51	0.642317408	0.716672971	127893.2208
4	277,828.51	0.554199661	0.607624908	93557.50494
EPV of Premium				913,175.60

4.4 Explanation of actual premium calculation for both the male and female life.

These figures are based on an assumed premium of UGX 200,000. The Goal Seek function is then used to iterate this premium until the Expected Present Value of Income equals the Expected Present Value of Outgo, after which all related figures, including the EPV of Premium, update automatically to reflect the exact premium.

The Expected Present Value (EPV) of Premium for male and female policyholders. Using the assumed annual premium of UGX 200,000 for males, discounted and weighted by survival probability across the five-year term, the EPV of Premium totals UGX 914,842.87 and the annual premium is UGX 278,558.90. For females, an assumed premium of UGX 200,000 gives an EPV of Premium of UGX 913,175.60 and annual premium of UGX 277,828.51.

4.5 Profit testing

In order for the insurance company to assess whether the designed product is viable and cost-effective, the insurer carries out a profit test comprising a unit fund, a non-unit fund, and discounted cash flows, the results of which are presented in the tables below.

Table 4.25: Unit fund for the male life

UNIT FUND								
Year	**Premium**	**Allocated Premium**	**B/O spread**	**Cost of Allocation**	**Fund after allocation**	**Fund after growth**	**Management Charge**	**Bid value of units(Fund at year end)**
1	278558.899	264630.9541	13231.5477	251399.4064	251399.4064	288857.9179	4332.868769	284525.0492
2	278558.899	236775.0642	11838.75321	224936.311	509461.3601	585371.1028	8780.566542	576590.5362
3	278558.899	236775.0642	11838.75321	224936.311	801526.8472	920954.3474	13814.31521	907140.0322
4	278558.899	236775.0642	11838.75321	224936.311	1132076.343	1300755.718	19511.33577	1281244.383
5	278558.899	236775.0642	11838.75321	224936.311	1506180.693	1730601.617	25959.02425	1704642.593

Table 4.26: Unit fund for the female life

UNIT FUND								
Year	**Premium**	**Allocated Premium**	**B/O spread**	**Cost of Allocation**	**Fund after allocation**	**Fund after growth**	**Management Charge**	**Bid value of units(Fund at year end)**
1	277828.5081	263937.0827	13196.85414	250740.2286	250740.2286	288100.5226	4321.50784	283779.0148
2	277828.5081	236154.2319	11807.7116	224346.5203	508125.5351	583836.2399	8757.543598	575078.6963
3	277828.5081	236154.2319	11807.7116	224346.5203	799425.2166	918539.5738	13778.09361	904761.4802
4	277828.5081	236154.2319	11807.7116	224346.5203	1129108.001	1297345.093	19460.17639	1277884.916
5	277828.5081	236154.2319	11807.7116	224346.5203	1502231.437	1726063.921	25890.95881	1700172.962

Table 4.27: Non-unit fund for the male life

NON-UNIT FUND										
Year	**Unallocated Premium**	**B/O spread**	**Expenses**	**Commission**	**Interest**	**Extra Death**	**Extra Disability Cost**	**Management Charge**	**Expected Surrender Penalty**	**Profit**
1	13927.94495	14962.23945	41783.83485	69639.72476	-12297.47291	4094.741457	25.15040137	4332.868769	0	-94617.8712
2	41783.83485	13387.26688	14359.71124	20892	2968.001486	3111.229387	47.14685891	8780.566542	34539.25602	63048.92086
3	41783.83485	13387.26688	14804.86229	20892	2901.673979	2340.208828	75.43431976	13814.31521	54340.91888	88115.58693
4	41783.83485	13387.26688	15263.81302	20892	2833.290321	1507.206201	108.3216725	19511.33577	76752.3701	116496.8396
5	41783.83485	13387.26688	15736.99123	20892	2762.786768	651.8410151	160.910883	25959.02425	0	46451.2522

Table 4.28: Non-unit fund for the female life.

NON-UNIT FUND										
Year	**Unallocated Premium**	**B/O spread**	**Expenses**	**Commission**	**Interest**	**Extra Death**	**Extra Disability Cost**	**Management Charge**	**Expected Surrender Penalty**	**Profit**
1	13891.42541	14962.23945	41674.27622	69457.12703	-12259.38302	3582.259996	19.13508559	4321.50784	0	-93817.00866
2	41674.27622	13387.26688	14322.05959	20837	2965.449463	2656.301292	36.6683997	8757.543598	34458.05289	63390.42165
3	41674.27622	13387.26688	14766.04344	20837	2899.29587	1956.643 74	57.6921261	13778.09361	54214.5444	88335.95955
4	41674.27622	13387.26688	15223.79079	20837	2831.091515	1225.947436	83.25963701	19460.17639	76575.71489	116558.3899
5	41674.27622	13387.26688	15695.7283	20837	2760.772826	525.107864	122.3052199	25890.95881	0	46532.99523

Table 4.29: EPV of profits for the male life.

Year	Profit	$_{t-1}(ap)_x$	Profit signature	Discount Factor	Discounted profit
1	-94617.8712	1.000000000	-94617.8712	0.86281277	-81637.50751
2	63048.92086	0.996729113	62842.69499	0.744445875	46782.98509
3	88115.58693	0.844468902	74410.87294	0.642317408	47795.399
4	116496.8396	0.715491623	83352.5128	0.554199661	46193.93437
5	46451.2522	0.606233343	28160.2979	0.478170545	13465.42499
Total					72600.23594

Table 4.30: EPV of profits for the female life.

Year	Profit	$_{t-1}(ap)_x$	Profit signature	Discount Factor	Discounted profit
1	-93817.00866	1.000000000	-93817.00866	0.86281277	-80946.51308
2	63390.42165	0.997238409	63215.36325	0.744445875	47060.41644
3	88335.95955	0.845360079	74675.69375	0.642317408	47965.49802
4	116558.3899	0.716672971	83534.24761	0.554199661	46294.65174
5	46532.99523	0.607624908	28274.60694	0.478170545	13520.0842
Total					73894.13733

Table 4.31: EPV of Premiums for the male life.

Year	Premium	$_{t-1}(ap)_x$	Discount Factor	Discount premium
1	278558.899	1.000000000	1	278558.899
2	278558.899	0.996729113	0.86281277	239558.0366
3	278558.899	0.844468902	0.744445875	175119.2249
4	278558.899	0.715491623	0.642317408	128018.0721
5	278558.899	0.606233343	0.554199661	93588.63485
Total				914842.8675

Table 4.32: EPV of Premiums for the female life.

Year	Premium	$_{t-1}(ap)_x$	Discount Factor	Discount premium
1	277828.5081	1.000000000	1	277828.5081
2	277828.5081	0.997238409	0.86281277	239051.9927
3	277828.5081	0.845360079	0.744445875	174844.377
4	277828.5081	0.716672971	0.642317408	127893.2208
5	277828.5081	0.607624908	0.554199661	93557.50494
Total				913175.6036

Table 4.33: Profit margin for the male life.

Profit Margin (Males)	0.079358148	7.93581483%

Table 4.34: Profit margin for the female life.

Profit Margin (Females)	0.080919964	8.09199644%

4.6 Premium distribution.

When the policyholder pays the premium, part of it is allocated to the unit fund, where the policyholder is assigned units equivalent to the amount invested. These units are invested in a relatively safe portfolio to generate a return over time. The remaining portion goes to the non-unit fund, which captures the insurer's profit after accounting for the expenses and income associated with each policy year. The results are reflected in Table 4.8 and Table 4.9 respectively.

The profit margin is determined as the ratio of the NPV of profits to the NPV of premiums. Taking a 27-year-old on a 5-year term as the baseline, the model yields a margin of 7.94% for a male policyholder and 8.09% for a female, as shown in Table 4.33 for the male and Table 4.34 for the female. Each margin is then measured against the insurer's benchmark to assess whether the product is profitable and cost-effective

4.7 Analysis of the results

This section examines how premiums and profit margins behave across different entry ages and policy terms. Understanding these variations is important for decision making, as it allows the insurer to identify which age groups and policy terms are most viable and where potential losses may arise.

4.7.1 Premiums

This policy is essentially designed for Factory & Industrial workers who are low income earners and their incomes are unstable. Therefore having premiums as low as possible was one of the objectives of the product. As a result, the premiums across all ages and policy terms under consideration range between UGX 147,308.09 & UGX 283,472.01 annually for males and between UGX 146,733.75 & UGX 285,013.23 annually for females. This ranges between UGX 12,275.67 & UGX 23,622.67 on a monthly basis for men and between UGX 12,227.81 & UGX 23,751.10 on a monthly basis for women. This is for the basic policy with a sum assured of UGX 2,000,000. Premiums can still be calculated depending on what the client desires.

Table 4.35: Premiums across all ages under policy terms considered

Age	Premiums (UGX)					
	5 year policy term		6 year policy term		7 year policy term	
	Male	Female	Male	Female	Male	Female
20	277,589.92	277,696.06	199,705.62	199,827.40	147,308.09	147,439.05
21	277,920.78	277,871.44	200,050.07	200,007.67	147,671.65	147,626.66
22	278,194.05	277,994.57	200,333.97	200,132.63	147,969.73	147,757.94
23	278,391.15	278,061.75	200,538.05	200,203.03	148,182.87	147,824.16
24	278,522.23	278,086.46	200,672.64	200,218.50	148,321.06	147,834.97
25	278,589.59	278,043.57	200,739.13	200,168.88	148,385.66	147,777.01
26	278,595.87	277,956.52	200,740.47	200,072.65	148,382.06	147,669.01
27	278,558.90	277,828.51	200,696.99	199,933.15	148,335.95	147,516.71
28	278,495.39	277,688.29	200,632.31	199,781.77	148,263.32	147,350.82
29	278,427.57	277,543.45	200,556.88	199,624.10	148,180.49	147,180.79
30	278,369.68	277,404.22	200,492.74	199,474.91	148,110.48	147,022.32
31	278,330.06	277,289.86	200,448.44	199,354.61	148,063.77	146,889.43
32	278,333.25	277,205.86	200,450.52	199,259.05	148,066.34	146,787.44
33	278,392.59	277,158.83	200,510.58	199,207.64	148,129.37	146,733.75
34	278,510.35	277,163.86	200,629.76	199,211.92	148,258.97	146,736.58
35	278,676.87	277,225.13	200,805.53	199,270.84	148,446.56	146,803.35
36	278,900.10	277,327.81	201,037.49	199,381.59	148,694.65	146,919.86
37	279,167.08	277,467.35	201,316.82	199,524.77	148,988.55	147,070.73
38	279,465.70	277,642.18	201,623.66	199,704.24	149,310.37	147,262.36
39	279,791.84	277,844.87	201,957.33	199,916.22	149,656.04	147,502.48
40	280,133.37	278,070.90	202,300.61	200,171.86	150,009.88	147,767.24
41	280,476.77	278,359.85	202,643.17	200,463.25	150,360.72	148,072.12
42	280,819.53	278,676.84	202,981.70	200,787.20	150,704.65	148,421.42
43	281,155.49	279,044.15	203,309.50	201,176.22	151,034.02	148,841.87
44	281,475.33	279,510.48	203,616.39	201,668.52	151,344.13	149,374.93
45	281,776.24	280,110.82	203,907.66	202,301.90	151,633.31	150,050.58
46	282,066.30	280,748.94	204,181.65	202,971.01	151,904.69	150,773.47
47	282,343.41	281,438.15	204,442.82	203,705.86	152,171.17	151,568.70
48	282,613.72	282,198.97	204,709.17	204,518.52	152,434.97	152,447.40
49	282,891.89	283,046.91	204,972.69	205,423.10	152,697.27	153,429.12
50	283,179.36	283,979.01	205,247.55	206,423.48		
51	283,472.01	285,013.23				

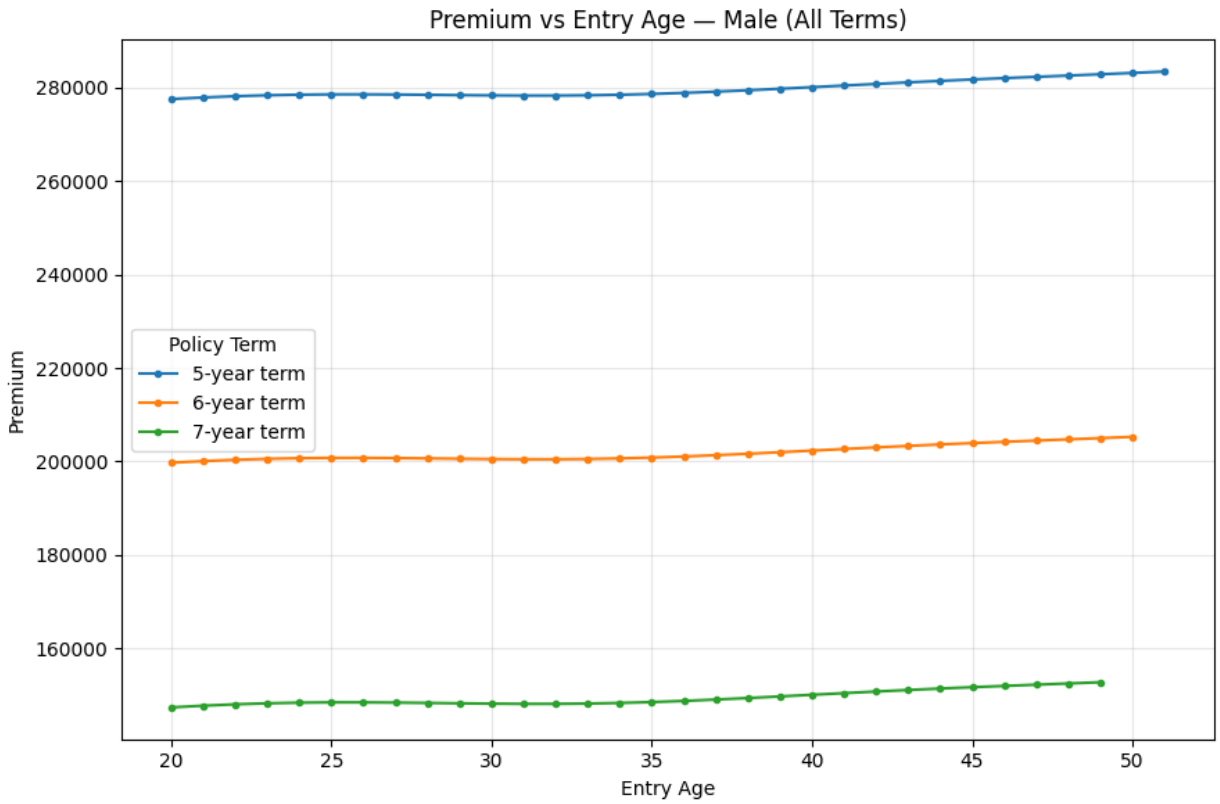

Figure 1: Premiums across all ages and terms under considerations for a male life

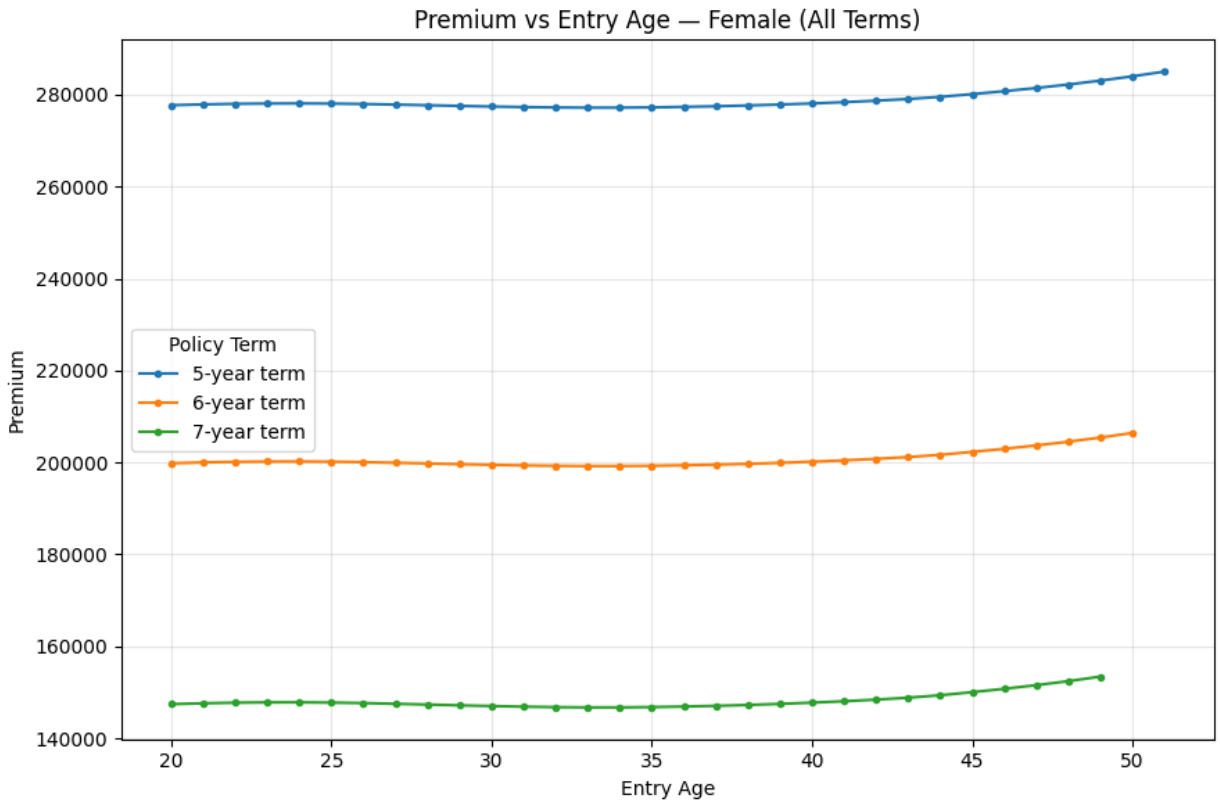

Figure 2: Premiums across all ages and terms under considerations for a female life

As illustrated in Figures 4.1 and 4.2, the 5-year policy consistently attracts the highest premiums across all ages, while the 7-year policy attracts the lowest, and this holds for both male and female policyholders. The longer the policy term, the lower the premium reflecting the lower accumulated benefit obligation the insurer must fund over a longer duration. Premiums rise steadily with entry age, due to increase in mortality and disability rates as policyholders grow older. Additional graphs that show how premiums behave across each individual policy term are included in the appendix.

4.7.2 Profit margins.

The results show that profit margins range from 8.1827% to 18.2256% for males and 8.2726% to 18.4962% for females across all ages and policy terms, as displayed in **Table 4.36**.

Table 4.36: Profit margins across all ages and policy terms considered

Age	Profit Margin					
	5 year policy term		6 year policy term		7 year policy term	
	Male	Female	Male	Female	Male	Female
20	8.1827%	8.1431%	13.2897%	13.2389%	18.2256%	18.1638%
21	8.1020%	8.0987%	13.1704%	13.1748%	18.0561%	18.0750%
22	8.0339%	8.0657%	13.0717%	13.1291%	17.9180%	18.0137%
23	7.9836%	8.0456%	13.0003%	13.1032%	17.8199%	17.9819%
24	7.9492%	8.0369%	12.9531%	13.0953%	17.7569%	17.9765%
25	7.9307%	8.0439%	12.9296%	13.1103%	17.7278%	18.0032%
26	7.9278%	8.0625%	12.9286%	13.1420%	17.7300%	18.0534%
27	7.9358%	8.0920%	12.9433%	13.1892%	17.7533%	18.1246%
28	7.9511%	8.1254%	12.9675%	13.2415%	17.7891%	18.2024%
29	7.9703%	8.1613%	12.9963%	13.2966%	17.8296%	18.2828%
30	7.9884%	8.1967%	13.0221%	13.3498%	17.8641%	18.3589%
31	8.0035%	8.2275%	13.0416%	13.3948%	17.8877%	18.4220%
32	8.0091%	8.2529%	13.0458%	13.4306%	17.8882%	18.4704%
33	8.0019%	8.2689%	13.0305%	13.4514%	17.8603%	18.4962%
34	7.9811%	8.2726%	12.9947%	13.4533%	17.8024%	18.4947%
35	7.9482%	8.2629%	12.9404%	13.4357%	17.7182%	18.4647%
36	7.9024%	8.2425%	12.8675%	13.4017%	17.6076%	18.4115%
37	7.8464%	8.2148%	12.7798%	13.3568%	17.4769%	18.3423%
38	7.7840%	8.1787%	12.6833%	13.2996%	17.3343%	18.2557%
39	7.7156%	8.1362%	12.5785%	13.2330%	17.1813%	18.1525%
40	7.6442%	8.0899%	12.4705%	13.1583%	17.0249%	18.0367%
41	7.5723%	8.0360%	12.3629%	13.0708%	16.8703%	17.9006%
42	7.5008%	7.9755%	12.2569%	12.9709%	16.7192%	17.7445%
43	7.4313%	7.9018%	12.1546%	12.8498%	16.5744%	17.5568%
44	7.3657%	7.8054%	12.0589%	12.6954%	16.4392%	17.3215%
45	7.3043%	7.6781%	11.9692%	12.4972%	16.3129%	17.0258%
46	7.2463%	7.5446%	11.8849%	12.2888%	16.1944%	16.7144%
47	7.1910%	7.4003%	11.8045%	12.0632%	16.0811%	16.3775%
48	7.1370%	7.2428%	11.7257%	11.8171%	15.9702%	16.0113%
49	7.0844%	7.0692%	11.6490%	11.5468%	15.8620%	15.6104%
50	7.0311%	6.8806%	11.5712%	11.2535%		
51	6.9795%	6.6752%				

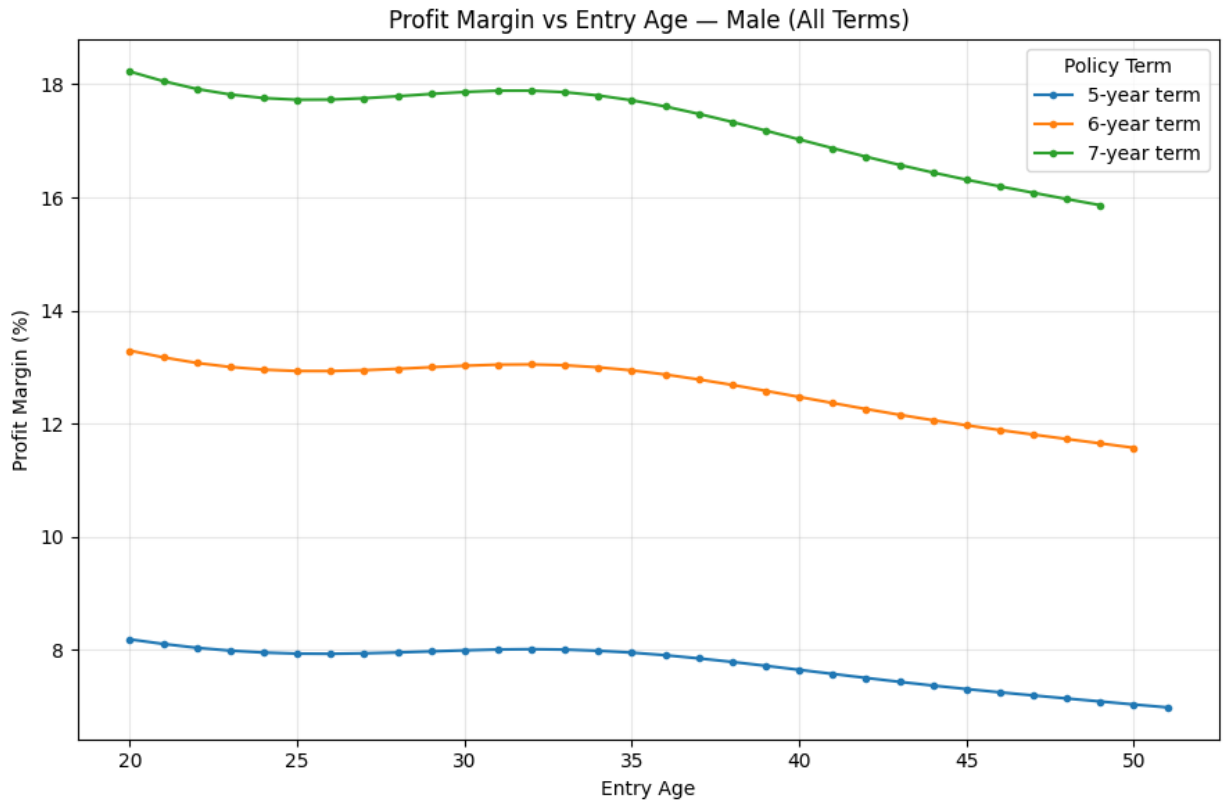

Figure 3: Profit margins across all ages and terms under considerations for a male life

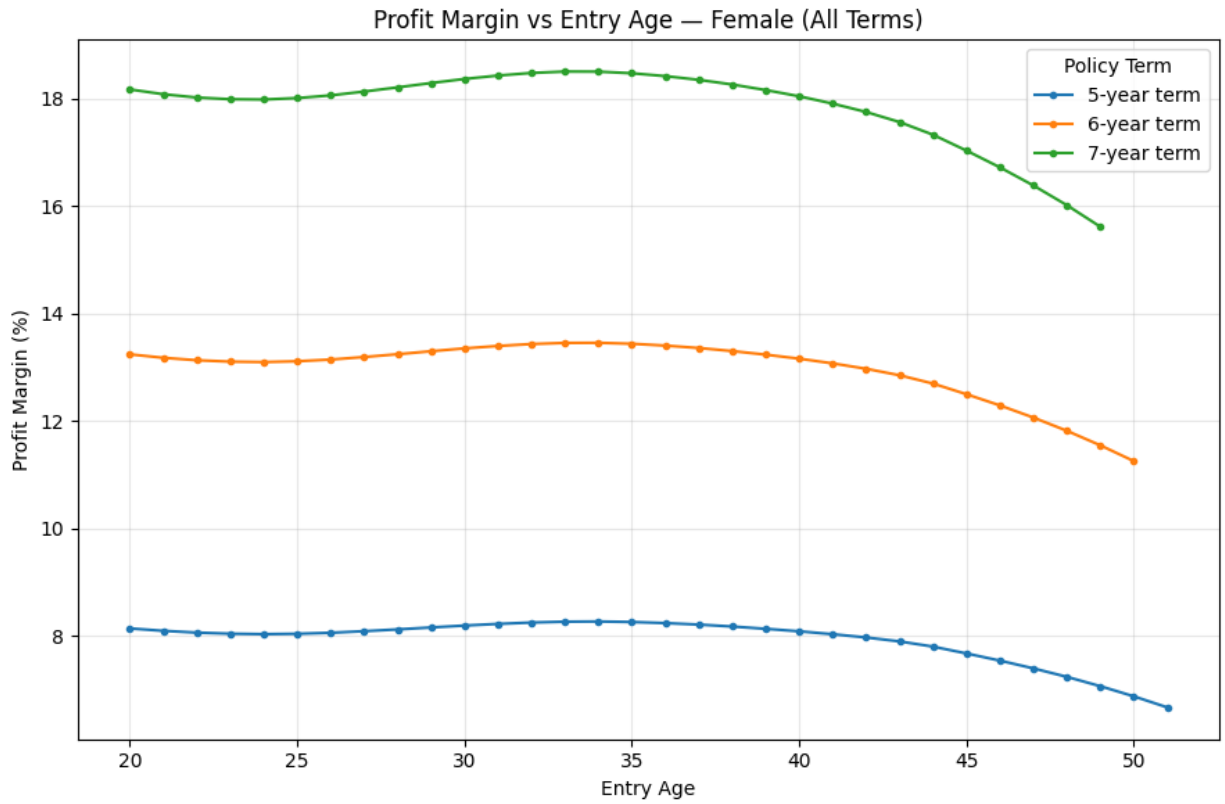

Figure 4: Profit margins across all ages and terms under considerations for a female life

As illustrated in **Figure 4.3** and **Figure 4.4**, the 7-year policy consistently produces the highest profit margins across all ages, while the 5-year policy produces the lowest, and this pattern holds for both male and female policyholders. The longer the policy term, the higher the profitability. This driven by the compounding growth of the unit fund over time, which progressively increases management charge income and surrender penalty relative to the fixed acquisition costs incurred at inception. Profit margins also decline gradually as entry age increases, reflecting the rising cost of mortality and disability cover with age. Female policyholders record slightly higher margins than males at every age and term, consistent with their lower mortality and disability rates. Additional graphs showing how margins behave across each individual policy term are included in the appendix.

4.8 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 4.15 below are for a 5 – year policy taken out by a 27-year-old male with an initial profit margin of 7.94% and a 27 year old female with an initial profit margin with 8.09%

Table 4.37: Sensitivity Analysis

Assumption	Variation	profit margin (Male)	profit margin (Female)	Remarks
Inflation rate	+10%	7.9112%	8.0674%	A 10% increase in the inflation rate leads to a 0.025pp decrease in profit margin for both the male and female
	0%	7.9358%	8.0920%	
	-10%	7.9603%	8.1165%	A 10% decrease in the inflation rate leads to a 0.024pp increase in profit margin for both the male and female
Management Charge	+10%	8.2590%	8.4158%	A 10% increase in the management charge leads to a 0.323pp increase in profit margin for both the male and female
	0%	7.9358%	8.0920%	
	-10%	7.6113%	7.7669%	A 10% decrease in the management charge leads to a 0.325pp decrease in profit margin for both the male and female
Initial Expenses	+10%	7.4580%	7.6130%	A 10% increase in the initial expenses leads to a 0.478pp decrease in profit margin for both the male and female
	0%	7.9358%	8.0920%	
	-10%	8.4137%	8.5710%	A 10% decrease in the initial expenses leads to a 0.478pp increase in profit margin for both the male and female
Renewal commission	+10%	7.3900%	7.5443%	A 10% increase in the initial expenses leads to a 0.546pp decrease in profit margin for both the male and female
	0%	7.9358%	8.0920%	

	-10%	8.4816%	8.6397%	A 10% decrease in the initial expenses leads to a 0.546pp increase in profit margin for both the male and female
Unit growth rate	+10%	8.2472%	8.4000%	A 10% increase in the initial expenses leads to a 0.311pp increase in profit margin for both the male and female
	0%	7.9358%	8.0920%	
	-10%	7.6317%	7.7912%	A 10% decrease in the initial expenses leads to a 0.304pp decrease in profit margin for both the male and female
Risk Discount rate	+10%	7.6713%	7.8375%	A 10% increase in the initial expenses leads to a 0.264pp decrease in profit margin for both the male and female
	0%	7.9358%	8.0920%	
	-10%	8.2181%	8.3644%	A 10% decrease in the initial expenses leads to a 0.282pp increase in profit margin for both the male and female

4.9 Results from the tables

Table 4.37 shows the results of a sensitivity analysis on factors affecting profit margin. Inflation, initial expenses, renewal commission, and the risk discount rate all have an inverse relationship with profit margin, an increase in any of these reduces profitability, while a decrease improves it. The management charge and unit growth rate move in the opposite direction, with higher values improving the margin. Among the factors tested, renewal commission has the greatest impact, followed closely by initial expenses and the risk discount rate. The management charge and unit growth rate have a moderate effect, while inflation has the smallest influence of all. This highlights that distribution costs are the primary lever available to an insurer seeking to protect margins. Encouragingly, the product remains profitable across every scenario tested, which speaks to the resilience of the pricing structure under changing economic conditions.

CHAPTER FIVE: SUMMARY OF THE RESULTS, CONCLUSIONS AND RECOMMENDATIONS.

5.0 Introduction

This chapter summarizes the principal findings of the study, draws conclusions against the stated objectives, and offers recommendations to support the practical delivery of the product to factory and industrial workers in Uganda.

5.1 Summary of Results

The model was developed for male and female policyholders aged 20 to 51, across policy terms of 5, 6, and 7 years, with a sum assured of UGX 2,000,000. For the baseline profile, a 27-year-old male on a 5-year term, the model produced an annual premium of UGX 278,558.90 and a profit margin of 7.94%, with corresponding figures of UGX 277,828.51 and 8.09% for a female of the same age.

Across all ages and terms, profit margins range from approximately 8.1827% to 18.2256% for males and 8.2726% to 18.4962% for females with a clear positive relationship between policy term length and profitability. Older policyholders pay higher premiums than younger ones, while female policyholders consistently produce marginally higher profit margins than males of the same age, reflecting their lower mortality and disability rates.

The sensitivity analysis identified renewal commission, the risk discount rate, and initial expenses as the most influential drivers of profitability, each shifting the profit margin by approximately 0.2–0.55 percentage points per 10% change. The unit growth rate carries a comparable positive effect, while inflation has the smallest impact at 0.025 percentage points per 10% change. Critically, the product remains profitable across all scenarios tested, confirming its resilience to moderate deviations from the base assumptions.

5.2 Conclusion

The study demonstrates that a unit-linked endowment micro insurance product for factory and industrial workers in Uganda can be priced affordably and profit-tested successfully using standard actuarial principles. Profit margins are positive across the full range of ages and policy terms

modelled, and the sensitivity analysis confirms that profitability is not unduly fragile. The results establish that the absence of such a product in the Ugandan market is not a question of actuarial infeasibility, and provide credible groundwork for insurers considering entry into this underserved segment.

5.3 Recommendations

Premium collection remains the principal operational challenge, particularly for workers in smaller or capsulized employment settings. Partnerships with mobile money providers such as MTN MoMo and Airtel Money would enable low-cost, accessible premium payment without requiring formal banking relationships. Employer-facilitated payroll deduction arrangements, modelled on existing NSSF contribution structures, offer a complementary channel that would also reduce lapse rates and improve the persistency assumed in this model.

Targeted financial literacy campaigns at the workplace level are necessary to build awareness and trust, both to grow uptake and to reduce early surrenders below the 15% rate assumed in the model. Finally, closer collaboration between insurers and the IRA, building on the regulator's supportive 2023 micro insurance circular and current strategic plan would help establish experience data on this segment and refine the actuarial assumptions underpinning future iterations of the product.

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BACKGROUND: Due to hazardous working conditions, welders are more likely to be exposed to mild to severe eye issues during the welding process. Globally, this issue is a major contributor to vision loss and blindness. One of the most frequent causes of unilateral blindness in the globe is ocular injury.This review aimed to assess the pooled prevalence of ocular protection practice and associated factors among welders in sub-Saharan Africa.Databases including PubMed, Scopus, web of Science, Google Scholar, and the African Journals Online were systematically searched for relevant literature. The statistical analysis was performed using STATA data analysis software version 14, while Microsoft Excel was used for data abstraction. We checked publication bias using a funnel plot and Egger and Begg regression tests. A p-value < 0.05 was considered significant, suggesting the presence of presence publication bias. The I 2 statistics were used to assess heterogeneity between studies. The study's overall effect was evaluated using the random effects model.From retrieved 2,326 original studies, 17 studies were included in the final pooled prevalence analysis. The overall prevalence of ocular protection practice among small-scale

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APPENDCIES

Appendix A: Kenyan Mortality (KE 2007-2010 mortality tables for assured lives)

Age(x)	l_x	q_x	Age(x)	Age(x)	l_x	q_x	Age(x)
20	100 000	0.00131	20				
21	99 869	0.00149	21	61	89 221	0.00755	61
22	99 720	0.00166	22	62	88 548	0.00850	62
23	99 555	0.00179	23	63	87 795	0.00956	63
24	99 376	0.00189	24	64	86 956	0.01076	64
25	99 188	0.00196	25	65	86 020	0.01212	65
26	98 994	0.00199	26	66	84 977	0.01363	66
27	98 796	0.00199	27	67	83 819	0.01534	67
28	98 599	0.00197	28	68	82 533	0.01726	68
29	98 405	0.00193	29	69	81 108	0.01942	69
30	98 215	0.00189	30	70	79 533	0.02185	70
31	98 029	0.00184	31	71	77 795	0.02457	71
32	97 849	0.00180	32	72	75 883	0.02763	72
33	97 673	0.00178	33	73	73 786	0.03107	73
34	97 499	0.00179	34	74	71 494	0.03492	74
35	97 324	0.00182	35	75	68 997	0.03924	75
36	97 147	0.00188	36	76	66 290	0.04409	76
37	96 964	0.00197	37	77	63 367	0.04952	77
38	96 773	0.00207	38	78	60 229	0.05559	78
39	96 572	0.00219	39	79	56 881	0.06239	79
40	96 361	0.00232	40	80	53 332	0.06998	80
41	96 137	0.00245	41	81	49 600	0.07847	81
42	95 901	0.00258	42	82	45 708	0.08793	82
43	95 654	0.00271	43	83	41 689	0.09846	83
44	95 394	0.00283	44	84	37 584	0.11019	84
45	95 125	0.00294	45	85	33 443	0.12321	85
46	94 846	0.00304	46	86	29 322	0.13765	86
47	94 558	0.00313	47	87	25 286	0.15362	87
48	94 262	0.00322	48	88	21 402	0.17126	88
49	93 958	0.00330	49	89	17 736	0.19069	89
50	93 648	0.00339	50	90	14 354	0.21203	90
51	93 330	0.00347	51	91	11 311	0.23538	91
52	93 007	0.00354	52	92	8 648	0.26086	92
53	92 677	0.00362	53	93	6 392	0.28854	93
54	92 342	0.00370	54	94	4 548	0.31848	94
55	92 000	0.00378	55	95	3 099	0.35069	95
56	91 652	0.00417	56	96	2 012	0.38515	96
57	91 270	0.00470	57	97	1 237	0.42178	97
58	90 841	0.00529	58	98	715	0.46043	98
59	90 361	0.00595	59	99	386	0.50087	99
60	89 823	0.00670	60	100	193	0.54280	100

Appendix B: Variation in profit margins for various policy terms;

Appendix B.1: Profit margins across all ages for a 5-year policy

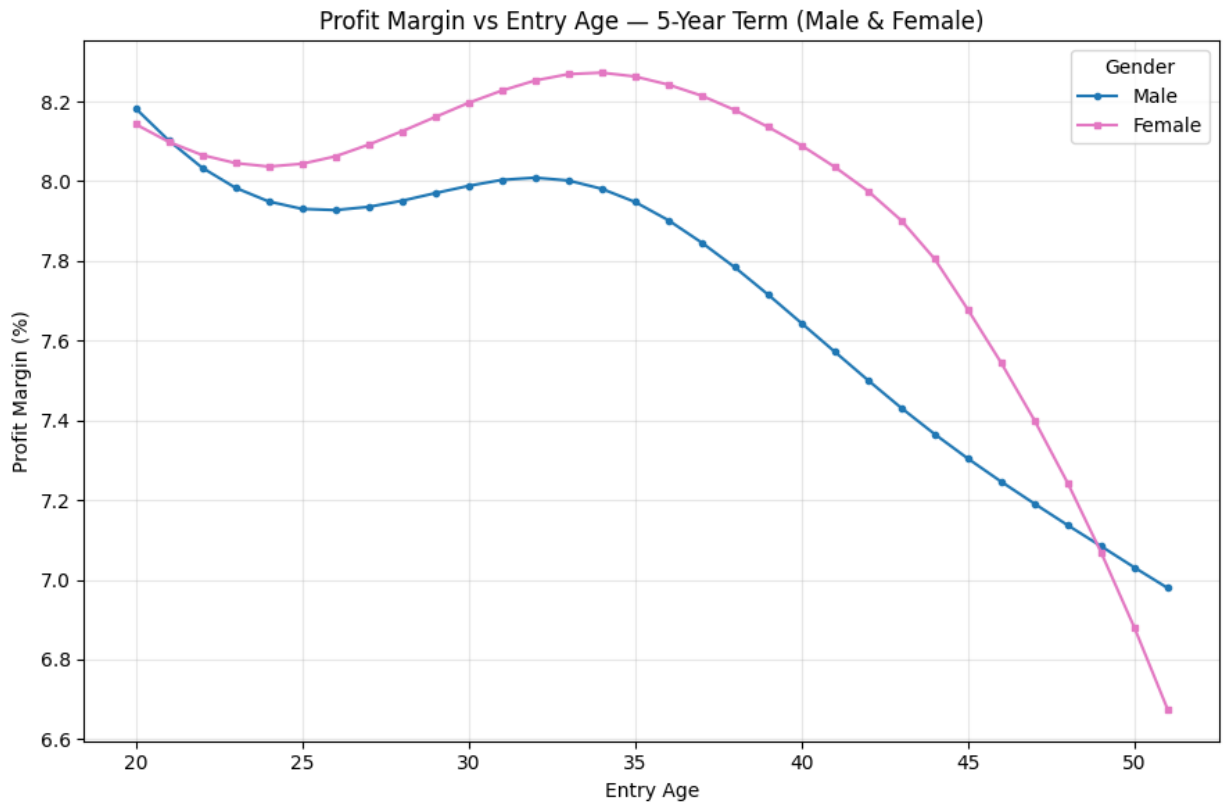


Figure 5: Profit margins across all ages for a 5-year policy

Appendix B.2: Profit margins across all ages for a 6-year policy

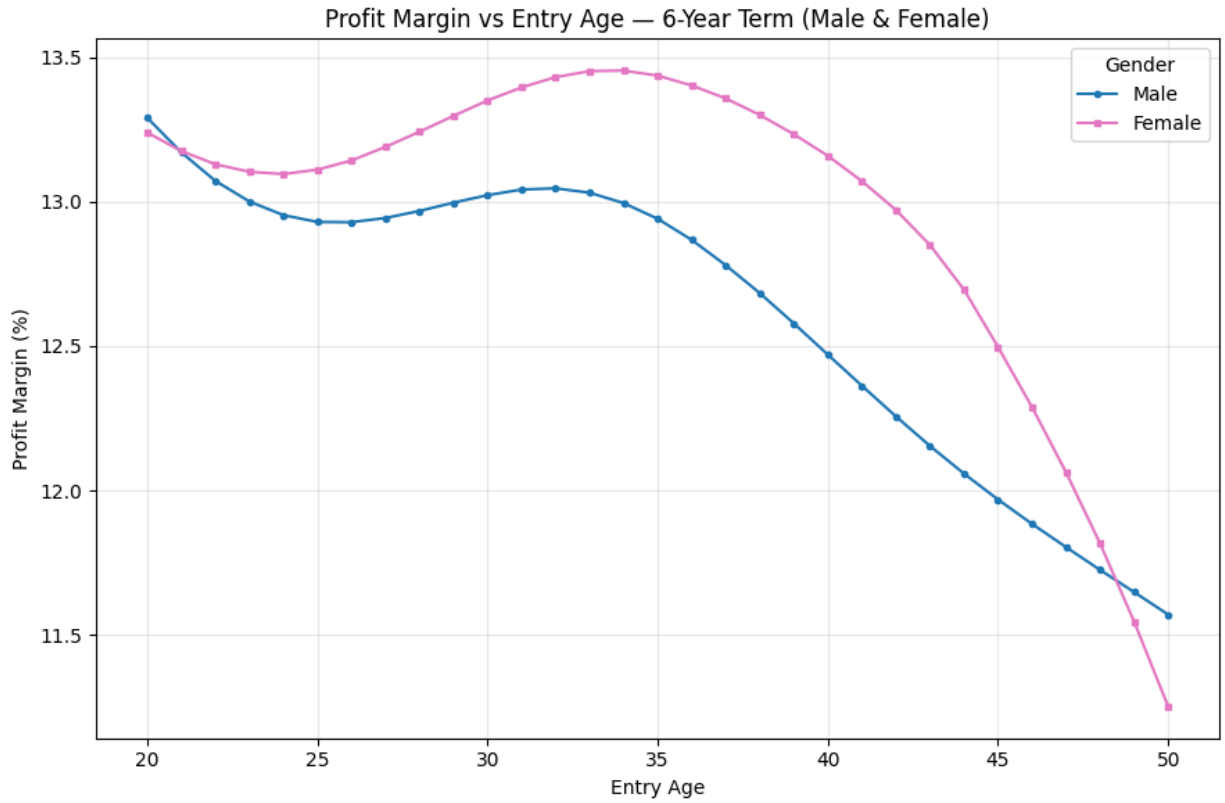


Figure 6: Profit margins across all ages for a 6-year policy

Appendix B.3: Profit margins across all ages for a 7-year policy

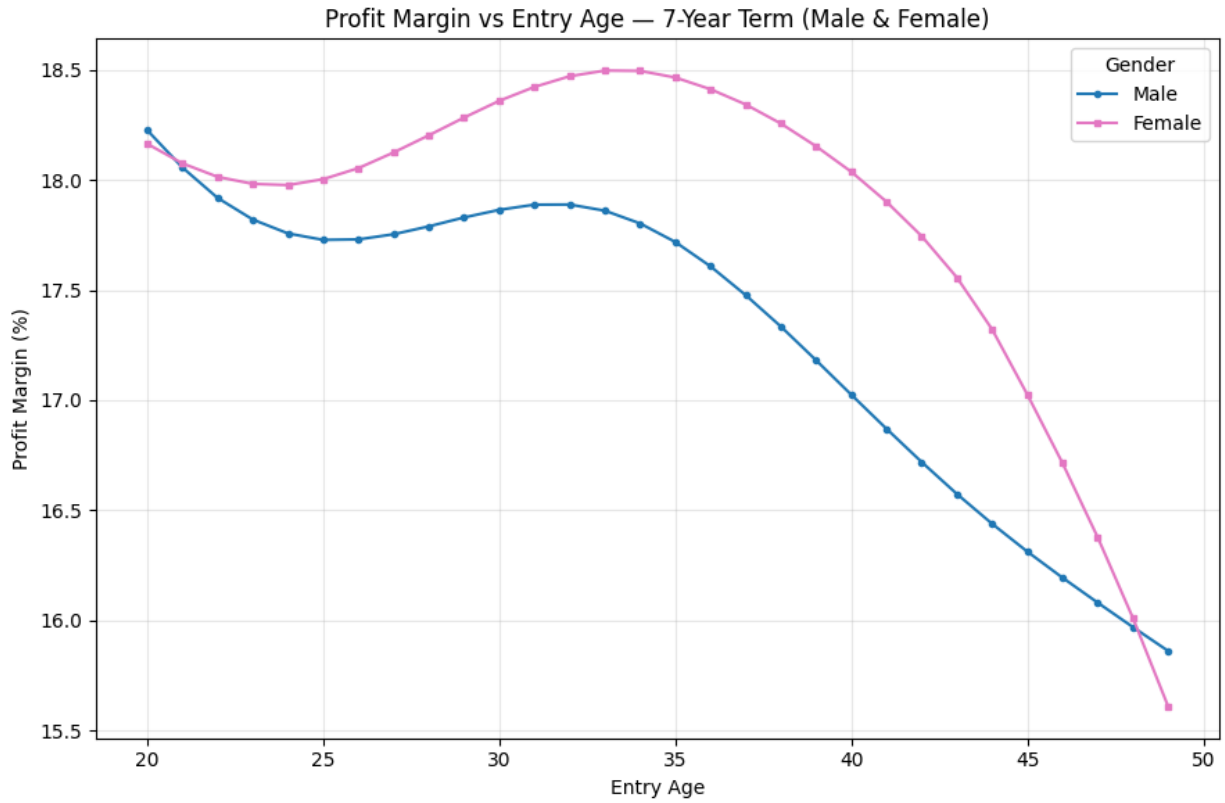


Figure 7: Profit margins across all ages for a 7-year policy

Appendix C: Variation in premiums for various policy terms

Appendix C.1: Premiums across all ages for a 5-year policy

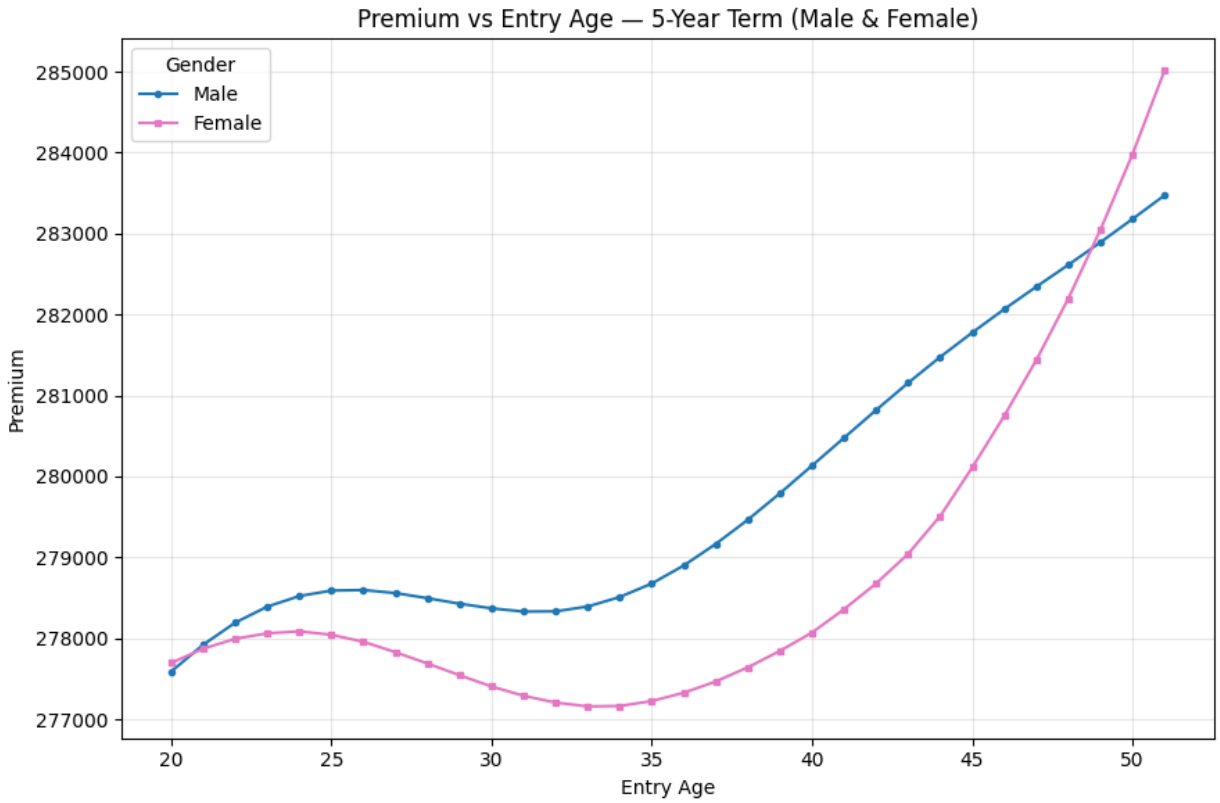


Figure 8: Premiums across all ages for a 5-year policy

Appendix C.2: Premiums across all ages for a 6-year policy

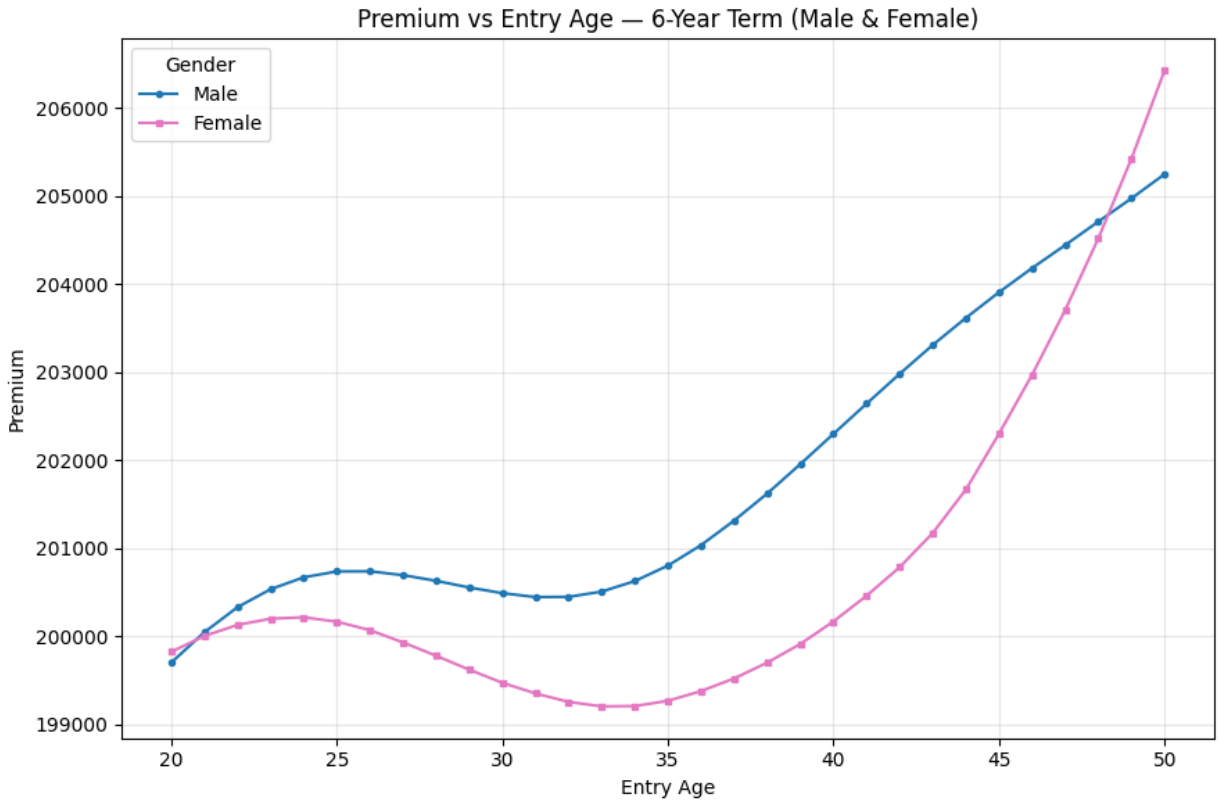


Figure 9: Premiums across all ages for a 6-year policy

Appendix C.3: Premiums across all ages for a 7-year policy

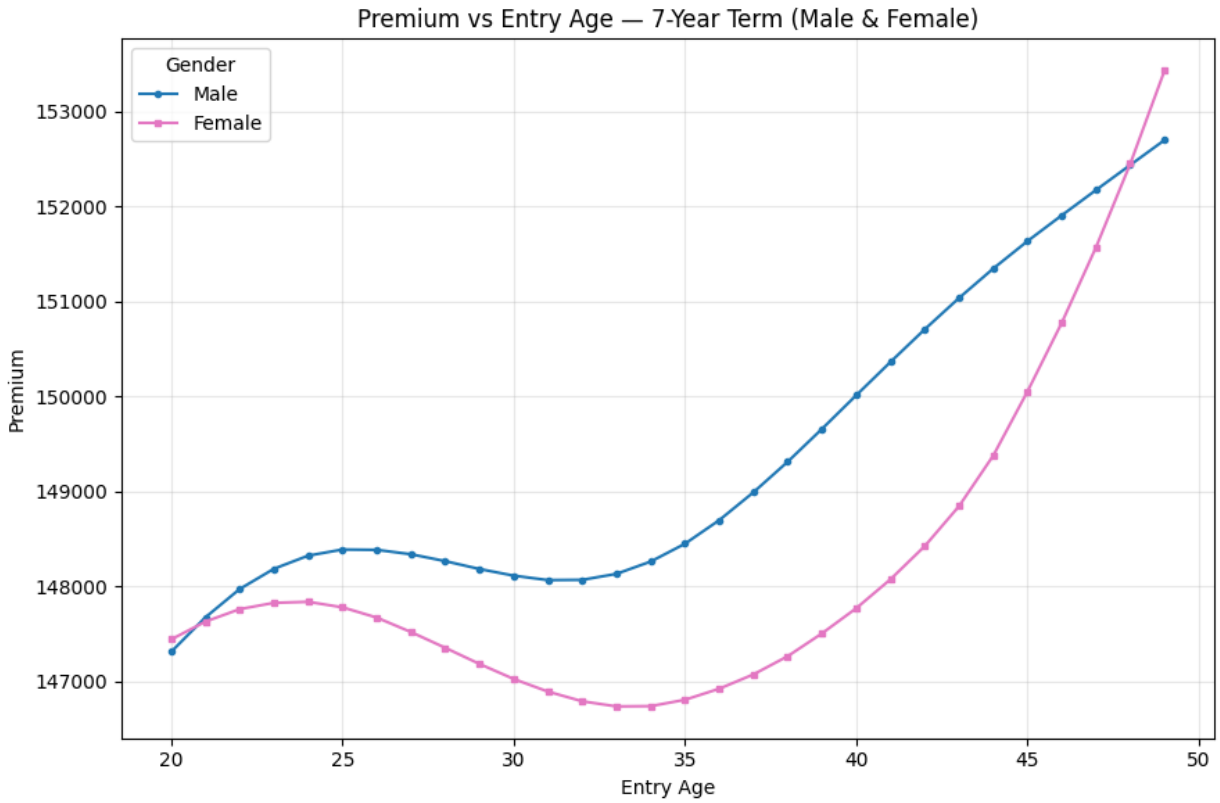
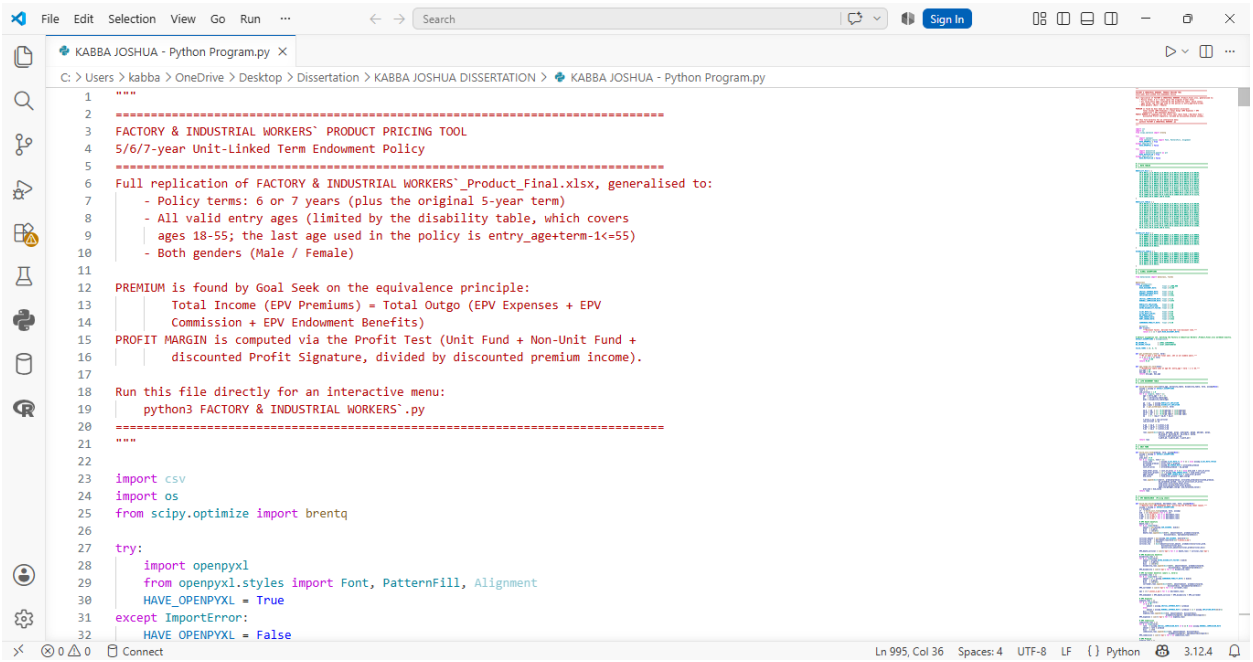
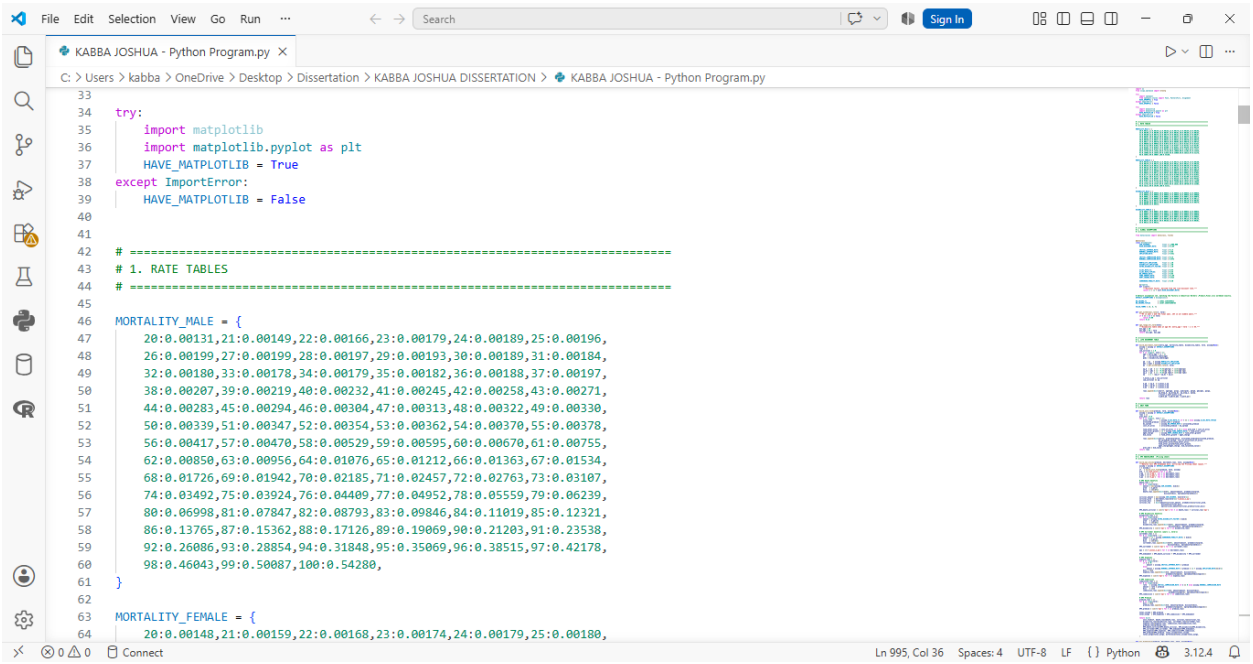
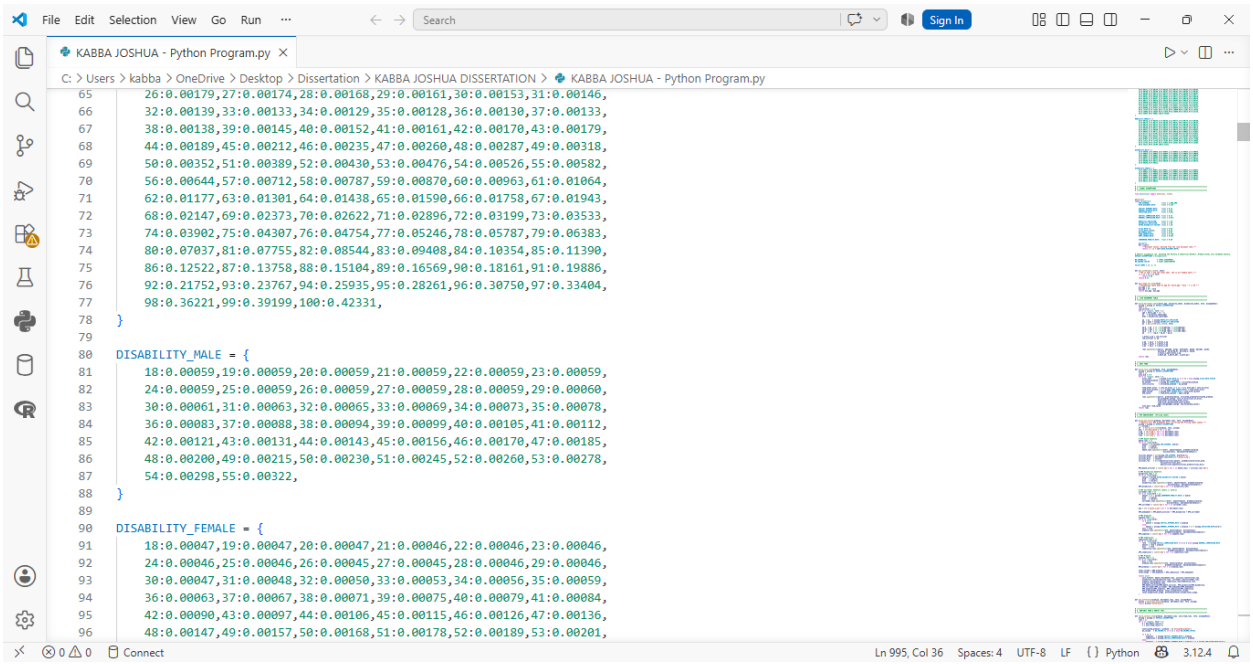


Figure 10: Premiums across all ages for a 7-year policy

Appendix D: Python program code.



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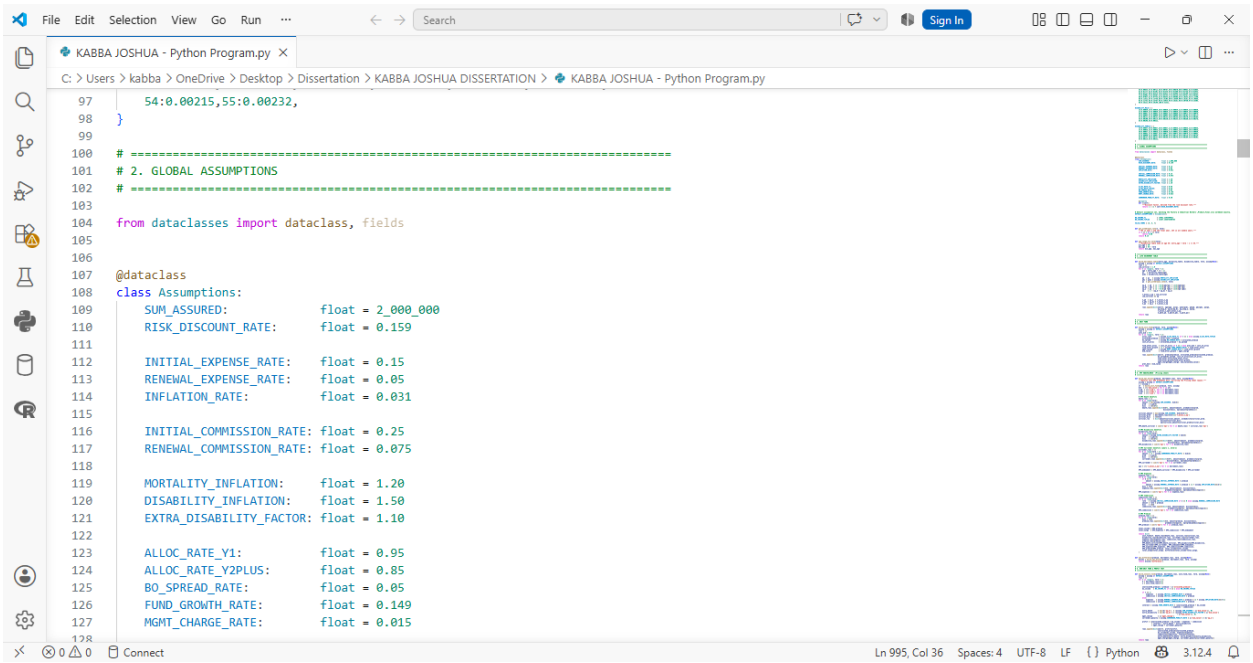
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# 2. GLOBAL ASSUMPTIONS
# ==
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@dataclass
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RISK_DISCOUNT_RATE: float = 0.159
INITIAL_EXPENSE_RATE: float = 0.15
RENEWAL_EXPENSE_RATE: float = 0.05
INFLATION_RATE: float = 0.031
INITIAL_COMMISSION_RATE: float = 0.25
RENEWAL_COMMISSION_RATE: float = 0.075
MORTALITY_INFLATION: float = 1.20
DISABILITY_INFLATION: float = 1.50
EXTRA_DISABILITY_FACTOR: float = 1.10
ALLOC_RATE_Y1: float = 0.95
ALLOC_RATE_Y2PLUS: float = 0.85
BO_SPREAD_RATE: float = 0.05
FUND_GROWTH_RATE: float = 0.149
MGMT_CHARGE_RATE: float = 0.015
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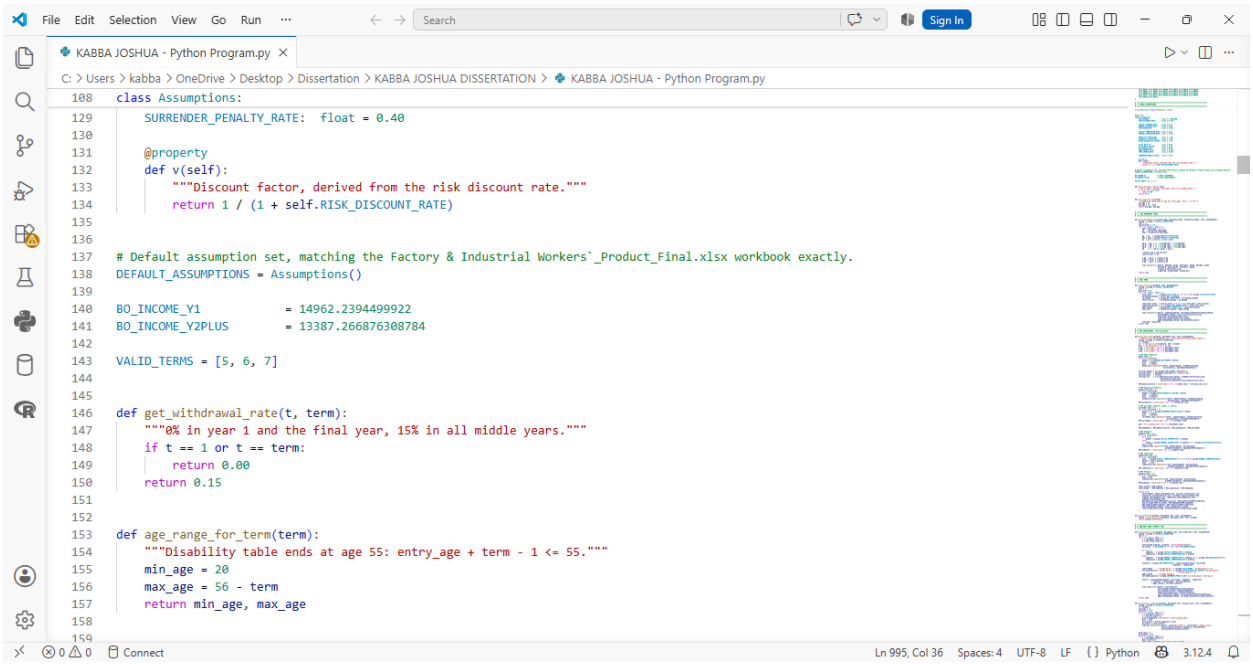
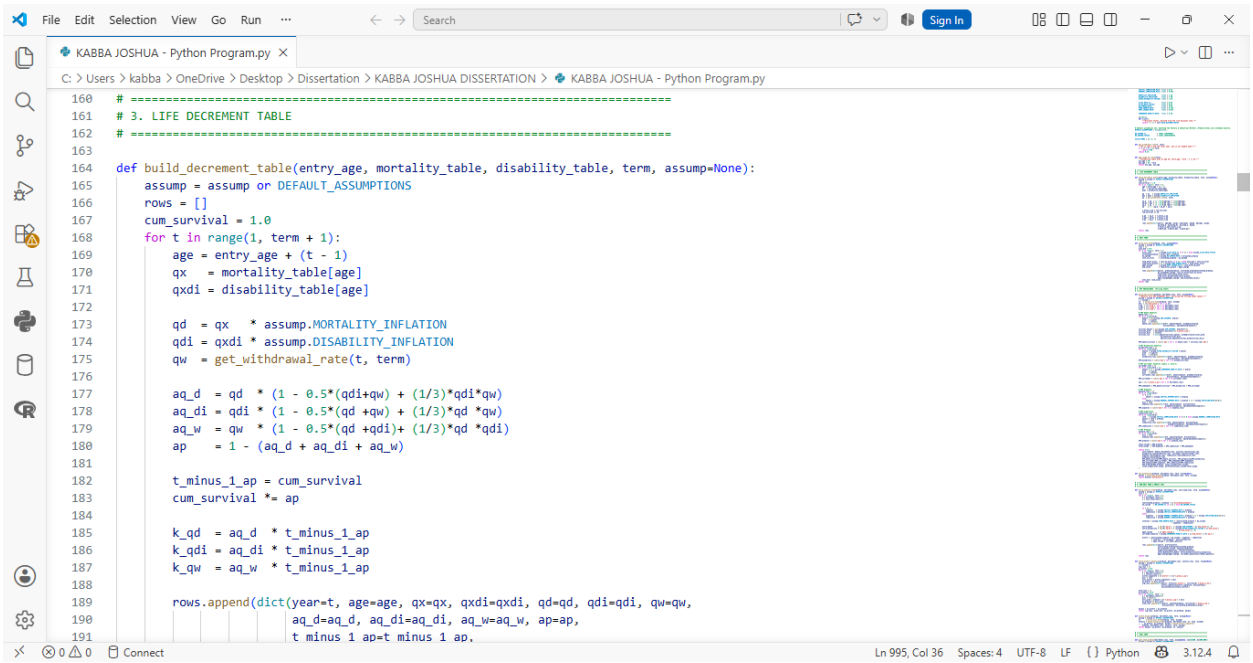
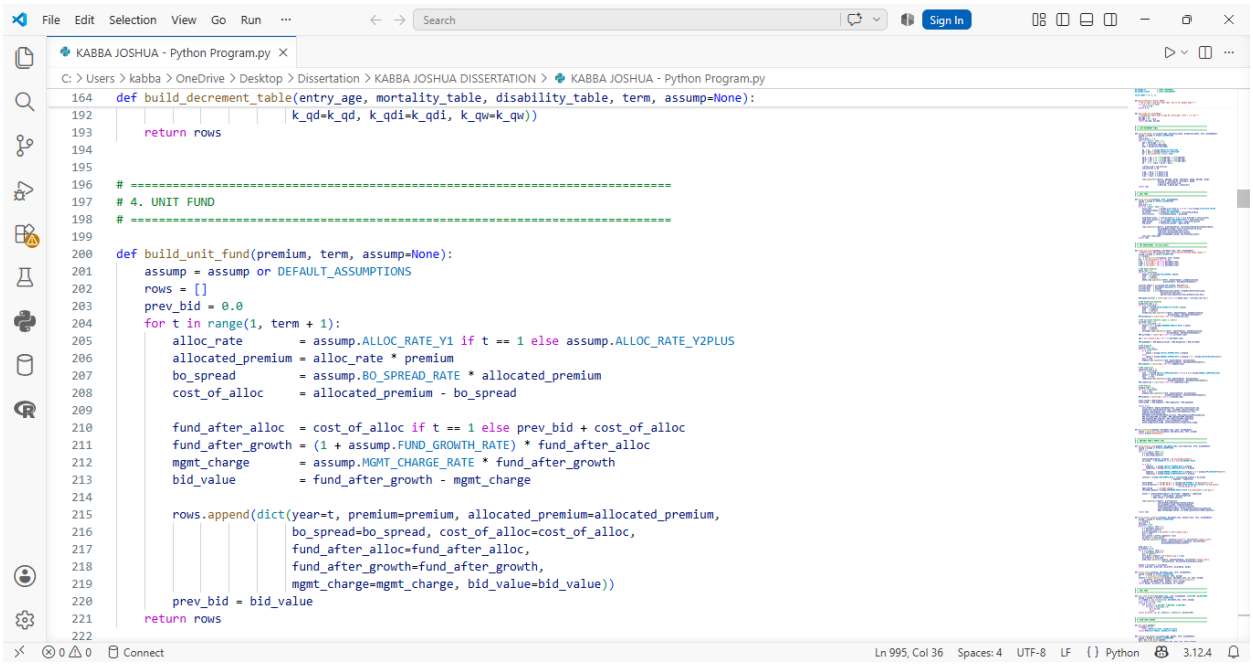
Ln 995, Col 36 Spaces: 4 UTF-8 LF Python 3.12.4



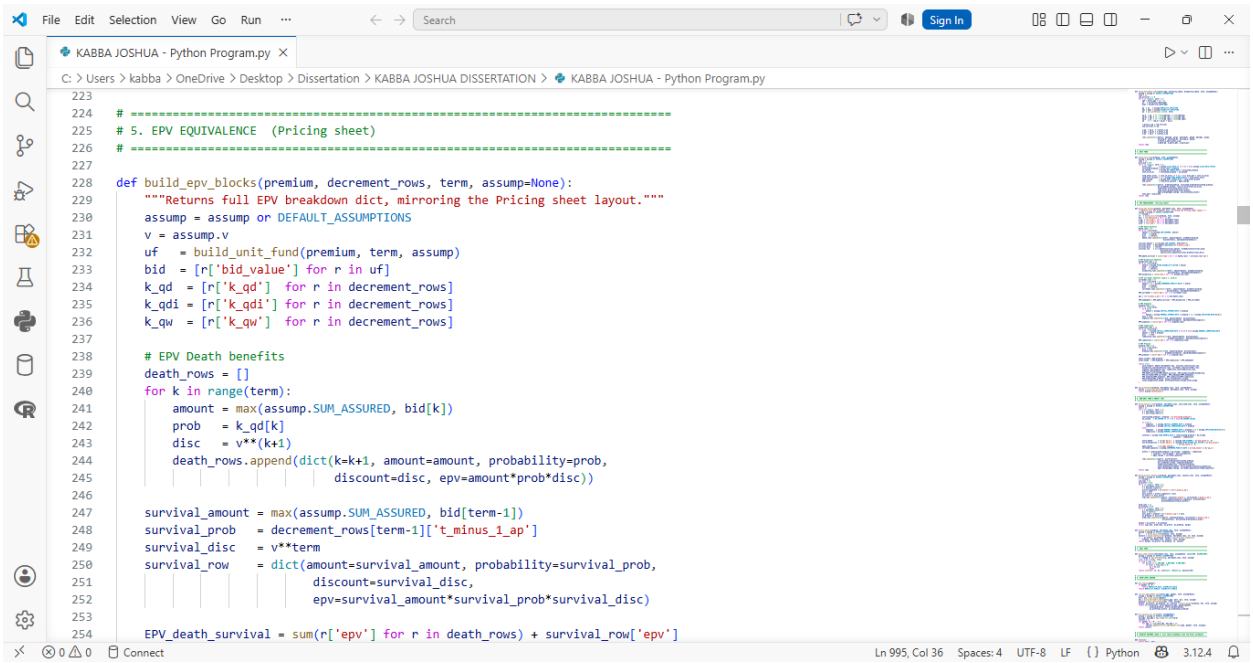
```
class Assumptions:
    SURRENDER_PENALTY_RATE:  float = 0.40

    @property
    def v(self):
        """Discount factor, derived from the risk discount rate."""
        return 1 / (1 + self.RISK_DISCOUNT_RATE)


# Default assumption set, matching the Factory & Industrial Workers`_Product_Final.xlsx workbook exactly.
DEFAULT_ASSUMPTIONS = Assumptions()

BO_INCOME_Y1            = 14962.2394499922
BO_INCOME_Y2PLUS        = 13387.266876308784

VALID_TERMS = [5, 6, 7]


def get_withdrawal_rate(t, term):
    """0% in year 1 and the final year, 15% in all middle years."""
    if t == 1 or t == term:
        return 0.00
    return 0.15


def age_range_for_term(term):
    """Disability table ends at age 55: entry_age + term - 1 <= 55."""
    min_age = 20
    max_age = 56 - term
    return min_age, max_age
```



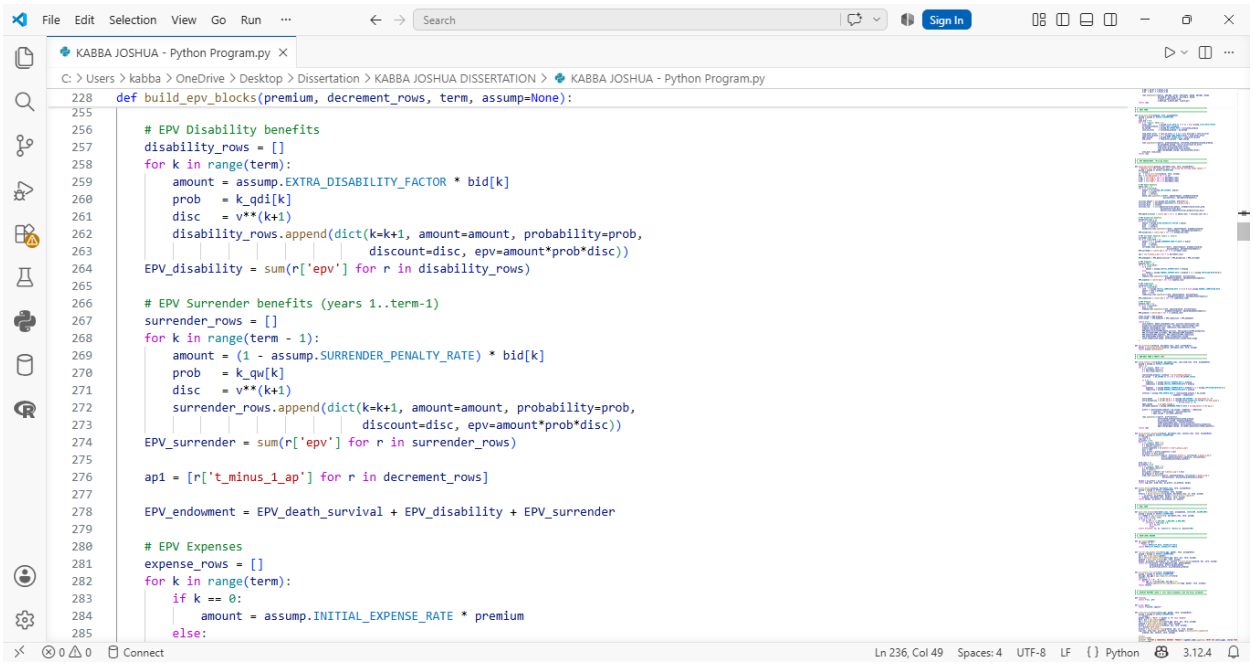
```
# ============================================================================
# 3. LIFE DECREMENT TABLE
# ============================================================================

def build_decrement_table(entry_age, mortality_table, disability_table, term, assump=None):
    assump = assump or DEFAULT_ASSUMPTIONS
    rows = []
    cum_survival = 1.0
    for t in range(1, term + 1):
        age = entry_age + (t - 1)
        qx   = mortality_table[age]
        qxdi = disability_table[age]

        qd  = qx   * assump.MORTALITY_INFLATION
        qdi = qxdi * assump.DISABILITY_INFLATION
        qw  = get_withdrawal_rate(t, term)

        aq_d  = qd  * (1 - 0.5*(qdi+qw) + (1/3)*qdi*qw)
        aq_di = qdi * (1 - 0.5*(qd +qw) + (1/3)*qd *qw)
        aq_w  = qw  * (1 - 0.5*(qd +qdi)+ (1/3)*qd *qdi)
        ap    = 1 - (aq_d + aq_di + aq_w)

        t_minus_1_ap = cum_survival
        cum_survival *= ap

        k_qd  = aq_d  * t_minus_1_ap
        k_qdi = aq_di * t_minus_1_ap
        k_qw  = aq_w  * t_minus_1_ap

        rows.append(dict(year=t, age=age, qx=qx, qxdi=qxdi, qd=qd, qdi=qdi, qw=qw,
                         aq_d=aq_d, aq_di=aq_di, aq_w=aq_w, ap=ap,
                         t_minus_1_ap=t_minus_1_ap,
```



```
def build_decrement_table(entry_age, mortality_table, disability_table, term, assump=None):
                          k_qd=k_qd, k_qdi=k_qdi, k_qw=k_qw))
    return rows


# ============================================================================
# 4. UNIT FUND
# ============================================================================

def build_unit_fund(premium, term, assump=None):
    assump = assump or DEFAULT_ASSUMPTIONS
    rows = []
    prev_bid = 0.0
    for t in range(1, term + 1):
        alloc_rate        = assump.ALLOC_RATE_Y1 if t == 1 else assump.ALLOC_RATE_Y2PLUS
        allocated_premium = alloc_rate * premium
        bo_spread         = assump.BO_SPREAD_RATE * allocated_premium
        cost_of_alloc     = allocated_premium - bo_spread

        fund_after_alloc  = cost_of_alloc if t == 1 else prev_bid + cost_of_alloc
        fund_after_growth = (1 + assump.FUND_GROWTH_RATE) * fund_after_alloc
        mgmt_charge       = assump.MGMT_CHARGE_RATE * fund_after_growth
        bid_value         = fund_after_growth - mgmt_charge

        rows.append(dict(year=t, premium=premium, allocated_premium=allocated_premium,
                         bo_spread=bo_spread, cost_of_alloc=cost_of_alloc,
                         fund_after_alloc=fund_after_alloc,
                         fund_after_growth=fund_after_growth,
                         mgmt_charge=mgmt_charge, bid_value=bid_value))
        prev_bid = bid_value
    return rows
```



```
# ============================================================================
# 5. EPV EQUIVALENCE  (Pricing sheet)
# ============================================================================

def build_epv_blocks(premium, decrement_rows, term, assump=None):
    """Returns full EPV breakdown dict, mirroring the Pricing sheet layout."""
    assump = assump or DEFAULT_ASSUMPTIONS
    v = assump.v
    uf   = build_unit_fund(premium, term, assump)
    bid  = [r['bid_value'] for r in uf]
    k_qd  = [r['k_qd']  for r in decrement_rows]
    k_qdi = [r['k_qdi'] for r in decrement_rows]
    k_qw  = [r['k_qw']  for r in decrement_rows]

    # EPV Death benefits
    death_rows = []
    for k in range(term):
        amount = max(assump.SUM_ASSURED, bid[k])
        prob   = k_qd[k]
        disc   = v**(k+1)
        death_rows.append(dict(k=k+1, amount=amount, probability=prob,
                               discount=disc, epv=amount*prob*disc))

    survival_amount = max(assump.SUM_ASSURED, bid[term-1])
    survival_prob   = decrement_rows[term-1]['t_minus_1_ap']
    survival_disc   = v**term
    survival_row    = dict(amount=survival_amount, probability=survival_prob,
                           discount=survival_disc,
                           epv=survival_amount*survival_prob*survival_disc)

    EPV_death_survival = sum(r['epv'] for r in death_rows) + survival_row['epv']
```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def build_epv_blocks(premium, decrement_rows, term, assump=None):
# EPV Disability benefits
disability_rows = []
for k in range(term):
amount = assump.EXTRA_DISABILITY_FACTOR * bid[k]
prob = k_qdi[k]
disc = v**(k+1)
disability_rows.append(dict(k=k+1, amount=amount, probability=prob,
discount=disc, epv=amount*prob*disc))
EPV_disability = sum(r['epv'] for r in disability_rows)
# EPV Surrender benefits (years 1..term-1)
surrender_rows = []
for k in range(term - 1):
amount = (1 - assump.SURRENDER_PENALTY_RATE) * bid[k]
prob = k_qw[k]
disc = v**(k+1)
surrender_rows.append(dict(k=k+1, amount=amount, probability=prob,
discount=disc, epv=amount*prob*disc))
EPV_surrender = sum(r['epv'] for r in surrender_rows)
ap1 = [r['t_minus_1_ap'] for r in decrement_rows]
EPV_endowment = EPV_death_survival + EPV_disability + EPV_surrender
# EPV Expenses
expense_rows = []
for k in range(term):
if k == 0:
amount = assump.INITIAL_EXPENSE_RATE * premium
else:
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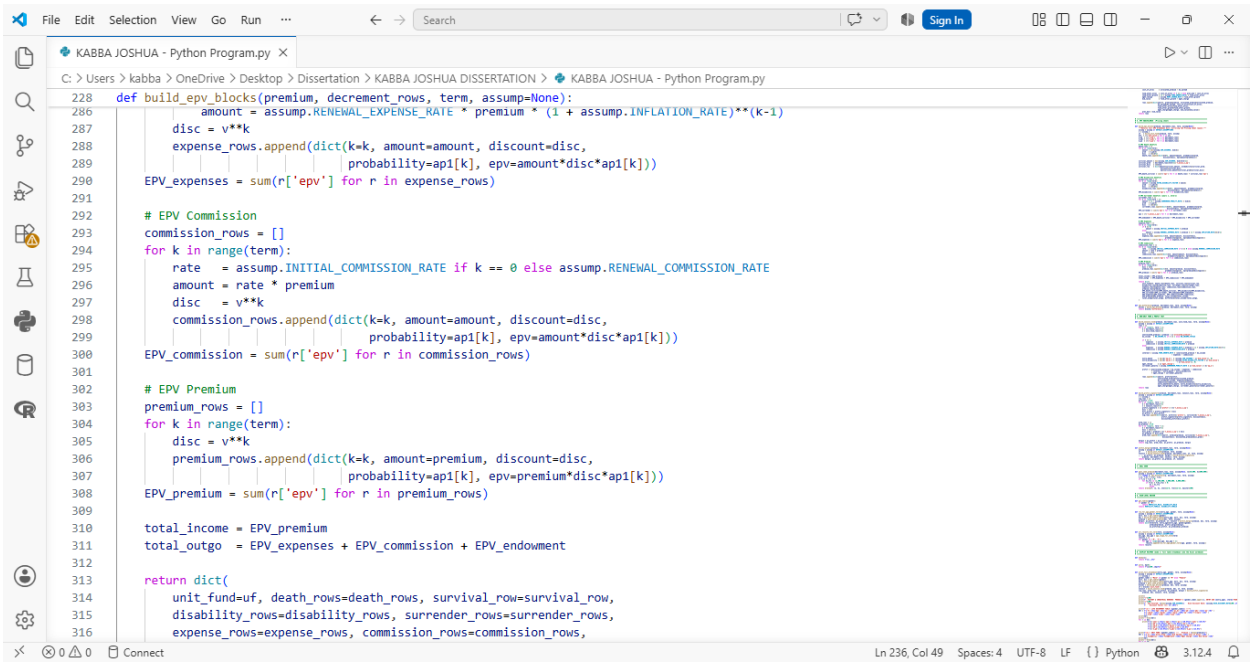
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def build_epv_blocks(premium, decrement_rows, term, assump=None):
amount = assump.RENEWAL_EXPENSE_RATE * premium * (1 + assump.INFLATION_RATE)**(k-1)
disc = v**k
expense_rows.append(dict(k=k, amount=amount, discount=disc,
probability=ap1[k], epv=amount*disc*ap1[k]))
EPV_expenses = sum(r['epv'] for r in expense_rows)
# EPV Commission
commission_rows = []
for k in range(term):
rate = assump.INITIAL_COMMISSION_RATE if k == 0 else assump.RENEWAL_COMMISSION_RATE
amount = rate * premium
disc = v**k
commission_rows.append(dict(k=k, amount=amount, discount=disc,
probability=ap1[k], epv=amount*disc*ap1[k]))
EPV_commission = sum(r['epv'] for r in commission_rows)
# EPV Premium
premium_rows = []
for k in range(term):
disc = v**k
premium_rows.append(dict(k=k, amount=premium, discount=disc,
probability=ap1[k], epv=premium*disc*ap1[k]))
EPV_premium = sum(r['epv'] for r in premium_rows)
total_income = EPV_premium
total_outgo = EPV_expenses + EPV_commission + EPV_endowment
return dict(
unit_fund=uf, death_rows=death_rows, survival_row=survival_row,
disability_rows=disability_rows, surrender_rows=surrender_rows,
expense_rows=expense_rows, commission_rows=commission_rows,
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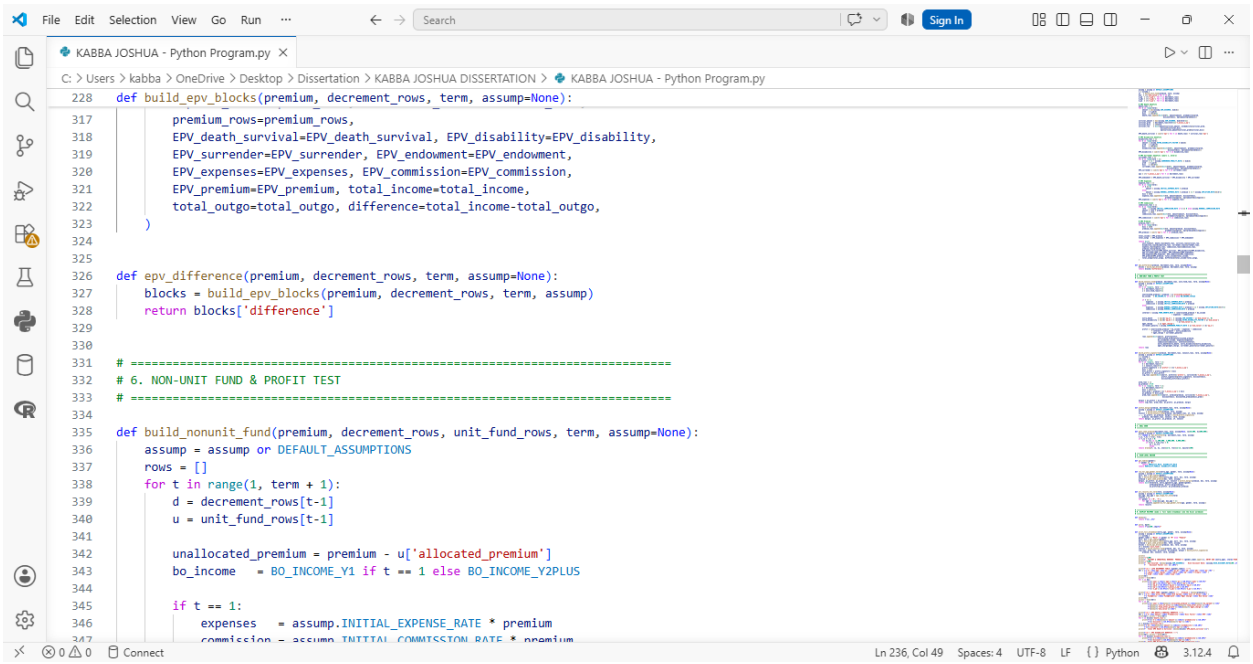
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def build_epv_blocks(premium, decrement_rows, term, assump=None):
premium_rows=premium_rows,
EPV_death_survival=EPV_death_survival, EPV_disability=EPV_disability,
EPV_surrender=EPV_surrender, EPV_endowment=EPV_endowment,
EPV_expenses=EPV_expenses, EPV_commission=EPV_commission,
EPV_premium=EPV_premium, total_income=total_income,
total_outgo=total_outgo, difference=total_income-total_outgo,
)
def epv_difference(premium, decrement_rows, term, assump=None):
blocks = build_epv_blocks(premium, decrement_rows, term, assump)
return blocks['difference']
# ==
# 6. NON-UNIT FUND & PROFIT TEST
# ==
def build_nonunit_fund(premium, decrement_rows, unit_fund_rows, term, assump=None):
assump = assump or DEFAULT_ASSUMPTIONS
rows = []
for t in range(1, term + 1):
d = decrement_rows[t-1]
u = unit_fund_rows[t-1]
unallocated_premium = premium - u['allocated_premium']
bo_income = BO_INCOME_Y1 if t == 1 else BO_INCOME_Y2PLUS
if t == 1:
expenses = assump.INITIAL_EXPENSE_RATE * premium
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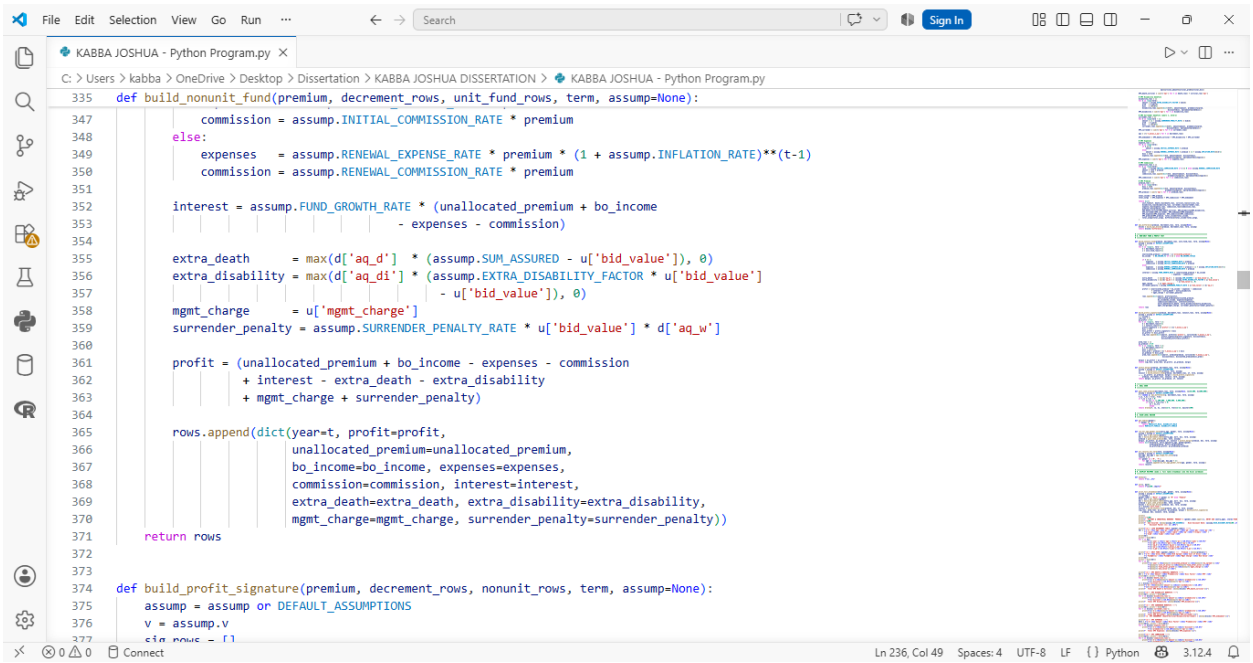
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def build_nonunit_fund(premium, decrement_rows, unit_fund_rows, term, assump=None):
commission = assump.INITIAL_COMMISSION_RATE * premium
else:
expenses = assump.RENEWAL_EXPENSE_RATE * premium * (1 + assump.INFLATION_RATE)**(t-1)
commission = assump.RENEWAL_COMMISSION_RATE * premium
interest = assump.FUND_GROWTH_RATE * (unallocated_premium + bo_income
- expenses - commission)
extra_death = max(d['aq_d'] * (assump.SUM_ASSURED - u['bid_value']), 0)
extra_disability = max(d['aq_di'] * (assump.EXTRA_DISABILITY_FACTOR * u['bid_value']
- u['bid_value']), 0)
mgmt_charge = u['mgmt_charge']
surrender_penalty = assump.SURRENDER_PENALTY_RATE * u['bid_value'] * d['aq_w']
profit = (unallocated_premium + bo_income - expenses - commission
+ interest - extra_death - extra_disability
+ mgmt_charge + surrender_penalty)
rows.append(dict(year=t, profit=profit,
unallocated_premium=unallocated_premium,
bo_income=bo_income, expenses=expenses,
commission=commission, interest=interest,
extra_death=extra_death, extra_disability=extra_disability,
mgmt_charge=mgmt_charge, surrender_penalty=surrender_penalty))
return rows
def build_profit_signature(premium, decrement_rows, nonunit_rows, term, assump=None):
assump = assump or DEFAULT_ASSUMPTIONS
v = assump.v
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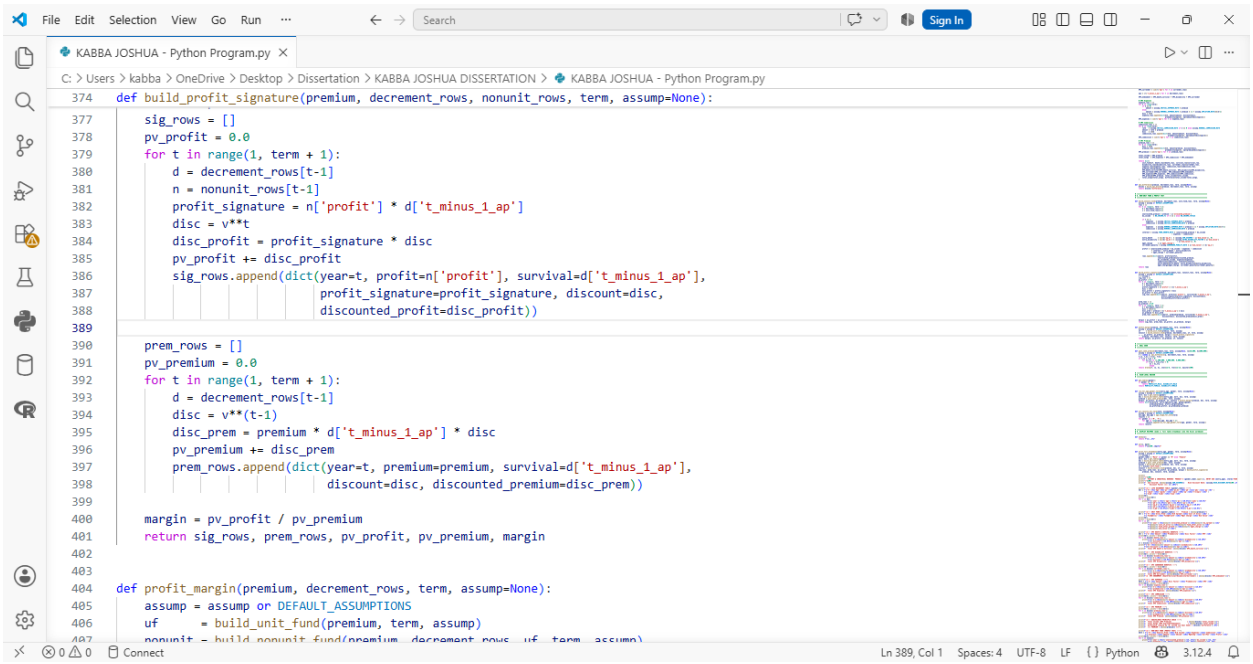
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374 def build_profit_signature(premium, decrement_rows, nonunit_rows, term, assump=None):
377 sig_rows = []
378 pv_profit = 0.0
379 for t in range(1, term + 1):
380 d = decrement_rows[t-1]
381 n = nonunit_rows[t-1]
382 profit_signature = n['profit'] * d['t_minus_1_ap']
383 disc = v**t
384 disc_profit = profit_signature * disc
385 pv_profit += disc_profit
386 sig_rows.append(dict(year=t, profit=n['profit'], survival=d['t_minus_1_ap'],
387 profit_signature=profit_signature, discount=disc,
388 discounted_profit=disc_profit))
389
390 prem_rows = []
391 pv_premium = 0.0
392 for t in range(1, term + 1):
393 d = decrement_rows[t-1]
394 disc = v**(t-1)
395 disc_prem = premium * d['t_minus_1_ap'] * disc
396 pv_premium += disc_prem
397 prem_rows.append(dict(year=t, premium=premium, survival=d['t_minus_1_ap'],
398 discount=disc, discounted_premium=disc_prem))
399
400 margin = pv_profit / pv_premium
401 return sig_rows, prem_rows, pv_profit, pv_premium, margin
402
403
404 def profit_margin(premium, decrement_rows, term, assump=None):
405 assump = assump or DEFAULT_ASSUMPTIONS
406 uf = build_unit_fund(premium, term, assump)
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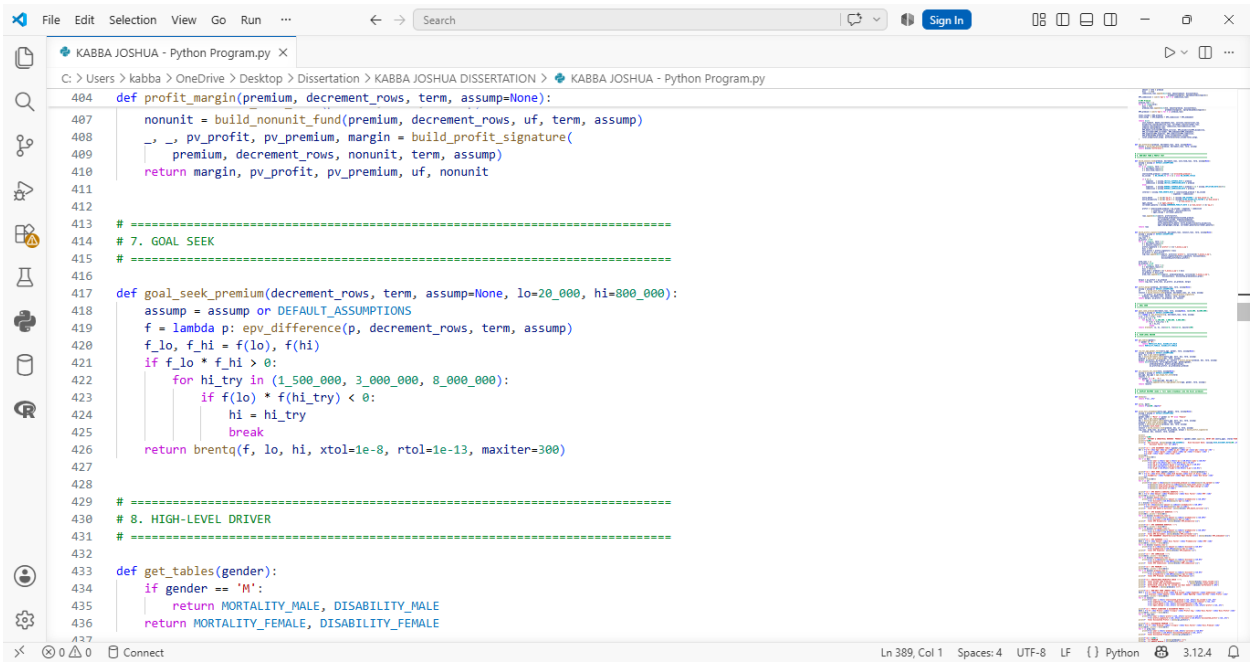
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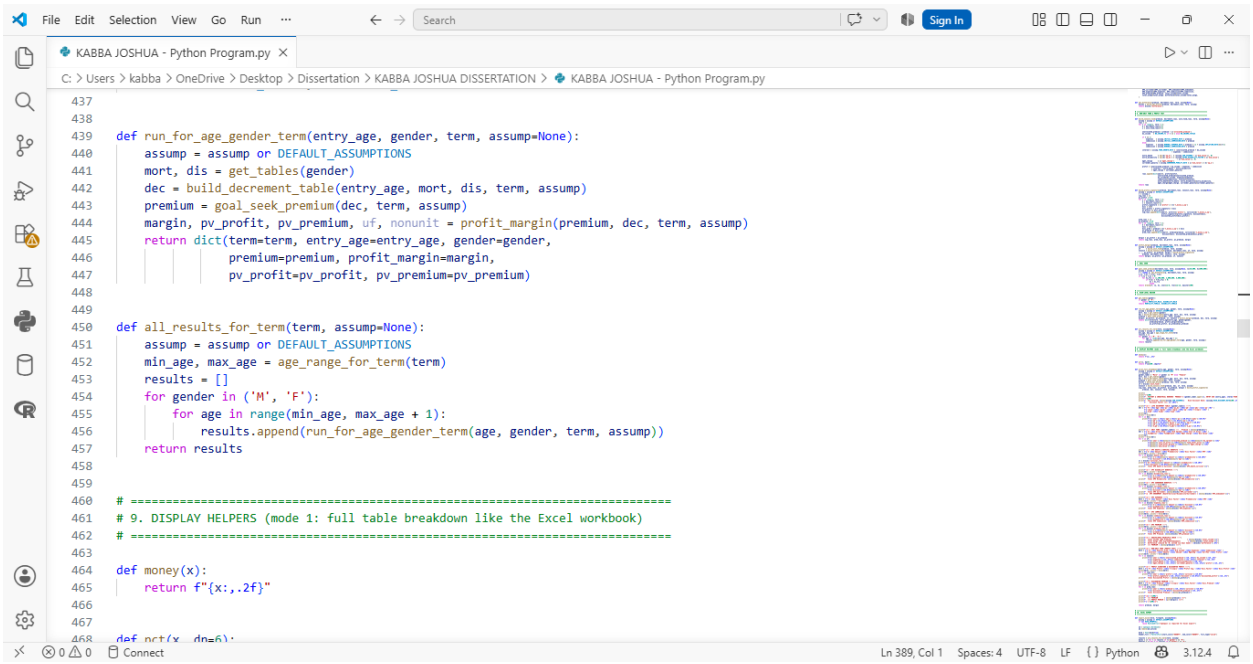
404 def profit_margin(premium, decrement_rows, term, assump=None):
407 nonunit = build_nonunit_fund(premium, decrement_rows, uf, term, assump)
408 _, _, pv_profit, pv_premium, margin = build_profit_signature(
409 premium, decrement_rows, nonunit, term, assump)
410 return margin, pv_profit, pv_premium, uf, nonunit
411
412
413 # ==
414 # 7. GOAL SEEK
415 # ==
416
417 def goal_seek_premium(decrement_rows, term, assump=None, lo=20_000, hi=800_000):
418 assump = assump or DEFAULT_ASSUMPTIONS
419 f = lambda p: epv_difference(p, decrement_rows, term, assump)
420 f_lo, f_hi = f(lo), f(hi)
421 if f_lo * f_hi > 0:
422 for hi_try in (1_500_000, 3_000_000, 8_000_000):
423 if f(lo) * f(hi_try) < 0:
424 hi = hi_try
425 break
426 return brentq(f, lo, hi, xtol=1e-8, rtol=1e-13, maxiter=300)
427
428
429 # ==
430 # 8. HIGH-LEVEL DRIVER
431 # ==
432
433 def get_tables(gender):
434 if gender == 'M':
435 return MORTALITY_MALE, DISABILITY_MALE
436 return MORTALITY_FEMALE, DISABILITY_FEMALE
Ln 389, Col 1 Spaces: 4 UTF-8 LF Python 3.12.4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437
438
439 def run_for_age_gender_term(entry_age, gender, term, assump=None):
440 assump = assump or DEFAULT_ASSUMPTIONS
441 mort, dis = get_tables(gender)
442 dec = build_decrement_table(entry_age, mort, dis, term, assump)
443 premium = goal_seek_premium(dec, term, assump)
444 margin, pv_profit, pv_premium, uf, nonunit = profit_margin(premium, dec, term, assump)
445 return dict(term=term, entry_age=entry_age, gender=gender,
446 premium=premium, profit_margin=margin,
447 pv_profit=pv_profit, pv_premium=pv_premium)
448
449
450 def all_results_for_term(term, assump=None):
451 assump = assump or DEFAULT_ASSUMPTIONS
452 min_age, max_age = age_range_for_term(term)
453 results = []
454 for gender in ('M', 'F'):
455 for age in range(min_age, max_age + 1):
456 results.append(run_for_age_gender_term(age, gender, term, assump))
457 return results
458
459
460 # ==
461 # 9. DISPLAY HELPERS (mode 1: full table breakdown like the Excel workbook)
462 # ==
463
464 def money(x):
465 return f"{x:,.2f}"
466
467
468 def pct(x, dp=6):
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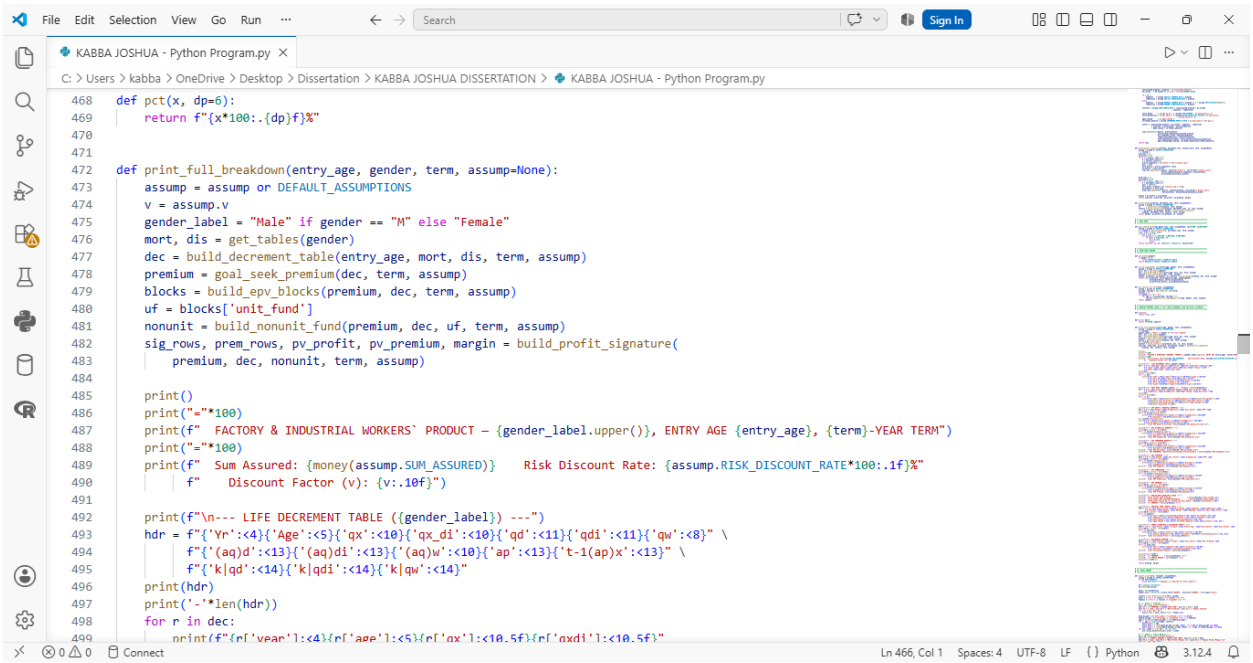
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468 def pct(x, dp=6):
469 return f"{x*100:.{dp}f}%"
470
471
472 def print_full_breakdown(entry_age, gender, term, assump=None):
473 assump = assump or DEFAULT_ASSUMPTIONS
474 v = assump.v
475 gender_label = "Male" if gender == "M" else "Female"
476 mort, dis = get_tables(gender)
477 dec = build_decrement_table(entry_age, mort, dis, term, assump)
478 premium = goal_seek_premium(dec, term, assump)
479 blocks = build_epv_blocks(premium, dec, term, assump)
480 uf = blocks['unit_fund']
481 nonunit = build_nonunit_fund(premium, dec, uf, term, assump)
482 sig_rows, prem_rows, pv_profit, pv_premium, margin = build_profit_signature(
483 premium, dec, nonunit, term, assump)
484
485 print()
486 print("="*100)
487 print(f" FACTORY & INDUSTRIAL WORKERS` PRODUCT — {gender_label.upper()}, ENTRY AGE {entry_age}, {term}-YEAR TERM")
488 print("="*100)
489 print(f" Sum Assured: {money(assump.SUM_ASSURED)} Risk Discount Rate: {assump.RISK_DISCOUNT_RATE*100:.1f}%"
490 f" Discount Factor (v): {v:.10f}")
491
492 print(f"\n--- LIFE DECREMENT TABLE ({gender_label}) ---")
493 hdr = f"{'Yr':<4}{'Age':<5}{'qx':<10}{'qx_di':<10}{'qd':<11}{'qdi':<11}{'qw':<8} \
494 f"{'(aq)d':<13}{'(aq)di':<13}{'(aq)w':<10}{'ap':<13}{'t-1(ap)x':<13}" \
495 f"{'k|qd':<14}{'k|qdi':<14}{'k|qw':<14}"
496 print(hdr)
497 print('-'*len(hdr))
498 for r in dec:
499 print(f"{r['year']:<4}{r['age']:<5}{r['qx']:<10.5f}{r['qxdi']:<10.5f}"
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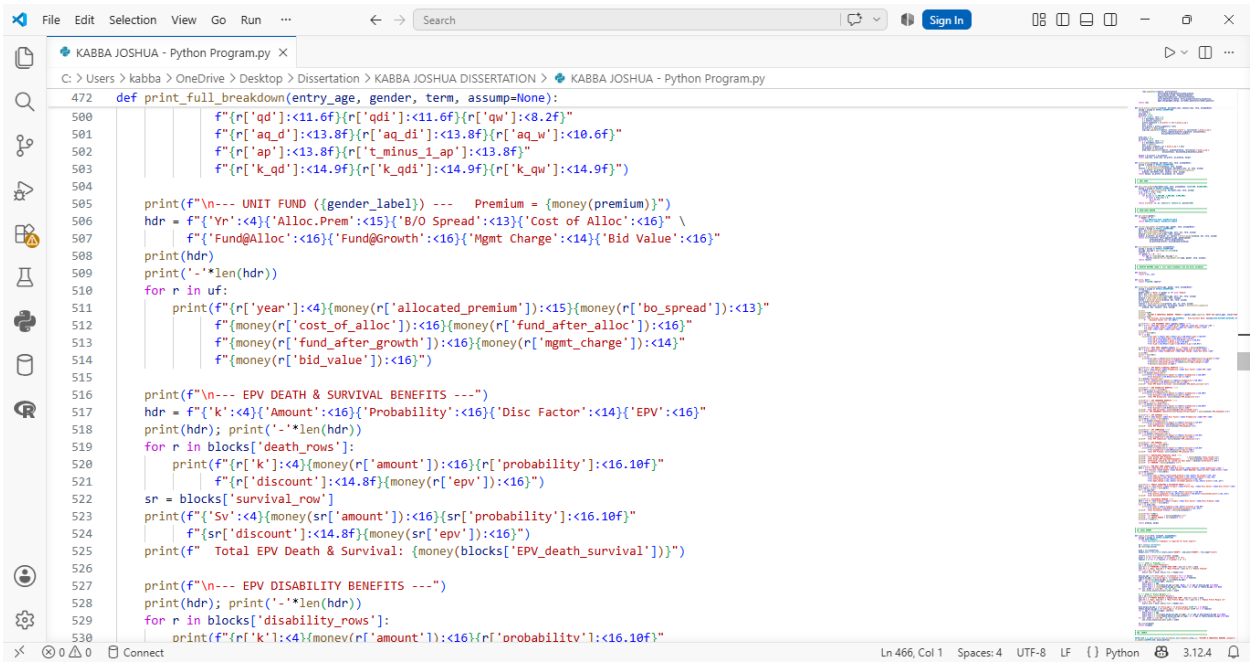
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472 def print_full_breakdown(entry_age, gender, term, assump=None):
500 f"{r['qd']:<11.6f}{r['qdi']:<11.6f}{r['qw']:<8.2f}"
501 f"{r['aq_d']:<13.8f}{r['aq_di']:<13.8f}{r['aq_w']:<10.6f}"
502 f"{r['ap']:<13.8f}{r['t_minus_1_ap']:<13.8f}"
503 f"{r['k_qd']:<14.9f}{r['k_qdi']:<14.9f}{r['k_qw']:<14.9f}")
504
505 print(f"\n--- UNIT FUND ({gender_label}) --- Premium = {money(premium)}")
506 hdr = f"{'Yr':<4}{'Alloc.Prem':<15}{'B/O Spread':<13}{'Cost of Alloc':<16}" \
507 f"{'Fund@Alloc':<16}{'Fund@Growth':<16}{'Mgmt Charge':<14}{'Bid Value':<16}"
508 print(hdr)
509 print('-'*len(hdr))
510 for r in uf:
511 print(f"{r['year']:<4}{money(r['allocated_premium']):<15}{money(r['bo_spread']):<13}"
512 f"{money(r['cost_of_alloc']):<16}{money(r['fund_after_alloc']):<16}"
513 f"{money(r['fund_after_growth']):<16}{money(r['mgmt_charge']):<14}"
514 f"{money(r['bid_value']):<16}")
515
516 print(f"\n--- EPV DEATH & SURVIVAL BENEFITS ---")
517 hdr = f"{'k':<4}{'Amount':<16}{'Probability':<16}{'Disc Factor':<14}{'EPV':<16}"
518 print(hdr); print('-'*len(hdr))
519 for r in blocks['death_rows']:
520 print(f"{r['k']:<4}{money(r['amount']):<16}{r['probability']:<16.10f}"
521 f"{r['discount']:<14.8f}{money(r['epv']):<16}")
522 sr = blocks['survival_row']
523 print(f"{'Sv':<4}{money(sr['amount']):<16}{sr['probability']:<16.10f}"
524 f"{sr['discount']:<14.8f}{money(sr['epv']):<16}")
525 print(f" Total EPV Death & Survival: {money(blocks['EPV_death_survival'])}")
526
527 print(f"\n--- EPV DISABILITY BENEFITS ---")
528 print(hdr); print('-'*len(hdr))
529 for r in blocks['disability_rows']:
530 print(f"{r['k']:<4}{money(r['amount']):<16}{r['probability']:<16.10f}"
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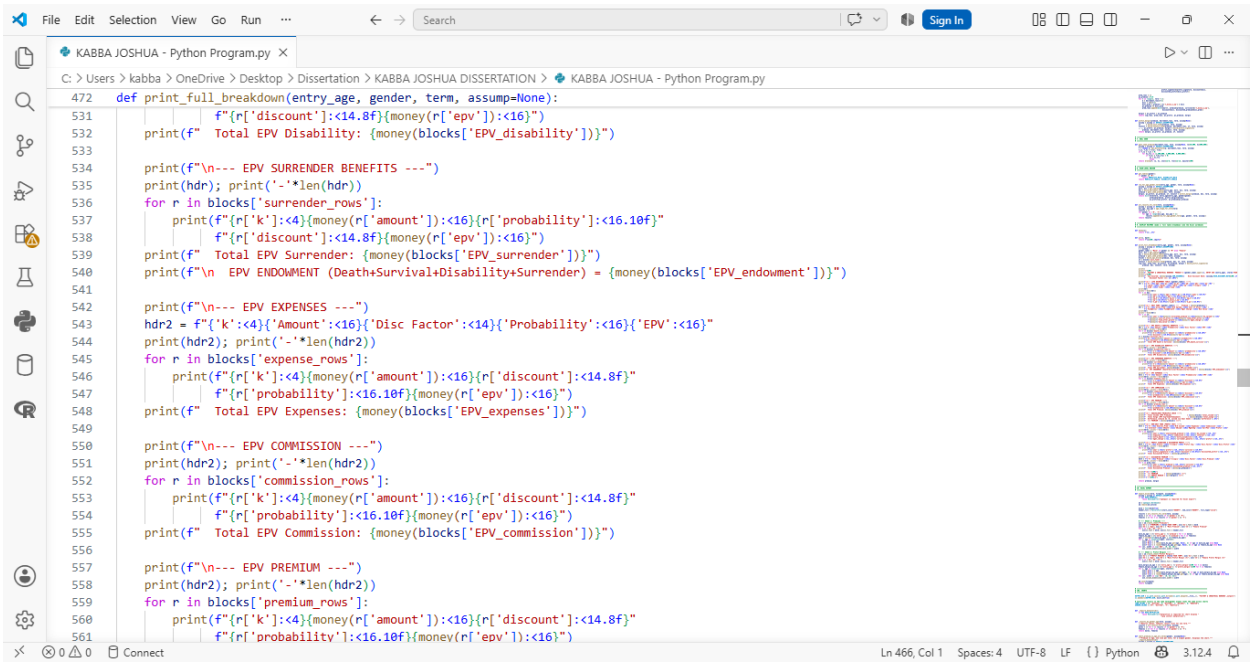
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472 def print_full_breakdown(entry_age, gender, term, assump=None):
531 f"{r['discount']:<14.8f}{money(r['epv']):<16}")
532 print(f" Total EPV Disability: {money(blocks['EPV_disability'])}")
533
534 print(f"\n--- EPV SURRENDER BENEFITS ---")
535 print(hdr); print('-'*len(hdr))
536 for r in blocks['surrender_rows']:
537 print(f"{r['k']:<4}{money(r['amount']):<16}{r['probability']:<16.10f}"
538 f"{r['discount']:<14.8f}{money(r['epv']):<16}")
539 print(f" Total EPV Surrender: {money(blocks['EPV_surrender'])}")
540 print(f"\n EPV ENDOWMENT (Death+Survival+Disability+Surrender) = {money(blocks['EPV_endowment'])}")
541
542 print(f"\n--- EPV EXPENSES ---")
543 hdr2 = f"{'k':<4}{'Amount':<16}{'Disc Factor':<14}{'Probability':<16}{'EPV':<16}"
544 print(hdr2); print('-'*len(hdr2))
545 for r in blocks['expense_rows']:
546 print(f"{r['k']:<4}{money(r['amount']):<16}{r['discount']:<14.8f}"
547 f"{r['probability']:<16.10f}{money(r['epv']):<16}")
548 print(f" Total EPV Expenses: {money(blocks['EPV_expenses'])}")
549
550 print(f"\n--- EPV COMMISSION ---")
551 print(hdr2); print('-'*len(hdr2))
552 for r in blocks['commission_rows']:
553 print(f"{r['k']:<4}{money(r['amount']):<16}{r['discount']:<14.8f}"
554 f"{r['probability']:<16.10f}{money(r['epv']):<16}")
555 print(f" Total EPV Commission: {money(blocks['EPV_commission'])}")
556
557 print(f"\n--- EPV PREMIUM ---")
558 print(hdr2); print('-'*len(hdr2))
559 for r in blocks['premium_rows']:
560 print(f"{r['k']:<4}{money(r['amount']):<16}{r['discount']:<14.8f}"
561 f"{r['probability']:<16.10f}{money(r['epv']):<16}")
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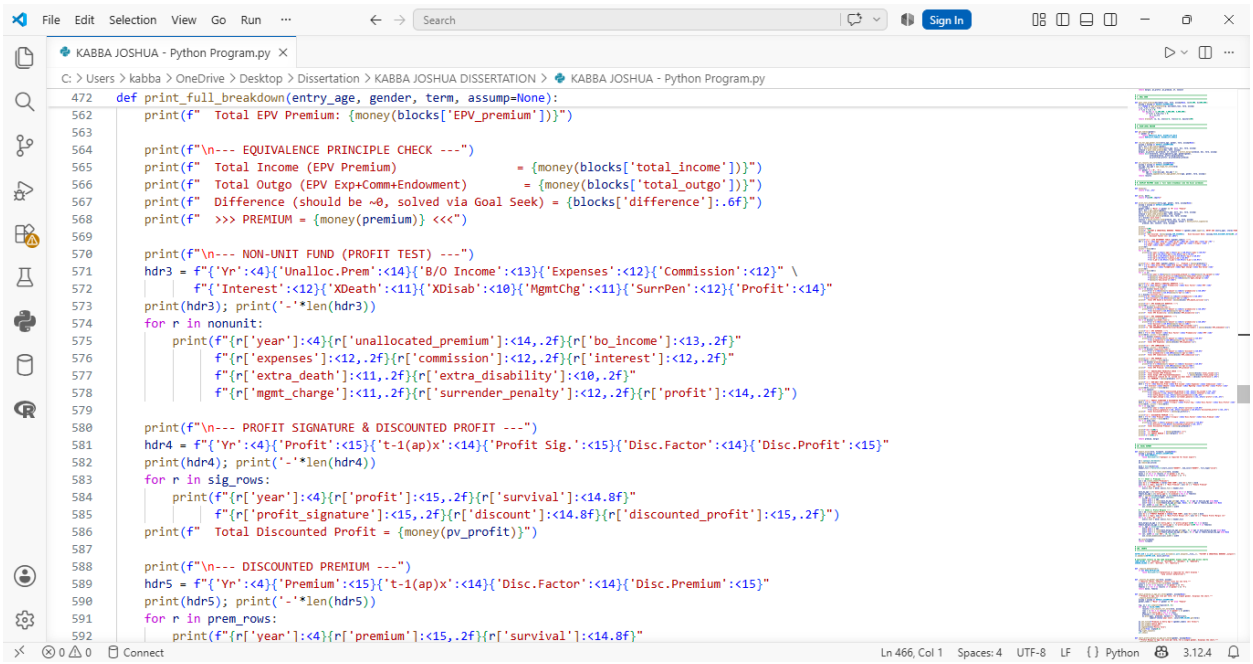
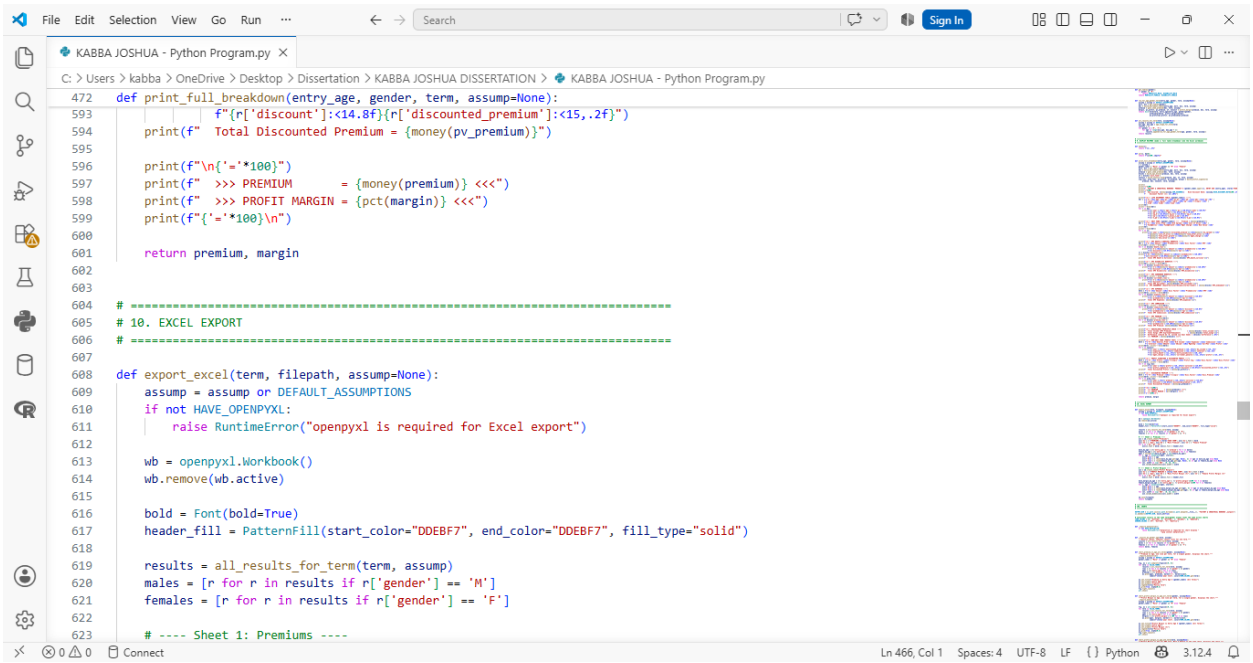
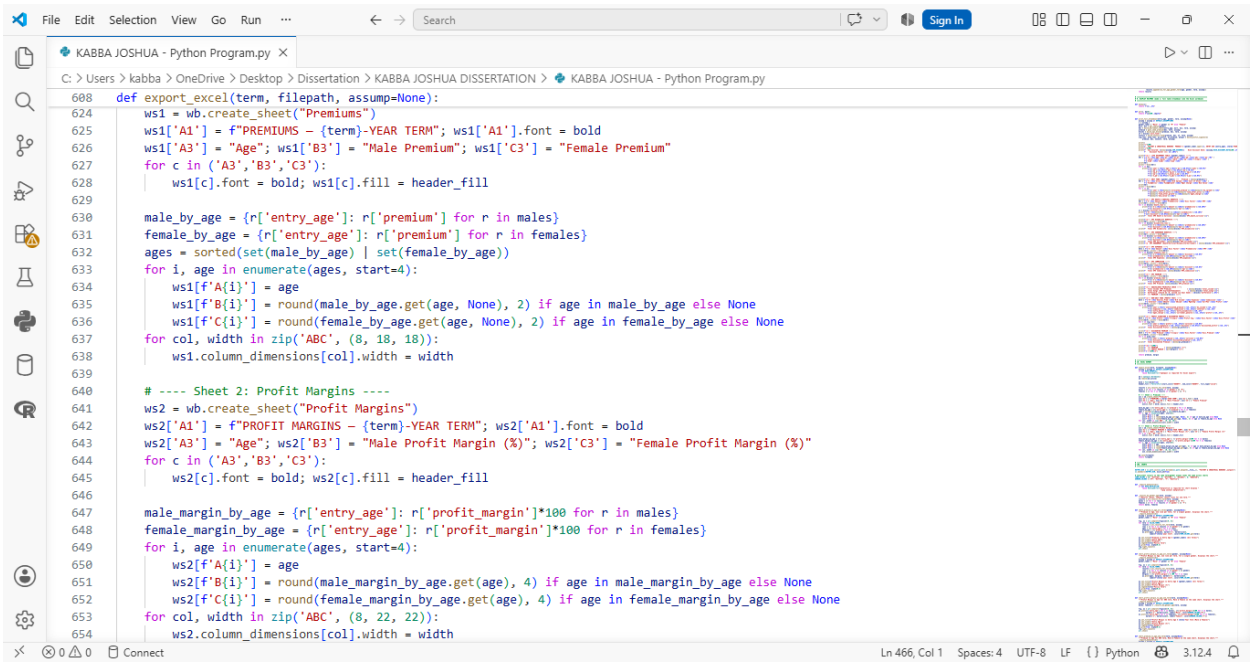


```
472  def print_full_breakdown(entry_age, gender, term, assump=None):
562      print(f"  Total EPV Premium: {money(blocks['EPV_premium'])}")
563
564      print(f"\n--- EQUIVALENCE PRINCIPLE CHECK ---")
565      print(f"  Total Income (EPV Premium)                = {money(blocks['total_income'])}")
566      print(f"  Total Outgo (EPV Exp+Comm+Endowment)       = {money(blocks['total_outgo'])}")
567      print(f"  Difference (should be ~0, solved via Goal Seek) = {blocks['difference']:.6f}")
568      print(f"  >>> PREMIUM = {money(premium)} <<<")
569
570      print(f"\n--- NON-UNIT FUND (PROFIT TEST) ---")
571      hdr3 = f"{'Yr':<4}{'Unalloc.Prem':<14}{'B/O Income':<13}{'Expenses':<12}{'Commission':<12}" \
572             f"{'Interest':<12}{'XDeath':<11}{'XDisab':<10}{'MgmtChg':<11}{'SurrPen':<12}{'Profit':<14}"
573      print(hdr3); print('-'*len(hdr3))
574      for r in nonunit:
575          print(f"{r['year']:<4}{r['unallocated_premium']:<14,.2f}{r['bo_income']:<13,.2f}"
576                f"{r['expenses']:<12,.2f}{r['commission']:<12,.2f}{r['interest']:<12,.2f}"
577                f"{r['extra_death']:<11,.2f}{r['extra_disability']:<10,.2f}"
578                f"{r['mgmt_charge']:<11,.2f}{r['surrender_penalty']:<12,.2f}{r['profit']:<14,.2f}")
579
580      print(f"\n--- PROFIT SIGNATURE & DISCOUNTED PROFIT ---")
581      hdr4 = f"{'Yr':<4}{'Profit':<15}{'t-1(ap)x':<14}{'Profit Sig.':<15}{'Disc.Factor':<14}{'Disc.Profit':<15}"
582      print(hdr4); print('-'*len(hdr4))
583      for r in sig_rows:
584          print(f"{r['year']:<4}{r['profit']:<15,.2f}{r['survival']:<14.8f}"
585                f"{r['profit_signature']:<15,.2f}{r['discount']:<14.8f}{r['discounted_profit']:<15,.2f}")
586      print(f"  Total Discounted Profit = {money(pv_profit)}")
587
588      print(f"\n--- DISCOUNTED PREMIUM ---")
589      hdr5 = f"{'Yr':<4}{'Premium':<15}{'t-1(ap)x':<14}{'Disc.Factor':<14}{'Disc.Premium':<15}"
590      print(hdr5); print('-'*len(hdr5))
591      for r in prem_rows:
592          print(f"{r['year']:<4}{r['premium']:<15,.2f}{r['survival']:<14.8f}"
```



```
472  def print_full_breakdown(entry_age, gender, term, assump=None):
593                f"{r['discount']:<14.8f}{r['discounted_premium']:<15,.2f}")
594      print(f"  Total Discounted Premium = {money(pv_premium)}")
595
596      print(f"\n{'='*100}")
597      print(f"  >>> PREMIUM       = {money(premium)} <<<")
598      print(f"  >>> PROFIT MARGIN = {pct(margin)} <<<")
599      print(f"{'='*100}\n")
600
601      return premium, margin
602
603
604  # ============================================================================
605  # 10. EXCEL EXPORT
606  # ============================================================================
607
608  def export_excel(term, filepath, assump=None):
609      assump = assump or DEFAULT_ASSUMPTIONS
610      if not HAVE_OPENPYXL:
611          raise RuntimeError("openpyxl is required for Excel export")
612
613      wb = openpyxl.Workbook()
614      wb.remove(wb.active)
615
616      bold = Font(bold=True)
617      header_fill = PatternFill(start_color="DDEBF7", end_color="DDEBF7", fill_type="solid")
618
619      results = all_results_for_term(term, assump)
620      males = [r for r in results if r['gender'] == 'M']
621      females = [r for r in results if r['gender'] == 'F']
622
623      # ---- Sheet 1: Premiums ----
```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608 def export_excel(term, filepath, assump=None):
624 ws1 = wb.create_sheet("Premiums")
625 ws1['A1'] = f"PREMIUMS – {term}-YEAR TERM"; ws1['A1'].font = bold
626 ws1['A3'] = "Age"; ws1['B3'] = "Male Premium"; ws1['C3'] = "Female Premium"
627 for c in ('A3','B3','C3'):
628 ws1[c].font = bold; ws1[c].fill = header_fill
629
630 male_by_age = {r['entry_age']: r['premium'] for r in males}
631 female_by_age = {r['entry_age']: r['premium'] for r in females}
632 ages = sorted(set(male_by_age) | set(female_by_age))
633 for i, age in enumerate(ages, start=4):
634 ws1[f'A{i}'] = age
635 ws1[f'B{i}'] = round(male_by_age.get(age, None), 2) if age in male_by_age else None
636 ws1[f'C{i}'] = round(female_by_age.get(age, None), 2) if age in female_by_age else None
637 for col, width in zip('ABC', (8, 18, 18)):
638 ws1.column_dimensions[col].width = width
639
640 # ---- Sheet 2: Profit Margins ----
641 ws2 = wb.create_sheet("Profit Margins")
642 ws2['A1'] = f"PROFIT MARGINS – {term}-YEAR TERM"; ws2['A1'].font = bold
643 ws2['A3'] = "Age"; ws2['B3'] = "Male Profit Margin (%)"; ws2['C3'] = "Female Profit Margin (%)"
644 for c in ('A3','B3','C3'):
645 ws2[c].font = bold; ws2[c].fill = header_fill
646
647 male_margin_by_age = {r['entry_age']: r['profit_margin']*100 for r in males}
648 female_margin_by_age = {r['entry_age']: r['profit_margin']*100 for r in females}
649 for i, age in enumerate(ages, start=4):
650 ws2[f'A{i}'] = age
651 ws2[f'B{i}'] = round(male_margin_by_age.get(age), 4) if age in male_margin_by_age else None
652 ws2[f'C{i}'] = round(female_margin_by_age.get(age), 4) if age in female_margin_by_age else None
653 for col, width in zip('ABC', (8, 22, 22)):
654 ws2.column_dimensions[col].width = width
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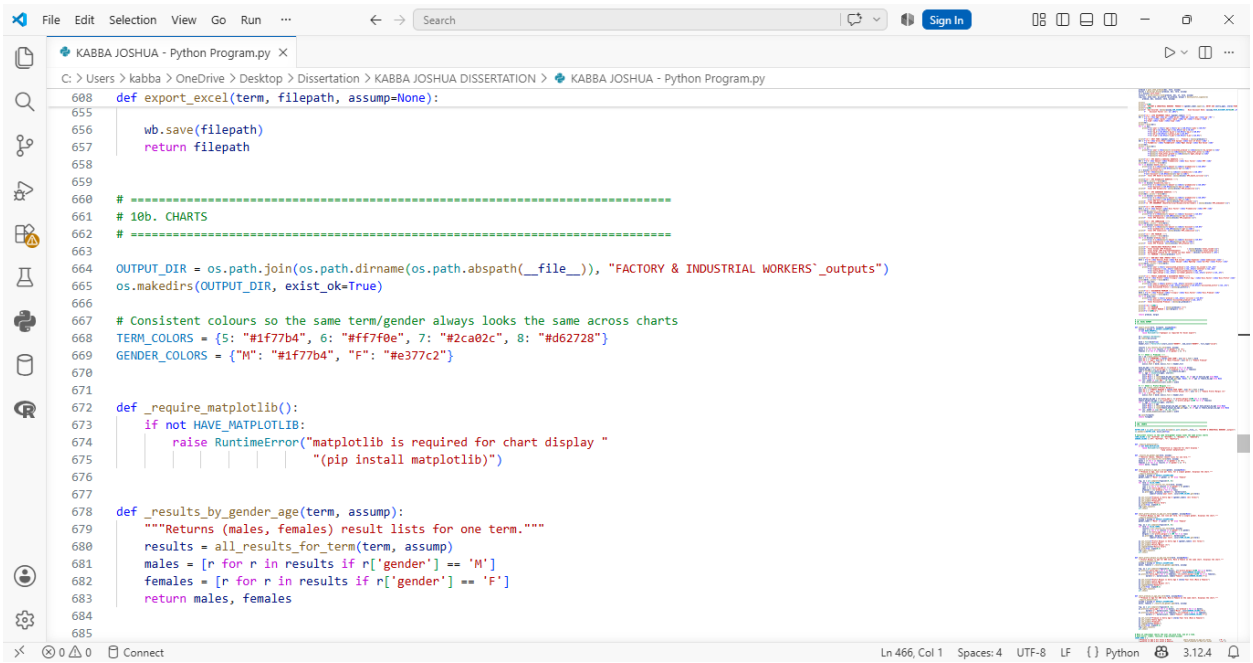
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608 def export_excel(term, filepath, assump=None):
655
656 wb.save(filepath)
657 return filepath
658
659
660 # ==
661 # 10b. CHARTS
662 # ==
663
664 OUTPUT_DIR = os.path.join(os.path.dirname(os.path.abspath(__file__)), "FACTORY & INDUSTRIAL WORKERS`_outputs")
665 os.makedirs(OUTPUT_DIR, exist_ok=True)
666
667 # Consistent colours so the same term/gender always looks the same across charts
668 TERM_COLORS = {5: "#1f77b4", 6: "#ff7f0e", 7: "#2ca02c", 8: "#d62728"}
669 GENDER_COLORS = {"M": "#1f77b4", "F": "#e377c2"}
670
671
672 def _require_matplotlib():
673 if not HAVE_MATPLOTLIB:
674 raise RuntimeError("matplotlib is required for chart display "
675 "(pip install matplotlib)")
676
677
678 def _results_by_gender_age(term, assump):
679 """Returns (males, females) result lists for one term."""
680 results = all_results_for_term(term, assump)
681 males = [r for r in results if r['gender'] == 'M']
682 females = [r for r in results if r['gender'] == 'F']
683 return males, females
684
685
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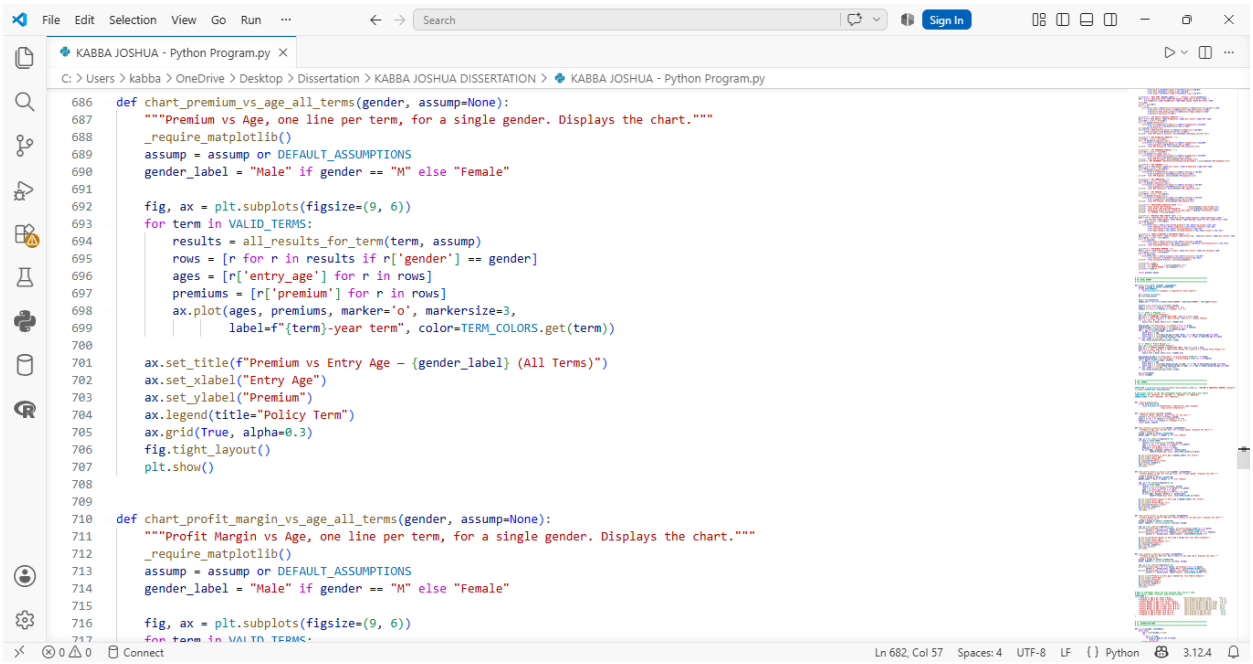
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def chart_premium_vs_age_all_terms(gender, assump=None):
"""Premium vs Age, one line per term, for a single gender. Displays the chart."""
_require_matplotlib()
assump = assump or DEFAULT_ASSUMPTIONS
gender_label = "Male" if gender == "M" else "Female"
fig, ax = plt.subplots(figsize=(9, 6))
for term in VALID_TERMS:
results = all_results_for_term(term, assump)
rows = [r for r in results if r['gender'] == gender]
ages = [r['entry_age'] for r in rows]
premiums = [r['premium'] for r in rows]
ax.plot(ages, premiums, marker='o', markersize=3,
label=f"{term}-year term", color=TERM_COLORS.get(term))
ax.set_title(f"Premium vs Entry Age — {gender_label} (All Terms)")
ax.set_xlabel("Entry Age")
ax.set_ylabel("Premium")
ax.legend(title="Policy Term")
ax.grid(True, alpha=0.3)
fig.tight_layout()
plt.show()
def chart_profit_margin_vs_age_all_terms(gender, assump=None):
"""Profit Margin vs Age, one line per term, for a single gender. Displays the chart."""
_require_matplotlib()
assump = assump or DEFAULT_ASSUMPTIONS
gender_label = "Male" if gender == "M" else "Female"
fig, ax = plt.subplots(figsize=(9, 6))
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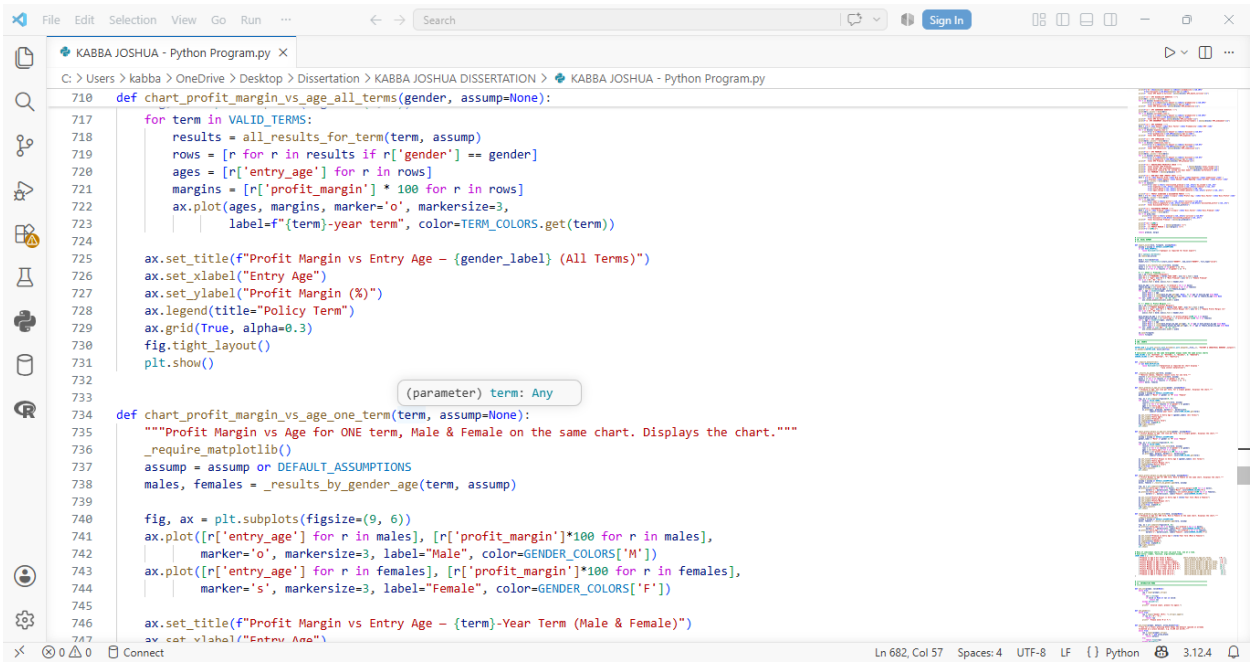
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def chart_profit_margin_vs_age_all_terms(gender, assump=None):
for term in VALID_TERMS:
results = all_results_for_term(term, assump)
rows = [r for r in results if r['gender'] == gender]
ages = [r['entry_age'] for r in rows]
margins = [r['profit_margin'] * 100 for r in rows]
ax.plot(ages, margins, marker='o', markersize=3,
label=f"{term}-year term", color=TERM_COLORS.get(term))
ax.set_title(f"Profit Margin vs Entry Age — {gender_label} (All Terms)")
ax.set_xlabel("Entry Age")
ax.set_ylabel("Profit Margin (%)")
ax.legend(title="Policy Term")
ax.grid(True, alpha=0.3)
fig.tight_layout()
plt.show()
(parameter) term: Any
def chart_profit_margin_vs_age_one_term(term, assump=None):
"""Profit Margin vs Age for ONE term, Male & Female on the same chart. Displays the chart."""
_require_matplotlib()
assump = assump or DEFAULT_ASSUMPTIONS
males, females = _results_by_gender_age(term, assump)
fig, ax = plt.subplots(figsize=(9, 6))
ax.plot([r['entry_age'] for r in males], [r['profit_margin']*100 for r in males],
marker='o', markersize=3, label="Male", color=GENDER_COLORS['M'])
ax.plot([r['entry_age'] for r in females], [r['profit_margin']*100 for r in females],
marker='s', markersize=3, label="Female", color=GENDER_COLORS['F'])
ax.set_title(f"Profit Margin vs Entry Age — {term}-Year Term (Male & Female)")
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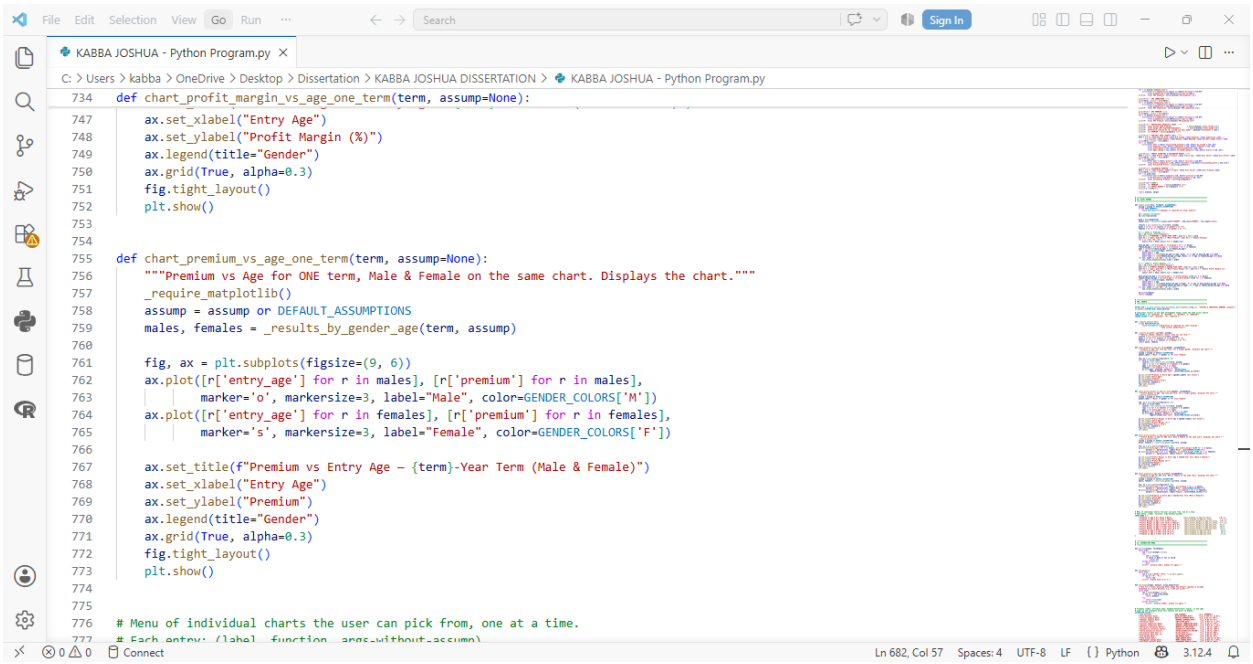
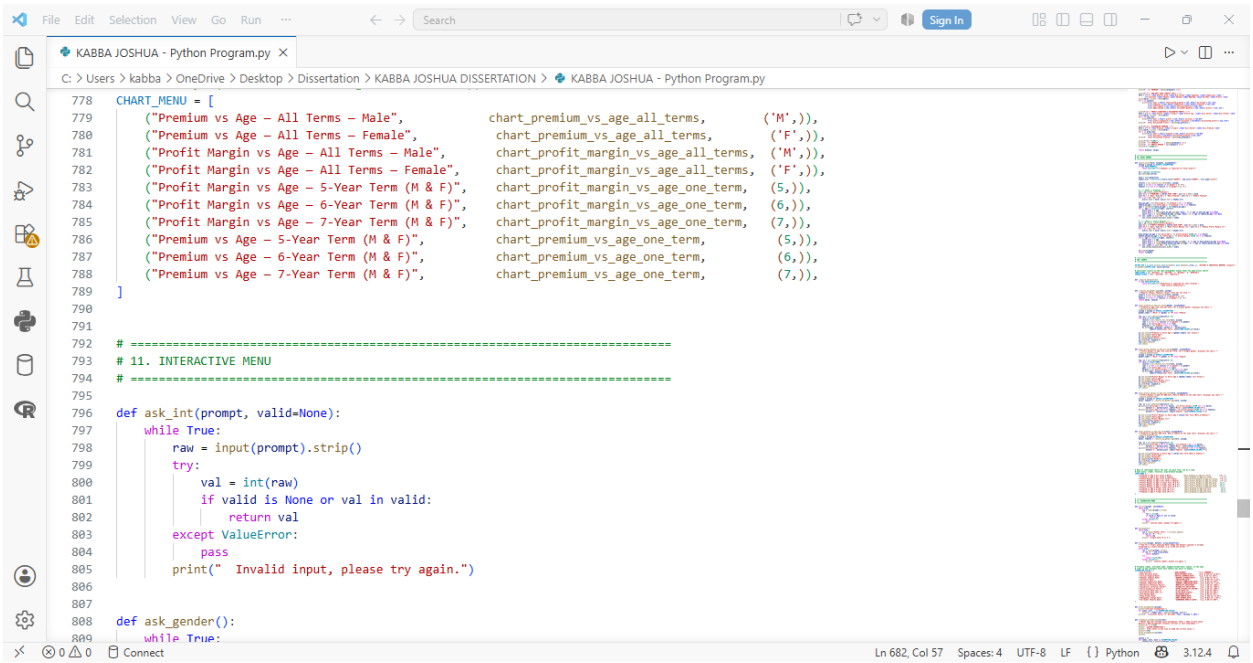
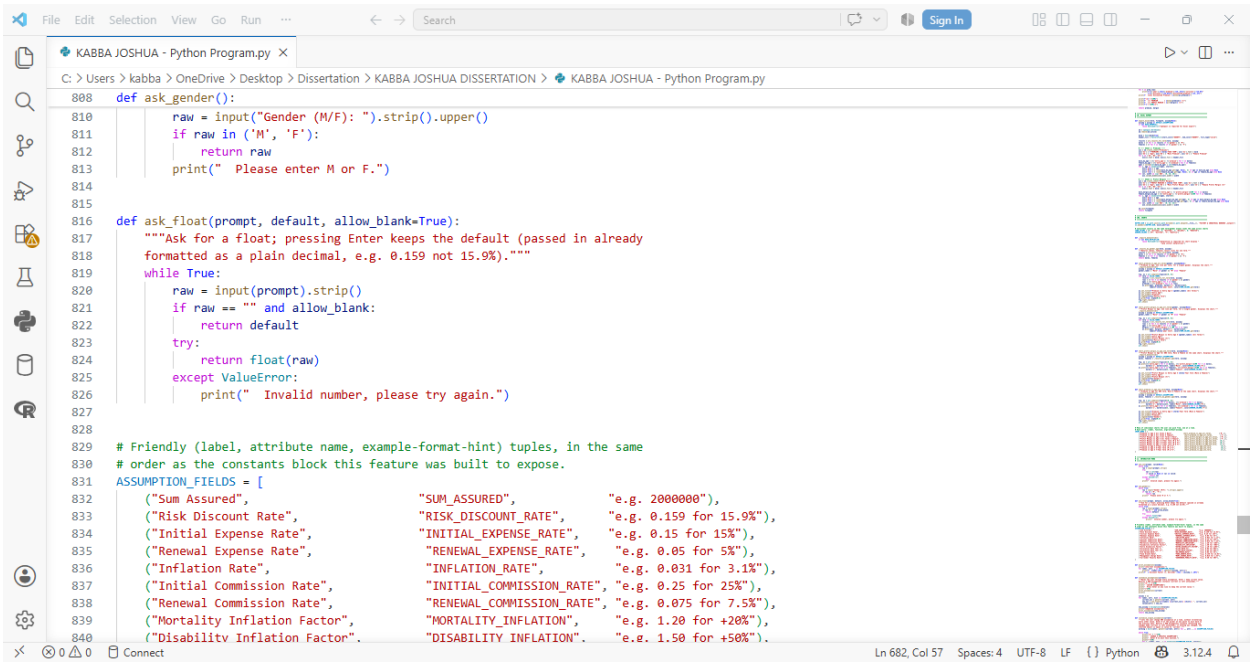


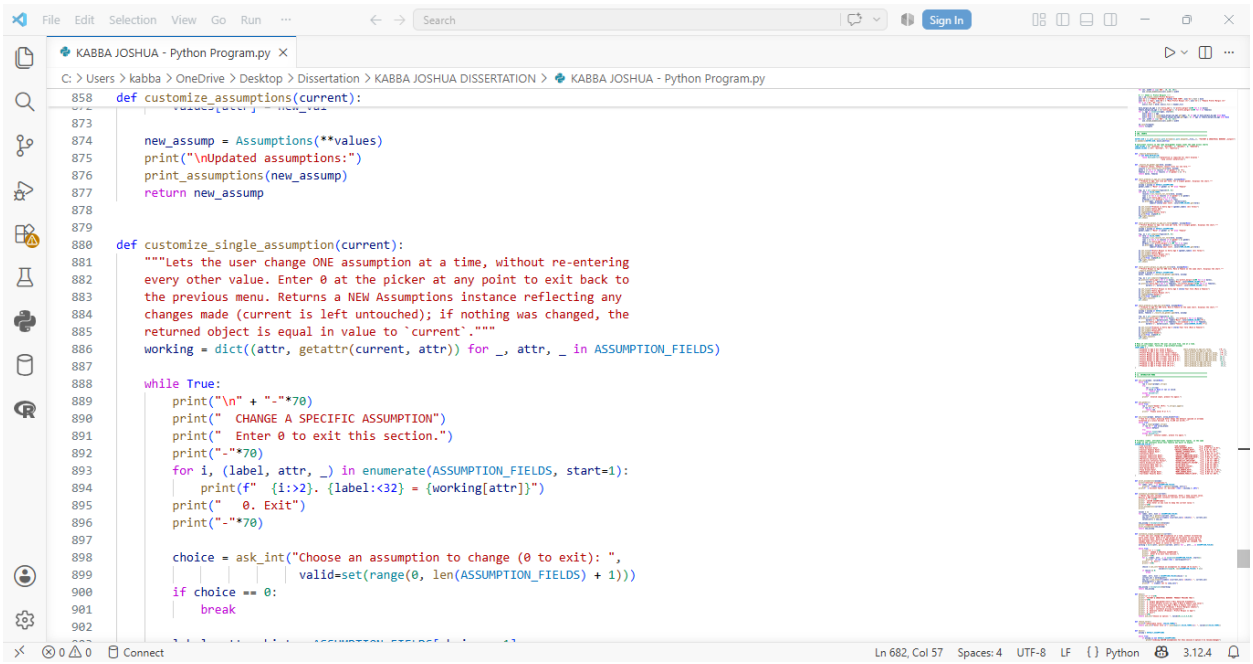
```
734 def chart_profit_margin_vs_age_one_term(term, assump=None):
747     ax.set_xlabel("Entry Age")
748     ax.set_ylabel("Profit Margin (%)")
749     ax.legend(title="Gender")
750     ax.grid(True, alpha=0.3)
751     fig.tight_layout()
752     plt.show()
753
754
755 def chart_premium_vs_age_one_term(term, assump=None):
756     """Premium vs Age for ONE term, Male & Female on the same chart. Displays the chart."""
757     _require_matplotlib()
758     assump = assump or DEFAULT_ASSUMPTIONS
759     males, females = _results_by_gender_age(term, assump)
760
761     fig, ax = plt.subplots(figsize=(9, 6))
762     ax.plot([r['entry_age'] for r in males], [r['premium'] for r in males],
763             marker='o', markersize=3, label="Male", color=GENDER_COLORS['M'])
764     ax.plot([r['entry_age'] for r in females], [r['premium'] for r in females],
765             marker='s', markersize=3, label="Female", color=GENDER_COLORS['F'])
766
767     ax.set_title(f"Premium vs Entry Age – {term}-Year Term (Male & Female)")
768     ax.set_xlabel("Entry Age")
769     ax.set_ylabel("Premium")
770     ax.legend(title="Gender")
771     ax.grid(True, alpha=0.3)
772     fig.tight_layout()
773     plt.show()
774
775
776 # Menu of individual charts the user can pick from, one at a time.
777 # Each entry: (label, function, args-without-assump)
```



```
778 CHART_MENU = [
779     ("Premium vs Age – All Terms – Male",           chart_premium_vs_age_all_terms,       ('M',)),
780     ("Premium vs Age – All Terms – Female",         chart_premium_vs_age_all_terms,       ('F',)),
781     ("Profit Margin vs Age – All Terms – Male",     chart_profit_margin_vs_age_all_terms, ('M',)),
782     ("Profit Margin vs Age – All Terms – Female",   chart_profit_margin_vs_age_all_terms, ('F',)),
783     ("Profit Margin vs Age – 5-Year Term (M & F)",  chart_profit_margin_vs_age_one_term,  (5,)),
784     ("Profit Margin vs Age – 6-Year Term (M & F)",  chart_profit_margin_vs_age_one_term,  (6,)),
785     ("Profit Margin vs Age – 7-Year Term (M & F)",  chart_profit_margin_vs_age_one_term,  (7,)),
786     ("Premium vs Age – 5-Year Term (M & F)",        chart_premium_vs_age_one_term,        (5,)),
787     ("Premium vs Age – 6-Year Term (M & F)",        chart_premium_vs_age_one_term,        (6,)),
788     ("Premium vs Age – 7-Year Term (M & F)",        chart_premium_vs_age_one_term,        (7,)),
789 ]
790
791
792 # ============================================================================
793 # 11. INTERACTIVE MENU
794 # ============================================================================
795
796 def ask_int(prompt, valid=None):
797     while True:
798         raw = input(prompt).strip()
799         try:
800             val = int(raw)
801             if valid is None or val in valid:
802                 return val
803         except ValueError:
804             pass
805         print("  Invalid input, please try again.")
806
807
808 def ask_gender():
809     while True:
```



```
808 def ask_gender():
809         raw = input("Gender (M/F): ").strip().upper()
810         if raw in ('M', 'F'):
811             return raw
812         print("  Please enter M or F.")
813
814
815 def ask_float(prompt, default, allow_blank=True):
816     """Ask for a float; pressing Enter keeps the default (passed in already
817     formatted as a plain decimal, e.g. 0.159 not 15.9%)."""
818     while True:
819         raw = input(prompt).strip()
820         if raw == "" and allow_blank:
821             return default
822         try:
823             return float(raw)
824         except ValueError:
825             print("  Invalid number, please try again.")
826
827
828 # Friendly (label, attribute name, example-format-hint) tuples, in the same
829 # order as the constants block this feature was built to expose.
830 ASSUMPTION_FIELDS = [
831     ("Sum Assured",                 "SUM_ASSURED",            "e.g. 2000000"),
832     ("Risk Discount Rate",          "RISK_DISCOUNT_RATE",     "e.g. 0.159 for 15.9%"),
833     ("Initial Expense Rate",        "INITIAL_EXPENSE_RATE",   "e.g. 0.15 for 15%"),
834     ("Renewal Expense Rate",        "RENEWAL_EXPENSE_RATE",   "e.g. 0.05 for 5%"),
835     ("Inflation Rate",              "INFLATION_RATE",         "e.g. 0.031 for 3.1%"),
836     ("Initial Commission Rate",     "INITIAL_COMMISSION_RATE","e.g. 0.25 for 25%"),
837     ("Renewal Commission Rate",     "RENEWAL_COMMISSION_RATE","e.g. 0.075 for 7.5%"),
838     ("Mortality Inflation Factor",  "MORTALITY_INFLATION",    "e.g. 1.20 for +20%"),
839     ("Disability Inflation Factor", "DISABILITY_INFLATION",   "e.g. 1.50 for +50%"),
840     ("Extra Disability Factor",     "EXTRA_DISABILITY_FACTOR","e.g. 1.10 for 110%"),
841     ("Allocation Rate Year 1",      "ALLOC_RATE_Y1",          "e.g. 0.95 for 95%"),
842     ("Allocation Rate Year 2+",     "ALLOC_RATE_Y2PLUS",      "e.g. 0.85 for 85%"),
843     ("B/O Spread Rate",             "BO_SPREAD_RATE",         "e.g. 0.05 for 5%"),
844     ("Fund Growth Rate",            "FUND_GROWTH_RATE",       "e.g. 0.149 for 14.9%"),
845     ("Management Charge Rate",      "MGMT_CHARGE_RATE",       "e.g. 0.015 for 1.5%"),
846     ("Surrender Penalty Rate",      "SURRENDER_PENALTY_RATE", "e.g. 0.50 for 50%"),
847 ]
848
849
850 def print_assumptions(assump):
851     print("\nCurrent assumptions:")
852     for label, attr, _ in ASSUMPTION_FIELDS:
853         print(f"  {label:<32} = {getattr(assump, attr)}")
854     print(f"  {'Discount Factor (v, derived)':<32} = {assump.v:.10f}")
855
856
857 def customize_assumptions(current):
858     """Walks the user through every assumption, Enter = keep current value.
859     Returns a NEW Assumptions instance (current is left untouched)."""
860     print("\n" + "="*70)
861     print("  CUSTOM ASSUMPTIONS")
862     print("  Press Enter on any line to keep the current value.")
863     print("="*70)
864     print_assumptions(current)
865     print()
866
867     values = {}
868     for label, attr, hint in ASSUMPTION_FIELDS:
869         current_val = getattr(current, attr)
870         new_val = ask_float(f"{label} [{current_val}] ({hint}): ", current_val)
871         values[attr] = new_val
872
```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def customize_assumptions(current):
new_assump = Assumptions(**values)
print("\nUpdated assumptions:")
print_assumptions(new_assump)
return new_assump
def customize_single_assumption(current):
"""Lets the user change ONE assumption at a time, without re-entering
every other value. Enter 0 at the picker at any point to exit back to
the previous menu. Returns a NEW Assumptions instance reflecting any
changes made (current is left untouched); if nothing was changed, the
returned object is equal in value to `current`."""
working = dict((attr, getattr(current, attr)) for _, attr, _ in ASSUMPTION_FIELDS)
while True:
print("\n" + "-"*70)
print(" CHANGE A SPECIFIC ASSUMPTION")
print(" Enter 0 to exit this section.")
print("-"*70)
for i, (label, attr, _) in enumerate(ASSUMPTION_FIELDS, start=1):
print(f" {i:>2}. {label:<32} = {working[attr]}")
print(" 0. Exit")
print("-"*70)
choice = ask_int("Choose an assumption to change (0 to exit): ",
valid=set(range(0, len(ASSUMPTION_FIELDS) + 1)))
if choice == 0:
break
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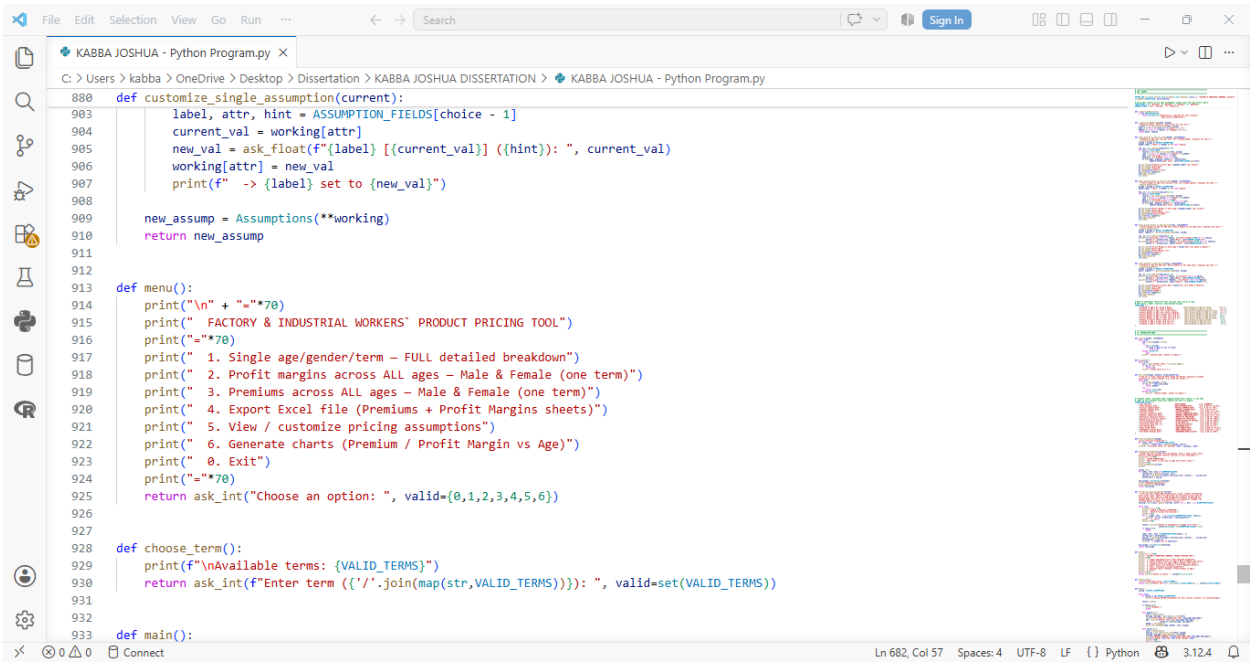
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def customize_single_assumption(current):
label, attr, hint = ASSUMPTION_FIELDS[choice - 1]
current_val = working[attr]
new_val = ask_float(f"{label} [{current_val}] ({hint}): ", current_val)
working[attr] = new_val
print(f" -> {label} set to {new_val}")
new_assump = Assumptions(**working)
return new_assump
def menu():
print("\n" + "="*70)
print(" FACTORY & INDUSTRIAL WORKERS` PRODUCT PRICING TOOL")
print("="*70)
print(" 1. Single age/gender/term — FULL detailed breakdown")
print(" 2. Profit margins across ALL ages — Male & Female (one term)")
print(" 3. Premiums across ALL ages — Male & Female (one term)")
print(" 4. Export Excel file (Premiums + Profit Margins sheets)")
print(" 5. View / customize pricing assumptions")
print(" 6. Generate charts (Premium / Profit Margin vs Age)")
print(" 0. Exit")
print("="*70)
return ask_int("Choose an option: ", valid={0,1,2,3,4,5,6})
def choose_term():
print(f"\nAvailable terms: {VALID_TERMS}")
return ask_int(f"Enter term ({'/'.join(map(str,VALID_TERMS))}): ", valid=set(VALID_TERMS))
def main():
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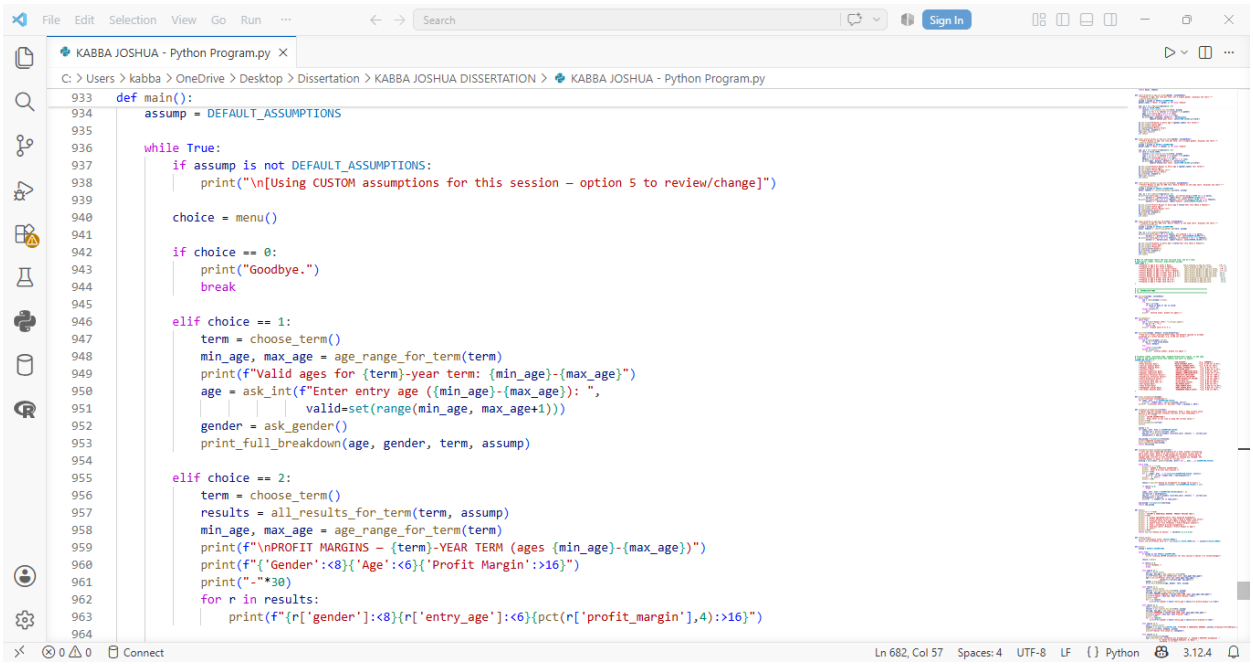
Python
3.12.4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933 def main():
934 assump = DEFAULT_ASSUMPTIONS
935
936 while True:
937 if assump is not DEFAULT_ASSUMPTIONS:
938 print("\n[Using CUSTOM assumptions for this session — option 5 to review/change]")
939
940 choice = menu()
941
942 if choice == 0:
943 print("Goodbye.")
944 break
945
946 elif choice == 1:
947 term = choose_term()
948 min_age, max_age = age_range_for_term(term)
949 print(f"Valid ages for {term}-year term: {min_age}-{max_age}")
950 age = ask_int(f"Enter entry age ({min_age}-{max_age}): ",
951 valid=set(range(min_age, max_age+1)))
952 gender = ask_gender()
953 print_full_breakdown(age, gender, term, assump)
954
955 elif choice == 2:
956 term = choose_term()
957 results = all_results_for_term(term, assump)
958 min_age, max_age = age_range_for_term(term)
959 print(f"\nPROFIT MARGINS — {term}-YEAR TERM (ages {min_age}-{max_age})")
960 print(f"{'Gender':<8}{'Age':<6}{'Profit Margin':>16}")
961 print("-"*30)
962 for r in results:
963 print(f"{r['gender']:<8}{r['entry_age']:<6}{pct(r['profit_margin'],4):>16}")
964
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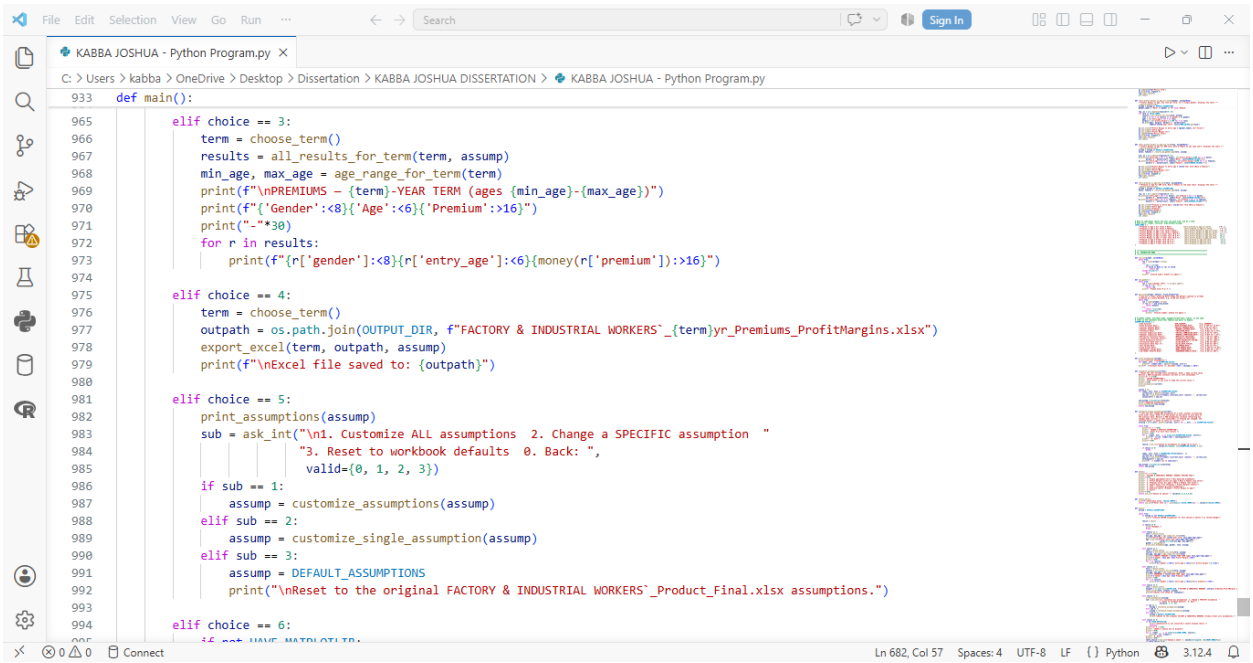
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933 def main():
965 elif choice == 3:
966 term = choose_term()
967 results = all_results_for_term(term, assump)
968 min_age, max_age = age_range_for_term(term)
969 print(f"\nPREMIUMS — {term}-YEAR TERM (ages {min_age}-{max_age})")
970 print(f"{'Gender':<8}{'Age':<6}{'Premium':>16}")
971 print("-"*30)
972 for r in results:
973 print(f"{r['gender']:<8}{r['entry_age']:<6}{money(r['premium']):>16}")
974
975 elif choice == 4:
976 term = choose_term()
977 outpath = os.path.join(OUTPUT_DIR, f"FACTORY & INDUSTRIAL WORKERS`_{term}yr_Premiums_ProfitMargins.xlsx")
978 export_excel(term, outpath, assump)
979 print(f"\nExcel file saved to: {outpath}")
980
981 elif choice == 5:
982 print_assumptions(assump)
983 sub = ask_int("\n1. Customize ALL assumptions 2. Change a SPECIFIC assumption "
984 "3. Reset to workbook defaults 0. Back: ",
985 valid={0, 1, 2, 3})
986 if sub == 1:
987 assump = customize_assumptions(assump)
988 elif sub == 2:
989 assump = customize_single_assumption(assump)
990 elif sub == 3:
991 assump = DEFAULT_ASSUMPTIONS
992 print("\nReset to the original FACTORY & INDUSTRIAL WORKERS`_Product_Final.xlsx assumptions.")
993
994 elif choice == 6:
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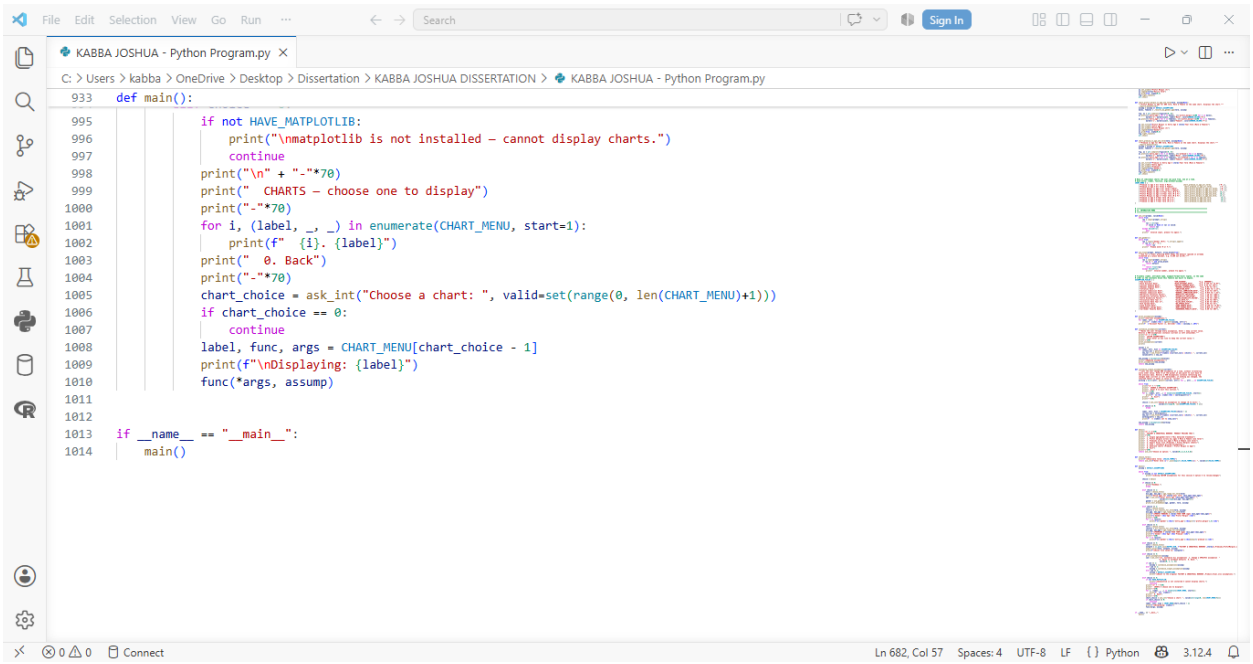
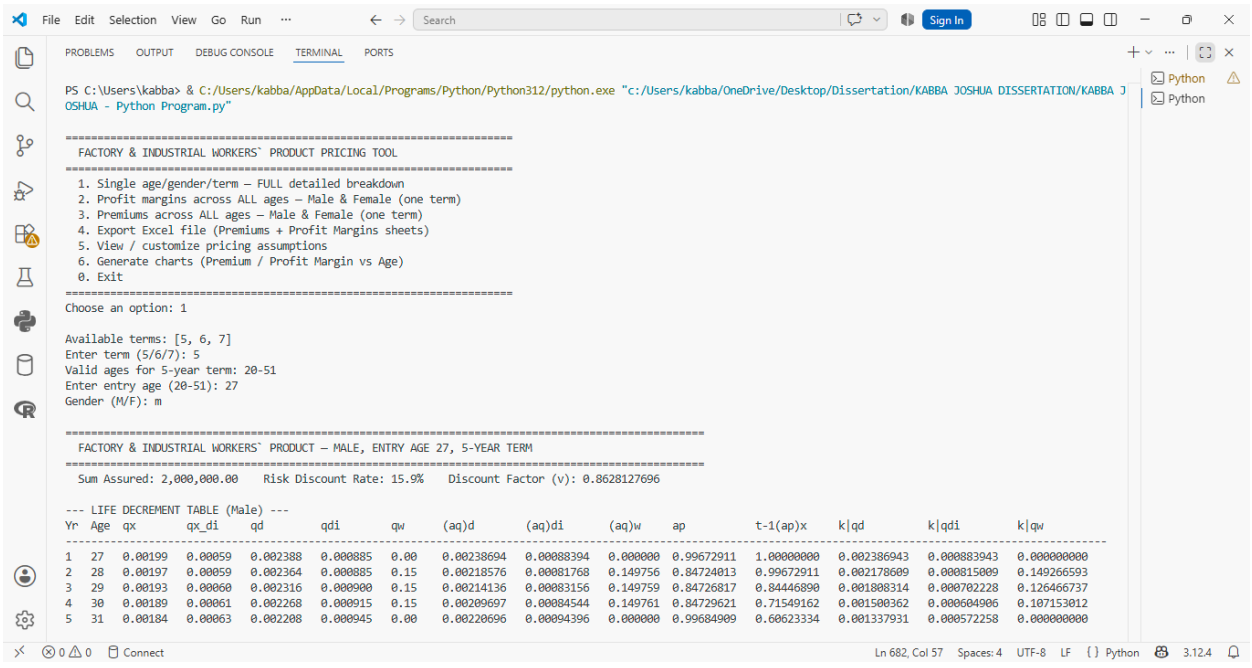
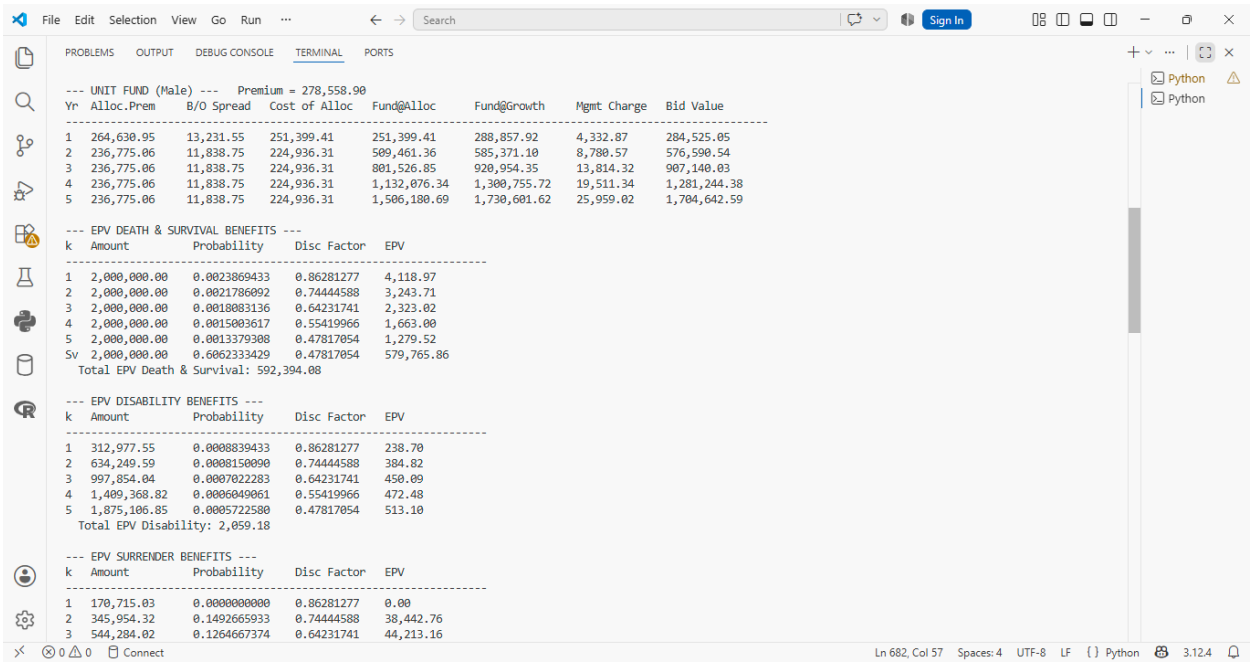
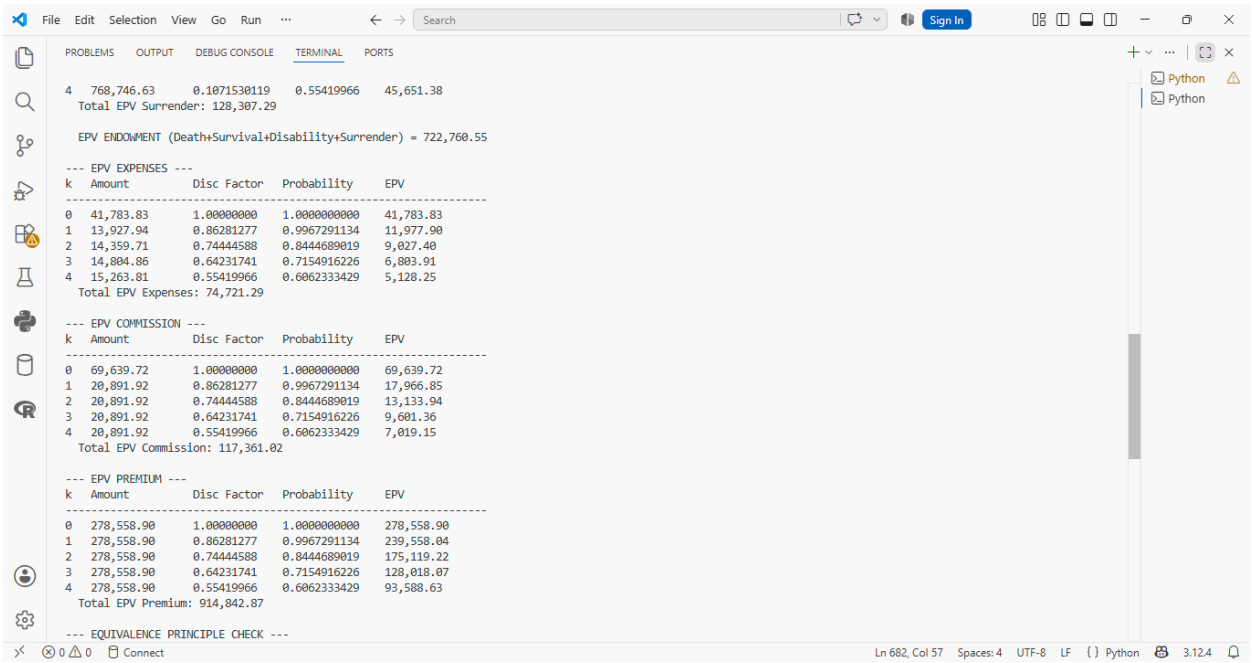


Appendix E: Python program output.

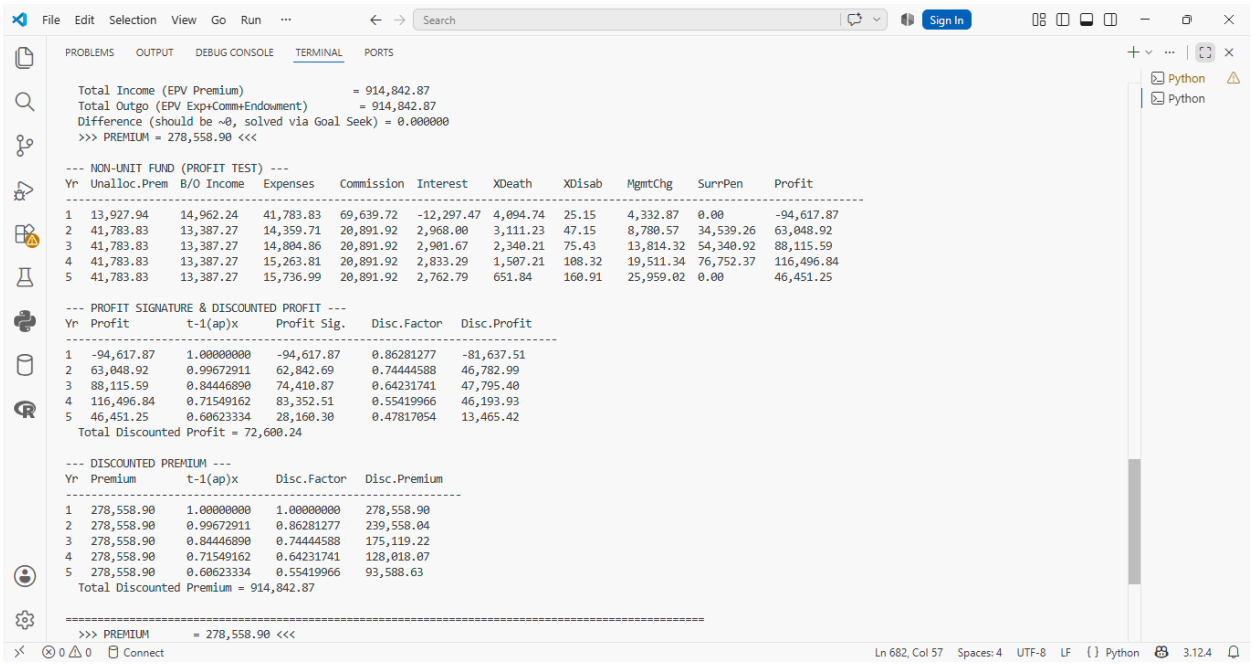





```
--- UNIT FUND (Male) ---   Premium = 278,558.90
Yr  Alloc.Prem     B/O Spread   Cost of Alloc   Fund@Alloc      Fund@Growth     Mgmt Charge   Bid Value
-------------------------------------------------------------------------------------------------------
1   264,630.95     13,231.55    251,399.41      251,399.41      288,857.92      4,332.87      284,525.05
2   236,775.06     11,838.75    224,936.31      509,461.36      585,371.10      8,780.57      576,590.54
3   236,775.06     11,838.75    224,936.31      801,526.85      920,954.35      13,814.32     907,140.03
4   236,775.06     11,838.75    224,936.31      1,132,076.34    1,300,755.72    19,511.34     1,281,244.38
5   236,775.06     11,838.75    224,936.31      1,506,180.69    1,730,601.62    25,959.02     1,704,642.59

--- EPV DEATH & SURVIVAL BENEFITS ---
k   Amount          Probability     Disc Factor   EPV
-----------------------------------------------------------------
1   2,000,000.00    0.0023869433    0.86281277    4,118.97
2   2,000,000.00    0.0021786092    0.74444588    3,243.71
3   2,000,000.00    0.0018083136    0.64231741    2,323.02
4   2,000,000.00    0.0015003617    0.55419966    1,663.00
5   2,000,000.00    0.0013379308    0.47817054    1,279.52
Sv  2,000,000.00    0.6062333429    0.47817054    579,765.86
  Total EPV Death & Survival: 592,394.08

--- EPV DISABILITY BENEFITS ---
k   Amount          Probability     Disc Factor   EPV
-----------------------------------------------------------------
1   312,977.55      0.0008839433    0.86281277    238.70
2   634,249.59      0.0008150090    0.74444588    384.82
3   997,854.04      0.0007022283    0.64231741    450.09
4   1,409,368.82    0.0006049061    0.55419966    472.48
5   1,875,106.85    0.0005722580    0.47817054    513.10
  Total EPV Disability: 2,059.18

--- EPV SURRENDER BENEFITS ---
k   Amount          Probability     Disc Factor   EPV
-----------------------------------------------------------------
1   170,715.03      0.0000000000    0.86281277    0.00
2   345,954.32      0.1492665933    0.74444588    38,442.76
3   544,284.02      0.1264667374    0.64231741    44,213.16
```




```
4   768,746.63      0.1071530119    0.55419966    45,651.38
  Total EPV Surrender: 128,307.29

  EPV ENDOWMENT (Death+Survival+Disability+Surrender) = 722,760.55

--- EPV EXPENSES ---
k   Amount          Disc Factor   Probability     EPV
-----------------------------------------------------------------
0   41,783.83       1.00000000    1.0000000000    41,783.83
1   13,927.94       0.86281277    0.9967291134    11,977.90
2   14,359.71       0.74444588    0.8444689019    9,027.40
3   14,804.86       0.64231741    0.7154916226    6,803.91
4   15,263.81       0.55419966    0.6062333429    5,128.25
  Total EPV Expenses: 74,721.29

--- EPV COMMISSION ---
k   Amount          Disc Factor   Probability     EPV
-----------------------------------------------------------------
0   69,639.72       1.00000000    1.0000000000    69,639.72
1   20,891.92       0.86281277    0.9967291134    17,966.85
2   20,891.92       0.74444588    0.8444689019    13,133.94
3   20,891.92       0.64231741    0.7154916226    9,601.36
4   20,891.92       0.55419966    0.6062333429    7,019.15
  Total EPV Commission: 117,361.02

--- EPV PREMIUM ---
k   Amount          Disc Factor   Probability     EPV
-----------------------------------------------------------------
0   278,558.90      1.00000000    1.0000000000    278,558.90
1   278,558.90      0.86281277    0.9967291134    239,558.04
2   278,558.90      0.74444588    0.8444689019    175,119.22
3   278,558.90      0.64231741    0.7154916226    128,018.07
4   278,558.90      0.55419966    0.6062333429    93,588.63
  Total EPV Premium: 914,842.87

--- EQUIVALENCE PRINCIPLE CHECK ---
```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Total Income (EPV Premium) = 914,842.87
Total Outgo (EPV Exp+Comm+Endowment) = 914,842.87
Difference (should be ~0, solved via Goal Seek) = 0.000000
>>> PREMIUM = 278,558.90 <<<
--- NON-UNIT FUND (PROFIT TEST) ---
Yr Unalloc.Prem B/O Income Expenses Commission Interest XDeath XDisab MgmtChg SurrPen Profit
1 13,927.94 14,962.24 41,783.83 69,639.72 -12,297.47 4,094.74 25.15 4,332.87 0.00 -94,617.87
2 41,783.83 13,387.27 14,359.71 20,891.92 2,968.00 3,111.23 47.15 8,780.57 34,539.26 63,048.92
3 41,783.83 13,387.27 14,804.86 20,891.92 2,901.67 2,340.21 75.43 13,814.32 54,340.92 88,115.59
4 41,783.83 13,387.27 15,263.81 20,891.92 2,833.29 1,507.21 108.32 19,511.34 76,752.37 116,496.84
5 41,783.83 13,387.27 15,736.99 20,891.92 2,762.79 651.84 160.91 25,959.02 0.00 46,451.25
--- PROFIT SIGNATURE & DISCOUNTED PROFIT ---
Yr Profit t-1(ap)x Profit Sig. Disc.Factor Disc.Profit
1 -94,617.87 1.00000000 -94,617.87 0.86281277 -81,637.51
2 63,048.92 0.99672911 62,842.69 0.74444588 46,782.99
3 88,115.59 0.84446890 74,410.87 0.64231741 47,795.40
4 116,496.84 0.71549162 83,352.51 0.55419966 46,193.93
5 46,451.25 0.60623334 28,160.30 0.47817054 13,465.42
Total Discounted Profit = 72,600.24
--- DISCOUNTED PREMIUM ---
Yr Premium t-1(ap)x Disc.Factor Disc.Premium
1 278,558.90 1.00000000 1.00000000 278,558.90
2 278,558.90 0.99672911 0.86281277 239,558.04
3 278,558.90 0.84446890 0.74444588 175,119.22
4 278,558.90 0.71549162 0.64231741 128,018.07
5 278,558.90 0.60623334 0.55419966 93,588.63
Total Discounted Premium = 914,842.87
>>> PREMIUM = 278,558.90 <<<
0 0 Connect
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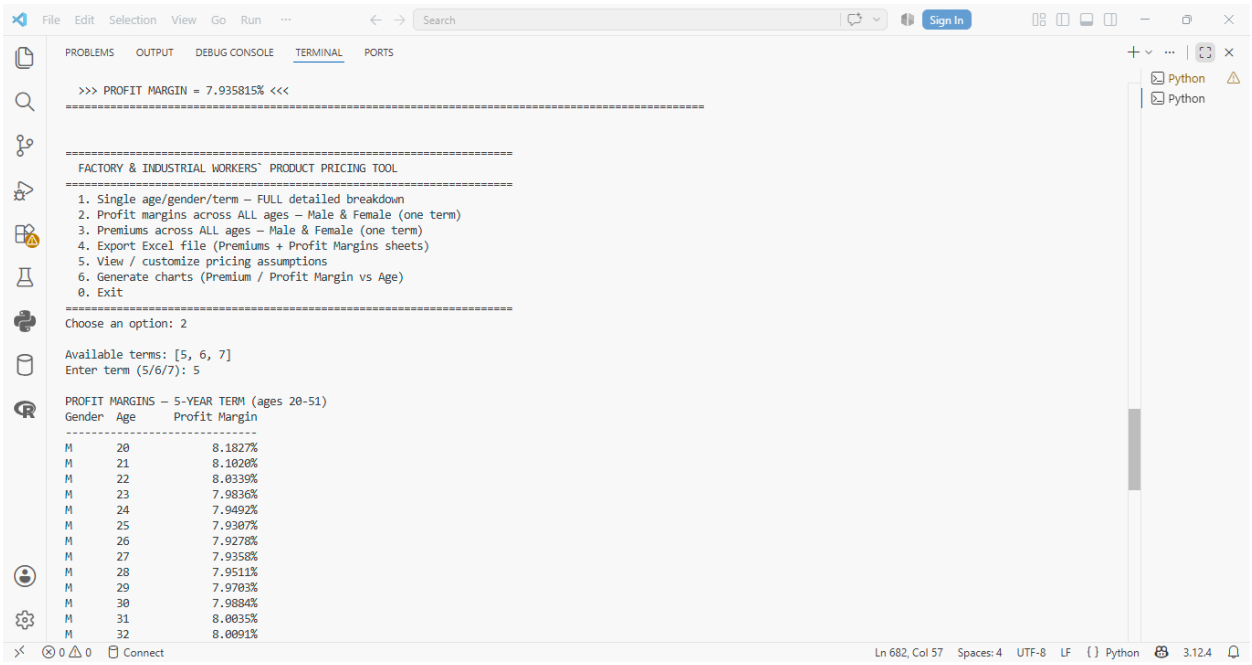
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>>> PROFIT MARGIN = 7.935815% <<<
FACTORY & INDUSTRIAL WORKERS` PRODUCT PRICING TOOL
1. Single age/gender/term — FULL detailed breakdown
2. Profit margins across ALL ages — Male & Female (one term)
3. Premiums across ALL ages — Male & Female (one term)
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: 2
Available terms: [5, 6, 7]
Enter term (5/6/7): 5
PROFIT MARGINS — 5-YEAR TERM (ages 20-51)
Gender Age Profit Margin
M 20 8.1827%
M 21 8.1028%
M 22 8.0339%
M 23 7.9836%
M 24 7.9492%
M 25 7.9307%
M 26 7.9278%
M 27 7.9358%
M 28 7.9511%
M 29 7.9703%
M 30 7.9884%
M 31 8.0035%
M 32 8.0091%
0 0 Connect
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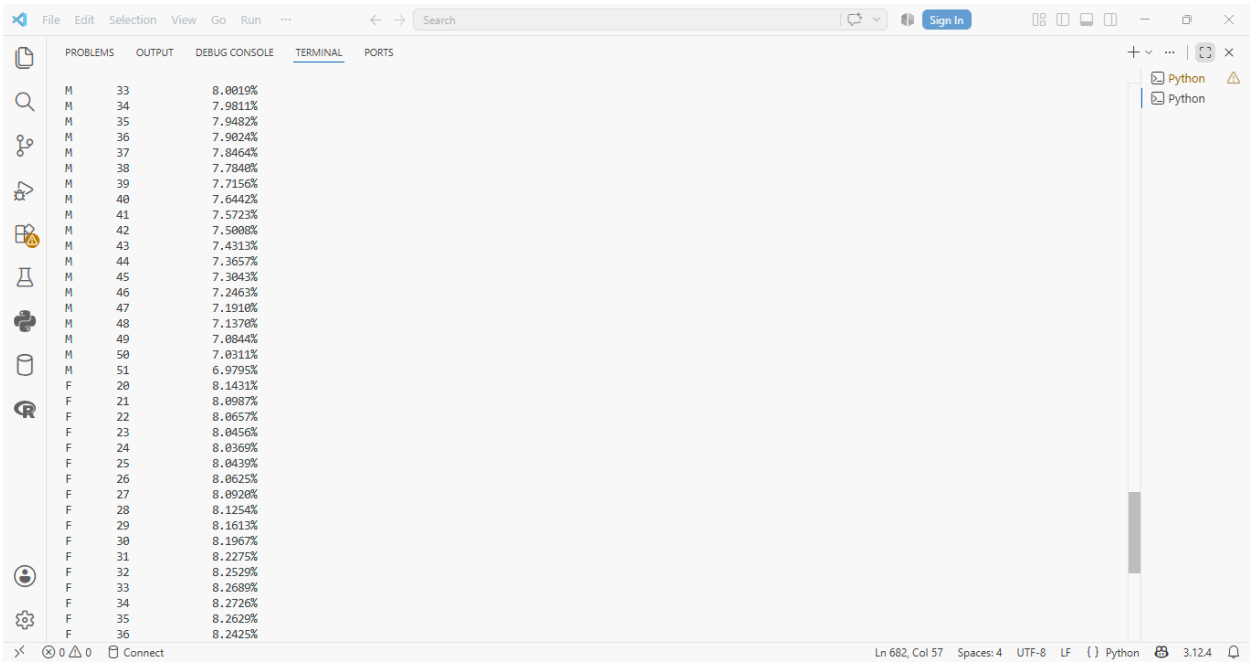
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M 33 8.0019%
M 34 7.9811%
M 35 7.9482%
M 36 7.9024%
M 37 7.8464%
M 38 7.7840%
M 39 7.7156%
M 40 7.6442%
M 41 7.5723%
M 42 7.5008%
M 43 7.4313%
M 44 7.3657%
M 45 7.3043%
M 46 7.2463%
M 47 7.1910%
M 48 7.1370%
M 49 7.0844%
M 50 7.0311%
M 51 6.9795%
F 20 8.1431%
F 21 8.0987%
F 22 8.0657%
F 23 8.0456%
F 24 8.0369%
F 25 8.0439%
F 26 8.0625%
F 27 8.0920%
F 28 8.1254%
F 29 8.1613%
F 30 8.1967%
F 31 8.2275%
F 32 8.2529%
F 33 8.2689%
F 34 8.2726%
F 35 8.2629%
F 36 8.2425%
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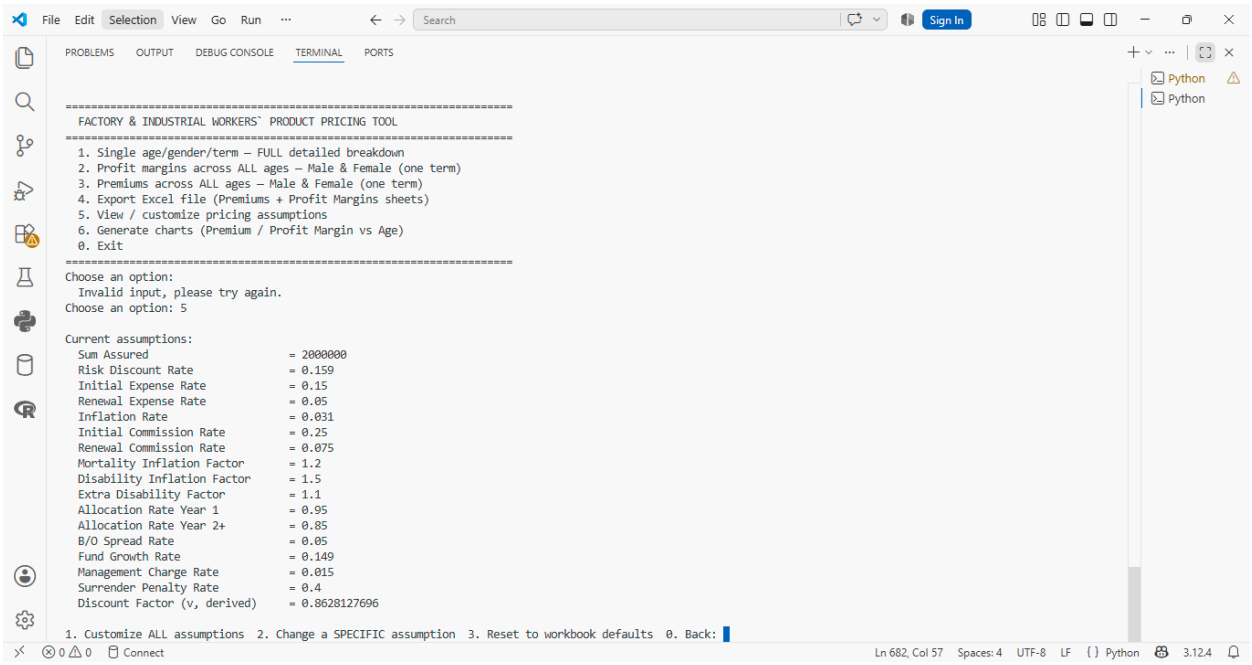
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FACTORY & INDUSTRIAL WORKERS` PRODUCT PRICING TOOL
1. Single age/gender/term — FULL detailed breakdown
2. Profit margins across ALL ages — Male & Female (one term)
3. Premiums across ALL ages — Male & Female (one term)
4. Export Excel file (Premiums + Profit Margins sheets)
5. View / customize pricing assumptions
6. Generate charts (Premium / Profit Margin vs Age)
0. Exit
Choose an option:
Invalid input, please try again.
Choose an option: 5
Current assumptions:
Sum Assured = 2000000
Risk Discount Rate = 0.159
Initial Expense Rate = 0.15
Renewal Expense Rate = 0.05
Inflation Rate = 0.031
Initial Commission Rate = 0.25
Renewal Commission Rate = 0.075
Mortality Inflation Factor = 1.2
Disability Inflation Factor = 1.5
Extra Disability Factor = 1.1
Allocation Rate Year 1 = 0.95
Allocation Rate Year 2+ = 0.85
B/O Spread Rate = 0.05
Fund Growth Rate = 0.149
Management Charge Rate = 0.015
Surrender Penalty Rate = 0.4
Discount Factor (v, derived) = 0.8628127696
1. Customize ALL assumptions 2. Change a SPECIFIC assumption 3. Reset to workbook defaults 0. Back:
Connect
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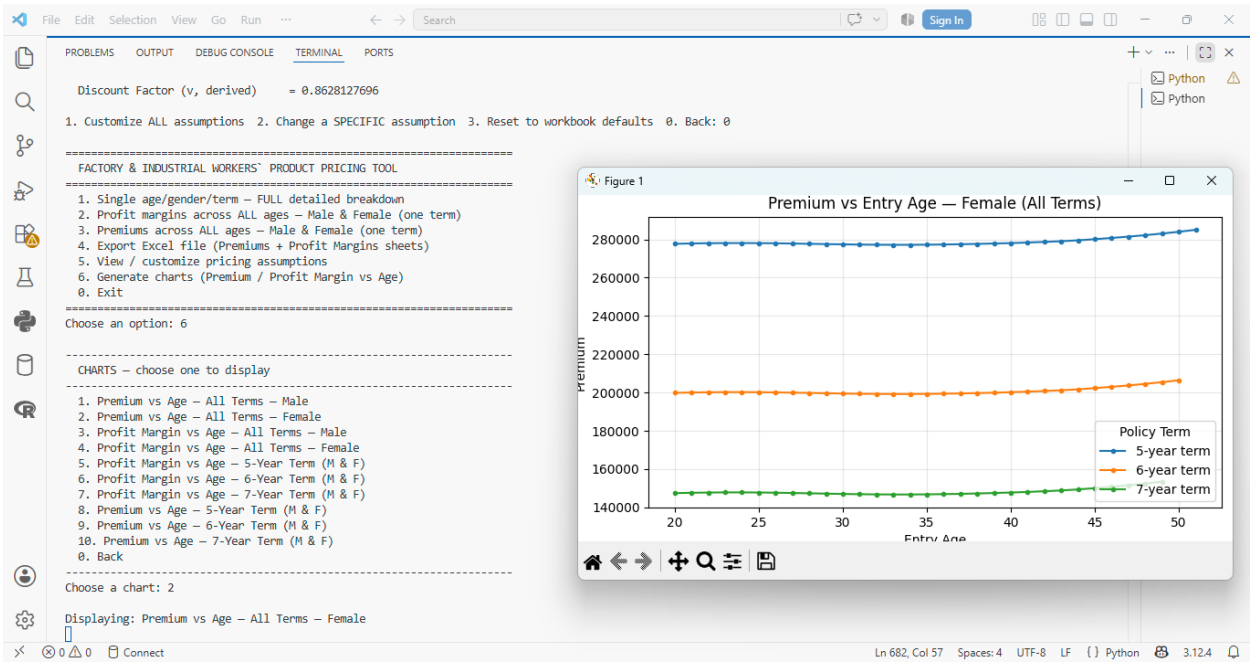
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Python
Python
Discount Factor (v, derived) = 0.8628127696
1. Customize ALL assumptions 2. Change a SPECIFIC assumption 3. Reset to workbook defaults 0. Back: 0
FACTORY & INDUSTRIAL WORKERS` PRODUCT PRICING TOOL
1. Single age/gender/term — FULL detailed 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: 6
CHARTS — choose one to display
1. Premium vs Age — All Terms — Male
2. Premium vs Age — All Terms — Female
3. Profit Margin vs Age — All Terms — Male
4. Profit Margin vs Age — All Terms — Female
5. Profit Margin vs Age — 5-Year Term (M & F)
6. Profit Margin vs Age — 6-Year Term (M & F)
7. Profit Margin vs Age — 7-Year Term (M & F)
8. Premium vs Age — 5-Year Term (M & F)
9. Premium vs Age — 6-Year Term (M & F)
10. Premium vs Age — 7-Year Term (M & F)
0. Back
Choose a chart: 2
Displaying: Premium vs Age — All Terms — Female
Figure 1
Premium vs Entry Age — Female (All Terms)
Premium
280000
260000
240000
220000
200000
180000
160000
140000
20
25
30
35
40
45
50
Entry Age
Policy Term
5-year term
6-year term
7-year term
Ln 682, Col 57 Spaces: 4 UTF-8 LF Python 3.12.4