THREE ESSAYS ON HOW LIFE INSURERS RESPOND TO A PROLONGED LOW INTEREST RATE ENVIRONMENT

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ABSTRACT

Life insurers, whose contractual liabilities include minimum guaranteed interest rates to policyholders, are significantly affected by persistently low interest rates. Hence, this dissertation reviews multiple perspectives and practices in different countries on the prolonged low interest rate environment and its impact on the industry (Essay 1). Followed by an empirical investigation of the life insurance industry in Thailand in two key areas liabilities management (Essay 2) and assets management (Essay 3). The second essay presents no potential interaction effect between solvency and return on assets during the "low rate" period. Nevertheless, large-size Thai life insurers have a higher mean proportion of interest-sensitive products when compared to mid and small-size life insurers. Essay 3 then examines the asset management of Thai life insurers by investigating the effect of asset allocation and investment strategy. Lower investment returns during a prolonged low interest rate environment emphasize the necessity of life insurers to make sufficient investment returns on separate accounts and derivatives to compensate for their potential underwriting losses from life insurance products.

KEY WORDS: LOW INTEREST RATE / MINIMUM INTEREST RATE GUARANTEE / INSURER SOLVENCY / LIABILITY MANAGEMENT / ASSET MANAGEMENT

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LIST OF ABBREVIATIONS

ALM	Asset and Liability Management
BLA	Bangkok Life Assurance
BUI	Bangkok Union Insurance
CAGR	Compound Annual Growth Rate
CET 1	Common Equity Tier 1
COVID	Coronavirus Disease
EIOPA	The European Insurance and Occupational Pensions Authority
IFRS	International Financial Reporting Standards
KWI	KWI Life
OIC	The Office of Insurance Commission
OECD	The Organization for Economic Cooperation and Development
ORSA	Own Risk and Solvency Assessment
QIS	Quantitative Impact Study
RBC	Risk-Based Capital
SI/ SII	Solvency I/ Solvency II
SAA	Strategic Asset Allocation
SCR	Solvency Capital Requirement
SET	The Stock Exchange of Thailand
TAA	Tactical Asset Allocation
TGH	Thai Group Holding (an umbrella of South East Life Insurance)
THREL	Thaire Life Assurance
TLAA	Thai Life Assurance Association
TLI	Thai Life Insurance
UK	The United Kingdom
US	The United States

CHAPTER I
INTRODUCTION

This Ph.D. dissertation consists of three academic essays:

Essay 1: How Do Life Insurers Respond to a Prolonged Low Interest Rate Environment? A Literature Review.

Essay 2: Liability Management of Life Insurers

Essay 3: Asset Management of Life Insurers

The first essay, reviewing multiple perspectives and practices in different countries used by insurance companies to deal with the prolonged low interest rate environment (Suwanmalai & Zaby, 2022), was extended from my Ph.D. Qualifying Paper. This published literature review will be the first essay of my dissertation, providing an overview of the impact of prolonged low interest rates on life insurers and their responses.

This dissertation mainly focuses on two empirical projects that examine life insurers' survival strategies in a prolonged low-interest rate environment. Both Essay 2 and Essay 3 contribute to an empirical investigation of the life insurance business in Thailand during a prolonged low interest rate environment. By investigating two key areas of liabilities management (Essay 2) and assets management (Essay 3), these two essays focus on various financial implications and highlight an observable shift in business outputs.

The second essay will investigate the nature of life insurance products in the Thai market, especially whether they are sensitive to interest rates or not. This essay aims to understand the impact of the prolonged low interest rate regime on Thai life insurance firms' business and financial strategies by analyzing decisions embedded in the life insurance outcomes. Critical outcomes are product mix, managing interest rate risk on guaranteed products, and solvency management of life insurers during the

prolonged low interest rate periods. Descriptive statistics and graph plots of the 10-year Thai government bond yield will be analyzed apart from an analysis of shifts in the product mix, profitability, and solvency position of life insurance firms over the past few decades to understand the phenomena of market interest rate movement,

The third essay will analyze the asset management strategy of life insurers in Thailand with changes in interest rate trends. Asset allocation based on investment portfolio composition and investment regulation, as imposed by the regulatory framework, are two key focuses. This part aims to understand the asset management strategy of life insurers during prolonged low interest rate periods. Regression analysis will estimate the relationship between the life insurer's asset allocation and investment strategy, including investment yields and regulations. According to regulatory requirements, Thai life insurers must manage asset portfolios to maintain sufficient minimum capital adequacy ratio requirements (Office of Insurance Commission, 2024).

1.1 An Overview of the Life Insurance Business in Thailand

Thailand is viewed as an aged society (more than 20% of the population over 60 years old: see Figure 1.1) and one of the fastest-aging societies in the world (World Health Organization, 2023). With this move toward a super-aged country soon, life insurance and a supportive healthcare system will be necessary for Thai society over the long run. All Thai life insurers held a sizable 4,021-billion-baht worth of total assets as of 2022 (Thai Life Assurance Association, 2023). With its substantial growth of 13% per annum during the past 20 years, the insurance industry is a financial institution that plays a vital role in the Thai financial economy (Connelly, 2004).

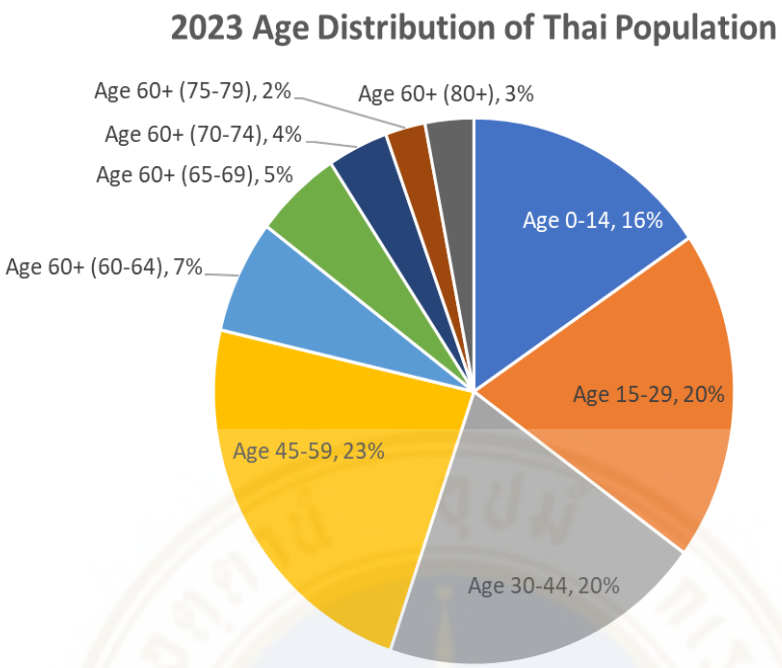

Figure 1.1: Population of Thailand: 2023 demographics (data collected from https://www.populationof.net/thailand/)

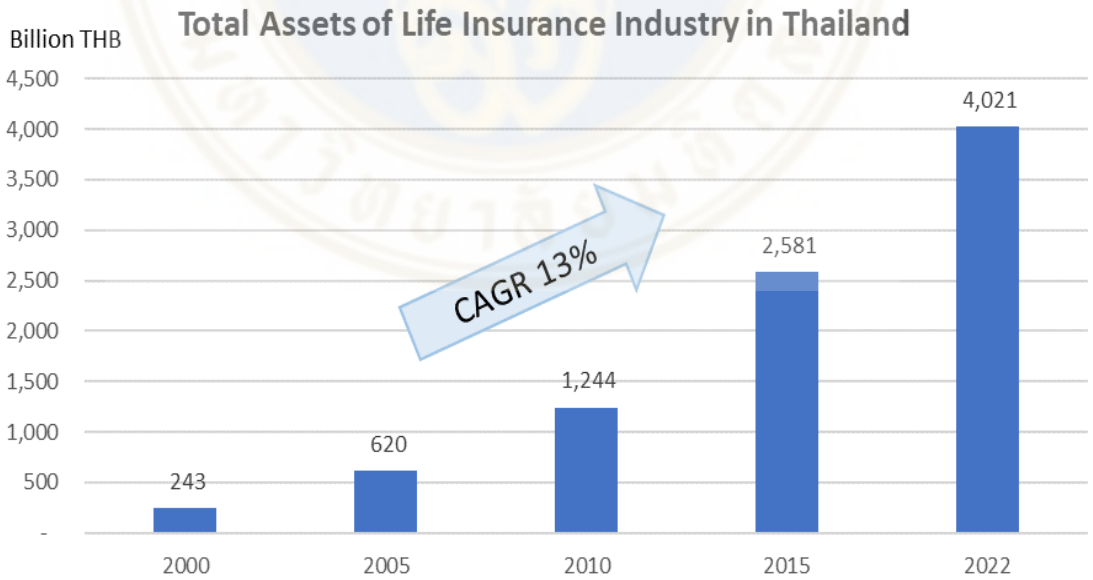

Figure 1.2: Growth of Life Insurance Industry Assets (data collected from Thai Life Assurance Association, 2023)

According to the Office of Insurance Commission's life registration information, there are 22 life insurers in Thailand as of December 2022 (Office of Insurance Commission, 2023). Despite all life insurers in Thailand being public companies as required by Thai regulation, they are not actively traded on the Stock Exchange of Thailand (SET), and only a few life insurers are listed and actively traded. Most of them are non-listed companies owned by either local Thai families or multi-national parent companies. Only six life insurers are currently listed in the Stock Exchange of Thailand (SET), namely: (1) BLA (Bangkok Life Assurance), (2) BUI (BUI Life Insurance), (3) TGH (Thai Group Holdings: Southeast Life Insurance), (4) KWI (KWI Life Insurance), (5) THREL (Thaire Life Assurance), and (6) TLI (Thai Life Insurance). SET groups these life insurers (or reinsurers) under the SET–INSUR (FINCIAL) index (Stock Exchange of Thailand, 2023).

The latest life insurance industry information from The Thai Life Assurance Association (TLAA) showed that the number of in-force life policies as of year-end 2021 was 26.17 million policies with a total sum assured of 20,790.58 billion baht (Thai Life Assurance Association, 2022). Regarding the 2022 market share, AIA (American International Assurance) ranks No. 1 with a 24% share by total premium, followed by Thai Life (15%) and FWD[1] – owned by Pacific Century Group (14%). When considering new business only, AIA is still dominant at 17% share, followed by Muang Thai Life (16%) and FWD (14%), respectively (Thai Life Assurance Association, 2022). AIA is considered a single life insurer structured as a foreign branch, while others are structured as domestic companies (Karim, 2005).

[1] Please note that the name "FWD" is an acronym for the company's name in Mandarin, "富衛 (Fú Wèi)" which means safety and wealth protection (https://www.fwd.com/en/newsroom/press-releases/fwd-comes-to-life/).

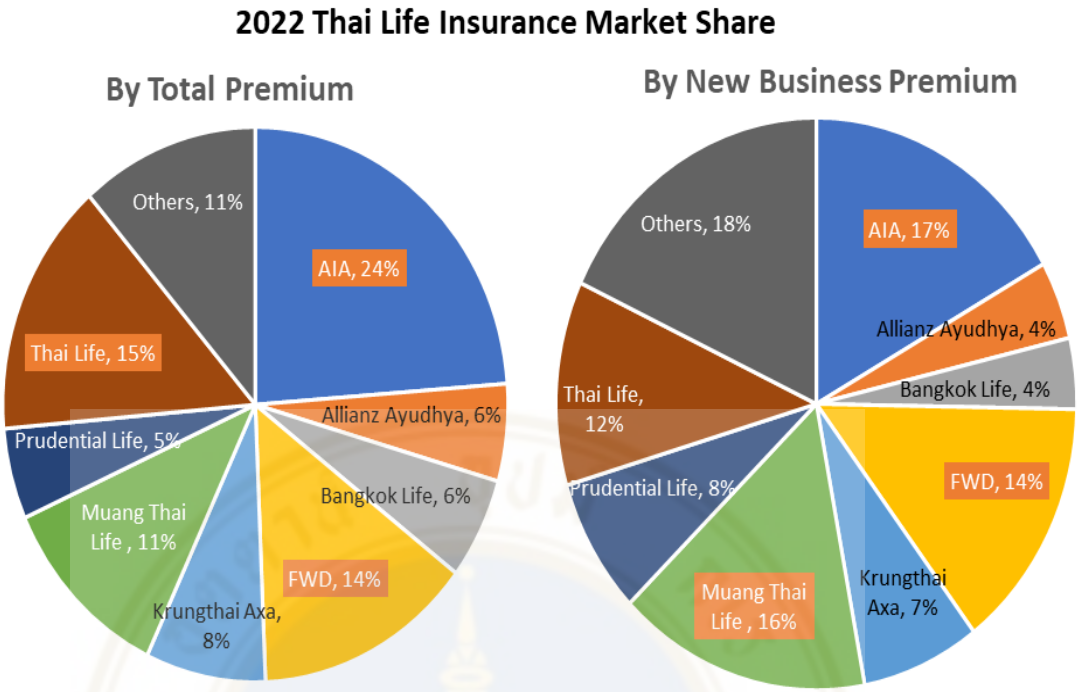

Figure 1.3: 2022 Thai Life Insurance Market Share (data collected from Thai Life Assurance Association, 2023)

As the Thai life insurance industry has been driven by multi-distribution channels and various life insurance products (Asvatanakul, 2011), life insurers face many challenges in complying with the Office of Insurance Commission (OIC) requirements. Life insurers, thus, executed several actions to rectify the regulator's concerns, such as placing a penalty on mis-selling for the agency distribution, setting up a vulnerable customer segment guidance for bancassurance salespersons, and implementing a do-not-call list for telemarketing channels. Apart from that, with the recent COVID-19 pandemic, which caused massive claims and insolvency of several non-life insurers in Thailand, life insurers are aware of the risks of mispricing and financial distress to the insurers. Besides, life insurers need to consider the interest rate effects on their products' profitability and linkage to their financial results (Suwanmalai & Zaby, 2022).

CHAPTER II

A LITERATURE REVIEW[2]

2.1 Introduction

During the past few decades, interest rates have dropped in various markets worldwide (Del Negro et al., 2019; Hartley et al., 2016; Holsboer, 2000; Reyna et al., 2022). For instance, in 2011, the long-term benchmark yield of a ten-year government bond declined for the first time to 3.92%, below the 4% technical interest rate provision required by European regulators (Kablau & Weiß, 2014). Berdin and Gründl (2015) described these low interest rates as "a threat to the stability of the life insurance industry" (p. 385). The life insurance business is susceptible to changes in long-term rates due to its contractual obligations to policyholders (Holsboer, 2000).

Today, most people are covered by life insurance. Life insurers function as financial intermediaries or "carriers." They buy financial instruments, such as government and corporate bonds, and bundle them with life and annuity benefits to offer to customers (Love and Miller, 2013). The successful operation of life insurance assumes that insurers balance consumers' needs for security against the interest rate sensitivity of the offered products. However, the life insurance industry operates in rising and falling interest rate environments, which impact profitability.

Eling & Holder (2013a) emphasized that "life insurance is an interest-sensitive business" (p. 354). The values of both assets and liabilities of life insurers change as the interest rate changes (Berends et al., 2013). Berends et al. (2013) asserted that liability duration might be extended in a low interest rate environment, as policyholders are unlikely to surrender their policies. We anticipate that policyholders' surrender behavior significantly impacts the duration of life insurance liabilities. This

[2] This Essay was published in Risks 10: 155. https://www.mdpi.com/2227-9091/10/8/155 dated 2 August 2022

phenomenon accelerates the negative duration gap because the increased duration of liabilities is much longer than that of held assets (Antolin et al., 2011). The longer the duration of liabilities, the higher the sensitivity to interest rate changes. Therefore, low interest rates are more likely to significantly impact life insurers due to the high sensitivity of liabilities to interest rate variations.

Over the past few decades, low interest rates have become a global issue, especially when long-term bond yields drop to historical lows (Holsboer, 2000). The present literature review provides new insights into the case of globally persistent low interest rates. The main objective of this study is to explore extant research insights regarding the impact of prolonged low interest rates on the life insurance business. This study addresses the following research questions:

1. What has been the trend in global interest rates since 1990?

2. How are life insurance products affected by a low interest rate?

3. How do low interest rates change insurer valuation and solvency?

4. How can financial management strategies respond to a prolonged low interest rate environment?

The remainder of this paper is organized as follows. Section 2 briefly reviews the study's conceptual background and the historical financial crises caused by low interest rates. Section 3 outlines the study's methodology. Section 4 presents the study's results on how low interest rates impact life insurance products and valuations of life insurers, proposing short- and long-term solutions for insurers to respond to low interest rate environments. Finally, Section 5 discusses the study's limitations, interpretations, and implications for future research.

Our study fills the gap in prior literature through two main perspectives. First, we summarize past research on life insurance's low interest rate environment. We also identify causes and effects for life insurers. Our main managerial contribution is to support life insurance companies' strategies with a course of action to deal with a low interest rate environment. Second, we address various perspectives on the prolonged low interest rate phenomena by synthesizing them into a knowledge base (Whittemore & Knafl 2005). Our extant literature focuses exclusively on either the product or

valuation perspective. The present review is the first to aggregate insights from these two standpoints to collectively define challenges life insurers face during a protracted low interest rate environment.

2.2 Conceptual Background

To respond to a prolonged low interest rate environment, life insurers must consider the interest rate's impacts on life insurance products' profitability, linking it to insurers' investment and financial results. Reyna et al. (2022) mentioned two primary profit sources for life insurance companies, one being a life insurance operation that guarantees premium income minus expenses. Brown and Galitz (1982) called this source "underwriting profit" (p. 290). This underwriting profit is insurance and product-related. Strengthening underwriting rules, lower product guarantees, and efficient cost management are keys to gains from this profitability part (Reyna et al., 2022). Another source of profit relates to investments in technical reserves. This non-insurance-related source is generated from an investment income earned on an asset portfolio. These two sources have a more noticeable impact in a low interest rate environment due to insurers' challenges in pricing from higher guarantees on products than investment yields on assets. Life insurers struggle with these challenges when the available margin from the investment return over the guaranteed minimum return is insufficient to fund future life insurance obligations (Kablau & Wedow, 2012).

Options such as a minimum guaranteed interest rate on the saving component and policyholder participation in the profit-sharing scheme of life insurers are often embedded in life insurance policies. These crucial guarantees require appropriate valuation and hedging to keep the insurer solvent (Schmeiser and Wagner, 2015). However, minimum guaranteed interest rates are usually set below-market interest rates at the first launch, with an out-of-the-money option (Berends et al., 2013). This strategy emphasizes that an adequate asset and liability management (ALM) framework may mitigate interest rate risk in a prolonged low interest rate environment, supporting new product development (Focarelli, 2015; Holsboer, 2000; Paetzmann, 2011).

This ALM framework, previously applied by the banking industry, is widely adopted by life insurers as a risk management tool (Holsboer, 2000). Banks have successfully used the duration-matching approach of ALM to minimize interest rate risks (Romanyuk, 2010). Borri et al. (2018) applied canonical correlation analysis to study the relationship between the assets and liabilities of European life insurers during a "low-rate" period. The result of high exposure to ALM risk from less dependency between assets and liabilities supplements the usefulness of the ALM tool in both industries.

Interest rates have varied significantly over the past few decades. In the early 1990s, the United States (US) began recovering from a recession, with the long-term interest rate hitting 6%, followed by a decrease to 4.7% by the end of 1998 (Holsboer, 2000). From the end of 2007 to mid-2009, the Great Recession in the US caused an economic downturn, a more than 10% decline in GDP, a 25% unemployment rate, a bursting of the housing bubble, a correction of the housing market, and a subprime mortgage crisis. The global financial crisis pushed interest rates close to zero to stimulate spending and investment (LePan, 2019). Europe's sovereign debt crisis followed, causing rating agencies to downgrade various Eurozone countries' debts. From 2009 to 2010, two European insurers, Victoria Life and Delta Lloyd Groep, stopped their new business underwriting (i.e., new policy issues) due to the low interest rate environment (Paetzmann, 2011). These outcomes are the negative effects of low interest rates on the business and economy.

Hartley et al. disaggregated the market into "normal" and "low-rate" periods (Figure 2.1). Between 2002 and mid-June 2007—a "normal" period—small changes in interest rates did not affect insurers' stock prices in the US and the United Kingdom (UK). Interest rates during the "normal" period were within their historical norm. However, after the 2007–2008 financial crisis, the long-term interest rate drastically decreased, leveled off at a historically low level, and stayed at that low rate until 2021, as shown in Figure 2.1. This later period is defined as the "low rate" period (Hartley et al., 2016). Reyna et al. (2022) emphasized that insurers must implement specific actions to recover their profit margins during this persistently low interest rate environment.

In mid-2016, most Asian countries, including Taiwan and Hong Kong, recorded historically low zero-coupon government bond yields. By contrast, government bond yields became negative for almost all tenors (Nieder, 2016). Between 2017 and 2018, ten years after the financial crisis, global interest rates remained low. For example, the ten-year US government bond yields fell below 3%, remained slightly above 1% in the UK, were approximately 0.40% in Germany, and were close to zero in Japan (DelNegro et al., 2019).

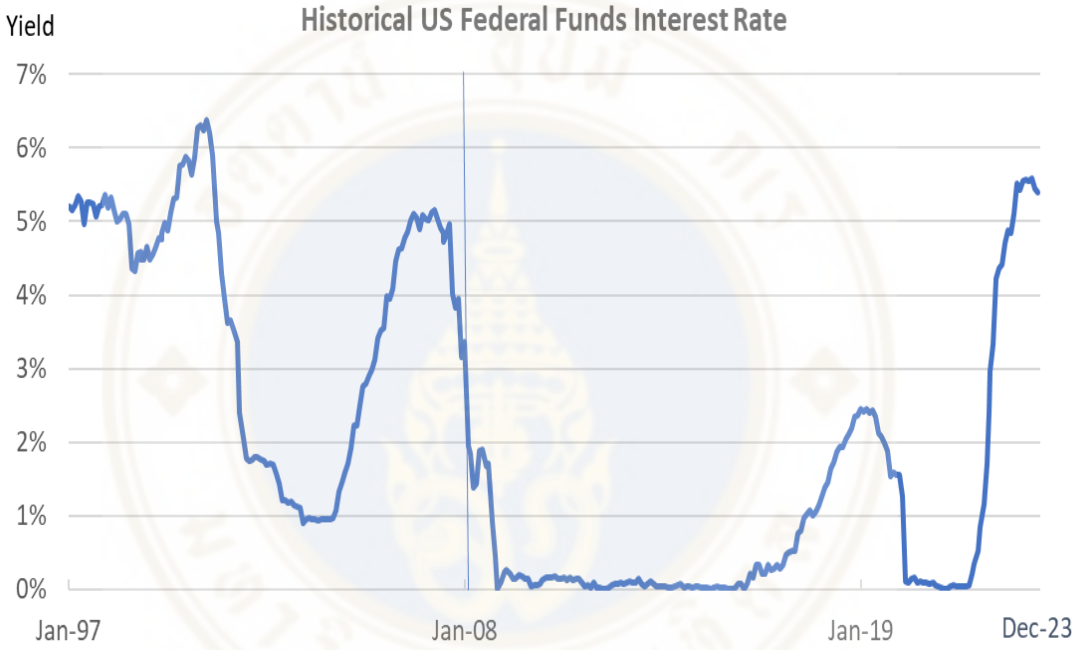

Figure 2.1: Historical US Federal Funds Interest Rates (adapted from United States Fed Funds Rate, 2024).

This decline in interest rates is a threat to insurance businesses, especially life insurance companies (Berdin and Gründl, 2015; Grosen and Jørgensen, 2000). Life insurers typically rely on fixed income markets, such as government and corporate bonds, to hedge their future obligation's returns and gather sufficient funds to repay policyholders' benefits. Several insurers use duration matching for hedging interest rate risk in periods of stability and near historical average risk, in line with US and European practices in early 2000 (Hartley et al., 2016). However, hedging interest rate risk is more

complicated in a low interest rate environment, primarily due to the guaranteed interest rate and policyholder behaviors (Hartley et al., 2016). Over the past few decades, numerous life insurers have faced difficulties due to high guaranteed interest rates despite hedging policies in place due to high guaranteed interest rates. A British life insurer, Equitable Life, was forced to shut down for new business following a House of Lords ruling in 2000 (Van der Heide, 2020). The same year, German Mannheimer Lebensversicherung had to stop their new business underwriting due to financial distress (Schmeiser and Wagner, 2015). These business challenges are constraints that life insurers have to overcome.

2.3 Materials and Methods

We employed a literature review methodology to gather various perspectives and information regarding different practices worldwide (Cronin & George, 2023), enhancing the current knowledge regarding the impact of persistently low interest rates on the life insurance business, synthesizing the related literature, and highlighting critical areas for future research and reviews (Cronin & George, 2023). Furthermore, we summarized the life insurance literature, systematizing the extant knowledge base (Whittemore & Knafl, 2005). We aim to synthesize key findings from previous literature and compare insurance with lessons learned from the banking industry. Therefore, this review seeks to understand persistent low interest rates and their impact on the life insurance business.

We searched the titles, abstracts, and keywords of articles related to life insurance and low interest rate environments in the Scopus database. Only articles related to “life insurance,” “low interest (rates),” “interest rate risk,” “interest rate guarantee,” and “minimum interest rate” were included. Then, we reviewed these articles, working papers, and discussion papers and integrated them using Google Scholar and institution and online publisher websites to analyze the global interest rate trend. Only a few search results were relevant to the prolonged interest rate environment, highlighting the interest rate risk that matches the topical focus of the present review.

Both quantitative and qualitative literature are included in the present review. The potential risk of bias in all included studies is alleviated by reconciling conclusions between countries, as all countries should share a standard paradigm regarding the same prolonged low interest rate phenomenon.

2.4 Results

This study adopts a qualitative approach. It reviews extant research and classifies it into three broad categories. The first literature stream addresses the impact of low interest rates on life insurance products, investigating the interest rate sensitivity of each product type and product shift strategy. The second branch in the literature examines the effects of low interest rates on life insurance companies' valuations, addressing the shift in the valuation interest rate (VIR) and the financial and solvency impacts. Finally, the third research stream explores short- and long-term solutions for life insurers operating in low interest rate environments.

2.4.1 Impacts of Low Interest Rates on Life Insurance Products

Life insurance products have two prominent features. One is the protection coverage at which compensation is paid to the policyholder in the form of a lump-sum payment (sum assured) following an adverse event (i.e., death, accident, or sickness). The other is the saving component, which allows wealth accumulation for policyholders (Berends et al., 2013). In most developed countries, retirement or pension funds receive excess savings from older adults (Reyna et al., 2022). The interest rates on savings that life insurers guarantee to policyholders are critical (Hartley et al., 2016). Eling & Holder (2013b) classified the measures of guaranteed interest rates into two broad approaches. The first is an actuarial approach to analyzing different products' risks and surplus appropriation schemes using an objective probability measure. Empirical studies comparing various products and surplus allocations employ this actuarial approach (Cummins et al., 2007; Grosen & Jørgensen, 2000; Kling et al., 2007). The second approach emphasizes the fair price of product participation and the value of the

embedded options. Both methods help assess the guaranteed interest rate of life insurance products (Eling & Holder, 2013b).

Products previously priced at guaranteed high investment returns, often without any assets backing liability, may lead to a loss in the investment's source of profit for insurance companies. A high guaranteed rate is consistent with the Association of Mexico Insurance Companies' evidence that investment returns are insurers' primary income source (Reyna et al., 2022). Hence, insurers typically seek other sources of profits to compensate for policy reserves and achieve the required profit. Due to the high competition in the insurance industry, insurance products are complex and move quickly regarding the product development approach (Holsboer, 2000). However, it is difficult to sell products profitably in a low interest rate environment unless a mark-up in prices or lower benefits are guaranteed from the insurance product design features. However, such a product may be less attractive to potential customers (Hartley et al., 2016).

Regulators in several jurisdictions, including the European Union and Japan, have set up a maximum allowable guaranteed interest rate, with an upper limit not exceeding 60% of the government bond's yield (Schmeiser & Wagner, 2015). In addition, the European Union directives relieve the impact of low interest rates, aligning them with the market interest rate movements. Regarding pricing strategies, regulators worldwide treat policyholders' perspectives as critical considerations for approving life insurance products. According to Schmeiser and Wagner (2015), policyholders believe that insurers' transaction costs, such as distribution and administration costs, are passed on to them. This concern has, in turn, induced insurers to better communicate with policyholders, reassuring them that transaction costs are acceptable.

2.4.1.1 Interest Rate Sensitivity of Each Product Type

Different types of businesses experience different impacts from interest rate movements. Non-life insurance (i.e., property and casualty insurance) is less sensitive to interest rate variations, as these products are short-tail liabilities (Reyna et al., 2022). Besides, nonlife insurers may adjust their product prices upon renewal. An adjustable renewal premium allows non-life insurers to charge a reasonable fee in line with the interest rate environment, thus reducing interest rate risk (Berends et al., 2013).

In contrast to life insurance products, these are long-term coverage and premium payment instruments.

Furthermore, life insurance products usually provide a guaranteed minimum return in their illustrated dividends such as whole life products in the US (Rybka, 2017). Hence, differences in product features determine the exposure level to interest rate risk. “With profit” (or participating) endowment and whole life products are interest-rate sensitive instruments. However, they are less susceptible to interest rate changes if the guarantee is paid at maturity (rather than annually) and no market value adjustment is allowed, with assets backing liabilities, as in the case of Italian products (Focarelli, 2015). On the contrary, in France, where minimum guaranteed rates are set lower than those in other European countries, profit-sharing, or a surplus appropriation scheme, plays a crucial role in meeting policyholders’ expectations (Borel-Mathurin et al., 2018).

A different mixture of life, outliving, and saving elements characterizes insurance products. For example, while the outliving benefit is crucial for annuity and pension products, the saving benefit is vital for tax privileges or tax-benefit deduction purposes. These essential elements help assess insurers’ exposure to interest rate risk. The effects of the guaranteed minimum return on saving benefits and policyholders’ behavior are complex and reflect the interest rate sensitivity of life insurers. Upon interest rate changes, policyholders exercise their available options. For instance, if it increases, they may surrender an annuity with a low guaranteed interest rate. By contrast, they may contribute more to that annuity product when the interest rate decreases (Hartley et al., 2016).

In the US, indexed universal life products usually provide a projected guaranteed interest rate as per the sale illustration at the moment of sale (Rybka, 2017).

Concerning pension and annuity products, German deferred annuity products provide a significant guarantee in the accumulation and annuity payout phases (Nieder, 2016). With an annuity, policyholders receive protection against late death and a stream of future lifetime payments upon survival in return for earlier premium payments (Berends et al., 2013). Group pension products with an extended

liability duration require more investment earnings from life insurers' assets than individual products to adequately fund their retirement benefits, especially in a prolonged low interest rate environment (Holsboer, 2000).

Grosen & Jørgensen (2000) performed a numerical analysis to disaggregate the features of traditional participating life insurance products into three baseline components. The first component is a risk-free bond representing the value of the guaranteed interest rate. The second component is the bonus (or dividend) option, and the last is the surrender option. The last two components are implicit options embedded in participating products. In the US, participating products typically combine these three components. This combined view is consistent with the approach that North American insurers view dividends as a release of an original price-benefit structure and return part of that premium if it is no longer needed for future risks to policyholders (Bowers et al., 1997). However, only the first two components are usually present in European participating products, as the maturity bonus only applies to European life insurance companies (Grosen and Jørgensen, 2000). Moreover, when an insurer's investment return is insufficient to generate profit-sharing in participating products, they must resort to their equity capital (Kablau & Wedow, 2012).

2.4.1.2 Product Shift Strategy

A high interest rate increases the demand for savings products, possibly resulting in a high lapse rate or surrender of insurance policies for alternative investments. By contrast, a low interest rate hurts insurance companies' profitability due to the low investment return on their asset-backing portfolio (Eling & Holder, 2013a). For life insurers, even a simple product, such as a whole life product, has an embedded saving element, such as a cash value that policyholders receive upon contract termination. This cash value usually builds up during the pre-maturity period until the contractual death or survival benefit payouts. Without a pre-maturity event, the cash value grows until the maturity payment (Berends et al., 2013). Besides receiving death benefit coverage during the policy lifetime, life insurance policies allow policyholders to exercise embedded options. For instance, they may cease premium payments by using their cash value or dividends to pay for the due premium (Love & Miller, 2013). And

their policy remains in force. Hence, the cash value benefits policyholders, especially with declining interest rates.

Product portfolio composition is the primary consideration for determining an insurer's shortfall risk (Bohnert et al., 2015). Product mix and its surplus appropriation scheme for participating products are crucial for life insurers and regulators. Focarelli (2015) showed that Italian life insurance companies mainly propose interest-sensitive products, such as participating endowment and whole life products. These single-premium products have a guaranteed maturity bonus. However, several insurers have moved their product portfolio toward the least investment return or even no-guarantee products. In 2014, evidence regarding the new business portfolio showed that one-third of the sales volume moved toward new "dynamic hybrid" products, supporting a shift in products toward a combination of participating endowment and unit-linked features (Focarelli, 2015).

Insurers focus on transferring the investment risk to policyholders, with the recent product trend moving toward variable life insurance products (Nieder, 2016). For instance, German life insurers have moved from traditional savings and deferred annuity products to protection products (e.g., disability income benefits and long-term care products) and the "alternative guarantee" concept. This concept lowers the guarantee to only the return on premiums at the end of the deferred period and minimizes annuity payouts during the annuity phase (Nieder, 2016).

2.4.2 The Impact on Valuation of Life Insurance Companies

Berends et al. (2013) applied a quantitative approach to analyze the sensitivity of life insurance companies to interest rate risk before the financial crisis (2002–2007) and during the low interest rate period of 2007 to 2012. Since the value of the insurer's current balance sheet and future profits are represented by the insurer's stock price, they examine an insurer's exposure to interest rate risk by addressing the correlation between changes in interest rates and an insurer's stock price. Before the financial crisis, the stock price of insurance companies was uncorrelated with benchmark government bond yields. However, it negatively correlated with bond yields

after the crisis, when the interest rate dropped. Upon the decline in interest rates, bond prices increased. Empirical evidence from 26 publicly traded US life insurance companies has shown that large insurers (measured in terms of total assets) experienced a negative correlation between stock prices and bond yields. In addition, stock returns of large life insurers fluctuate more than those of small insurers because large life insurers have more interest-rate-sensitive life insurance products in their portfolio (Berends et al., 2013).

2.4.2.1 The Shift in Valuation Interest Rate

Valuation interest rate (VIR) or actuarial interest rate, namely, the technical interest rate, is "a conservative estimate of future investment earnings" (Holsboer, 2000, p. 42). The technical interest rate helps determine reserves in a company's balance sheet. Since the VIR is used as a discount rate for reserve calculation, the greater the VIR, the smaller the reserve amount (Eling & Holder, 2013a). Consistent with Lidstone's theorem, the reserve held for a life insurance policy decreases with an increase in interest (Macdonald, 2004). Regulators in various countries have set an upper limit for the VIR and named it the "maximum technical interest rate," typically subject to an annual review for its adequacy as an implicit determiner of the minimum guaranteed interest rate for policyholders (Eling & Holder, 2013a). The German regulator determines the maximum allowable interest rate for the reserve calculation and the pricing of new life insurance products in that country (Nieder, 2016).

Insurers use reserves to allocate an additional interest provision and maintain policyholders' future obligations, which aligns with the legally prescribed reserve methodology (Kablau & Weiß, 2014). If the guaranteed interest rate exceeds the VIR at policy contract inception, insurers are typically expected to hold higher reserves than those priced in the contract. Eling & Holder (2013a) called this case an "undesirable positive initial reserve" since the insurer must be pre-financed. However, when the guaranteed interest rate is less than the VIR, an opposite case of the negative initial reserve emerges, which is not recognized in the balance sheet, even though insurance companies consider it a receivable (Eling & Holder, 2013a).

The maximum VIR is regulated and driven by long-term government bond yields in Germany, Austria, and Switzerland, where the maximum VIR entails a partially formula-based approach. In contrast, in the US, the VIR is fully formula-based and driven by corporate bond yields without any regulator involvement (Eling & Holder, 2013a). The situation differs in the UK, where the maximum VIR relies on a company-specific principle-based approach rather than an explicit rule-based "one-size-fits-all" concept (Eling & Holder, 2013a).

The German regulator has moved from relying on 60% of the past ten-year average of long-term nine or ten-year (remaining) tenor government bond yields to the past five-year average to reflect better the current low interest rate scenario (Eling & Holder, 2013a). Similarly, the Austrian regulator has set the maximum VIR at 2% since 1 April 2011. This rate is based on 60% of the ten-year average of the secondary market of Austrian government bond yields. Along these lines, Switzerland (a non-European Union country) has set the maximum VIR at 1.5% since 1 January 2012 (Eling & Holder, 2013a).

In the US, the VIR follows the so-called "Commissioner's Reserve Valuation Method" (Eling & Holder, 2013a). According to the Standard Valuation Law, the maximum statutory VIR differs by product type and cohort year based on the average US investment-grade corporate bond yields. The VIR used at the policy inception date remains unchanged until the contract's maturity date; this clause applies to the VIR of all the mentioned countries (Eling & Holder, 2013a).

By contrast, the maximum VIR in the UK is determined from current and expected future earnings on insurance company-specific investment strategies, with sufficient allowance for margins in the case of an adverse deviation. The maximum VIR varies by product category. For example, the maximum VIR for traditional life insurance products (long-term) should not exceed 97.5% of the risk-adjusted return, assuming these liabilities are asset-backed (Eling & Holder, 2013a).

Holsboer (2000) showed that a 2% VIR was applied for new life insurance business products in Japan and the European Union in 2000. This low VIR reflects that the capital market interest rate was less than the products' guaranteed interest rate at that time. Regulators worldwide have started to adjust the maximum VIR

based on solvency assessments and exposure to low interest rate environments (Holsboer, 2000). Eling & Holder (2013a) contributed to the research using stochastic simulation and a principle-based approach to capture company-specific risk. They emphasized that the VIR should continue to decrease in the future. Japan's life insurers addressed this issue by moving their asset allocation toward USD-denominated bonds, particularly with negative returns on government bonds (Nieder, 2016). Berends et al. (2013) contended that life insurers use derivatives, such as interest rate swaps, for hedging interest rate risk despite their limited proportions.

2.4.2.2 The Financial and Solvency Impacts

Love and Miller (2013) mentioned one primary source of profit for insurance companies, called "spread compression." This spread reflects insurers' gain from investment portfolios over and above the benefits policyholders receive for insurance policies. Even though some insurers may choose their targeted spreads to maintain profit at a manageable level, they cannot sustain those spread positions due to their products' minimum guaranteed credit rates (Love & Miller, 2013). For example, assume that the new product's guaranteed interest rate is 2–3%, whereas the old business block (old products) has a minimum of 4%. An insurer may no longer be able to keep the targeted spread of 1.5% if investment returns only amount to 4.5%. Thus, insurers must delay the policy credit (interest rate) increase until they can recover the investment spread (Love & Miller, 2013). As new money rates earned on insurers' investment portfolios reflect the market interest rate environment, the life insurance policy credit (declared rate) lags behind new money rates (Love & Miller, 2013).

Based on Lidstone's theorem, the change in the reserve of life insurance products and interest rate changes move in the opposite direction (Macdonald, 2004). As such, low interest rates also extensively worsen the solvency position of life insurers due to an increase in reserves that insurers must hold. During 1997–2001, with the protracted low interest rate environment, seven middle-sized life insurers in Japan declared insolvency due to a drastic decline in the profitability of high guaranteed interest rates for their in-force business (Berdin & Gründl, 2015). Nieder (2016) contended that negative spread, increased competition, and loss of customer confidence in those seven insurers led to insolvency. The European Union insurance regulators first

developed a prescribed solvency regime called the "Solvency I (SI)" framework to address this issue. The regime required insurers to hold 4% of the premium reserve and 0.3% of the capital at risk as a solvency margin or regulatory own fund requirements (Kablau & Weiß, 2014). Kablau & Weiß (2014) used coverage ratio, the ratio of eligible regulatory own funds to solvency margin, to measure the impact of low interest rates on insurers' solvency. Results indicate that all German life insurers can manage their SI own funds requirements in the base scenario. In contrast, almost 40% will be unable to do so by 2023 under a severe low-yield stress scenario.

Like Basel III[3] in the banking industry, "Solvency II" (SII, hereafter) is a recent risk-based framework governed by insurance regulators. It applies a market-consistent approach to improve the transparency and stability of the financial system in the European Union. The SII standards set aside solvency over a one-year horizon based on a full range of risks on insurance companies' asset and liability sides in the 99.5 percentile—a one in two hundred years loss event (Niedrig, 2015). SII helps guard against insurance products with a minimum guaranteed interest rate. However, the more significant regulatory capital requirement set for this product type makes them less likely to be promoted by life insurers (Paetzmann, 2011). Holsboer (2000) contended that life insurers should set the risk-adjusted return on capital as a determinant for the minimum capital that life insurers should hold for different businesses based on their risk profiles. The riskier the business, the higher capital insurers should set aside from high-profit investment to compensate for business risk (Holsboer, 2000).

Marked-to-market on assets and liabilities is a prerequisite for a market-consistent valuation of the solvency position under SII (Berdin and Gründl, 2015). The discount rate reduction due to declining market bond yields increases the present value of future benefits and the market-consistent value of liabilities (Niedrig, 2015). Since the liability duration is usually much longer than the duration of assets (Hartley et al., 2016), the higher this gap, the greater the reinvestment risk faced by insurers. These duration gaps lead to a potential issue in the insurer's solvency position,

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3 Basel III is an international regulatory accord rolled out by the Basel Committee on Banking Supervision to govern the banking sector's ability to improve risk management and promote transparency. It sets appropriate risk-based capital as a cushion to deal with financial distress and maintain the continuity of bank operations (Bloomenthal 2020).

as an insurance company's asset values are lower than the market-consistent value of liabilities (Nieder, 2016).

From 2009 to 2013, the European Insurance and Occupational Pensions Authority (EIOPA) emphasized the financial stability risk for insurance and pension companies, especially during a persistently low interest rate environment (Focarelli, 2015). The EIOPA implemented a low interest rate stress test (called a "Japanese-like scenario") in 2014 to test the sustainability of interest rate guarantees embedded in life insurance products. In addition, the EIOPA addressed the solvency capital requirement (SCR) ratio[4], interest rate exposures (measured in terms of duration or cash flow matching), and profitability (measured in terms of internal rate of return). According to Focarelli (2015), product design and segregated funds allow insurers to compute booked and realized values in Italy, assuring relatively stable and non-volatile returns. As a result, the Italian insurance industry's SCR ratio outperforms the European average.

The International Accounting Standards specify that equity holding should be determined at market value, whereas liabilities must reflect book values. These requirements may lead to a solvency issue in a prolonged low interest rate environment (Holsboer, 2000). When insurers adjust their assets' portfolio quicker than the growth rate of liabilities to provide the high guarantee promised to policyholders, in a low interest rate environment, they increase their asset allocation to a riskier asset class. This asset reallocation makes liabilities more volatile than assets, requiring substantial capital to support businesses (Niedrig, 2015). Risky investments are more vulnerable to disruption and variations in earnings. Hence, this shift toward risky investment may adversely impact insurers' financial stability (Kablau & Weiß, 2014). The riskier the high yield investments, the wider the duration gap between assets and liabilities, and the higher the volatility of asset portfolios. Berends et al. (2013) contended that life insurers might be exposed to credit risk on high-yield investments due to the potential loss of their asset values. This credit risk makes regulators worldwide (including in the US) enforce a risk-based capital (RBC) framework to help

[4] Solvency capital available based on eligible own funds (post-stress) divided by SCR (pre-stress).

mitigate potential threats to insurance companies. Similar to the SII, the RBC framework establishes a minimum required capital that a life insurer must hold to assure solvency (Berends et al., 2013).

The required capital increases with higher risk charges. Empirical evidence from Niedrig (2015) indicates that changes in the long-term interest rate affect the insurer's optimal risk portfolio by adding riskier asset classes in search of yields. As in the case of Germany, life insurers aim to increase the asset allocation to more illiquid investments, such as infrastructure bonds, to obtain higher yields (Nieder, 2016). This investment strategy increases risk-taking to enhance investment returns and meet policyholders' obligations (Kablau & Weiß, 2014). By contrast, insurers' asset portfolio is invested in risk-free government bonds upon a long-term upward interest rate increase. Hence, a narrowed duration gap leads to a decrease in the capital requirement for insurers.

Berdin and Gründl (2015) enhanced the balance sheet approach (market value) to summarize the key findings of the Deutsche Bundesbank regarding stress scenarios to quantify the impact of interest rate on life insurer solvency during a prolonged low interest rate period. The Financial Stability Review produced by the Deutsche Bundesbank (2013) showed that more than one-third of all German life insurers will not meet the regulatory capital requirements by 2023, based on a market-consistent balance sheet model. High guaranteed interest offered to policyholders is the main threat to insurers' solvency. By contrast, using scenario analysis, Kablau & Weiß (2014) analyzed the impact of a low interest rate environment on the solvency of German life insurers. Even though they consider the SI regime, all baseline, mild, and severe stress tests help visualize net investment returns for those situations, besides identifying a coverage ratio required to fulfill their own funds' requirements.

2.5 Solution Approaches

Insurers worldwide take plausible actions to deal with a prolonged low interest rate environment. This study summarizes them into short- and long-term solutions.

2.5.1 Short-Term Solutions

US insurers have previously reduced the interest component of their dividend crediting rate as a prudent response to a low interest rate environment (Rybka, 2017). Nieder (2016) emphasized the recent move toward USD-, Euro- or AUD-denominated life insurance policies in Japan to promise a much higher guaranteed interest rate than that denominated in the local currency. However, this approach may expose policyholders to exchange rate risk. From the product implementation perspective, insurers respond to the prolonged low interest rate environment by lowering the guaranteed interest rate on new products (Antolin et al., 2011). In addition, insurers react differently depending on the product type. For example, Love and Miller (2013) compared and contrasted potential corrective courses of action to alleviate the impact of prolonged low interest rates, which differ between in-force and new business blocks, as summarized in Table 2.1.

Table 2.1: Impact of Each Product in a Prolonged Low Interest Rate Environment (adapted from Love and Miller 2013).

Product	Structure	In-force Block	New Business Block
Whole Life (WL) base plan only	Premium-dependent	- None on base. - Potential lower death benefit (DB) growth from lower dividend additions (Paid-up addition option in case policyholders choose paid dividends to buy additional DB for future remaining covered years) - Lower cash value from dividends	
WL with Term Riders	Dividend-dependent	- Additional out-of-pocket premiums - Increase annual premium requirements - Reduce in DB - Increase in policy expenses	Higher illustrated premiums
Modified Premium Whole Life	Dividend-dependent	- Additional out-of-pocket premiums - Payment of a higher ultimate premium	- Higher out-of-pocket costs - Lower DB growth
Suspended Premium Whole Life	Dividend-dependent	- Reappearing out-of-pocket premiums - Reduce in cash value and DB	Inability to suspend premiums
		Increase the number of required out-of-pocket premiums	
Universal Life (UL) with Secondary Guarantees	Premium-dependent	- Lower cash value - No impact on a guaranteed DB	- Higher premiums (especially for sizable up-front fees) - Restrictions on the lump-sum amount - Few insurers to offer this product
Most UL	Cash-value-dependent	- Lower cash value - Reduce in policy duration and no additional premiums - Increase in policy expenses	Higher illustrated premiums

Table 2.1: Impact of Each Product in a Prolonged Low Interest Rate Environment (Cont.)

Product	**Structure**	**In-force Block**	**New Business Block**
Variable UL with DB Guarantees (GMDB)	Premium-dependent	No impact on a guaranteed DB	- Premiums for guarantees have been reduced - Restrictions on allowable investment allocations with guarantees
Variable UL without GMDB	Cash-value-dependent	- Lower cash values if investment performance is lower than expected - Earlier policy lapse and no additional premiums - Restrictions on allocations to fixed accounts	- Lower guaranteed interest rates in fixed account options - Limitations on allocations to fixed accounts
Indexed UL with GMDB	Premium-dependent	No impact on a guaranteed DB	Introduction of products with limited long-term guarantees
Indexed UL without GMDB	Cash-value-dependent	- Lower cap or participation rates - Reduce policy duration in the absence of additional premiums - Increase in policy expenses	- Lower cap or participation rates - Higher illustrated premiums

However, customers' reactions to the insurer's choices may vary. Therefore, insurers should help policyholders fully understand their decisions (Love and Miller, 2013).

Concerning short-term financial monitoring, life insurers use ALM monitoring to assess and mitigate interest rate risk by lengthening the duration of assets (Holsboer, 2000). Unlike banking institutions, they typically employ the ALM framework for long-term strategic management (Romanyuk, 2010). We recognize that a potentially different approach could be caused by the varying nature of longer-term assets than liabilities for banks versus shorter-term assets than liabilities for life insurance. ALM is an investment approach based on matching asset and liability durations, helping insurers confine potential exposures to interest rate risk (Berends et al., 2013). Raising equity might also be necessary during a prolonged low interest rate environment, as it is the quickest approach to gathering sufficient equity funds (Kablau & Weiß, 2014). We emphasize that life insurers should balance meeting policyholders' reasonable expectations and maintaining enough equity capital. This point is partially supported by empirical evidence from Borel-Mathurin et al. (2018), who investigated the main drivers of the participating strategies of French life insurers. The econometric analyses showed that the average participation rate is essentially determined by the government bond rate and the insurer's asset return. Insurers should make long-term investments and lock in asset duration upon decreasing interest rates. This action will lower the duration gap between life insurance liabilities and assets. Duration gap management helps protect life insurers' equity capital (Paetzmann, 2011). By contrast, when interest rates rise, life insurers must quickly invest in shorter-duration assets to meet policyholders' expectations (Paetzmann, 2011). Under the ALM framework, apart from the duration matching approach, we noted that several strategies and techniques depend on the life insurer's objective. For example, cash flow matching is applied to minimize the difference between asset and liability cash flows or immunization and to maintain the surplus from asset and liability portfolios with fixed cashflows (Van der Meer & Smink, 1993). Besides, the dedication approach to economically match cashflows within a boundary that sufficient cashflows could be paid out for incurred liabilities (Dahl, 1993) is a quantitative solution adopted mainly in practice.

2.5.2 Long-Term Solutions

The long-term view emphasizes the strategic implications of potential solutions for life insurers to respond to a prolonged low interest rate environment. Insurance companies seem reluctant to provide a high guaranteed return on their new products from a product development perspective (Holsboer, 2000). Moreover, German life insurers have adopted alternative guaranteed product concepts like a return of paid premiums or minimum annuity payouts, plus payout from profit-sharing or participating products. An example of alternative product concepts is the guaranteed return of premiums for deferred annuities at the end of the deferral period (Nieder, 2016).

Concerning the future product mix, Paetzmann (2011) emphasized the need for adjustments in the product mix of insurers' portfolios to move away from guaranteed interest rate products and reduce the explicit and implicit impacts of guaranteed interest rates. Many insurers focus on selling more unit-linked products, transferring investment risk to policyholders (Holsboer, 2000). Focarelli (2015), supported the role of linked-type products and proposed asset reallocation (mainly corporate and structured bonds) and new premiums to achieve sustainable minimum interest rate guarantees in a prolonged low interest rate environment.

Due to their low claims, Japan and Germany moved toward selling more protection-oriented services. These protection-oriented products are disability income, medical insurance, cancer insurance, and long-term care products (Nieder, 2016), which best suit customers' needs in aging societies. In addition, Focarelli (2015) suggested moving toward new product features based on customers' life cycle needs to fill the gap between consumption and earnings (Figure 2.2).

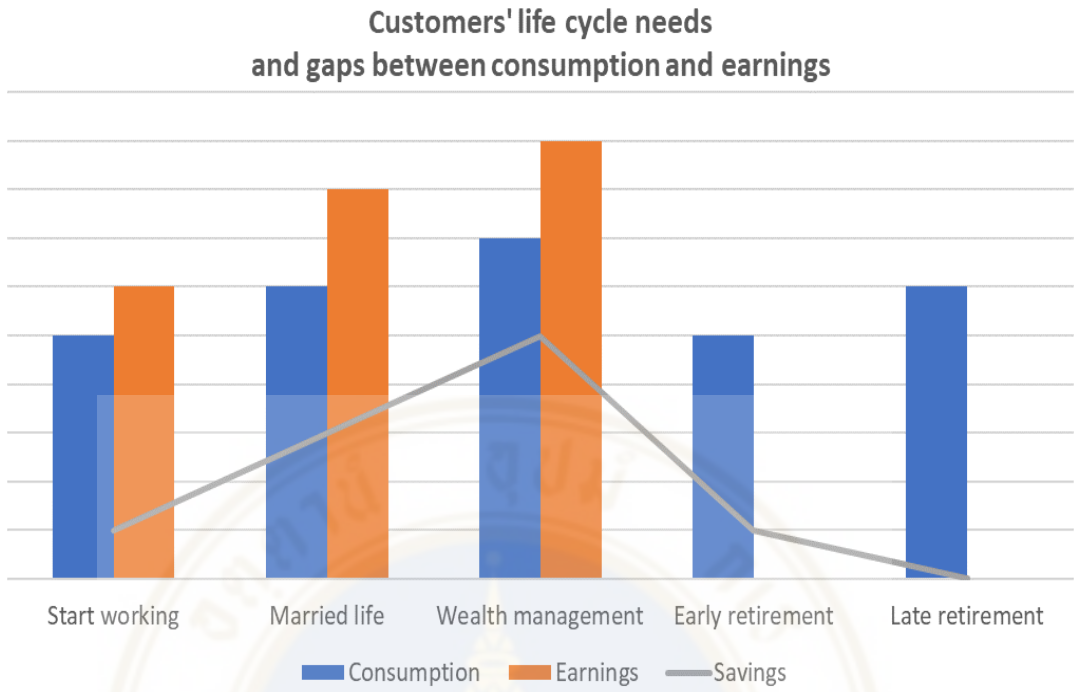


Figure 2.2: Customers' Life Cycle Needs (adapted from Focarelli, 2015).

Concerning financial impacts, Rybka (2017) recommended implementing reasonable economic assumptions for the expected credit rates consistent with the asset portfolio earnings forecast. This assumption aligns the policyholder's reasonable expectations with the market interest rate environment. In addition, insurers should implement an active monitoring policy, especially targeting the deviation of actual credit rates or dividend scales from expected rates.

Some insurers focus on increasing response efficiency to compensate for revenue compression when their investment yields decrease (Holsboer, 2000). Capital efficiency is significantly high when insurers switch their business portfolio to products with no minimum guaranteed interest rate (Wieland, 2017). Holsboer (2000) highlighted that insurers know the need to actively manage financial risk and assess life insurance companies' profitability. In addition, insurers should measure market risk, which reflects the potential loss due to unfavorable market movements based on value-at-risk (VaR). The VaR indicator uses various statistics to assess price movements in financial securities.

Bohnert et al. (2015) emphasized surplus appropriation schemes as practical tools to deal with shortfall risk in shareholder values. They substantially impact the guaranteed interest rates embedded in products offered to policyholders. Various schemes of surplus appropriation exist for determining fair dividend rates, including an increase in surplus appropriation for the remainder of the coverage period, an increase in the following benefit payout, and interest-bearing accumulation schemes. These schemes affect the dynamics of insurers' assets and liabilities (Bohnert et al., 2015). Thus, insurers should seek proper duration matching between asset and liability portfolios (Antolin et al., 2011).

2.6 Discussion

This literature review aimed to identify the impact of a prolonged low interest rate risk on life insurers' pricing and valuation, proposing potential short and long-term solutions for life insurance companies. The protracted low interest rate environment requires life insurers to move their business mix toward non-interest-rate-sensitive products and lower their reliance on investment income (Focarelli, 2015). Life insurers transfer investment risk to policyholders (Nieder, 2016). Regulators in several countries require annual reviews to establish an adequate upper limit of the VIR (Eling & Holder, 2013a) and implement SII and RBC risk-based frameworks governed by global insurance regulators, requiring life insurers to hold the capital needed to guarantee solvency (Berends et al., 2013).

2.6.1 Limitations

This review primarily focused on appraising past crises, their significant impacts, and potential solutions. Studies from the Scopus database and Google Scholar concentrate on the life insurance business during the recent persistent low interest rate period. Thus, its findings rely on limited studies and only apply to the life insurance business. Indeed, the literature on the topic is limited, and there has also been little research in the past five years.

Moreover, the review examined vital common characteristics of worldwide life insurance products. Therefore, no new initiatives or products are considered in this review.

Finally, this research was conducted throughout a persistently low interest rate environment, which might have reached an (unforeseeable) end in the second quarter of 2022.

2.6.2 Interpretation and Implications of the Study's Findings

Life insurers struggle to pay guaranteed contractual obligations in a prolonged low interest rate environment and maintain a solid financial position regarding profitability and solvency (Berdin & Gründl, 2015). Insurers may struggle to survive a substantial existing in-force business block unless they set an optimal mix between their products' saving and protection components. Numerical analysis (Eling & Holder, 2013b) emphasizes that interest rate sensitivity increases when life insurers continually maintain an existing practice of guaranteed rate setting in their products. Further evidence was provided by research from Kablau & Weiß (2014), pointing out that German life insurers will no longer be able to manage their SI fund requirements by 2023, given a low yield stress scenario. Hence, life insurers must proactively support their product portfolio and capital resilience.

While low market interest rates incentivize life insurers to invest in risky investments (Berdin & Gründl, 2015), this scenario may also represent an opportunity to reshape their strategies and enhance their efficiency. Further analysis of the relationships among life insurance product types, asset portfolio returns, and life insurers' solvency may clarify the regulatory impact on and determinants of insurers' financial stability.

Future research should consider Asian and emerging markets, mostly ignored by extant studies, addressing the impact of prolonged low interest rates on life insurers' financial stability and solvency in these countries. Future interest rate trends, especially in emerging markets, are under the pressure of persistently low interest rates, partially from excess savings and a lack of investment opportunities (Reyna et al., 2022).

Potential future development of alternative product designs might appeal to life insurers seeking lower interest rate risk, increased profitability, and improved capital efficiency, as Wieland (2017) mentioned. In addition, with the upcoming new international financial reporting standards, IFRS 17 (insurance contracts) and IFRS 9 (financial instruments), liabilities from insurance contracts and assets from financial instruments have become more closely connected. These standards may generate more pressure on life insurers regarding profitability, as IFRS 9 and 17 adopt a forward-looking perspective. Last, the new reporting standards impact earnings volatility differently, depending on insurers' balance sheet management choices and whether changes in fair values relate to profit and loss statements or other comprehensive income statements (Hogendoorn, 2019).

CHAPTER III
LIABILITY MANAGEMENT OF LIFE INSURERS

3.1 Introduction

During the past few decades, interest rates have dropped in various markets worldwide (Del Negro, Giannone, Giannoni, & Tambalotti, 2019; Hartley, Paulson, & Rosen, 2016; Holsboer, 2000; Reyna, Fuentes, & Núñez, 2021). For instance, in 2011, the long-term benchmark yield of a German 10-year government bond dropped for the first time to 3.92%, below the 4% technical interest rate provision required by European regulators (Kablau & Weiß, 2014). Berdin & Gründl (2015) have described these low interest rates as "a threat to the stability of the life insurance industry" (p. 385). Eventually, the German 10-year bond yield even became negative in 2019: see Figure 3.1 below. The life insurance business is susceptible to changes in long-term rates due to its contractual obligations to policyholders (Holsboer, 2000).

Life insurers are liability-driven financial institutions with path-dependent liability cash flows due to their products' embedded options and interest rate guarantees (Albrecher et al., 2018). There are two broad categories of life insurance products. The first group is protection-type products, including disabilities, income protection, term, health, cancer insurance, and long-term care. The second group is a saving-type products group. Products in this group have a saving element as a key feature that makes them sensitive to interest rate changes. Sample products in the second group are variable annuities, single premium endowments, single premium life, and annuities. (Neider, 2016). This paper elaborates on interest rate movements and identifies their impact on life insurance products. Key findings and observations on liability management by Thai life insurers are revealed. The remainder of this essay is organized as follows. Section 3.2 addresses literature reviews on rationales for liability management of life insurers. Section 3.3 identifies this essay's expected contribution, followed by the conceptual

framework and hypotheses in Section 3.4. The research methodology, source of data, and variable measurement are mentioned in Sections 3.5 and 3.6, respectively. The data analysis and research outcomes are presented in Sections 3.7 and 3.8. Finally, Section 3.9 exhibits the conclusions and recommendations of the research.

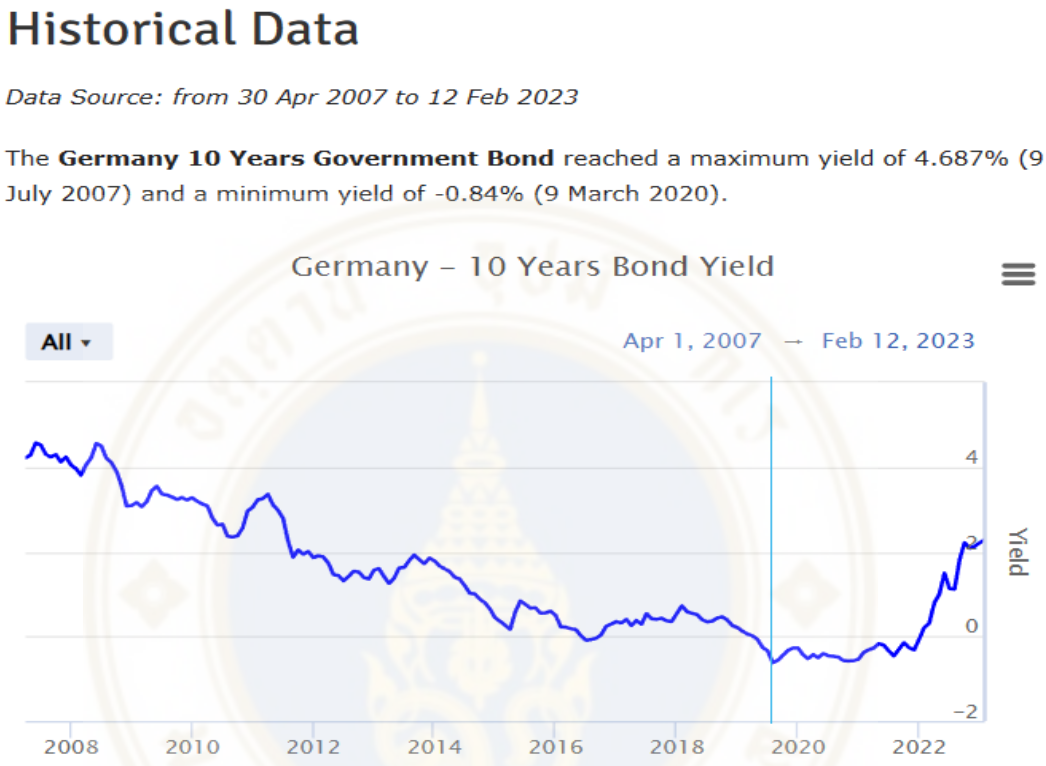


Figure 3.1: Historical German 10-year Government Bond Yield (World Government Bonds, 2023)

3.2 Rationales for Liability Management of Life Insurers

Life insurers act as financial intermediaries or "carriers." They buy financial instruments, such as government and corporate bonds, and bundle them with life and annuity benefits to offer to customers (Love & Miller, 2013). The successful operation of life insurance assumes that insurers balance consumers' security needs against the

offered products' interest rate sensitivity. However, the life insurance industry operates in rising and falling interest rate environments, which impacts profitability.

Paetzmann (2011) emphasized the need for adjustments in the product mix of insurers' portfolios to move away from guaranteed interest rate products and reduce the explicit and implicit impacts of guaranteed interest rates. Many insurers focus on selling more unit-linked products to transfer investment risk to policyholders (Holsboer, 2000; Yuldashev, 2020). Unit-linked is a combination of protection and saving coverages. Life insurers typically invest the unit-linked premium in the capital market (e.g., debentures, equity, or money market funds) on behalf of their customers and get favorable low cost of capital under Solvency II (Yuldashev, 2020) as well as under Thailand RBC scheme.

Eling & Holder (2013a) emphasized that "life insurance is an interest-sensitive business" (p. 354). Berends, McMenamin, Plestis, and Rosen (2013) have asserted that liability duration may be extended in a low interest rate environment as policyholders are unlikely to surrender their policies. This phenomenon accelerates the negative duration gap because the extent of liabilities is much longer than assets' lives (Antolin, Schich, & Yermo, 2011). The longer the duration of liabilities, the higher the sensitivity to interest rate changes. Therefore, low interest rates significantly impact life insurers due to the high sensitivity of liabilities to interest rate variations. Over the past few decades, low interest rates have become a global issue, notably when long-term bond yields drop to historically low levels (Reyna et al., 2021; Fuentes & Núñez, 2021; Neider, 2016; Holsboer, 2000).

A prolonged low interest rate has been evaluated continually as a concerning issue for life insurance business operations as well as a challenge for their strategic decision of moving toward asset classes with lower capital requirements (Paetzmann, 2011). Consequently, investment returns are the primary contribution to income for insurers (Reyna et al., 2021). Given the above reasons, this dissertation aims to understand the prolonged low interest rate phenomena and examine Thai life insurance companies' strategic decisions embedded in product mix, financial performance results, and capital efficiency. To understand the phenomena of market interest rate movement, descriptive statistics and graph plots of 10-year Thai government bond yields will be

analyzed together with an analysis of shifts in the product mix, profitability, and solvency position over the past few decades.

3.2.1 Historical Global Interest Rate Situation

Hartley, Paulson, and Rosen (2016) have classified interest rates into "normal" and "low rate" periods (Figure 3.2). Between 2002 and mid-June 2007—a "normal" period—small changes in interest rates did not affect insurers' stock prices in the United States (US) and the United Kingdom (UK). Interest rates were within the historical norm. However, after the 2007-2008 financial crisis, the long-term interest rate drastically decreased, leveled off at a historically low level, and stayed at that low level until recently in 2021 (Hartley et al., 2016). Reyna et al. (2021) have emphasized that insurers must implement specific actions to recover their profit margins after a persistently low interest rate period.

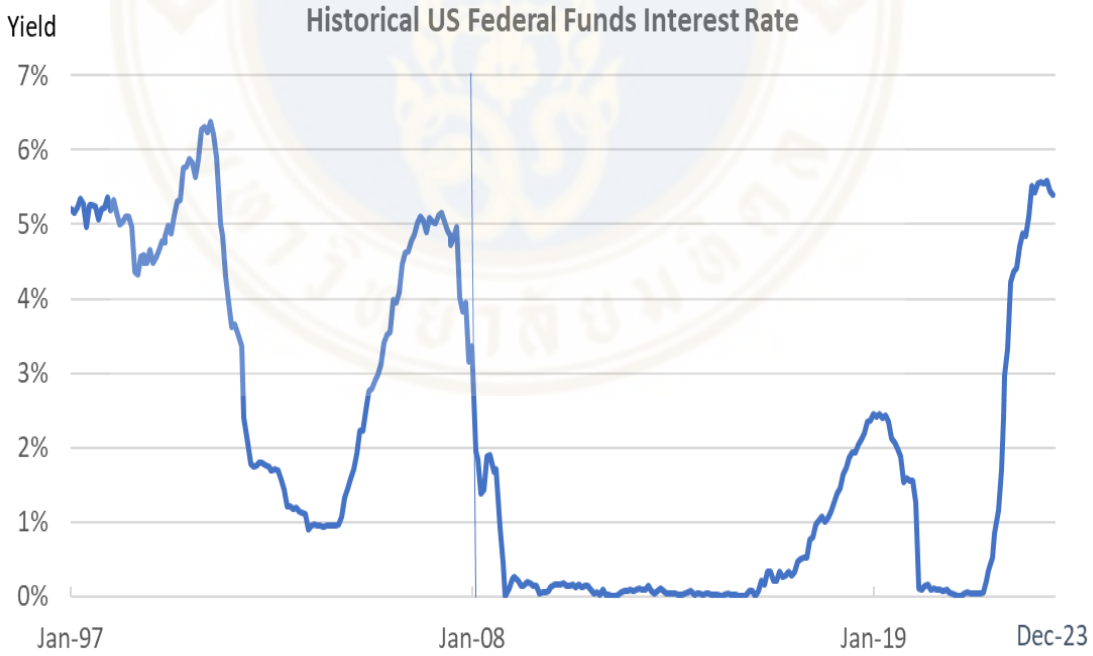
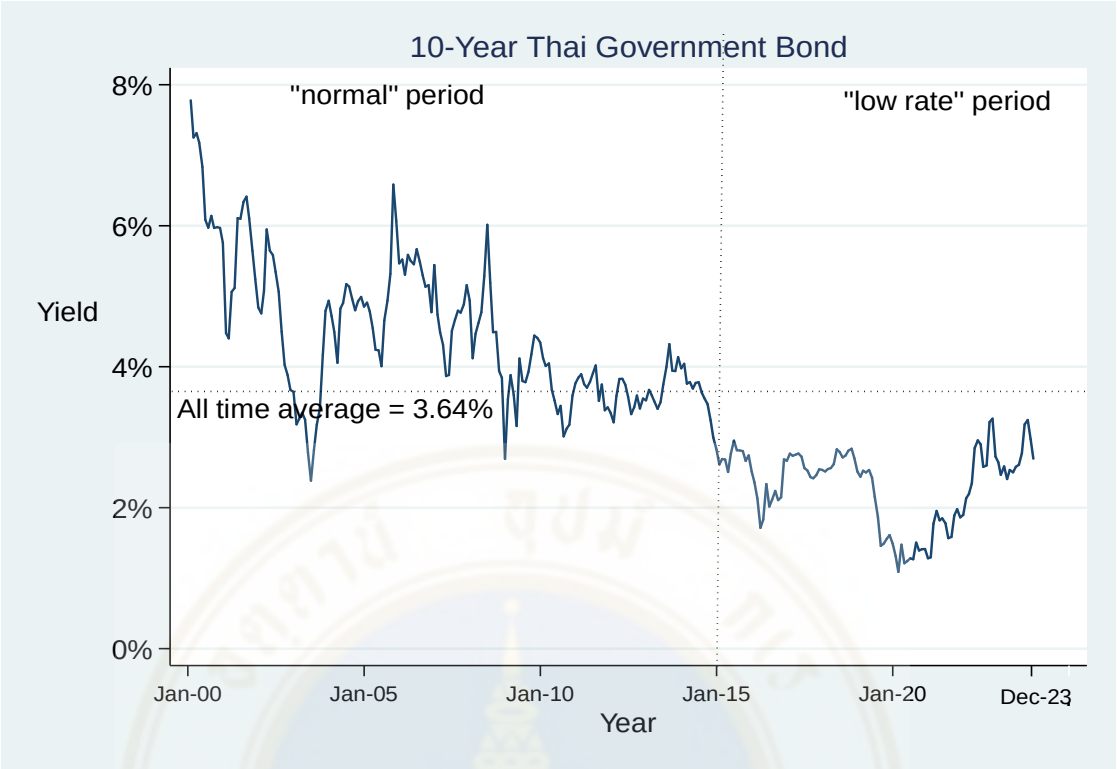


Figure 3.2: Historical US Federal Funds Interest Rates (data extracted from United States Fed Funds Rate, 2024).

From the end of 2007 to mid-2009, the Great Recession in the US caused an economic downturn, a more than 10% decline in GDP, and a 25% unemployment rate, followed by the housing bubble burst, the housing market correction, and the subprime mortgage crisis. Such a global financial crisis drove interest rates to close to zero at that time to stimulate spending and investment (LePan, 2019). Then, it was followed by Europe's sovereign debt crisis that caused several Eurozone countries' debts to be downgraded by rating agencies. From 2009 to 2010, two European insurers, Victoria Life and Delta Lloyd Groep, stopped their new business underwriting (i.e., new policy issue) due to the low interest rate environment (Paetzmann, 2011).

In Thailand, since 2000, the historical Thai Government bond yield has shown an average of 3.64% per annum. Until December 2023, bond yield reached the record lowest of 1.09% per annum in February 2020. As such, for this study, the period from 2015, when yields were below the all-time average of 3.64%, will be defined as the "low rate" period. We consider 2015 to be the cut-off year because of the substantial decline since then; yields never increased to reach that 3.64% average level, and pre-2015 will be measured as the "normal" period. Figure 3.3 presents the historical Thai interest rate from January 2000 to December 2023. The cut-off point is January 2015 - the period since then, the interest rates never reached the all-time average level.



10-Year Yield	Observation period		(1)	(2)	(3)	(4)
	From	To	Obs.	Mean	Std. Dev.	Min	Max
Pre-2015	Jan-00	Dec-14	176	0.0446	0.0101	0.0238	0.0778
2015 onwards	Jan-15	Dec-23	112	0.0233	0.0057	0.0109	0.0360
All time	Jan-00	Dec-23	288	0.0364	0.0135	0.0109	0.0778

Figure 3.3: Historical Thai Interest Rates – data extracted from ThaiBMA (Thai Bond Market Association, 2023)

3.2.2 The Impact on Products and Product Shift Strategy

Product portfolio composition is the primary consideration for determining an insurer's shortfall risk (Bohnert et al., 2015). Product mix and its surplus appropriation scheme for participating products are crucial for life insurers and regulators.

Some insurers focus on increasing efficiency to compensate for revenue compression when their investment yields decrease (Holsboer, 2000). Capital efficiency is significantly high when insurers switch their business portfolio to products with no

minimum guaranteed interest rate (Wieland, 2017). The protracted low interest rate environment requires life insurers to move their business mix toward non-interest-rate-sensitive products and lower reliance on investment income (Focarelli, 2015) since they cannot profitably offer saving-oriented products (Hartley et al., 2016). Life insurers prefer to transfer investment risk to policyholders (Nieder, 2016). As such, a shift in products to non-guarantee (without investment return dependency or non-interest-sensitive) reduces the financial risk of life insurers and increases their solvency position.

In Thailand, life insurance products comprise a main policy (called "Base") and a rider. Customers who buy life insurance policies choose base coverage available in Whole Life, Endowment, Term, Annuity, Unit-linked, Universal Life, or Personal Accident. On top of that, customers may select additional coverage of Accidents, Health, or Waiver of Premium as a supplement (Thai Life Assurance Association, 2022). For this essay, we applied datasets categorized by Thai Life Assurance Association: TLAA.

Under TLAA, whole life, endowment, and term are grouped under "Ordinary" - based on the type of policy contract for individual customers. A separate group, "Industrial", is also defined for a small ticket size individual policy. This industrial life product is mainly an Endowment product with a small sum assured. Another fundamental classification is "Group" - a life insurance policy issued to master policyholders to cover members in their organization. Table 3.1 below describes the trend of the past five years of total premiums in the Thai industry (including the first year, renewal year, and single premium netted off reinsurance premiums – if any).

Table 3.1: 2018-2022 Total Premium of Thai Life Insurance Industry - Data extracted from TLAA (Thai Life Assurance Association, 2023).

Unit: Million THB

Total Premium		**2022**	**2021**	**2020**	**2019**	**2018**
Main Policy	Ordinary	361,901	370,441	387,987	407,802	423,518
	Industrial	4,527	4,946	5,410	5,805	6,122
	Annuity	15,735	14,234	13,769	11,776	10,604
	Group	42,591	39,072	39,251	43,288	44,067
	Unit-linked	34,900	45,469	24,759	24,486	35,998
	Universal Life	2,873	3,093	2,063	1,604	1,695
	Personal Accident	4,296	4,349	4,626	4,669	4,731
	Subtotal	466,822	481,603	477,864	499,431	526,735
Rider	Accident	20,697	19,516	16,244	14,134	13,247
	Health	93,534	86,530	79,594	75,285	69,151
	Other	8,763	8,277	10,943	9,248	7,948
	Subtotal	122,994	114,323	106,781	98,666	90,346
Total		589,816	595,925	584,645	598,097	617,081

Thai life insurers guaranteed a return on saving elements of both endowment and some whole life products. Despite no explicit saving component, traditional whole life is still exposed to low interest rate risk upon reinvestment (Nieder 2016). Thus, we follow Hartley et al. (2016) definition of this saving-oriented to classify "Ordinary" and "Industrial" as an interest-sensitive product. Nieder (2016) classified deferred annuities with guaranteed annuities as saving-type products. This guaranteed payout after the deferment period is similar to the annuity product in the Thai market. So, we also grouped "Annuity" under interest-sensitive products. Yuldashev (2020) described unit-linked investment risk as being transferred to customers. Then, the protection element left over makes Unit-linked a non-interest-sensitive product. Thus, the remaining main policy and rider groups in Table 2 are categorized as non-interest-sensitive products due to their protection-oriented features.

The 2022 life insurance industry information (see Figure 3.4) showed that an interest-sensitive product covers approximately 65% of total premiums and emphasizes the need for further investigation of linkage to liability management of life insurers from these product's guarantees.

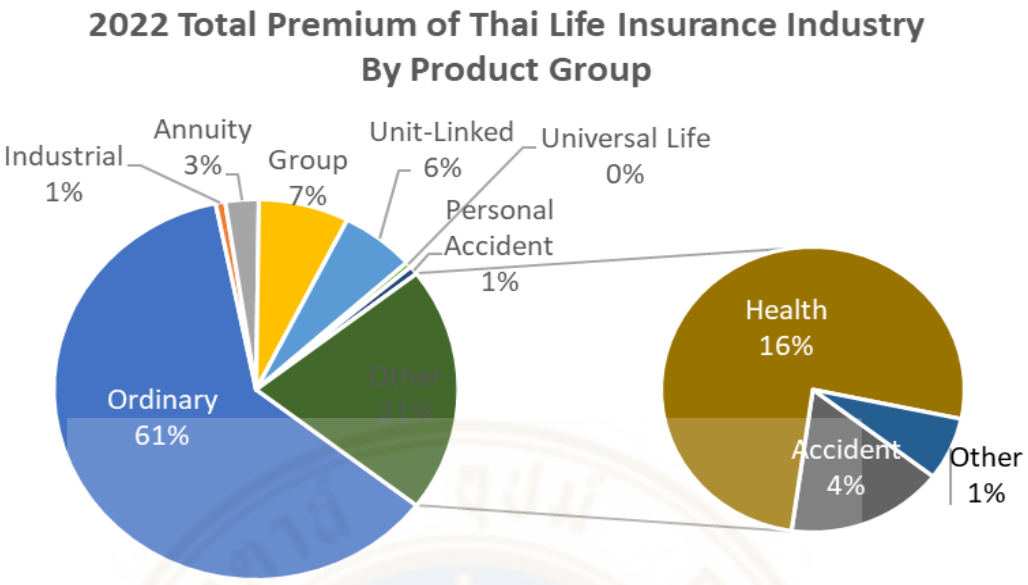


Figure 3.4: 2022 Total Premium of Thai Life Insurance – Data extracted from TLAA (Thai Life Assurance Association, 2023).

3.2.3 The Impact on Financial Results of Life Insurance Companies

Berends et al. (2013) analyze the sensitivity of life insurance companies to interest rate risk before the financial crisis (sample period from August 2002 to mid-2007) and during the low interest rate period of late 2007 through December 2012. They examined an insurer's exposure to interest rate risk by addressing the correlation between changes in interest rates and an insurer's stock price. Before the financial crisis, the stock price of insurance companies was uncorrelated with benchmark government bond yields. However, stock prices became negatively correlated with bond prices after the economic crisis. This correlation means the stock prices decreased when bond prices increased (or bond yields decreased). Upon the decline in interest rates, large-size life insurers suffered from lower investment income and lower future profitability (Berends et al., 2013). Empirical evidence from 26 publicly traded US life insurance companies has shown that large insurers (measured by total assets) experienced a negative correlation between stock prices and bond prices. In addition, stock prices of large life

insurers fluctuate more than those of small insurers because they have more interest-rate-sensitive life insurance products in their portfolio (Berends et al., 2013).

Reyna, Fuentes, and Núñez (2021) have mentioned two primary sources of profit for life insurance companies. One are life insurance operations that generate positive premium income minus expenses. Brown and Galitz (1982) called this source "underwriting profit" (p. 290). Another source of profit comes from the investments of technical reserves. These two profit sources have a more noticeable impact in a low interest rate environment due to insurers' challenges in pricing and valuation. Life insurers struggle when the available margin from the investment return over the guaranteed minimum return is insufficient to fund future life insurance obligations (Kablau & Wedow, 2012). Past research further showed that a "negative spread" that emerged in Japan in July 1991 was caused by the guaranteed liability return of 4%, which was much higher than the investment yield of just 2% (Nieder, 2016). These crucial guarantees require appropriate valuation and hedging to keep the insurer solvent (Schmeiser & Wagner, 2015).

With the upcoming new International Financial Reporting Standards (IFRS), IFRS 9 for financial instruments, and IFRS 17 for insurance contracts, the value of liabilities from insurance contracts and assets invested in financial instruments have become more closely connected. These standards may generate more pressure on life insurers in terms of profitability as IFRS 9 and 17 adopt a forward-looking perspective. Fair value measurement under the principal-based approach of the reporting standards requires profits to spread over the entire liability-covered period. Thus, profitability results are easy to compare among global insurers. Furthermore, the new reporting standards impact earnings volatility differently, depending on insurers' selected measurement approach and whether changes in financial incomes and expenses are chosen to go through either a profit and loss statement or other comprehensive income (Hogendoorn, 2019).

3.2.4 The Impact on Solvency to Life Insurance Companies

From 2009 to 2013, the European Insurance and Occupational Pensions Authority (EIOPA) emphasized the financial stability risk for insurance and pension companies, especially during a persistently low interest rate environment (Focarelli, 2015). In 2014, the EIOPA implemented a low interest rate stress test (a "Japanese-like scenario") to test the sustainability of interest rate guarantees embedded in life insurance products. In addition, the EIOPA has addressed the solvency capital requirement (SCR) ratio,[5] interest rate exposures (measured in terms of duration or cash flow matching), and profitability (measured in terms of internal rate of return). According to Focarelli (2015), product design and segregated funds allow insurers to compute booked and realized values in Italy, assuring relatively stable and non-volatile returns. As a result, the Italian insurance industry's SCR ratio outperforms the European average by 7% in this 2014 stress test exercise.

The European Union insurance regulators first developed a prescribed solvency regime called the "Solvency I (SI)" framework to measure and prevent insolvency risk. The regime required insurers to hold 4% of the premium reserve and 0.3% of capital at risk as solvency margin or regulatory own funds requirements (Kablau & Weiß, 2014). Kablau & Weiß (2014) use coverage ratio, the ratio of eligible regulatory own funds to solvency margin, to measure the impact of low interest rates on insurers' solvency. Results indicate that all German life insurers can manage their SI own funds requirements in the base scenario. In contrast, almost 40% will be unable to do so by 2023 under a severe low-yield stress scenario.

Like Basel III in the banking industry, "Solvency II" (SII, hereafter) is a current risk-based framework introduced and governed by insurance regulators since 2009. It applies a market-consistent approach to improve the transparency and stability of the financial system in the European Union. The SII standards set aside solvency capital over a one-year horizon based on a full range of risks on insurance companies' asset and liability sides in a 99.5 percentile–one in two hundred years–loss event (Niedrig, 2015). SII capital helps guard against insurance products with a minimum guaranteed interest rate. However, the more significant regulatory capital requirement

[5] Solvency capital available based on an eligible own funds (post stress) divided by SCR (pre stress).

for this product type makes them the least likely to be promoted and sold by life insurers (Paetzmann, 2011).

Mark-to-market on both the assets and liabilities sides of the balance sheet is a prerequisite for a market-consistent valuation of the solvency position under SII (Berdin & Gründl, 2015). The discount rate reduction due to declining market bond yield increases the present value of future benefits and the market-consistent value of liabilities (Niedrig, 2015). Since the liability duration is usually much longer than the life of assets (Hartley et al., 2016), the higher this gap, the greater the reinvestment risk faced by insurers. These duration gaps lead to a potential issue in the insurer's solvency position when an insurance company's asset values are lower than the market-consistent value of liabilities (Nieder, 2016) unless they implement a hedging interest rate risk policy.

The International Accounting Standards specify that equity holding should be valued at market value, while liabilities must reflect book values. These requirements may lead to a solvency issue in a prolonged low interest rate environment (Holsboer, 2000). When insurers adjust their assets' portfolio quicker than the growth rate of liabilities to provide the high guarantee promised to policyholders in a low interest rate environment, they increase their asset allocation to a riskier asset class. This reallocation makes assets more volatile, requiring substantial capital to cover potential losses (Niedrig, 2015). Risky investments are more vulnerable to losses and can lead to variations in reported earnings. Hence, this shift toward risky investment may adversely impact insurers' financial stability (Kablau & Weiß, 2014). The riskier the high-yield investments, the wider the duration gap between assets and liabilities, and the higher the volatility of asset portfolios. Berends et al. (2013) contend that life insurers may be exposed to credit risk on high-yield investments due to the potential loss of their asset values. This credit risk makes regulators worldwide (including in the US) enforce RBC framework to help mitigate potential threats to insurance companies. Similar to SII, the RBC framework establishes a minimum required capital that a life insurer must hold to assure solvency (Berends et al., 2013).

The required capital increases with higher risk exposures. Empirical evidence from Niedrig (2015) indicates that changes in the long-term interest rate affect

the insurer's optimal risk portfolio by adding riskier asset classes in search of yields. As in the case of Germany, life insurers aim to increase the asset allocation to more illiquid investments, such as infrastructure bonds, to obtain higher yields (Nieder, 2016). This investment increases risk-taking to enhance investment returns and meet policyholder's obligations (Kablau & Weiß, 2014). Under the RBC framework, solvency position is measured by the total capital available divided by the total required capital. This framework also specified the level of capital that a life insurer must hold (Berends et al., 2013).

Berdin and Gründl (2015) summarize the key findings of the Deutsche Bundesbank on stress scenarios during a prolonged low interest rate period. This Financial Stability Review in 2013 (produced by the Deutsche Bundesbank) shows that more than one-third of all German life insurers will not meet the regulatory capital requirements by 2023 based on a market-consistent balance sheet model. High-guaranteed interests offered to policyholders are a threat to insurers' solvency. By contrast, Kablau & Weiß (2014) perform scenario analysis to analyze the impact of a low interest rate environment on the solvency of German life insurers. Even though they consider the SI regime, all baseline, mild, and severe stress scenarios help visualize net investment returns for those situations besides identifying a coverage ratio required to fulfill their own funds' requirement.

In mid-2016, most Asian countries, including Taiwan and Hong Kong, recorded historically low zero-coupon government bond yields. By contrast, government bond yields became negative for almost all tenors (Nieder 2016). Between 2017 and 2018, ten years after the financial crisis, global interest rates remained low. For example, the ten-year US government bond yields fell below 3%, remained slightly above 1% in the UK, were approximately 0.40% in Germany, and were close to zero in Japan (DelNegro et al. 2019). This decline in interest rates is a threat to insurance businesses, especially life insurance companies (Reyna 2021; Berdin & Gründl 2015; Grosen & Jørgensen 2000).

3.3 Expected Contribution

This dissertation makes two primary contributions to the management of life insurance liabilities. The first contribution is quantifying the relationship among potential drivers of liability management for life insurers during a prolonged low interest rate period. Insurers manage their liabilities portfolio by changing their life insurance product mix, investment strategy, and capital adequacy. In addition to the paper by Wieland (2017), it could be inferred that future research could focus on life insurers' capital efficiency measures and enhance the Risk-based Capital (RBC) and Own Risk and Solvency Assessment (ORSA) frameworks for solvency analysis apart from financial soundness. This dissertation will take these viewpoints into account. New variables related to RBC and ORSA frameworks, such as regulatory solvency and new business product mix of interest and non-interest-sensitive products, will be incorporated to explain the relationship among variables.

The second contribution is an extension of research to the Asian market, where most of the literature does not review the impact of prolonged low interest rates on life insurers' financial position and solvency. Previous studies analyze the effect of low interest rates on the solvency of German life insurers using a scenario analysis (Kablau & Weiß, 2014) and highlight that products sold with guarantees generate substantial capital requirements under Solvency II (SII) (Nieder, 2016). This research on the Thai life insurance market aims to explore whether the situation in the Thailand market could potentially be similar to those of global impacts and be a representative of the Asian market. Despite this study being built on existing knowledge, it will expand with a new dataset from Thailand from 2001-2020 and organize to give new insight into the Thai market. The study also aims to answer the question of how Thailand's prolonged low interest rate differs from that of other countries.

Furthermore, this research examines regulatory solvency and factors influencing life insurers' financial stability and profitability. The relationship between various life insurance product types and the market interest rate movement is also investigated. Some insurers focus on increasing their efficiency in response to compensating for revenue compression due to lowering insurers' investment yield (Holsboer, 2000). Capital efficiency, measured by the present value of future profits over solvency capital required for interest rate risk, is expected to rise when insurers

switch their new business portfolio to products without a minimum guaranteed interest rate (Wieland, 2017). Thus, this research will be conducted to understand the Thai life insurers' solvency position and the potential shift in product mix during the prolonged low interest rate environment since there has been no prior study in this area.

3.4 Conceptual Framework and Hypotheses

Life insurers manage their liabilities portfolio by changing their life insurance product mix, managing interest rate risk on guaranteed products, and solvency management.

In terms of product mix, several life insurers, during a prolonged low interest rate environment, move their new product portfolio toward the least investment return dependent or non-guaranteed (non-interest-sensitive) products (Focarelli, 2015) since they cannot profitably offer saving-oriented products (Hartley et al., 2016). Reyna et al. (2021) highlighted that insurers must implement specific actions to recover their profit margins after a continually "low rate" period. Therefore, it is anticipated that the mean volume of non-interest-sensitive new business should be higher during a "low rate" period than during a "normal" period (Hypothesis 1).

Matching asset and liability durations under ALM framework helps insurers limit potential exposures to interest rate risk (Berends et al., 2013). Upon decreasing interest rates, life insurers make long-term investments to lock in asset duration and lower the duration gap with life insurance liabilities (Paetzmann, 2011). Life insurers typically use ALM monitoring to assess and mitigate interest rate risk by lengthening the duration of assets (Holsboer, 2000). To manage the interest rate risk of life insurance products, life insurers usually rely on investment in the fixed income markets (i.e., government and corporate bonds) to hedge future benefit payments as per obligations with policyholders (Hartley et al. 2016). As investment returns are the key source of profit for insurers, especially for the guaranteed (interest-sensitive) product features (Reyna et al., 2021), we anticipate that the return on assets of life insurers should be positively correlated with the proportion of the interest-sensitive products (Hypothesis 2).

Thai life insurers guaranteed returns on saving elements of both endowment and some whole life products. Traditional insurance agents are familiar with selling these interest-sensitive products, as evidence showed a substantial proportion of 65% of total premiums in Figure 3.4. In other Asian countries, for example, Taiwan, bancassurance (selling life insurance products via banks) has become sizable and has dominated the traditional agent distribution channel (Chen, 2015). Despite fast growth in the bancassurance channel in Thailand, as of year-end 2022, agency distribution is still the leading distribution channel, generating volume at 51% (see Figure 3.5) as compared to 39% share for bancassurance - measured by the total premium (Thai Life Assurance Association, 2023). It is worth analyzing whether life insurers in Thailand, mainly selling saving-oriented products through the traditional channel - agency, could get support from their main distribution for the product shift strategy. This observation leads to Hypothesis 3: Agency channel positively correlated with the proportion of interest-sensitive products

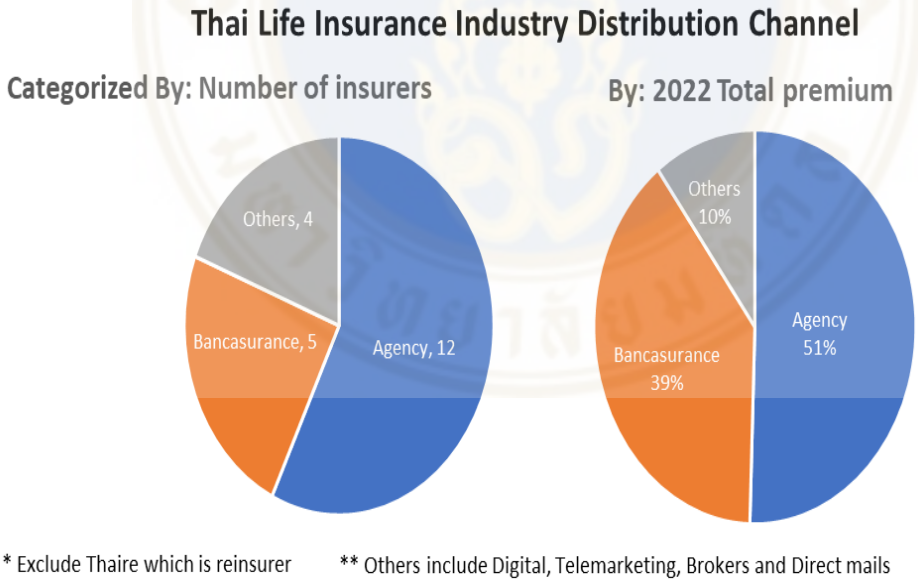


Figure 3.5: Distribution Channels of Life Insurance in Thailand – data extracted from TLAA (Thai Life Assurance Association, 2023)

Kablau & Weiß (2014) analyze the impact of a low interest rate environment on the solvency of German life insurers using scenario analysis. Even though they consider the SI regime, all baseline, mild, and severe stress scenarios help visualize net

investment returns for those situations besides identifying a coverage ratio required to fulfill their own funds' requirement. This study suggests that the average level of solvency is lower during a “low rate” period. In addition, capital efficiency is significantly high when insurers switch their business portfolio to products with no minimum guaranteed interest rate (Wieland, 2017). The protracted low interest rate environment requires life insurers to move their business mix toward non-interest-rate-sensitive products and lower reliance on investment income (Focarelli, 2015). As such, the solvency position decreases with an increase in the proportion of interest-sensitive new business products - Hypothesis 4.

Low interest rates hurt insurance companies' profitability due to the low investment return on their asset-backing portfolio (Eling & Holder, 2013a). Therefore, insurers generally pursue other sources of profit to compensate for the required profitability to pay for guaranteed liabilities. Some insurers focus on increasing their efficiency in response to compensate for revenue compression when their investment yields decrease (Holsboer, 2000). From 1997 to 2001, with the protracted low interest rate environment, seven middle-sized life insurers in Japan declared insolvency due to a drastic decline in the profitability of high-guaranteed interest rates for their in-force business (Berdin & Gründl, 2015). Thus, it is anticipated that the average level of solvency in the Thai life insurance market is also lower during “low rate” period (Hypothesis 5). In addition, the level of life insurers’ profitability should be positively correlated with the level of their solvency (Hypothesis 6).

Empirical evidence from Niedrig (2015) indicates that changes in the long-term interest rate affect the insurer's optimal investment portfolio by adding riskier asset classes in search of yields. As in the case of Germany, life insurers aim to increase the asset allocation to more illiquid investments, such as infrastructure bonds, to obtain higher yields (Nieder, 2016). These investments increase risk-taking to enhance investment returns and meet policyholders' obligations (Kablau & Weiß, 2014). However, from capital adequacy management’s perspective, the required capital increases with higher risk exposures. It is thus anticipated that the proportion of risky investment assets is negatively correlated with the solvency position: Hypothesis 7, as the increase in required capital, dominates the additional return from riskier investments in the short term. This relation exists because of the substantial increase in capital

requirements from a shift to risky asset classes and the impact of the high guarantees in life insurance products (Nieder, 2016).

In addition, to measure insurers' exposure to interest rate risk, Berends et al. (2013) analyze the sensitivity of the US life insurance companies to interest rate risk before the financial crisis (sample period from August 2002 to July 2007) and during the low interest rate period of August 2007 through December 2012 using data from SNL financial (a leading provider of industry-focused financial, business and market data). They examined the relation between changes in interest rates and an insurer's stock price. Before the financial crisis, the stock price of publicly traded life insurance companies in SNL Financial was uncorrelated with benchmark 10-year government bond yields. However, stock returns negatively correlated with bond yields after the financial crisis (Berend et al., 2013). This positive relationship should be significant for the Thai market as the product portfolios are dominated by "ordinary" endowments, a relatively interest-sensitive product type mentioned in Figure 3.4. Also, interest rate risk is high if the life insurer has not fully hedged against the decline in interest rate (Berend et al., 2013). Thus, Thai life insurers' stock returns are expected to negatively correlate with 10-year government bond yields during a "low rate" period (Hypothesis 8). Besides, stock prices of large life insurers fluctuate more than those of small insurers because they have more interest-rate-sensitive life insurance products in their portfolio (Berends et al., 2013). Due to the large fluctuations of large firms' stock returns during a "low rate" period, it is anticipated that the proportion of interest-sensitive products is higher for large-size life insurers than others (mid- and small-size life insurers) - Hypothesis 9.

3.5 The Methodology and Sources of Data

This dissertation relies on a multivariate design where two or more measures on each observation will be analyzed using Stata/SE 15.0. Parametric procedures will be applied as data are ratio-scaled.

This study will use secondary data from four fundamental sources as follows.

1. Thai Bond Market Association: http://www.thaibma.or.th/

ThaiBMA's 10-year monthly government bond yield from 2000 to 2022 is used as a benchmark for the long-term interest rate in the Thai market. The "normal" and "low rate" periods will be identified to analyze the impact of the prolonged low interest rate environment.

2. Life insurance industry 2000-2020 annual statistics broken down by individual insurer (a panel of different insurance companies), including market share measured by first-year premiums and total premiums, numbers of new business policies, invested asset values, operating expenses, balance sheet, and profit and loss statements from The Thai Life Assurance Association (TLAA).

3. Publicly available insurer data will be collected manually from the website and the Office of Insurance Commission (OIC) for capital adequacy and RBC results.

4. Stock prices of public companies listed in SET will be collected from Bloomberg (individual company data will be gathered since IPO).

This timeframe will include the effects of the Thai market decline in interest rates in August 2019.

In addition, a robustness check will be performed using the Hausman test (Hausman, 1978) to check between fixed and random effects models of these panel datasets.

3.6: Variable Measurement

The following are measurements of all variables used for hypotheses testing:

1. A “low rate” period is when the long-term interest rate drastically decreases (Hartley et al., 2016). For this study of the Thai market, the period since 2015 will be considered the “low rate” period - The period since 2015 has yielded lower than the all-time average of 3.3%. (see Figure 3.3).

2. The “normal” period is beyond the “low rate” period. For this study to apply to the Thailand market, pre-2015 will be considered the “normal” period as the

period before 2015 generated greater yields than the all-time average of 3.3%. (see Figure 3.3).

3. The proportion of interest-sensitive new business is measured by the new business sales volume of interest-sensitive products divided by the total new business sales volume. The higher of this number represents the move toward interest-sensitive products.

4. New business sales volume is a summation of new business premiums from both first-year and single premiums.

5. Solvency is measured by total capital available divided by total risk charges. This solvency is represented by a capital adequacy ratio (as a percentage of RBC). RBC framework specifies a level of capital that a life insurer must hold (Berends et al., 2013). For example, in Thailand (under RBC2 QIS2), the minimum capital adequacy ratio is 100%, and the supervisory capital adequacy ratio (OIC's intervention level) is 140% (Office of Insurance Commission, 2022).

6. The proportion of risky invested assets is measured by the amount of investment in the risky asset class (e.g., equity, derivatives, and property) divided by total investment (all asset classes). Please note that the level of risk in invested assets is high for risky assets and low for low-risk ones, as these risk levels are a function of the insurer's asset holdings (Berends et al., 2013).

7. Profitability is measured in terms of return on total asset (ROA) resulting from investment return and insurance performances (measuring in terms of "ratio" to eliminate potential scale effect from different sizes of life insurers).

8. A dominated agency distribution channel of each insurer is determined from a higher proportion of the total premium produced by the agent channel compared to other channels.

3.7 The Data Analysis

Three empirical models are estimated to evaluate the liability management of Thai life insurers. Multiple regression techniques are used to analyze the time series data and test the hypotheses.

This dissertation analysis will follow Hartley et al. (2016) by breaking down the observation period into “low rate” and “normal” periods. In previous research, Hartley et al. (2016) have classified interest rates into "normal" and "low rate" periods. Between 2002 and mid-June 2007—a “normal” period—small changes in interest rates did not affect insurers' stock returns in the US and the UK. Interest rates were within their historical norm. However, after the 2007–2008 financial crisis, the long-term interest rate drastically decreased, leveled off at a historically low level, and has stayed at that low rate since then (Hartley et., 2016). During the “low rate” period, life insurers move their new business mix toward non-interest rate sensitive products, rely less on investment income (Focarelli, 2015), and focus more on the transfer of the investment risk to policyholders (Nieder, 2016; Reyna et al., 2021). For our Thai sample, the period since 2015 will be considered a “low rate” period, and the period before 2015 will be a “normal” period. Please note that the period since 2015 with yields below the all-year average of 3.64% will be considered the “low rate” period, and pre-2015 will be measured as the “normal” period – see also Figure 3.3.

Managing interest rate risk is a crucial consideration for liability management. Upon decreasing interest rates, life insurers must invest in long-term investments to lock in asset duration and lower the duration gap with life insurance liabilities under ALM framework (Paetzmann, 2011). During a prolonged low interest rate situation, life insurers move their new product portfolio toward the least investment return dependent or non-guaranteed (non-interest-sensitive) products to lower the guaranteed rate or to transfer investment risk to policyholders (Focarelli, 2015). Thus, life insurers need to consider the impact of the guaranteed interest rates on products. We will measure the proportion of interest-sensitive new business (IS) as a dependent variable to understand the impact of change on new business product mix, as analyzed by Wieland (2017). Variable *LowRate* is incorporated to investigate the product mix shift portfolio during different interest rate environments and determine any potential impact of the firm’s size, the distribution channel model, proportion of risky investment, solvency position, and return on assets for liability management. Therefore, the first model incorporates the independent variables *LargeSize*, *Agency*, *Risky*, *RBC*, and *RoA*.

$$IS_{i,t} = \beta_0 + \beta_1 LowRate_t + \beta_2 LargeSize_{i,t} + \beta_3 Agency_{i,t} + \beta_4 Risky_{i,t} + \beta_5 RBC_{i,t}$$

$$+ \beta_6 ROA_{i,t} + \varepsilon_{i\,t} \quad (1),$$

Where the dependent variable *IS*: Proportion of interest-sensitive products of company *i* in year *t*, and the independent variables are:

$LowRate_t$ = 1 for "low rate" period; or = 0 for "normal" period

$LargeSize_{i,t}$ = 1 for large-size life insurers (total assets at least 90,000 million baht); or = 0 for small-to-medium-size life insurers (total assets < 90,000 million baht)

$Agency_{i,t}$ = 1 for the company with a dominant agency distribution channel; or = 0 for the company with a dominant non-agency business model

$Risky_{i,t}$ = Proportion of risky investment of company *i* in year *t*

$RBC_{i,t}$ = Capital Adequacy Ratio of company *i* in year *t*

$ROA_{i,t}$ = Return on total assets of company *i* in year *t*

(Focarelli, 2015; Hartley et al., 2016; Nieder, 2016; Reyna et al., 2021).

The second equation, solvency measured by *RBC*, is a dependent variable to identify the relationship between interest rates and life insurers' solvency (similar to the Tobit regression approach by Reyna et al., 2021). Life insurers may be unable to entirely balance the interest rate sensitivity of their assets and liabilities upon interest rate changes (Berends et al., 2013). Berends et al. (2013) emphasized that banks and life insurers have similar interest rate risk exposure at which large firms are more interest rate sensitive than smaller ones. With various life insurers' sizes in the Thai life insurance industry, *LargeSize* is then incorporated to study further any potential relationship between the size of a firm and capital adequacy. On top of this, this equation also investigates the correlation between assets (*Risky*), returns (ROA), and capital adequacy *(RBC*), as insurers should properly balance assets and their returns to support higher risk charges on risky assets based on RBC framework (Berends et al., 2013).

$$RBC_{i,t} = \beta_0 + \beta_1 LowRate_t + \beta_2\, LargeSize_{i,t} + \beta_3 Risky_{i,t} + \beta_4\, ROA_{i,t} + \varepsilon_{i\,t} \quad (2a),$$

$$RBC_{i,t} = \beta_0^{*} + \beta_1 LowRate_t + \beta_2\, LargeSize_{i,t} + \beta_3 Risky_{i,t} + \beta_4\, ROA_{i,t} + \beta_4^{*} LowRate_t\, XROA_t + \varepsilon_t \quad (2b)$$

Where the dependent variable $RBC_{i,t}$ *is* the capital adequacy ratio (based on Thailand RBC framework) of company *i* in year *t*, and the independent variables are:

$LowRate_t$ = 1 for "low rate" period; or = 0 for "normal" period

$LargeSize_{i,t}$ = 1 for large-size life insurers (total assets at least 90,000 million baht); or = 0 for small-to-medium size life insurers (total assets < 90,000 million baht)

$Risky_{i,t}$ = Proportion of risky investment of company *i* in year *t*

$ROA_{i,t}$= Return on total assets of company *i* in year *t.*

$LowRate_tXROA_t$ = an interaction term between $LowRate_t$ and $ROA_{i,t}$ to explain a moderation effect: the effect of return on assets to solvency is higher during a "low rate" period.

(Berends et al., 2013; Reyna et al., 2021).

To measure insurers' exposure to interest rate risk, Berends et al. (2013) analyze the sensitivity of the US life insurance companies to interest rate risk before the financial crisis (sample period from August 2002 to July 2007) and during the low interest rate period of August 2007 through December 2012. They examined the correlation between changes in interest rates and an insurer's stock price. The third multiple regression equation takes the form:

$$y_{i,t} = \beta_0 + \beta_1 BondYield_t + \beta_2 SET\_I_t + \varepsilon_t \quad (3a)$$

$$y_{i,t} = \beta_0^* + \beta_1^* BondYield_t + \beta_2^* LowRate_t XBondYield_t + \beta_3^* SET\_I_t + \beta_4^* LowRate_t XSET\_I_t + \varepsilon_t \quad (3b)$$

Where the dependent variable is the *monthly stock returns of insurer i* and the independent variables are:

$LowRate_t$ = 1 for "low rate" period; or = 0 for "normal" period

$BondYield_t$ = change in 10-year government bond yield at the end of month t (i.e., *Yield(t) – Yield(t-1)*)

SET_I_t = average monthly SET market index returns where stock return = stock price(*t*)/stock price(*t-1*) – 1

$LowRate_tXBondYield_t$ = an interaction term between $LowRate_t$ and $BondYield_t$ to explain a moderation effect: the effect of bond yield on stock returns is higher during a “low rate” period.

$LowRate_t\ XSET\_I_t$ = an interaction term between $LowRate_t$ and SET_I_t to explain a moderation effect: the effect of SET market index return on stock returns is higher during a “low rate” period.

(Berend et al., 2013; Hartley et al., 2016).

3.8 Research Outcomes

3.8.1 The Descriptive Statistics

Currently, there are 22 life insurance companies still doing business in Thailand. This panel dataset is composed of annual data from 2000 to 2020 of 25 life insurers. Three of them, Thai Cardif, Tanachart Life, and SCB Life, are no longer active, but their data are retained during the sample period.

Table 3.2 presents descriptive statistics of all variables (dependent and independent variables of a panel dataset) in the first table - Table 3.2(a). The second table, Table 3.2(b), further breaks down all data over “normal” and “low rate” periods. The number of observations, standard deviation, minimum, and maximum values are shown for each variable. Table 3.2(d) presents the descriptive statistics of Thai life insurers actively traded in SET from January 2000 to December 2022.

Table 3.2: Descriptive Statistics Data Summary

Panel A of Table 3.2: This table summarizes descriptive statistics of dependent and independent variables of a panel dataset in Chapter 3. This first table presents an overview of 525 firm-year data collected from January 2000 to December 2020.

Perspective	Measurement	Variable	Obs.	(1) Mean	(2) Std. Dev.	(3) Min	(4) Max
Accounting Profitability	Return on asset (including realized capital gain/loss)	ROA	511	-0.020	0.128	-1.487	0.270
Firm Size	LargeSize = 1 vs. Others = 0 (LargeSize: total asset at least 90,000 million THB)	LargeSize	525	0.196	0.397	0	1
Distribution Channel	Agency-led = 1 vs. Others = 0	Agency	525	0.480	0.500	0	1
Asset - Investment	Percentage of investment in risky assets[1]	Risky	509	0.057	0.063	0.000	0.334
Statutory Solvency	Capital Adequacy Ratio under Risk-Based Regime	RBC	156	3.254	1.219	1.050	7.450
Market Situation	Prolonged low interest rate period indicator LowRate = 1 vs. Normal = 0	LowRate	525	0.286	0.452	0	1
Liability – New Business	Proportion of interest-sensitive new business premiums[2]	IS	510	0.678	0.284	0	1
Liability – New Business	Proportion of non-interest-sensitive new business premium	NIS	510	0.322	0.284	0	1

Remark: [1] Risky assets are Listed Equity, Derivatives, and Property
[2] Ordinary, Industrial, and Annuity products

Table 3.2: Descriptive Statistics Data Summary (Cont.)

Panel B of Table 3.2: This table further breakdowns 525 firm-year data over "normal" and "low rate" periods. Data from 2000 to 2014 are under "normal" period while data since 2015 are considered under "low rate" period.

Perspective	Measurement	Variable	Period	Observation period		Obs.	(1) Mean	(2) Std. Dev.	(3) Min	(4) Max
				From	To					
Accounting Profitability	Return on Asset (% of total assets)	ROA	Normal	2000	2014	373	-0.031	0.146	-1.487	0.270
			LowRate	2015	2020	138	0.010	0.050	-0.164	0.244
Firm Size	LargeSize = 1 vs. Others = 0	LargeSize	Normal	2000	2014	375	0.123	0.328	0	1
			LowRate	2015	2020	150	0.380	0.487	0	1
Distribution Channel	Agency-led = 1 vs. Others = 0	Agency	Normal	2000	2014	375	0.480	0.500	0	1
			LowRate	2015	2020	150	0.480	0.501	0	1
Asset - investment	Investment in risky assets (% of total assets)	Risky	Normal	2000	2014	372	0.053	0.059	0.000	0.279
			LowRate	2015	2020	137	0.067	0.073	0.000	0.334
Statutory Solvency	Capital Adequacy Ratio under Risk-Based Regime	RBC	Normal	2008	2014	39	3.173	1.242	1.280	7.410
			LowRate	2015	2020	117	3.281	1.216	1.050	7.450
Liability - New Business	Proportion of interest-sensitive new business premium	IS	Normal	2000	2014	372	0.692	0.285	0	1
			LowRate	2015	2020	138	0.640	0.279	0	1
Liability - New Business	Proportion of non-interest-sensitive new business premium	NIS	Normal	2000	2014	372	0.308	0.285	0	1
			LowRate	2015	2020	138	0.360	0.279	0	1

Remark: Data from 2000 to 2014 are under "normal" period, while data since 2015 are considered under "low rate" period.

Table 3.2: Descriptive Statistics Data Summary (Cont.)

Panel C of Table 3.2: Public life insurance companies listed in SET – Data extracted from SET (Stock Exchange of Thailand, 2023).

	Stock	Insurers	Listed Shares	First Trade Date	Market Value (MB)	
					31/1/2000*	30/12/2022
1	BUI	Bangkok Union Insurance	32,998,926	22/12/1988	144	540
2	KWI	KWI Life Insurance	2,044,331,987	01/02/1993	10,140	5,765
3	BLA	Bangkok Life Assurance	1,707,566,000	25/09/2009	23,052	49,093
4	THREL	Thaire Life Assurance	609,998,247	09/10/2013	5,795	2,556
5	TGH	Thai Group Holdings: Southeast Life Insurance	752,097,832	31/07/2019	27,452	15,192
6	TLI	Thai Life Insurance	11,450,000,000	25/07/2022	183,200	170,605

* Market value of stock No. 3-6 are at IPO (Initial Public Offering) or first trade date.

At present, only six public companies are listed in SET (see Table 3.2). Monthly stock return data from January 2000 until December 2022 are analyzed by excluding TGH and TLI due to their small sample size.

Table 3.2: Descriptive Statistics Data Summary (Cont.)

Panel D of Table 3.2: This table presents the descriptive statistics of Thai life insurers' monthly stock returns for insurer stocks actively trading in SET from January 2000 to December 2022.

Variable	Obs.	Mean	Std. Dev.	Min	Max
LowRate	276	0.3478	0.4771	0	1
BondYield	276	-0.0002	0.0032	-0.0128	0.0127
SET_I	276	0.0065	0.0622	-0.3018	0.2362
BUI	276	0.0096	0.1115	-0.4170	0.6532
KWI	276	0.0174	0.2134	-0.4821	1.4257
BLA	160	0.0049	0.1276	-0.9893	0.3426
THREL	111	-0.0105	0.1448	-0.9907	0.5232
TGH	41	-0.0579	0.2264	-1.0000	0.2193
TLI	6	-0.1671	0.4018	-0.9848	0.0526

3.8.2 The Results of the Two-sample t-test

For a two-sample t-test on liability management with an observable shift in life insurance product mix., Table 3.3(a) shows that the mean volume of a non-interest-sensitive new business (*NIS*) is statistically higher during "low rate" periods at a 5% significance level for the Thai market. The protracted low interest rate environment requires several life insurers to move their business mix toward non-interest-rate-sensitive products, as emphasized by Focarelli (2015), to reduce reliance on investment income. On top of that, the large-size Thai life insurers have a higher mean proportion of interest-sensitive products (*IS*) when compared to mid and small-size life insurers - refer to Table 3.3(b). This result supports the prior conclusion by Berends et al. (2013) that stock prices of large life insurers fluctuate more than those of small insurers because large life insurers have more interest-rate-sensitive life insurance products in their portfolio (Berends et al., 2013). In contrast, under the Thai RBC regime, Table 3.3(a) shows that the average solvency level of life insurers is not statistically different between Thailand's "normal" and the prolonged low-interest rate environments.

Table 3.3: Two-sample t-test

Panel A of Table 3.3: This table presents the t-test result of *H0: Mean [variable] is higher for the "low rate" period* using a sample of 525 firm-years in the Thai life insurance market from 2000 to 2020.

Variable		"Normal" period	"Low rate" period	Overall	One-sided p-values	
RoA	n =	374	138	512		
	Mean	-0.029	0.010	-0.018	[0.0020]	***
	Std. Dev.	0.154	0.050	0.135		
LargeSize	n =	375	150	525		
	Mean	0.123	0.380	0.196	[0.0000]	***
	Std. Dev.	0.328	0.487	0.397		
Agency	n =	375	150	525		
	Mean	0.480	0.480	0.480	[0.5000]	
	Std. Dev.	0.500	0.501	0.500		
Risky	n =	372	137	509		
	Mean	0.053	0.067	0.057	[0.0096]	***
	Std. Dev.	0.059	0.073	0.063		
RBC	n =	29	117	146		
	Mean	3.173	3.281	3.254	[0.3175]	
	Std. Dev.	1.242	1.216	1.219		
IS	n =	372	138	510		
	Mean	0.692	0.640	0.678	[0.9670]	
	Std. Dev.	0.285	0.279	0.284		
NIS	n =	372	138	510		
	Mean	0.308	0.360	0.322	[0.0330]	**
	Std. Dev.	0.285	0.279	0.284		

Differences between the means (averages) of each variable during the "*l*ow rate" and "normal" periods are tested with *H0: Mean [variable] is higher for the "low rate" period*.

Also, p-values are shown in brackets with results significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

Table 3.3: Two-sample t-test (Cont.)

Panel B of Table 3.3: This table presents the t-test result of *H0: Mean [variable] is higher for LargeSize* using a sample of 525 firm-years in the Thai life insurance market from 2000 to 2020.

Variable		Small-to-mid size	Large size	Overall	One-sided p-values	
RoA	n =	409	103	512		
	Mean	-0.029	0.024	-0.018	[0.0002]	***
	Std. Dev.	0.149	0.014	0.135		
Agency	n =	424	103	527		
	Mean	0.448	0.612	0.480	[0.0014]	***
	Std. Dev.	0.498	0.490	0.500		
Risky	n =	406	103	509		
	Mean	0.055	0.064	0.057	[0.0817]	*
	Std. Dev.	0.067	0.042	0.063		
RBC	n =	97	59	156		
	Mean	3.131	3.455	3.254	[0.0543]	*
	Std. Dev.	1.416	0.767	1.219		
Low rate	n =	422	103	525		
	Mean	0.220	0.553	0.286	[0.0000]	***
	Std. Dev.	0.415	0.500	0.452		
IS	n =	407	103	510		
	Mean	0.661	0.744	0.678	[0.0040]	***
	Std. Dev.	0.305	0.162	0.284		
NIS	n =	407	103	510		
	Mean	0.339	0.256	0.322	[0.9960]	
	Std. Dev.	0.305	0.162	0.284		

Differences between the means (averages) of each variable among two groups of large-size and small-to-mid-size Thai life insurers are tested with *H0: Mean [variable] is higher for LargeSize.*

Also, p-values are shown in brackets with results significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

3.8.3 Multivariate Regression Model Validations

Hausman tests were performed to confirm the robustness of the model. We tested for random and fixed effects in the model before adopting the estimators (Hausman, 1978). Results in Table 3.4 on regression estimation Equation 1 and Table 3.5 for Equation 2 (with and without moderation effects) are summarized. We cannot reject the null hypothesis that the random effects model is consistent and more appropriate. Thus, we use and interpret the random-effects model results of these two-panel regression models in the next section.

Table 3.4: Hausman Test of Regression Estimation for IS.

Dependent Variable: IS	(1) Fixed-effects (fe)		(2) Random-effects (re)	
LowRate	-0.172	***	-0.184	***
	[0.000]		[0.000]	
LargeSize	0.015		0.077	
	[0.847]		[0.198]	
Agency	omitted due to		-0.052	
	multicollinearity		[0.543]	
Risky	1.480	**	0.384	
	[0.022]		[0.403]	
RBC	-0.011		-0.014	
	[0.465]		[0.364]	
RoA	0.563	*	0.653	**
	[0.095]		[0.046]	
Constant	0.734	***	0.766	**
	[0.000]		[0.011]	
Group by	InsurerNo		InsurerNo	
N	155		155	
R-square	0.0085		0.1162	
H0: The random effects model is consistent				
p-value	[0.1176]			

This table presents the Hausman test of regression estimation equations for the Thai life insurance panel dataset from 2000 to 2022.

The dependent variable is the proportion of interest-sensitive products (IS).

Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

Table 3.5: Hausman Test of Regression Estimation for RBC.

Dependent Variable: RBC	(1) Fixed-effects (fe)		(2) Random-effects (re)		(3) Fixed-effects (fe) with moderation effect		(4) Random-effects (re) with moderation effect	
LowRate	0.150		0.021		0.163		0.029	
	[0.542]		[0.927]		[0.511]		[0.899]	
LargeSize	-0.684		-0.044		-0.729		-0.075	
	[0.119]		[0.876]		[0.105]		[0.795]	
Risky	-1.674		-2.531		-1.762		-2.600	
	[0.648]		[0.230]		[0.632]		[0.221]	
RoA	5.024	***	6.013	***	4.415	*	5.188	**
	[0.008]		[0.000]		[0.053]		[0.016]	
LowRate*ROA	n/a		n/a		1.709		1.955	
	n/a		n/a		[0.633]		[0.543]	
Constant	3.472	***	3.389	***	3.479	***	3.391	***
	[0.000]		[0.000]		[0.000]		[0.000]	
Group by	InsurerNo		InsurerNo		InsurerNo		InsurerNo	
N	155		155		155		155	
R-square	0.0212		0.1023		0.1052		0.1052	
H0: The random effects model is consistent								
p-value	[0.3326]				[0.4382]			

This table presents the Hausman test of regression estimation equations for the Thai life insurance panel dataset from 2000 to 2022.

The dependent variable is the capital adequacy ratio (RBC).

Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

3.8.4 The Results of Panel Regressions

Life insurers manage liability portfolios by considering interest rate risk on guaranteed products. In the Thai market, the proportion of interest-sensitive product is statistically significant with an increase in return on assets of life insurers. Thus, the protracted low interest rate environment requires life insurers to move their business mix toward non-interest-rate-sensitive products to lower reliance on investment income (Focarelli, 2015).

For capital adequacy and solvency management, four potential factors are examined for the dependent variable RBC: Solvency of a company i in year t. Only return on assets (ROA) influences the Thai life insurer's solvency level - see Table 3.5. Empirical evidence from Niedrig (2015) indicates that changes in the long-term interest rate affect the insurer's optimal risk portfolio by adding riskier asset classes in search of yields. As in the case of Germany, life insurers aim to increase the asset allocation to more illiquid investments, such as infrastructure bonds, to obtain higher yields (Nieder, 2016). Thus, the higher the risk exposures, the higher the required capital is, and potentially, the solvency level will be lower. In contrast, despite life insurers increasing risk-taking opportunities to enhance investment returns and meet policyholders' obligations (Kablau & Weiß, 2014), the proportion of risky investment assets (Risky) is not related to the level of solvency position (RBC) for the Thai market. This outcome might be caused by the Thai life insurers' ability to balance asset allocation and capital risk charges.

For stock return analysis, only the market index return (SET_I) can explain the stock return very well at a 1% significance on an aggregated portfolio of all six insurers. Change in interest rate sensitivity is not statistically significant between "low rate" and "normal" periods. This sensitivity is insignificant for the Thai market (due to data limitations) as most Thai life insurers are non-listed companies. Also, there are no moderation effects in a "low rate" environment. Please refer to Table 3.6 and Table 3.7 for the output summary.

Table 3.6: Multivariate Regression of Stock Returns of Thai Life Insurers

Independent variable	Dependent variable											
	BUI		KWI		BLA	THREL		TGH		All		
BondYield	0.156		-5.030		-0.176	10.531	**	15.228		1.013		
	[0.932]		[0.101]		[0.977]	[0.048]		[0.298]		[0.643]		
SET_I	0.498	***	1.009	***	0.646 *	1.069	***	-0.253		0.627	***	
	[0.001]		[0.000]		[0.065]	[0.003]		[0.756]		[0.000]		
Constant	0.006		0.010		0.000	-0.012		-0.058		0.012		
	[0.312]		[0.425]		[0.968]	[0.354]		[0.110]		[0.141]		
N	276		276		160	111		41		276		
R-square	0.078		0.091		0.057	0.112		0.030		0.078		

Remark: Individual results are excluded TLI due to the small sample size.

This table presents the regression estimation results using Thai life insurers' monthly stock returns sample from January 2000 to December 2022.

The dependent variables are the monthly stock returns of individual life insurers (BUI, KWI, BLA, THREL, TGH) and the portfolio of all six life insurers (All).

Robust standard errors without interaction effect are applied. Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

Table 3.7: Multivariate Regression of Stock Returns of Thai Life Insurers with Moderation Effect

Independent variable	Dependent variable											
	BUI		KWI		BLA		THREL		TGH	All		
BondYield	0.192		-4.510		-18.514		9.958		15.228	0.187		
	[0.921]		[0.148]		[0.151]		[0.631]		[0.298]	[0.930]		
LowRate*BondYield	0.297		-1.684		30.808	**	0.388		(omitted)	5.241		
	[0.948]		[0.871]		[0.022]		[0.985]			[0.540]		
SET_I	0.463	***	0.873	***	0.141		-2.294		-0.253	0.686	***	
	[0.003]		[0.000]		[0.827]		[0.328]		[0.756]	[0.000]		
LowRate*SET_I	0.202		0.769		0.950		3.706		(omitted)	-0.306		
	[0.6]		[0.105]		[0.168]		[0.119]			[0.313]		
Constant	0.007		0.010		0.002		-0.010		-0.058	0.012		
	[0.302]		[0.407]		[0.851]		[0.41]		[0.11]	[0.15]		
N	276		276		160		111		41	276		
R-square	0.079		0.099		0.134		0.216		0.030	0.082		

Remark: Individual results are excluded TLI due to the small sample size.

This table presents the regression estimation results using Thai life insurers' monthly stock returns sample from January 2000 to December 2022.

The dependent variables are the monthly stock returns of individual life insurers (BUI, KWI, BLA, THREL, TGH) and the portfolio of all six life insurers (All).

Robust standard errors without interaction effect are applied. Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

3.9 Conclusions and Recommendations

This study has investigated the liability management of Thai life insurers. Life insurers manage their liabilities portfolio by changing their life insurance product mix, managing interest rate risk on guaranteed products, and solvency management. Life insurers, during a prolonged low interest rate environment, move their new product portfolio toward the least investment return dependent or non-guaranteed (non-interest-sensitive) products (Focarelli, 2015) as they cannot profitably offer saving-oriented products (Hartley et al., 2016). Since interest rate risk is higher for life insurers in the *"low rate"* period, as previously observed in the US market (Hartley et al., 2016), it is anticipated that the Thai insurance market has different performance results during "*normal*" and "*low rate*" periods. Upon interest rate changes, policyholders exercise their available options. For instance, they may surrender an annuity with a low guaranteed interest rate when the market interest rate increases. By contrast, they may contribute more to the product when the market interest rate decreases. A combined effect of guaranteed minimum return on product and policyholder's behavior is a crucial consideration for the interest sensitivity of life insurers (Hartley et al., 2016).

Despite the Thai life insurance market mainly relying on agency distribution (refer to Figure 3.5), there is no evidence to support a significant higher proportion of interest-sensitive products produced by the agency-led insurers compared to life insurers that are bancassurance-led or others. Thai life insurers' return on assets rises with increases in solvency as some insurers focus on improving their capital adequacy to compensate for revenue compression when their investment yields decrease (Holsboer, 2000). There is no potential interaction effect between solvency and return on assets during the *"low rate"* period. Nevertheless, large-size Thai life insurers have a higher mean proportion of interest-sensitive products when compared to mid and small-size life insurers.

Global life insurers seek to act by exactly matching long-term liabilities with long-term assets of government or corporate bonds during the "normal" period and move to riskier asset classes during the "low rate" period per Hartley et al. (2016). In contrast, the proportion of risky investment assets held by Thai life insurers is not related to their level of solvency.

Like several global insurers that move their new business product portfolio toward the least investment return dependent or even non-guaranteed products during a prolonged low-interest rate environment (Focarelli, 2015), the mean volume of a non-interest-sensitive new business is statistically higher during “low rate” period for the Thai market.

Upon identifying the Thai life insurers’ solvency position over the period, the average level of solvency based on Thailand's regulatory regime is not statistically different between Thailand's “normal” and the prolonged low interest rate situation. The proportion of risky investment assets does not relate significantly to the level of solvency position of Thai life insurers. Under a regulatory risk-based capital regime, these insurers should properly balance asset and capital allocation to support higher risk charges on risky assets (Berends et al., 2013).

For possible future studies, researchers can extend the analysis to the non-life insurance industry and simultaneously compare two insurance sectors (life and non-life). It will uncover the missing short-term view of liability management in non-life products to fulfill the insurance business analysis. The measure of efficiency improvement in response to a “low rate” situation is out of the scope of this research. Besides, the result of this paper may vary if other risk factors are considered, such as policyholder behavior, management decisions, and intervention by the company board of directors.

CHAPTER IV
ASSET MANAGEMENT OF LIFE INSURERS

4.1 Introduction

With the recent global surge in interest rates and the significant rise in inflation worldwide, the prolonged low interest rate may no longer persist. This perspective is supported by evidence of the fluctuation in the federal funds rate that began to rise in 2017 but came down again in 2019, then, from 2020 to early 2022, dropped back close to zero and rebounded to reach a 5% level in 2023 (United States Fed Funds Rate, 2024). Such fluctuations in interest rates make it hard to predict long-term interest rate movements. This movement is a crucial challenge to life insurers in managing their asset portfolios to earn sufficient returns for the minimum guarantees on liabilities.

A life insurer's investment return on assets is considered a profitability source of financial activity from an investment of policyholders' premiums (Greene & Segal, 2004). In the past, a "negative spread" emerged from guaranteed life insurance liability returns of 4%, much higher than the investment yield from the invested asset portfolio of just 2% (Nieder, 2016). A low interest rate hurts insurance companies' profitability due to the low investment return on their asset portfolio (Eling & Holder, 2013a).

Life insurers typically invest premiums collected from their customers in different asset classes. They perform an asset and liability management (ALM) model to monitor asset values such that gains or losses can be determined for profit-sharing obligation on their liabilities (Alfonsi et al., 2020). They also put in place assets to back their liabilities and hedge systemic mortality-related risks by transferring the underlying mortality risk to the capital market using securitizations (Leppisaari, 2008). Examples are issuing longevity bonds to hedge against longevity risks or even relying upon

mortality-linked derivatives in well-developed markets (Thomsen & Andersen, 2007), and catastrophe risk securitization in the forms of catastrophe bonds (Doherty, 1997).

Upon changes in interest rate, the market values of assets and liabilities change. Even though insurers choose to manage interest rate risk using asset-backing liability, they cannot easily balance the interest rate sensitivity of their asset and liability portfolio (Berends et al., 2013). Life insurance typically manages this interest rate risk by using asset liability management (ALM) or derivatives to hedge embedded options in their products (Berends et al., 2013). Under the ALM framework, apart from the duration matching approach proposed by most researchers, we noted several strategies/approaches could be employed depending on the life insurer's goal. For example, the cashflow matching strategy to minimize the difference between asset and liability cashflows, the immunization approach to maintain the surplus from asset and liability portfolios with fixed cashflows (Van der Meer & Smink, 1993), and the dedication approach to economically match cashflows within a boundary that sufficient cashflows could be paid out for incurred liabilities (Dahl, 1996). These facts make the asset management strategy, apart from liability management mentioned in the second essay, another strategy to be considered by life insurers.

This third essay will analyze the asset management strategy of life insurers in Thailand under changes in interest rate trends. This dissertation aims to understand the asset management strategy of life insurers during a prolonged low interest rate phenomenon. Regression analysis measures the relationship between profitability and insurer asset portfolio characteristics, including investment yields, total assets, and asset allocation. It is anticipated that during a prolonged low interest rate environment, potential underwriting losses from life insurance products will result in life insurers critically aiming to make a sufficient return from investment to compensate for their losses and achieve survival or growth strategies (Akotey et al., 2013).

4.2 The Asset Management of Life Insurance Companies in Thailand

In Thailand, the total asset size of the life insurance industry, on an aggregated basis, has increased substantially from 243 billion Baht in 2000 to 4.021 trillion Baht in 2022 (Thai Life Assurance Association, 2022). In contrast, there was a decrease in investment returns over the same period from as high as overall 6.03% in 2000 to 3.48% in 2022 (see Figure 4.1). This deterioration in yield was modest at 20 basis points over the first decade of 2000, while in the second decade afterward, yield sharply declined by 235 basis points. Given this extensive growth of life insurance asset portfolio and observable shift in yields, it is worth understanding where the assets have been held or invested.

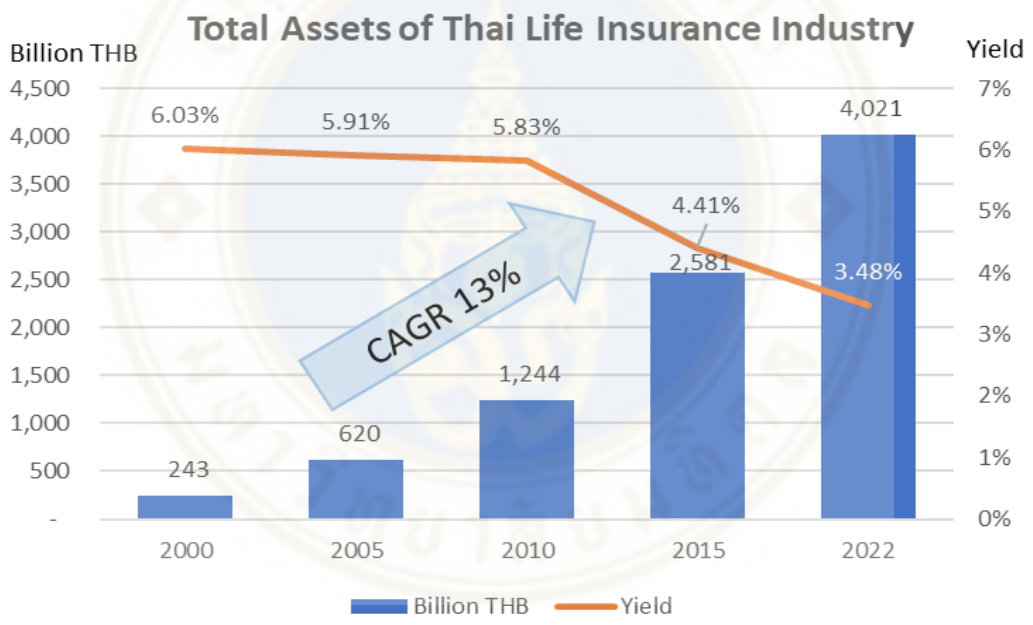


Figure 4.1: Volume and Return of The Thai Life Insurance Industry Asset Portfolio (data collected from Thai Life Assurance Association, 2023).

According to the Office of Insurance Commission (OIC) regulatory framework, life insurers must invest in appropriate assets to obtain sufficient returns consistent with their obligations. Life insurers are required to get their board of directors' approval on investment policy and their investment risk management process

(Office of Insurance Commission, 2024). Restrictions to individual life insurers on investment regulation imposed by OIC include: -

1. Issuer limits which are: -
   (a) Maximum 30% of total invested assets for each financial institution,
   (b) Maximum 15% of total invested assets for each issuer of investment grade debentures and 5% of total invested assets for others.
   (c) Maximum 10% of total invested assets for each property and real estate issuer.
2. Asset classification limits are as follows: -
   (a) Corporate debentures: Maximum 60% of total invested assets,
   (b) Domestic and foreign equities: Maximum 30% of total invested assets.
   (c) Property and real estate Maximum 30% of total invested assets.
   (d) Derivatives: Aggregation of all net contract positions must not exceed the total values of the underlying exposures.
   (e) Foreign investments: Maximum 30% of total invested assets.
   (f) Policy loans: Maximum 100% of each policy's cash surrender value.
   (g) Employee's loan: Maximum 5% of total invested assets.
   (h) Other loans and leasing: Maximum 20% of total invested assets.
   (i) All subordinated debentures and non-listed equities: Maximum 5% of total invested assets.

Furthermore, the selection of types, individual securities, and asset allocation limits are defined based on each life insurer's management of its risk appetite. This invested asset typically enables life insurers to monitor and control risks from their invested assets.

Market, credit, insurance, operational, and concentration risks are key risk-related considerations from a regulatory perspective. This risk consideration links asset management and the RBC regime imposed by OIC for life insurance solvency. The recent Thai RBC regulatory regime requires a minimum capital adequacy ratio (total capital available divided by total capital requirements) of 140% since 2022. Increment or decrement in appraisal values of invested assets can be incorporated in a Common Equity Tier 1: CET 1 as part of capital available. Capital requirements on market and credit risk charges will be varied by asset classes and described in detail next.

According to the OIC, the regulatory framework imposes restrictions on investment strategies. Life insurers set each asset class limitation concerning risk charges from a risk-based capital (RBC) regime (Office of Insurance Commission, 2024).

Gründl & Gal (2017) classified asset allocation into two sub-categories. One is strategic asset allocation (SAA), a mid-to-long-term asset allocation strategy. Another is a short to mid-term or tactical asset allocation (TAA). SAA should be aligned with the life insurer's risk-bearing capability, whereas TAA can be determined simply from market expectations (Gründl & Gal, 2017). For the Thai life insurance industry, the overall asset allocation movements are presented in Figure 4.2. During our observation period from 2000 to 2020, bonds (government, corporate, and foreign) were the main investment assets in the Thai life insurance industry portfolio.

As of year-end 2022, the life insurance asset portfolio comprised 76% bonds, 6% listed equity, 5% loans, and 3% separate accounts (see Figure 4.2). The remaining assets are cash or financial institution deposits, derivatives, property, accrued premiums, reinsurance, and operating assets (e.g., real estate and office buildings). Life insurers' asset portfolio fraction in bonds increased from 58% in 2000 to 76% in 2022. Focarelli (2015) emphasizes the move of new product portfolios toward the least investment return dependent, like unit-linked products, to lower the guaranteed rate during the low yield environment. Life insurers focus on selling more unit-linked products to transfer investment risk to policyholders (Holsboer, 2000). As a result, the proportion of separate accounts (an investment separately reported as one segregated asset class on the balance sheet) also increased to transfer investment risk to policyholders. In contrast, loans, mainly policy loans and mortgage loans, showed a deterioration in proportion from 16% in 2000 to just only 5% in 2022 (Thai Life Assurance Association, 2023). This move toward a higher proportion of bonds and separate accounts is consistent with an effort of life insurance companies to adjust their investment portfolio by keeping a small duration gap of assets and liabilities (under ALM approach) to deal with their interest rate risk from selling long-term coverage of protection and unit-linked products (Ozdagli & Wang, 2019).

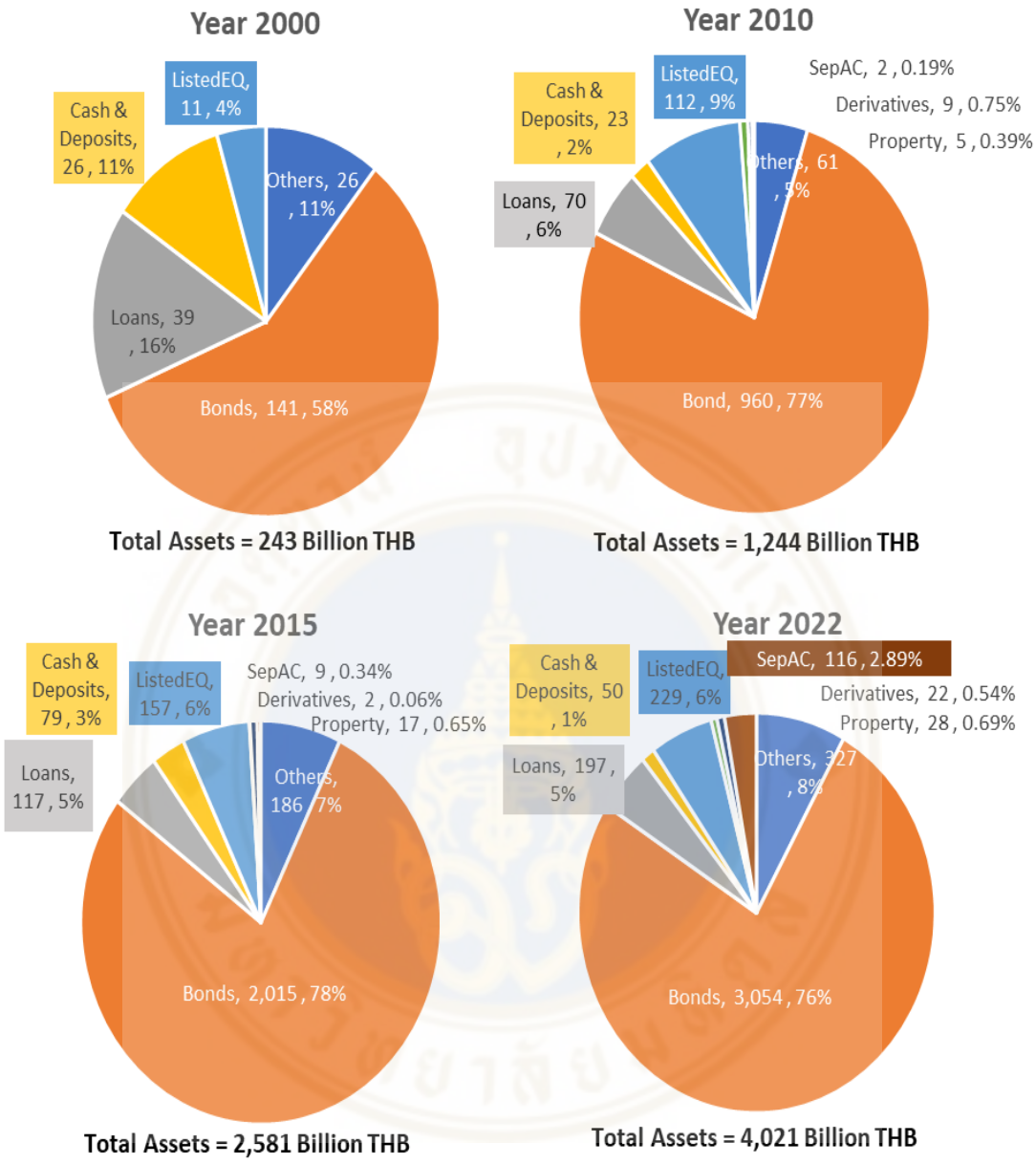


Figure 4.2: Asset Allocation for the Thai Life Insurance Industry (data collected from Thai Life Assurance Association, 2022)

Despite a continual increase in the bond portfolio at 17% growth over the past 20 years, this bond proportion is relatively stable at 76%-78% of total assets during the past decade (see Figure 4.3). This large proportion of fixed-income investment is consistent with the Asian life insurers' investment (Gründl & Gal, 2017).

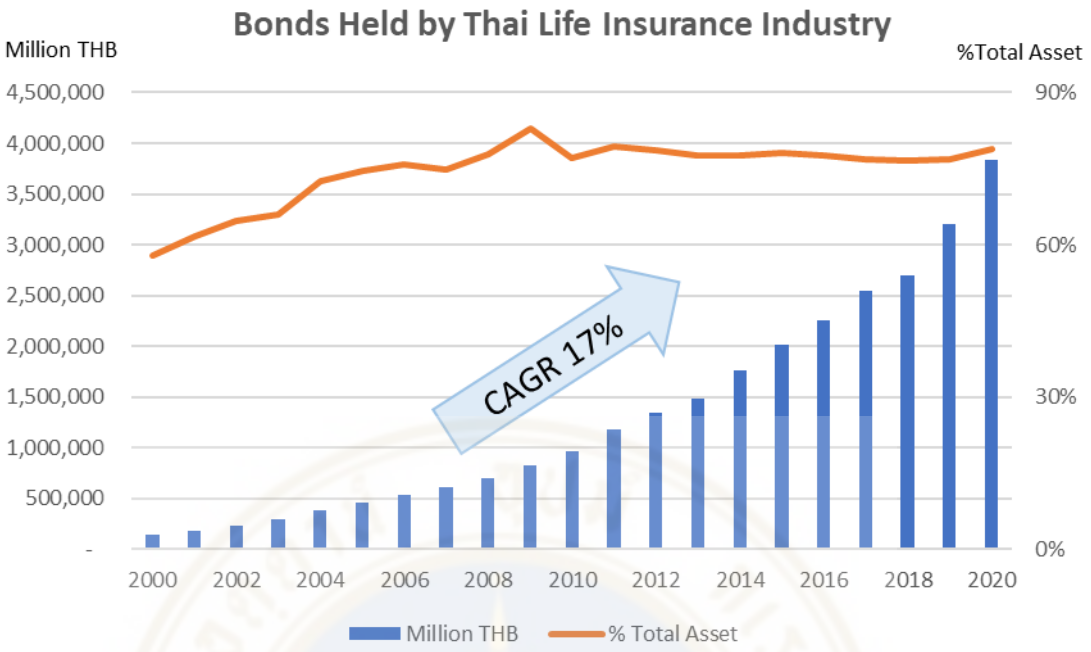


Figure 4.3: Growth of Bonds Held by the Thai Life Insurance Industry (data collected from Thai Life Assurance Association, 2022)

For fixed-income instruments, the Thai capital requirements are equivalent to the marked-to-market value of the bond instrument multiplied by the "specific risk" charge factor of the bond's issuer credit rating (see Table 4.1). The RBC "specific risk" charge factor on bonds of each life insurer must be re-evaluated quarterly. For example, for an AA-rated (by S&P) corporate bond with a remaining time to maturity (TTM) of 8 months, the specific risk charge factor for this debenture of risk grade 2 is 0.70%. Global evidence showed that during periods with negative yields on government bonds, Japan's life insurers addressed their low yield issue by moving their asset allocation toward USD-denominated bonds (Nieder, 2016). This yield enhancement by broadening the asset universe leads to a foreign exchange risk (Mee, 2015) and a concern for the Thai market based on this specific risk charge on the issuer's rating under the Thai RBC regime.

Table 4.1: RBC Specific Risk Charges for Bonds Held by the Thai Life Insurers (Office of Insurance Commission, 2024).

Time to maturity	Risk Grade					
(TTM)	1	2	3	4	5	6
< 6 months (6M)	0.30%	0.35%	0.40%	0.45%	45.00%	68.00%
6M<TTM<1Y	0.65%	0.70%	0.75%	0.80%	45.00%	68.00%
1Y<=TTM<3Y	1.30%	1.50%	1.75%	2.00%	45.00%	68.00%
3Y<=TTM<5Y	2.55%	2.70%	3.70%	4.75%	45.00%	68.00%
TTM>=5Y	3.70%	4.00%	5.45%	7.30%	45.00%	68.00%

Risk Grade	Thai Rating		Offshore Rating			
	TRIS	Fitch	S&P	Moody's	Fitch	A.M.Best
1	AAA	AAA(THA)	AAA	Aaa	AAA	A++
2	AA+	AA+(THA)	AA+	Aa1	AA+	A+
	AA	AA(THA)	AA	Aa2	AA	
	AA-	AA-(THA)	AA-	Aa3	AA-	
3	A+	A+(THA)	A+	A1	A+	A
	A	A(THA)	A	A2	A	A-
	A-	A-(THA)	A-	A3	A-	
4	BBB+	BBB+(THA)	BBB+	Baa1	BBB+	B++
	BBB	BBB(THA)	BBB	Baa2	BBB	B+
	BBB-	BBB-(THA)	BBB-	Baa3	BBB-	
5	Not assessed	Not assessed	BB+	Ba1	BB+	B
			BB	Ba2	BB	B-
			BB-	Ba3	BB-	
6	BB+ or lower or non-rated	BB+(THA) or lower or non-rated	B+ or lower or non-rated	B1 or lower or non-rated	B+ or lower or non-rated	C++ or lower or non-rated

From TLAA data, the usage of derivatives in the Thai life insurance market started in 2008 and reached its highest point in 2019 (see Figure 4.4). The derivatives used by the Thai life insurance market include currency futures, cross-currency swaps, interest rate futures, interest rate swaps, equity futures, equity options, and bond forwards. Berends et al. (2013) assert that life insurers use derivatives such as interest rate swaps to hedge interest rate risk. Currency hedging is another yield enhancement approach that life insurers implement to put their assets in foreign currencies rather than keep them in local currency (Mee, 2015).

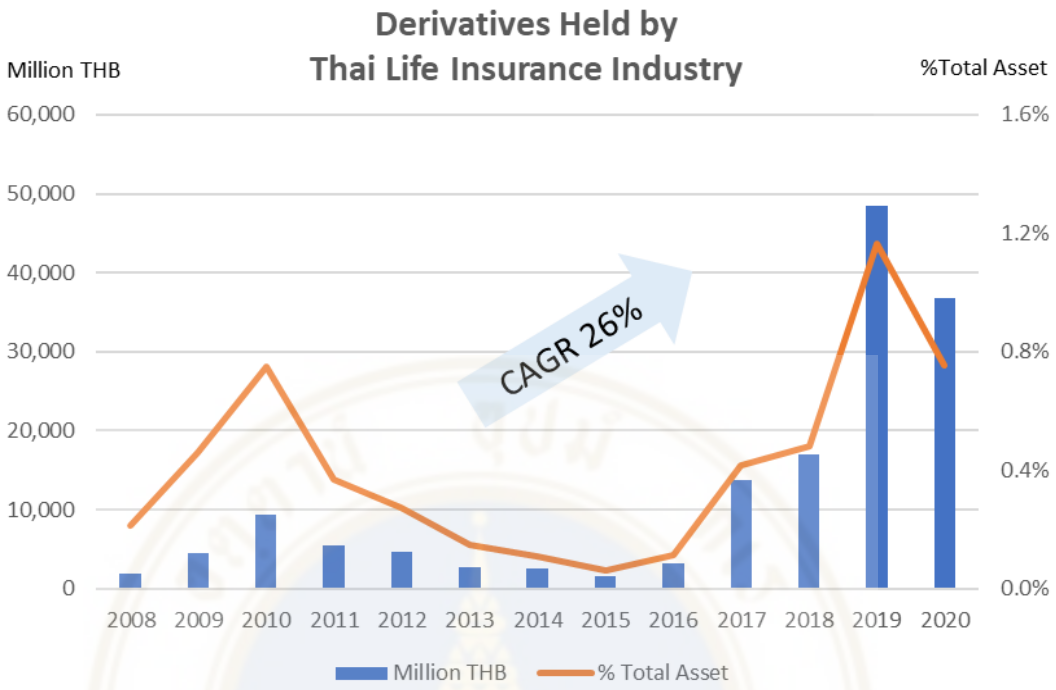


Figure 4.4: Growth of Derivatives Held by the Thai Life Insurance Industry (data collected from Thai Life Assurance Association, 2022)

Even though the maximum limit for equity investment is 30% of total invested assets, all Thai life insurers invested not more than 12% in listed equities (see Figure 4.5). Due to the regulator's maximum 5% limit on all subordinate debentures and non-listed equities, life insurers are cautious with their invested asset selection.

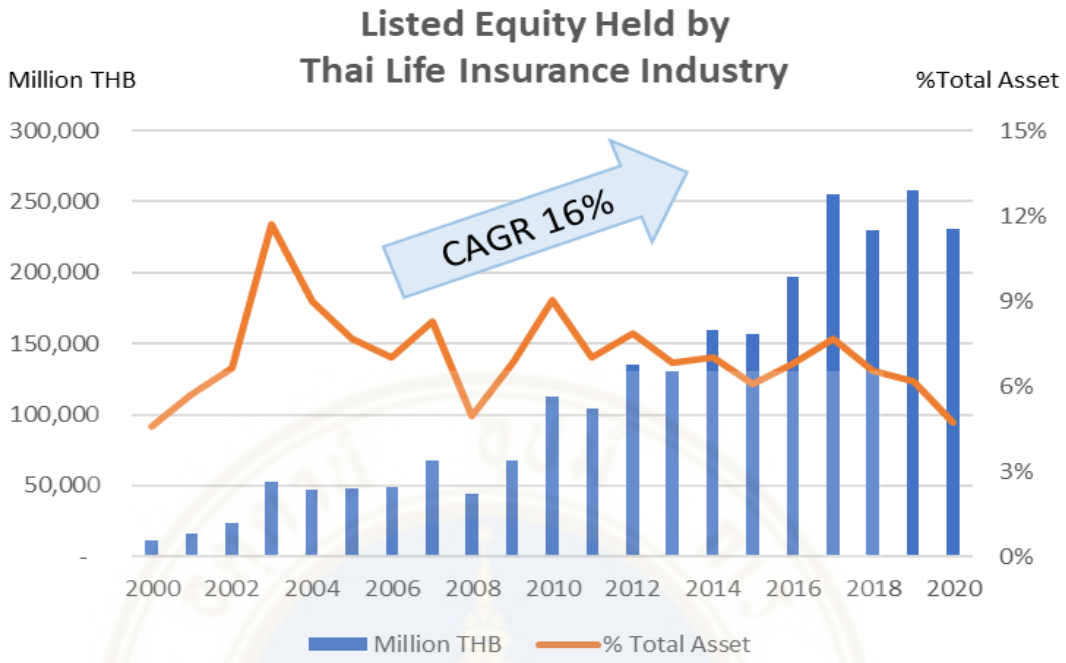


Figure 4.5: Growth of Listed Equity Held by the Thai Life Insurance Industry (data collected from Thai Life Assurance Association, 2022)

Apart from a general fund that life insurers use to generate the investment return for traditional, a separate account is another segregated fund in which variable-rate policyholders bear investment risk based on the life insurer's available investment choices (Henebry & Diamond, 1998). The separate accounts in the Thai life insurance market started in 2005 (see Figure 4.6) with the introduction of unit-linked products to the Thai market. Separated accounts for the Thai market are typically investments in the form of mutual funds. These invested assets must be held by life insurers on behalf of policyholders and put in the life insurers' balance sheet. Thus, life insurers must consider this asset class in their asset management.

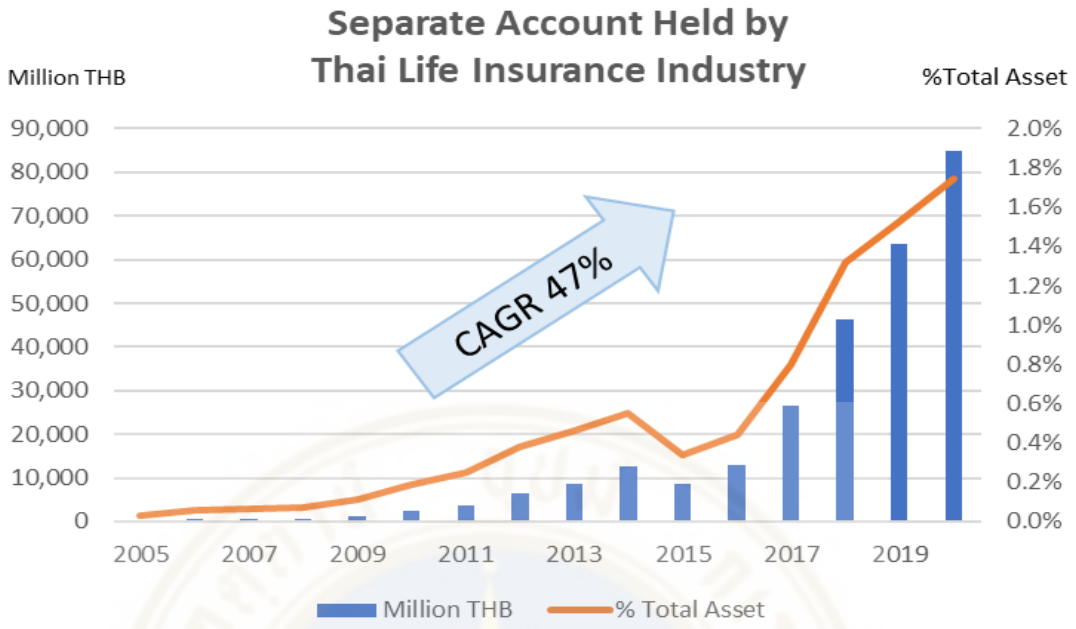


Figure 4.6: Growth of Separate Accounts Held by the Thai Life Insurance Industry (data collected from Thai Life Assurance Association, 2022)

4.3 Rationales for Asset Management of Life Insurers

When insurers adjust their assets' portfolios to match the growth rate of liabilities to provide the high guarantee as promised with policyholders during a low interest rate environment, they increase their asset allocation to a riskier asset class. This reallocation of assets makes their portfolio more volatile, requiring substantial capital to cover potential losses (Niedrig, 2015). Risky investments are more vulnerable to disruption and variations in earnings. Hence, this shift toward risky investment may adversely impact insurers' financial stability (Kablau & Weiß, 2014). The riskier the high-yield investments, the wider the duration gap between assets and liabilities, and the higher the volatility of asset portfolios. Berends et al. (2013) contend that life insurers may be exposed to credit risk on high-yield investments due to the potential loss of their asset values.

Interest rates in several markets declined during the past few decades. For example, in a fast-growing and emerging market like Mexico, the interest rate was exceptionally high at 50% in 1995 and decreased to 30% in 1998, then stayed at protracted rates below 10% till 2018 (Reyna et al., 2021). Life insurers struggle to meet previously high product guarantees (Holsboer, 2000). Furthermore, a lack of investment opportunities puts excessive pressure on insurers in emerging countries (Reyna et al., 2021).

Given the above reasons, this dissertation aims to analyze the asset management strategy of life insurers in Thailand with changes in interest rate trends toward a prolonged low interest rate environment. The investment strategy of a life insurer is disclosed in their asset portfolio mix and risk-based capital composition (based on broad categories of asset classification invested by life insurers). This result will also help explain the movement in life insurance asset portfolios during prolonged low interest rate periods.

4.4 Expected Contribution

There are two significant contributions to this research. The first contribution is to provide a better understanding of influential strategic decisions to manage prolonged interest rate risk for the life insurance business on the asset management side. When the capital markets decline, insurance companies are exposed to losses in their returns upon reinvestment. Therefore, insurers must reinvest in yield enhancement instruments, e.g., derivatives or stocks (listed equity), to keep up with sufficient funds for future obligations (Berdin & Gründl, 2015). Holsboer (2000) assessed that approximately after 4 to 10 years, if "*low rate*" period persists, insurers' investment portfolio returns would drop to the capital market level, with the speed of adjustment depending upon the mix of portfolio assets maturities. Thailand's market could be considered an emerging market representative for exploring life insurers' investment portfolios in detail. Broad asset classification categories will be analyzed and measured among different sizes of firms.

The second contribution is that this study can complement prior research on life insurers' asset management portfolio strategy. This extension of research to the Thai market, an Asian emerging market economy where the preceding literature does not review the impact of prolonged low interest rates on the asset side of the life insurers. Previous studies analyze the investment portfolio composition by examining individual US life insurer asset allocation from 1988 to 1995 (Henebry & Diamond, 1998) and utilize the ALM approach to get an optimal asset allocation for a general portfolio of life insurance policies (Ozdagli & Wang, 2019). Also, Borri et al. (2018) apply canonical correlation analysis to study the relationship between assets and liabilities of European life insurers during a “low rate” period. The result of high exposure to ALM risk due to a weak relation between assets and liabilities supplements the usefulness of the ALM tool (Borri et al., 2018). Despite this study being built on existing knowledge, it will expand with a new dataset from Thailand and be organized to give further insight into the issue.

This research will examine the relationship of investment strategy to life insurers’ asset portfolio, aiming to understand changes in asset portfolio composition and investment strategies of Thai life insurers during a prolonged low-interest rate environment.

4.5 Conceptual Framework and Hypotheses

Life insurers typically invest their premium deposits in different asset classes, for example, in bonds, equity, and property, to ensure earned interest from investment portfolios meets the guarantees on products to their policyholders. They must define an appropriate allocation among the different types of assets to make a certain balance between risks and returns to withstand the capital requirement enforced by the regulator (Alfonsi et al., 2020). As such, for asset management of life insurance companies, two key considerations are asset allocation on investment portfolio composition and investment regulation as imposed by the regulatory framework.

4.5.1 Asset Allocation

Gründl & Gal (2017) classified asset allocation into two sub-categories. One is strategic asset allocation (SAA), a mid-to-long-term asset allocation strategy. Another is a short to mid-term or tactical asset allocation (TAA). SAA should be aligned with the life insurer's risk-bearing capability, whereas TAA can be determined simply from market expectations (Gründl & Gal, 2017). Asset and liability management (ALM) is an important framework in the life insurance industry that supports determining the proper asset allocation for life insurers (Alfonsi et al., 2020). Matching asset and liability durations under ALM framework helps insurers confine potential exposures to interest rate risk (Berends et al., 2013). Upon decreasing interest rates, insurers should make long-term investments to lock in asset duration and lower the duration gap with life insurance liabilities. By contrast, when interest rates rise, life insurers must quickly invest in shorter-duration assets to meet policyholders' expectations (Paetzmann, 2011).

ALM is an investment approach based on matching asset and liability durations, helping insurers confine potential exposures to interest rate risk (Berends et al., 2013). Under the ALM framework, apart from the duration matching approach, we noted that several strategies and techniques depend on the life insurer's objective. For example, cash flow matching is applied to minimize the difference between asset and liability cash flows or immunization and to maintain the surplus from asset and liability portfolios with fixed cashflows (Van der Meer & Smink 1993). Besides, the dedicated approach to economically matching cashflows within a boundary is a quantitative solution adopted in practice (Dahl, 1993). ALM is typically used to assess and mitigate life insurers' interest rate risk (Holsboer, 2000). Although we do not have sufficient assets and liabilities cash flow data for the Thai market to calculate and observe changes in duration gaps, Thai life insurers should be incentivized to maintain a small duration gap of assets and liabilities to deal with their interest rate risk on guaranteed products (Ozdagli & Wang, 2019). The key reason is that the interest rate (or ALM) risk charge is one fundamental factor under RBC risk-based frameworks governed by OIC (Office of Insurance Commission, 2024) and global insurance regulators (Berends et al., 2013).

According to OECD's global survey of large insurers in 2012-2014 summarized by Gründl & Gal (2017), there is no markable shift in asset allocation

during a prolonged low interest rate environment. This survey classifies assets into six broad categories: (1) cash and deposits, (2) fixed income, (3) loans, (4) listed equity, (5) alternative investments[6], and (6) other investments. Fixed income and loans still cover more than 80% of total investments. Despite Asian life insurers investing a relatively high proportion of 14% in listed equity, fixed income, and loans are still the largest proportion of life insurers' asset allocation (Gründl & Gal, 2017). Despite the proportion of listed equity investment during the past 20 years being less than 12% in Thailand, its proportion in the past few years has increased notably (please refer to Figure 4.4 in Section 4.2). Therefore, it is anticipated that in Thailand, the portion of listed equity is higher during a "low rate" period - Hypothesis 1.

During negative returns on Japanese government bonds, Japan's life insurers addressed their low yield issue by moving their asset allocation toward USD-denominated bonds (Nieder, 2016). Enhancing yields by broadening the asset universe leads to a foreign exchange risk (Mee, 2015). Currency hedging is another investment approach life insurers implement to put their assets denominated in foreign currencies rather than keep them in local currency (Mee, 2015). Berends et al. (2013) contend that life insurers use derivatives such as interest rate swaps to hedge interest rate risk. In Thailand, the potential usage of derivatives as a yield enhancement tool is remarkably increasing (please refer to Figure 4.5 in Chapter 4.2). Thus, Hypothesis 2 is developed: the proportion of derivatives is higher during a "low rate" period.

In practice, life insurers set aside two core investment funds. One is the general fund account used for traditional products where insurers retain investment risk. Another is the separate account that variable-rate policyholders bear investment risk based on available investment choices (Henebry & Diamond, 1998). During the prolonged low interest rate environment, life insurers move their new business mix toward non-interest rate sensitive products with less reliance on an embedded saving element (Focarelli, 2015) and focus more on transferring the investment risk to policyholders (Nieder, 2016). Life insurers set up a separate account, an investment separately reported as one segregated asset class on the balance sheet, to transfer

[6] Samples are land and buildings, unlisted real estate equity, private equity, unlisted infrastructure equity, hedge funds and commodities.

investment risk to policyholders (Henebry & Diamond, 1998). As such, the proportion of life insurers' separate accounts (or segregated investment funds) is higher during a “low rate” period - Hypothesis 3.

4.5.2 Investment Regulation

Regarding regulatory influence on the asset management of life insurers, asset risk is a key consideration due to the rules imposed by the regulator. Life insurers typically have a long-term investment strategy following the long-term nature of future obligations on the liability side. They usually intend to hold bonds to maturity (held-to-maturity bonds) and keep track of the credit rating assessment until there are any observable market factors to alter the situation (Mee, 2015).

Under the long-term investment strategy, the investment return of life insurers declines during a prolonged low interest rate environment (Greene & Segal, 2004). Greene & Segal (2004) emphasized that life insurers, especially during a protracted low interest rate environment, search for high yields from their investment. Therefore, the mean investment return of the Thai life insurance industry is expected to be lower during a “low rate” period - Hypothesis 4.

Greene & Segal (2004) highlighted that investments are a primary activity of life insurers. Life insurers, especially during a prolonged low interest rate environment, search for high yields from their investment. They either take a “re-risking” strategy: invest in emerging markets or alternative investments in illiquid assets. Or they take a “de-risking” approach: invest in short-term assets to keep pace with regulatory changes and solvency capital requirements (Gründl & Gal, 2017). Therefore, the capital adequacy of Thai life insurers is expected to be lower during a “low rate” period due to the dominant effect of higher capital risk charges from searching for high-yield investments under the “re-risking” strategy - Hypothesis 5.

4.6 The Methodology and Source of Data

This dissertation relies on a multivariate design where two or more measures on each observation will be analyzed using Stata/SE 15.0. Parametric procedures will be applied as data are ratio-scaled.

This study will use secondary data from three sources as follows.

1. Thai Bond Market Association: http://www.thaibma.or.th/

ThaiBMA's 10-year monthly government bond yield from 2000 to 2022 is used as a benchmark for the long-term interest rate in the Thai market. The "normal" and "low rate" periods will be identified to analyze the impact of the prolonged low interest rate environment (Thai Bond Market Association, 2023)

2. The life insurance industry 2000-2020 annual statistics by insurers (a panel of different insurance companies) include invested asset values, balance sheets, and profit and loss statements from The Thai Life Assurance Association: TLAA (Thai Life Assurance Association, 2022).

This timeframe will include the effects of the recent Thai market decline in interest rates in August 2019.

In addition, a robustness check will be performed using the Hausman test (Hausman, 1978) to check between fixed and random effects models of these panel datasets.

4.7 Variable Measurement

The following are measurements of all variables used for hypotheses testing:

1. A “Low rate” period is when the long-term interest rate drastically decreases (Hartley et al., 2016). For this study of the Thai market, the period since 2015 will be considered the “low rate” period - The period since 2015 has yielded lower than the all-time average of 3.3%. (see Figure 3.3).

2. The “Normal” period is beyond the “low rate” period. For this study to apply to the Thailand market, pre-2015 will be considered the “normal” period – the period before 2015 generated greater yields than an all-time average of 3.3%. (see Figure 3.3).

3. Investment return (or yield rate) is derived from dividing net investment income over the year by average total investments. For example, yield rate 2019 = net investment income 2019 / {(total investments 2019 + 2018) /2} (Thai Life Assurance Association, 2022).

4. A separate account is an investment separately reported as one segregated asset class on the balance sheet in which the insurers transferred investment risk to policyholders (Henebry & Diamond, 1998).

5. The proportion of listed equity is measured by the investment (amount) in equity securities listed on the Stock Exchange of Thailand (SET) and other stock exchanges divided by total investments (all asset classes).

6. The proportion of derivatives is measured by the amount of investment in derivatives divided by total investments (all asset classes).

7. Profitability is measured in terms of return on total asset (ROA) resulting from investment return and insurance performances (measuring in terms of "ratio" to eliminate potential scale effect from different sizes of life insurers).

4.8 The Data Analysis

Two empirical models are estimated to evaluate the asset management of Thai life insurers. Multiple regression technique is used to analyze the time series data and test the hypotheses. An asset allocation on investment requires consideration in terms of investment returns, measured with "Yield" dependent variable. We expect that life insurers increase their asset allocation to a riskier asset class in a low interest rate environment. This reallocation of assets makes assets more volatile, requiring substantial capital to cover potential losses (Niedrig, 2015). Also, a low interest rate hurts insurance companies' profitability due to the low investment returns on their asset-backing portfolio (Eling & Holder, 2013a). Thus, the first multiple regression equations take the form:

$$Yield_{i,t} = \beta_0 + \beta_1 LowRate_{i,t} + \beta_2 SepAC_{i,t} + \beta_3 EQ_{i,t} + \beta_4 Rx_{i,t} + \beta_5 Bond_{i,t} + \varepsilon_{i,t} \quad (1a)$$

$$Yield_{i,t} = \beta_0^* + \beta_1^* LowRate_{i,t} + \varepsilon_{i,t} \quad (1b),$$

where the dependent variable is *Yield* (or investment return) of the company *i* in year *t* and the independent variables are:

$LowRate_{i,t}$ = 1 for "low rate" period; or = 0 for "normal" period

$SepAC_{i,t}$ = Proportion of separate accounts of the company *i in year t*

$EQ_{i,t}$ = Proportion of listed equity of company *i in year t*

$Rx_{i,t}$ = Proportion of derivatives of company *i in year t*

$Bond_{i,t}$ = Proportion of bonds of company *i in year t* (Eling & Holder, 2013a; Niedrig, 2015; Hartley et al., 2016).

From Equation 1a, the coefficient of LowRate will show how yield rates are different in "low rate" and "normal" periods, after controlling for changes in company asset allocation and business strategy. Keeping all of those constant, it is worth understanding how the "low rate" period affects the yield rate if the companies do not change their business strategies. On the other hand, Equation 1b: only Yield and LowRate (whether "low rate" or "normal" periods) would help illustrate changes in yield rate, taking into account the effect of company actions, changes in strategy, and asset allocation.

This analysis part will follow Hartley et al. (2016) by breaking down the observation period into "low rate" and "normal" periods. Thus, independent variables *SepAC*, *EQ*, *Rx*, and *Bond* are incorporated into the model to measure movement in the investment portfolio during a prolonged interest rate environment. Past research disclosed that the decision to invest in bonds does not diverge with market interest rate changes due to the relatively stable return of bonds (Henebry & Diamond, 1998). By contrast, Ozdagli and Wang (2019) observed that life insurers invested more in longer-tenure bonds than bonds with high credit risk when interest rates declined (Ozdagli & Wang, 2019). The research aims to observe the Thai market and explore potential explanations when the market interest rate changes.

The second equation analyses firm solvency during "low rate" vs. "normal" periods using the insurance industry's capital adequacy ratio as a dependent variable.

$$RBC_{i,t} = \beta_0 + \beta_1 LowRate_{i,t} + \beta_2 SepAC_{i,t} + \beta_3 EQ_{i,t} + \beta_4 Rx_{i,t} + \beta_5 Bond_{i,t} + \varepsilon_{i,t} \quad (2)$$

where the dependent variable is *RBC*: capital adequacy ratio of company *i* in year *t* and the independent variables are:

$LowRate_{i,t}$ = 1 for "low rate" period or = 0 for "normal" period

$SepAC_{i,t}$ = Proportion of separate account of company *i in year t*

$EQ_{i,t}$ = Proportion of listed equity of company *i in year t*

$Rx_{i,t}$ = Proportion of derivatives of company *i in year t*

$Bond_{i,t}$ = Proportion of bonds of company *i in year t* (Office of Insurance Commission, 2024).

According to the Office of Insurance Commission (OIC), the regulatory framework imposes restrictions on investment strategies. Market, credit, insurance, operational, and concentration risks are key risk-related considerations from a regulatory perspective. This consideration links asset management and the RBC regime imposed by OIC for life insurance solvency. Increment or decrement in appraisal values of invested assets can be incorporated in a Common Equity Tier 1: CET 1 as part of the capital available. Life insurers set each asset class limitation based on determining proper risk charges from the RBC regime (Office of Insurance Commission, 2024).

4.9 Research Outcomes

4.9.1 The Descriptive Statistics

The panel's annual 512 firm-year data are collected from January 2000 to December 2020. Table 4.2(a) presents descriptive statistics of all variables (dependent and independent variables of a panel dataset). Then, Table 4.2(b) further breaks down all data over "normal" and "low rate" periods. The number of observations, standard deviation, minimum, and maximum values are shown from three perspectives on each variable's investment strategy, regulation, and asset portfolio composition. Figure 4.7

further presents the average annual investment returns (yield) and its cross-sectional standard deviation over the same period.

Table 4.2: Descriptive Statistics Data Summary

Panel A of Table 4.2: This table summarizes descriptive statistics of dependent and independent variables of a panel dataset.

The first table presents an overview of 512 firm-year data collected from January 2000 to December 2020.

Perspective	Measurement	Variable	Obs.	(1) Mean	(2) Std. Dev.	(3) Min	(41) Max
Investment Strategy	Investment Return	Yield	512	0.0438	0.0110	0.0099	0.0978
Statutory Solvency	Capital Adequacy Ratio under Risk-Based Capital Regime	RBC	156	3.2537	1.2195	1.0500	7.4500
Asset Allocation	Proportion of Bonds	Bond	511	0.6809	0.1801	0	0.9766
	Proportion of Listed Equity	EQ	511	0.0498	0.0578	0	0.3220
	Proportion of Derivatives	Rx	312	0.0015	0.0054	0	0.0624
	Proportion of Property	Property	311	0.0017	0.0080	0	0.0910
	Proportion of Separated Account	SepAC	386	0.0038	0.0167	0	0.1607

Table 4.2: Descriptive Statistics Data Summary (Cont.)

Panel B of Table 4.2: This table summarizes descriptive statistics of dependent and independent variables of a panel dataset.

The second table below presents an overview of 512 firm-year data collected from January 2000 to December 2020 and further breakdowns over "normal" and "low rate" period.

Perspective	Measurement	Variable	Period	Observation period		Obs.	(1) Mean	(2) Std. Dev.	(3) Min	(41) Max
				From	To					
Investment Strategy	Investment Return	Yield	Normal	2000	2014	374	0.0469	0.0109	0.0099	0.0978
			LowRate	2015	2020	138	0.0355	0.0055	0.0233	0.0512
Asset Risk Charges	Capital Adequacy Ratio under Risk-Based Regime	RBC	Normal	2008	2014	39	3.1730	1.2422	1.2800	7.4100
			LowRate	2015	2020	117	3.2806	1.2160	1.0500	7.4500
Asset Allocation	Proportion of Bonds	Bond	Normal	2000	2014	373	0.6715	0.1897	0	0.9766
			LowRate	2015	2020	138	0.7066	0.1486	0.2174	0.9047
	Proportion of Listed Equity	EQ	Normal	2000	2014	373	0.0471	0.0531	0	0.2756
			LowRate	2015	2020	138	0.0570	0.0686	0	0.3220
	Proportion of Derivatives	Rx	Normal	2008	2014	173	0.0004	0.0018	0	0.0161
			LowRate	2015	2020	139	0.0029	0.0076	0	0.0624
	Proportion of Property	Property	Normal	2008	2014	173	0.0007	0.0031	0	0.0232
			LowRate	2015	2020	138	0.0029	0.0115	0	0.0910
	Proportion of Separated Account	SepAC	Normal	2005	2014	248	0.0006	0.0023	0	0.0218
			LowRate	2015	2020	138	0.0095	0.0269	0	0.1607

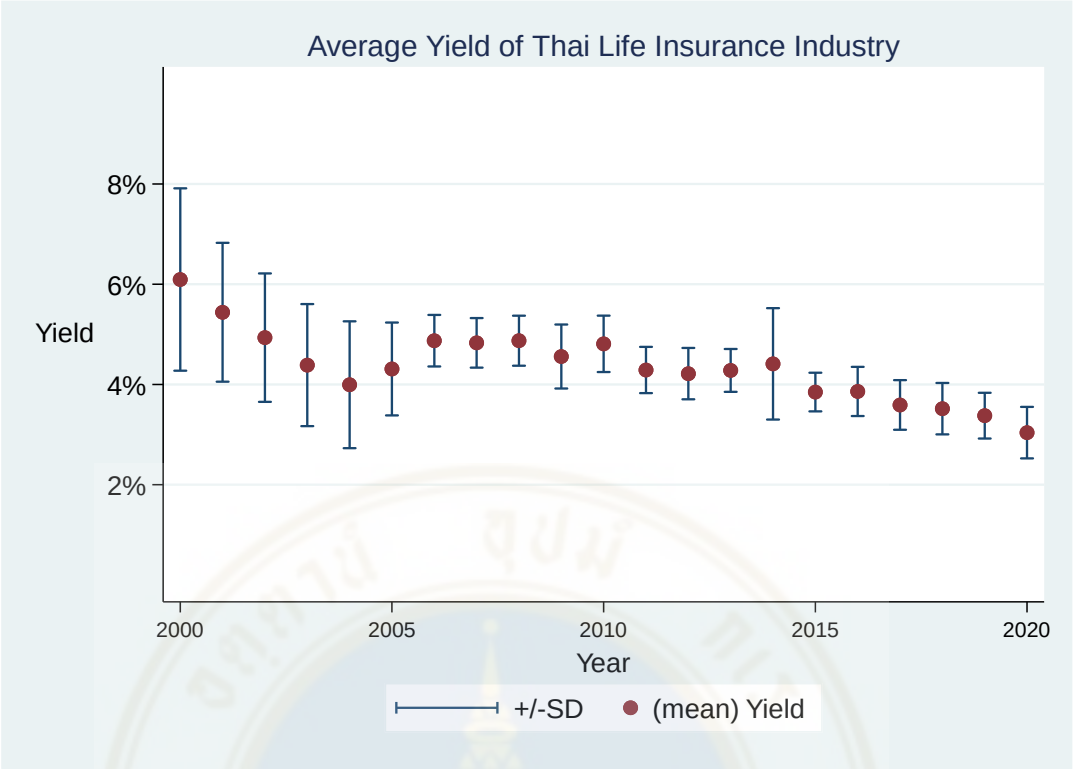


Figure 4.7: The Average Annual Investment Returns (graph generated from Stata).

4.9.2 The Results of the Two-sample t-test

For a two-sample t-test of asset allocation in the Thai market based on an investment portfolio composition perspective, Table 4.3 shows that the proportion of listed equity investment (*EQ*) is statistically higher during "low rate" periods at a 5% significance level for the Thai life insurance market. This empirical evidence is consistent with Figure 4.4 in Chapter 4.2, showing that the proportion of investment in listed equity during the past few years has increased markedly. In addition, life insurers in Thailand generally use derivatives as a yield enhancement tool, and we observe a remarkable increase in derivative usage, as shown in Figure 4.5 in Chapter 4.2. Table 4.3 also indicates that the proportion of derivatives is statistically high during a "low rate" period at a 1% significance level. This result emphasizes that life insurers use derivatives such as interest rate swaps to hedge interest rate risk, as Berends et al. (2013) mentioned.

During the prolonged low interest rate environment, life insurers focus more on transferring the investment risk to policyholders (Nieder, 2016). Thus, the separate account that variable-rate policyholders bear investment risk based on available investment choices (Henebry & Diamond, 1998) was set aside as one segregated asset class on the balance sheet. This segregated asset class is another asset expected to grow and requires life insurers to ensure proper asset allocation in their asset management portfolio. As per our result, Thai life insurers' proportion of separate accounts (or segregated investment funds) is statistically significant during a “low rate” period at a 1% significance level - Table 4.3.

Table 4.3: Two-sample t-test.

Variable		"normal" period	"low rate" period	Overall	One-sided p-value	
H0: Mean [Variable] is lower during the "low rate" period.						
Yield	n =	374	138	512		
	Mean	0.0469	0.0355	0.0438	[0.0000]	***
	Std. Dev.	0.0109	0.0055	0.0110		
RBC	n =	39	117	156		
	Mean	3.1730	3.2806	3.2537	[0.6825]	
	Std. Dev.	1.2422	1.2160	1.2195		
H0: Mean [Variable] is higher during the "low rate" period.						
Bond	n =	373	138	511		
	Mean	0.6715	0.7066	0.6809	[0.0252]	**
	Std. Dev.	0.1897	0.1486	0.1801		
EQ	n =	373	138	511		
	Mean	0.0471	0.0570	0.0498	[0.0427]	**
	Std. Dev.	0.0531	0.0686	0.0578		
Rx	n =	173	139	312		
	Mean	0.0004	0.0029	0.0015	[0.0000]	***
	Std. Dev.	0.0018	0.0076	0.0054		
Property	n =	173	138	311		
	Mean	0.0007	0.0029	0.0017	[0.0078]	***
	Std. Dev.	0.0031	0.0115	0.0080		
SepAC	n =	248	138	386		
	Mean	0.0006	0.0095	0.0038	[0.0000]	***
	Std. Dev.	0.0023	0.0269	0.0167		

This table presents the t-test result using a sample of 525 firm-years in the Thai life insurance market from 2000 to 2020.

Differences between each variable's means (averages) among low- and high-interest rate regimes are tested.

Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

4.9.3 Multivariate Regression Model Validations

Hausman tests were performed to confirm the robustness of the model. We tested for random and fixed effects in the model before adopting the estimators (Hausman, 1978). Results in Table 4.4 on regression estimation Equation 1 and Table 4.5 for Equation 2 are summarized. We reject the null hypothesis for Equation 1a (Yield) but cannot reject the null hypothesis that the random effects model is consistent and more appropriate for Equation 2 (RBC). Thus, we use and interpret the fixed-effects model result for the investment return measure. On the other hand, we use the random-effects model result for the solvency measure.

Table 4.4: Hausman Test of Regression Estimation for Yield

Dependent Variable: Yield	(1) Fixed-effects		(2) Random-effects	
LowRate	-0.009	***	-0.009	***
	[0.000]		[0.000]	
SepAC	-0.068	***	-0.075	***
	[0.002]		[0.000]	
Equity (EQ)	0.001		-0.005	
	[0.908]		[0.590]	
Derivatives (Rx)	-0.106	*	-0.083	
	[0.097]		[0.186]	
Bond	0.005		-0.001	
	[0.313]		[0.675]	
Constant	0.042	***	0.046	***
	[0.000]		[0.000]	
Group by	InsurerNo		InsurerNo	
N	311		311	
R-square	0.370		0.397	
H0: The random effects model is consistent.				
p-value	[0.0020] ***			

This table presents the Hausman test of regression estimation equations for the Thai life insurance panel dataset from 2000 to 2020.

The dependent variable is investment return (Yield). Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

Table 4.5: Hausman Test of Regression Estimation for RBC.

Dependent Variable: RBC	(1) Fixed-effects		(2) Random-effects	
LowRate	0.054		0.052	
	[0.824]		[0.823]	
SepAC	1.349		0.694	
	[0.793]		[0.871]	
Equity (EQ)	2.842		1.079	
	[0.539]		[0.707]	
Derivatives (Rx)	14.672		18.228	
	[0.318]		[0.178]	
Bond	3.758	*	2.572	**
	[0.080]		[0.045]	
Constant	0.292		1.262	
	[0.862]		[0.238]	
Group by	InsurerNo		InsurerNo	
N	155		155	
R-square	0.038		0.049	
H0: The random effects model is consistent.				
p-value	[0.7219]			

This table presents the Hausman test of regression estimation equations for the Thai life insurance panel dataset from 2000 to 2020.

The dependent variable is the capital adequacy ratio (RBC). Also, p-values are shown in brackets.

Coefficients significantly different from zero at a significance level of 10%, 5%, and 1% are marked *, **, and ***, respectively.

4.9.4 The Results of Panel Regressions

Life insurers also manage asset portfolios by considering investment strategies and regulations imposed by the OIC. They tend to hold bonds to maturity (held-to-maturity bonds) and keep track of the credit rating assessment until there are any observable market factors to alter the situation (Mee, 2015). In the Thai market, yields are statistically lower at a 1% significance level in a low interest rate environment. Regarding factors influencing yield, the proportion of separate accounts and derivatives are statistically significant at 1% and 10% significance levels, respectively (refer to Table 4.4).

The results from Table 4.4 also show that Equation 1b: only *LowRate* (whether "low rate" or "normal" periods) helps explain changes in yield rate, considering the effect of company actions, changes in strategy, and asset allocation. However, after controlling differences in company asset allocation and business strategy as in Equation 1a, *LowRate, SepAC* - the proportion of separate accounts, and *Rx* - derivatives are three factors that explain the Yield well at a 10% significance level. This outcome supports Greene & Segal's (2004) finding that investment strategy is a crucial activity of life insurers. Life insurers, especially during a prolonged low interest rate environment, search for high yields from their investment (Greene & Segal, 2004) and focus on transferring investment risk to policyholders (Nieder, 2016).

Under the RBC regime enforced by OIC for life insurance solvency, Thai life insurers must manage asset portfolios to maintain sufficient minimum capital adequacy ratio requirements. Results from Table 4.5 point out that the proportion of bonds has an influential impact on the level of life insurance solvency at a 5% significance level as capital requirements on risk charges are varied by asset classes. Besides, bonds are further subjected to specific risk charges on top of market and credit risk charges – please refer to Table 4.1 for RBC-specific risk charges for bonds (Office of Insurance Commission, 2024).

4.10 Conclusions and Recommendations

This research has examined the asset management of Thai life insurers by investigating the effect of asset allocation and investment regulation as imposed by the regulatory framework. Three factors, *LowRate, SepAC* - the proportion of separate accounts, and *Rx* - derivatives, explain *the Yield* well at a 10% significance level. The negative coefficient of *LowRate* indicates that life insurers have generated lower investment returns during a prolonged low interest rate environment. Besides, yields are statistically lower during a low interest rate environment at a 1% significance level. Proportions of separate accounts and derivatives are crucial to making sufficient investment returns to compensate for their potential underwriting losses from life insurance products (Akotey et al., 2013).

During a prolonged low-interest rate environment, life insurers pursue high yields from their investment (Greene & Segal, 2004). From the asset management's perspective, the proportion of separate accounts, equity, and derivatives is a key focus. Life insurers concentrate more on transferring the investment risk to policyholders (Nieder, 2016), which is a revelation in the high growth in the proportion of separate accounts (refer to Figure 4.6). A relatively high proportion of investment in listed equity in the Asian life insurance market, as found by Gründl & Gal (2017), also supports this effort. Derivatives like currency and interest rate swaps are utilized for hedging foreign currency (Mee, 2015) and interest rate risks (Berends et al., 2013) for life insurers' yield enhancement purposes.

Under the RBC regime enforced by OIC for life insurance solvency, Thai life insurers must manage asset portfolios to maintain sufficient minimum capital adequacy ratio requirements. The proportion of bonds has an influential impact on the level of life insurance solvency at a 5% significance level, as capital requirements on risk charges vary by asset class. Besides, bonds are further subjected to specific risk charges on top of the market and credit risk charges (Office of Insurance Commission, 2024).

Life insurers seek to perform a course of action to alleviate their low profitability results. Asset portfolio composition plays a crucial role in this achievement since investment activity is one of the primary profitability sources (Greene & Segal,

2004). This research shows that the profitability from investment is lower during a "*low rate*" period than during a "*normal*" period. This fact could partially explain the asset management approach by life insurers during the prolonged low-interest rate situation in Thailand and show the changes in terms of asset allocation and investment strategy of Thai life insurers.

With changes in the economic situation and the insurance regulatory requirements that may affect life insurers' business strategy and decision-making, other factors could potentially affect life insurers' asset management. These changes would be the part that future researchers could explore further beyond the scope of Thailand's territory and local regulatory framework.

CHAPTER V
CONCLUSIONS

Life insurers are liability-driven financial institutions with path-dependent liability cash flows due to their products' embedded options and interest rate guarantees (Albrecher et al., 2018). Life insurers struggle to pay guaranteed contractual obligations in a prolonged low interest rate environment and maintain a solid financial position regarding profitability and solvency (Berdin and Gründl, 2015). The first essay reviews multiple perspectives and practices in different countries used by insurance companies to deal with the prolonged low interest rate environment (Suwanmalai & Zaby, 2022).

This literature review primarily focused on an overview of the impact of prolonged low interest rates on life insurers and their responses. The appraisal of past crises, significant consequences, and potential solutions during the recent persistent low interest rate period was highlighted. We noted that findings rely on limited studies and only apply to the life insurance business. Indeed, the literature on the topic is limited, and there has also been little research in the past five years. Moreover, the review examined key common characteristics of worldwide life insurance products. Therefore, any new initiatives products are not considered in this review.

Essay 1 emphasized that future research should consider Asian and emerging markets, mostly ignored by extant studies, and address the impact of prolonged low interest rates on life insurers' financial stability and solvency in these countries. Future interest rate trends, especially in emerging markets, are under the pressure of persistently low interest rates, partially from excess savings and a lack of investment opportunities (Reyna et al., 2022). As such, an extension of the Thai life insurance market has been explored in Essay 2 and Essay 3, as Thailand is viewed as an aged society (more than 20% of the population over 60 years old: see Figure 1.1) and one of the fastest-aging societies in the world (World Health Organization, 2023). With this move toward a super-aged country soon, life insurance and a supportive healthcare

system will be necessary for Thai society over the long run. All Thai life insurers held a sizable 4,021-billion-baht worth of total assets as of 2022 (Thai Life Assurance Association, 2023). With its substantial growth of 13% per annum during the past 20 years, the insurance industry is a financial institution that plays a vital role in the Thai financial economy (Connelly, 2004).

Both Essay 2 and Essay 3 contribute to an empirical investigation of the life insurance business in Thailand during a prolonged low interest rate environment. By investigating two key areas of liabilities management (Essay 2) and assets management (Essay 3), these two essays focus on various financial implications and highlight an observable shift in business outputs.

The second essay has investigated the liability management of Thai life insurers. Life insurers manage their liabilities portfolio by changing their life insurance product mix, managing interest rate risk on guaranteed products, and solvency management. Life insurers, during a prolonged low interest rate environment, move their new product portfolio toward the least investment return dependent or non-guaranteed (non-interest-sensitive) products (Focarelli, 2015) since they cannot profitably offer saving-oriented products (Hartley et al., 2016). The saving element in an endowment product is a crucial benefit for tax deduction privilege. These fundamental elements support identifying insurers' exposure to interest rate risk. A combined effect of guaranteed minimum return on endowment and policyholder's behavior is a crucial consideration for the interest sensitivity of life insurers (Hartley et al., 2016).

Despite the Thai life insurance market mainly relying on agency distribution, there is no evidence to support a significantly higher proportion of interest-sensitive products produced by agency-led insurers compared to life insurers that are bancassurance-led or others. Thai life insurers' return on assets rises with an increase in solvency as some insurers focus on improving their capital adequacy to compensate for revenue compression when their investment yields decrease (Holsboer, 2000). There is no potential interaction effect between solvency and return on assets during the "low rate" period. Nevertheless, large-size Thai life insurers have a higher mean proportion of interest-sensitive products when compared to mid and small-size life insurers.

Like several global insurers that move their new business product portfolio toward the least investment return dependent or even non-guaranteed products during a prolonged low-interest rate environment (Focarelli, 2015), the mean volume of a non-interest-sensitive new business is statistically higher during “low rate” period for the Thai market. Upon identifying the Thai life insurers’ solvency position over the period, the average level of solvency based on Thailand's regulatory regime is not statistically different between Thailand's “normal” and the prolonged low interest rate situation. The proportion of risky investment assets does not relate significantly to the level of solvency position of Thai life insurers. Under a regulatory risk-based capital regime, these insurers should properly balance asset and capital allocation to support higher risk charges on risky assets (Berends et al., 2013).

While low market interest rates incentivize life insurers to invest in risky investments (Berdin and Gründl, 2015), this scenario may also represent an opportunity to reshape their strategies and enhance their efficiency. As mentioned in Essay 1, further analysis of the relationships among life insurance product types, asset portfolio returns, and life insurers' solvency may clarify the regulatory impact and determinants of insurers’ financial stability. Essay 3 then examined the asset management of Thai life insurers by investigating the effect of asset allocation and investment regulation. The negative coefficient of *LowRate* indicates that life insurers have generated lower investment returns during a prolonged low interest rate environment. Besides, the result emphasizes the necessity of life insurers to make sufficient investment returns on separate accounts and derivatives to compensate for their potential underwriting losses from life insurance products (Akotey et al., 2013).

During a prolonged low-interest rate environment, life insurers pursue high yields from their investment (Greene & Segal, 2004) as asset investment is the primary source of profit from financial activity life insurers typically earn from their collected policyholders’ premiums (Greene & Segal, 2004). From the asset management‘s perspective, the proportion of separate accounts, equity, and derivatives is a key focus. Life insurers concentrate more on transferring the investment risk to policyholders (Nieder, 2016), which is a revelation in the high growth in the proportion of separate accounts for the Thai life insurance industry. A relatively high proportion of investment

in listed equity in the Asian life insurance market, as found by Gründl & Gal (2017), also supports this effort. Derivatives like currency and interest rate swaps are utilized for hedging foreign currency (Mee, 2015) and interest rate risks (Berends et al., 2013) for life insurers' yield enhancement purposes.

Global life insurers seek to act by exactly matching long-term liabilities with long-term assets of government or corporate bonds during the *"normal*" period and move to riskier asset classes during the "low rate" period per Hartley et al. (2016). In contrast, the proportion of risky investment assets held by Thai life insurers is unrelated to their level of solvency.

Life insurers seek to perform a course of action to alleviate their low profitability results. Asset portfolio composition plays a crucial role in this achievement since investment activity is one of the primary profitability sources (Greene & Segal, 2004). This research shows that the profitability from investment is lower during a "*low rate*" period than during a "*normal*" period. This fact could partially explain the asset management approach by life insurers during the prolonged low-interest rate situation in Thailand and show the changes in terms of asset allocation and investment strategy of Thai life insurers.

With changes in the economic situation and the insurance regulatory requirement that may affect life insurers' business strategy and decision-making, other factors could potentially affect life insurers' asset and liability management. These changes would be the part that future researchers could explore further beyond the scope of Thailand's territory and local regulatory framework. Also, researchers can extend an analysis to the non-life insurance industry and compare two insurance sectors (life and non-life) simultaneously. It will uncover the missing short-term view of liability management in non-life products to fulfill the insurance business analysis.

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