CONTENTS

1

Introduction to Modern Insurance

IN SECTION 1.1, we start with an overview of the insurance sector in the context of financial markets and, more broadly, financial intermediation. In Section 1.2, we describe the insurance products that we cover in the empirical work throughout the book. In Section 1.3, we summarize the data sources for research on insurance. In Section 1.4, we summarize the relevant institutional background, including state guaranty associations, risk-based capital regulation, and accounting standards. In Section 1.5, we present a baseline model of insurance pricing with financial frictions and market power.

1.1 Overview of the Insurance Sector

We start with an overview of the insurance sector through historical data on the balance sheets of both life insurers and property and casualty insurers. Since the 1980s, life insurers have grown significantly, and the composition of their liabilities has shifted from life insurance to variable annuities. Along with the changing nature of their business, life insurers' leverage has become more volatile because of greater risk mismatch since the 1990s. Thus, the primary function of life insurers has changed from traditional insurance to financial engineering. The presence of high leverage and risk mismatch makes life insurers similar to pension funds. However, the minimum return guarantees make life insurers unique because they are engineering complex payoffs for policyholders over long horizons that are difficult to hedge with traded options. In terms of portfolio choice, life insurers have shifted from loans to corporate bonds since the 1960s.

TABLE 1.1. Liabilities of Financial Institutions in 2017

Sector	Trillion $
Life insurance	6.5
Property and casualty insurance	1.2
Banks	16.9
Private defined contribution	6.2
Private defined benefit	3.2

Authors' tabulation based on the *Financial Accounts of the United States* (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

1.1.1 Liabilities

Insurers are among the largest of financial institutions. Table 1.1 reports the liabilities of US financial institutions in 2017. Life insurers had $6.5 trillion of liabilities, and property and casualty insurers had $1.2 trillion of liabilities. Life insurers are larger than private defined contribution plans and private defined benefit plans but smaller than banks. However, size does not tell the whole story because these financial institutions serve distinct and important functions.

The large size of the banking sector reflects its importance for payments and short-term liquid savings. Of the $16.9 trillion in liabilities, $11.7 trillion are in savings deposits, which is a rough estimate of the short-term liquid savings function of the banking sector. In contrast, defined contribution plans are long-term retirement savings in tax-advantaged accounts. Defined benefit plans are also long-term retirement savings but typically offer guaranteed income during retirement. Annuities sold by life insurers have a similar function to defined contribution plans because they are long-term savings products with a tax advantage. Fixed annuities have a similar function to defined benefit plans because they offer guaranteed income during retirement. In addition to guaranteed income, variable annuities offer and an upside potential if investment returns are high.

Figure 1.1 shows the shares of US household net worth that are intermediated by insurers and pension funds. In 2017, life insurers accounted for 10.0% of household savings, which is higher than 9.6% for private defined contribution plans and 5.0% for private defined benefit plans. Property and casualty insurers accounted for 1.9% of household savings. Although property and casualty insurance is important for insuring idiosyncratic risk, it is

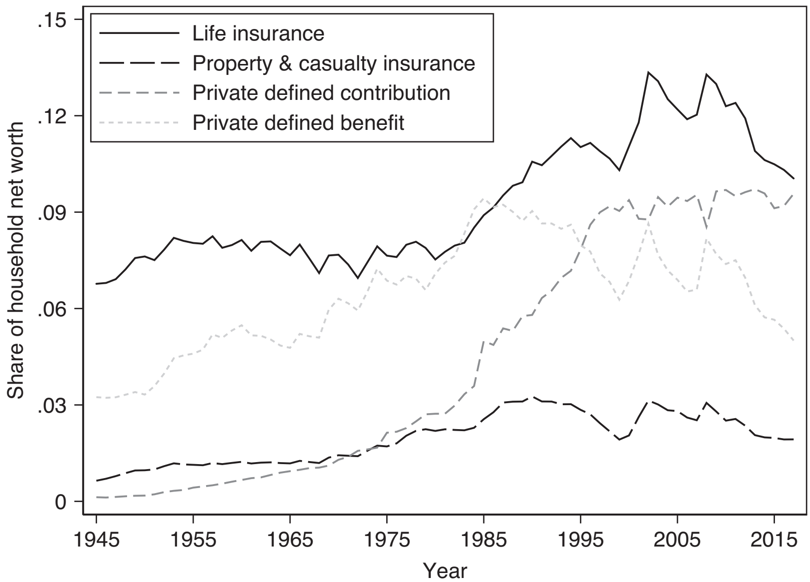

FIGURE 1.1. Insurance and Pension Liabilities. Authors' tabulation based on the *Financial Accounts of the United States* for 1945 to 2017 (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

not a large share of household savings because the policies typically have short maturities.

Private defined benefit plans peaked at 9.4% of household net worth in 1985 and fell thereafter. The fall of defined benefit plans is offset by the rise of life insurers and defined contribution plans. Private employers are shifting from defined benefit plans to defined contribution plans to avoid the risk of underfunded pensions. However, not all employers offer defined contribution plans, and some employees may not be eligible for pension benefits. In contrast, life insurers could play an important role in retirement savings, even for households without access to defined contribution plans. Households can hold annuities in defined contribution plans, individual retirement accounts, and non-retirement accounts.

Table 1.2 reports the composition of US life insurers' liabilities in 2017. Life insurance and annuities in the general account each accounted for $1.2 trillion of liabilities. Life insurers manage some private pension funds, and these liabilities accounted for $0.7 trillion. Other liabilities, including accident and health insurance, accounted for $0.8 trillion.

TABLE 1.2. Composition of Life Insurers' Liabilities in 2017

Liability	Trillion $
General account	
Life insurance	1.2
Annuities	1.2
Pension funds	0.7
Other (including accident & health)	0.8
Separate account (variable annuities)	2.7

Authors' tabulation based on the *Financial Accounts of the United States* (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

Separate account liabilities, which are primarily variable annuities, accounted for $2.7 trillion in 2017. The mutual fund underlying a variable annuity is held in a separate account on behalf of policyholders, which is not subject to the insurer's default risk. The minimum return guarantee on the mutual fund is part of annuity liabilities in the general account. General account liabilities are subject to default risk because of risk mismatch with general account assets.

Figure 1.2 shows the composition of US life insurers' liabilities, which are in shares of household net worth for comparison with Figure 1.1. In the early part of the sample before the 1980s, life insurance was larger than annuities. Since the 1990s, variable annuities have grown rapidly and are now the largest liability. In 2017, fixed and variable annuities together accounted for 4.9% of household net worth, which is about twice the size of 2.4% for life insurance. The label "life insurance companies" was appropriate back in 1945, but they should perhaps be relabeled "annuity and life insurance companies" in modern times. However, even the latter label does not do justice to the fact that the majority of the annuity business involves financial engineering of complex payoffs.

1.1.2 *Assets*

Figure 1.3 shows the composition of US life insurers' general account assets. Loans (primarily mortgages) were a major share of assets in the early part of the sample. Loans were 44% of assets in 1967 but were only 15% of assets by 2017. Instead, 58% of assets are in corporate and foreign bonds, and 15% are in government bonds in 2017.

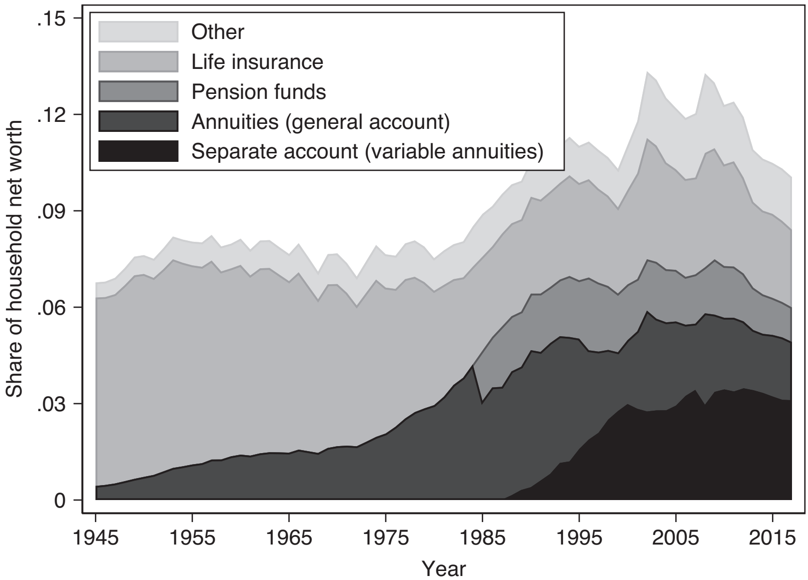

FIGURE 1.2. Composition of Life Insurers' Liabilities. Authors' tabulation based on the *Financial Accounts of the United States* for 1945 to 2017 (Board of Governors of the Federal Reserve System, 2017). General account annuities include pension liabilities before 1985. See Appendix A.1 for variable definitions.

Figure 1.3 also shows the composition of US property and casualty insurers' assets. Government bonds have always been the largest asset class in their portfolio. Property and casualty insurers have a more conservative portfolio than life insurers because of the less predictable nature of their liabilities with tail risk. Nevertheless, property and casualty insurers have gradually shifted their portfolio from government bonds to corporate bonds since the 1960s.

Figure 1.4 shows the institutional ownership of US corporate bonds. Insurers have always been the largest institutional investors of corporate bonds and thus play a central role in corporate funding and investment. In 2017, insurers owned 38% of corporate bonds, which is higher than 16% for pension funds, 10% for banks, and 30% for mutual funds.

1.1.3 Leverage

Figure 1.5 shows the leverage (i.e., ratio of liabilities to assets) of US financial institutions. Property and casualty insurers have always had lower and more volatile leverage than life insurers because of the less predictable nature

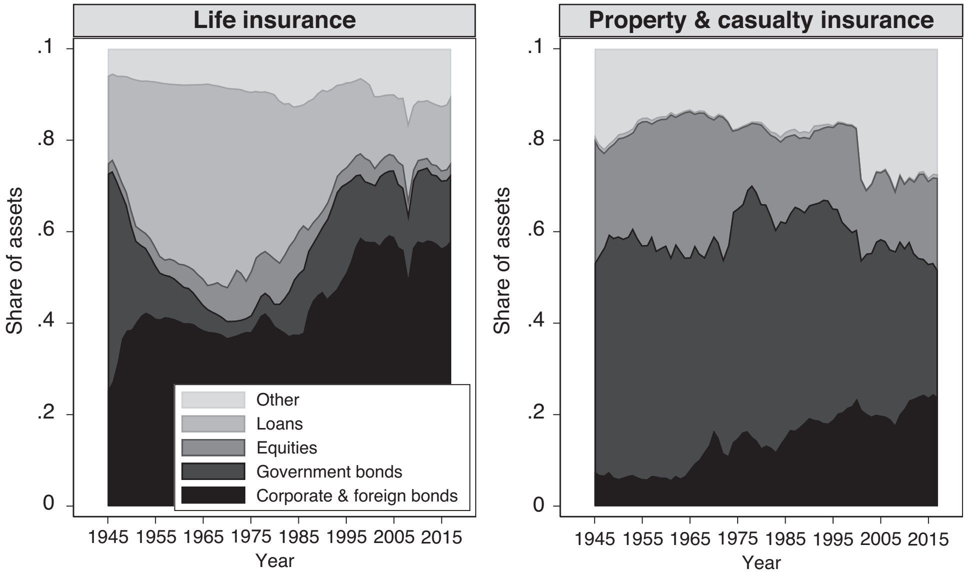

FIGURE 1.3. Composition of General Account Assets. Authors' tabulation based on the *Financial Accounts of the United States* for 1945 to 2017 (Board of Governors of the Federal Reserve System, 2017). Government bonds include Treasury, agency, and municipal bonds. Equities include mutual funds. See Appendix A.1 for variable definitions.

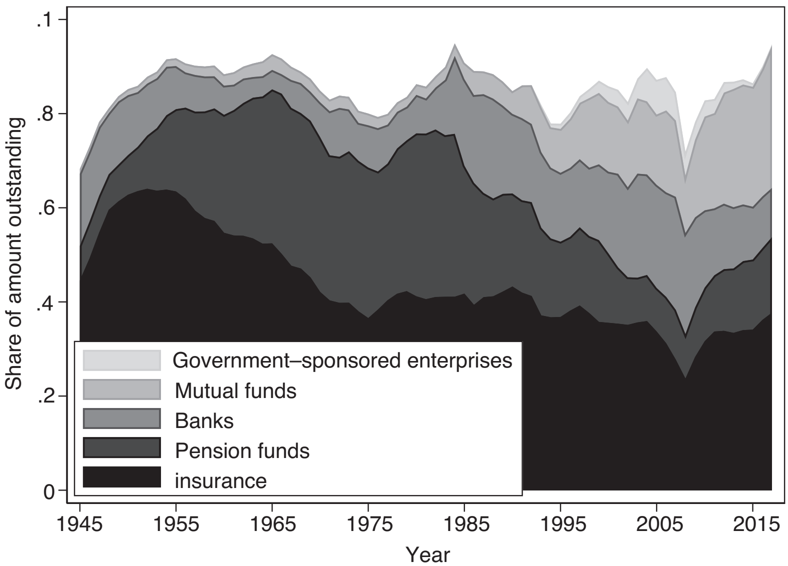

FIGURE 1.4. Institutional Ownership of Corporate Bonds. Authors' tabulation based on the *Financial Accounts of the United States* for 1945 to 2017 (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

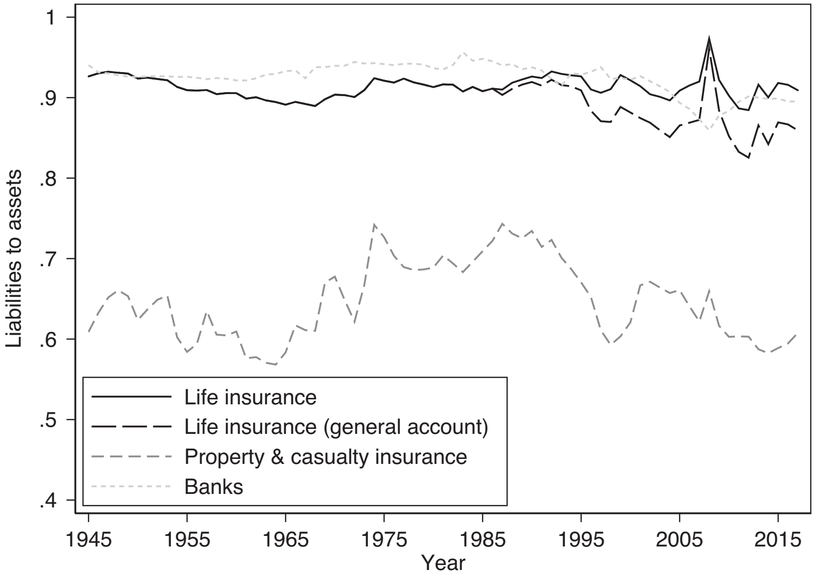

FIGURE 1.5. Leverage of Financial Institutions. Authors' tabulation based on the *Financial Accounts of the United States* for 1945 to 2017 (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

of their liabilities. Life insurers have a nearly constant leverage ratio of just above 90% from 1945 through the 1990s. However, the shift from life insurance to variable annuities since the 1990s means that life insurers now have less predictable liabilities subject to risk mismatch. Along with the changing nature of their business, life insurers' leverage has become more volatile since the 1990s.

Life insurers and banks have similar levels of leverage, but they moved in opposite directions during the global financial crisis. In 2008, life insurers' leverage spiked up to 97%, while banks' leverage spiked down to 86%. Life insurers can afford to let leverage increase in response to a transitory shock to asset values because of the long-term and less runnable nature of their liabilities.

1.1.4 Ownership Structure

An insurance company could be either a stock or a mutual company. The shareholders receive the dividends in a stock company, whereas the policyholders receive the dividends in a mutual company. A stock company need

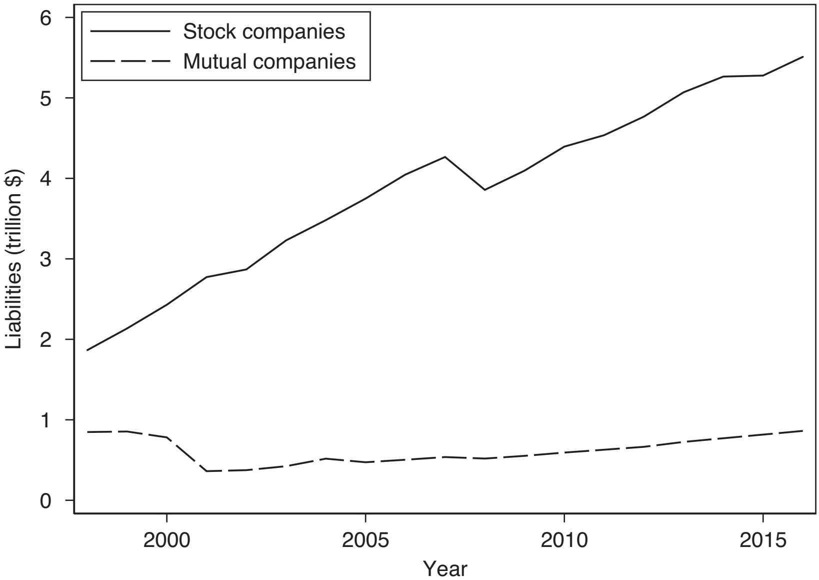

FIGURE 1.6. Life Insurers' Liabilities by Ownership Structure. Authors' tabulation based on the *Best's Statement File* for 1998 to 2016 (A.M. Best Company, 1999–2017).

not be publicly traded because it could be privately held. An advantage of a stock company is access to external capital markets, which facilitates faster growth. A disadvantage is that the stockholders' incentives are not necessarily aligned with the policyholders' incentives, so there is greater scope for agency problems (Mayers and Smith, 1981).

Figure 1.6 shows US life insurers' liabilities by ownership structure. Stock companies have accounted for all of the growth since the late 1990s. On the extensive margin, there was a higher than average rate of demutualization from 1997 to 2001 (Erhemjamts and Phillips, 2012). On the intensive margin, access to external capital markets partly explains the faster growth of stock companies. In addition, stock companies specialize in insurance products that have experienced the fastest growth since the 2000s. Figure 1.7 shows that variable annuities are the largest liability for stock companies, while life insurance is the largest liability for mutual companies.

Another recent trend in ownership structure is the acquisition of life insurers by private equity firms. Kirti and Sarin (2020) find that private equity investment in life insurers grew from $23 billion in 2009 to $250 billion in 2014. When acquired by private equity firms, life insurers increase leverage

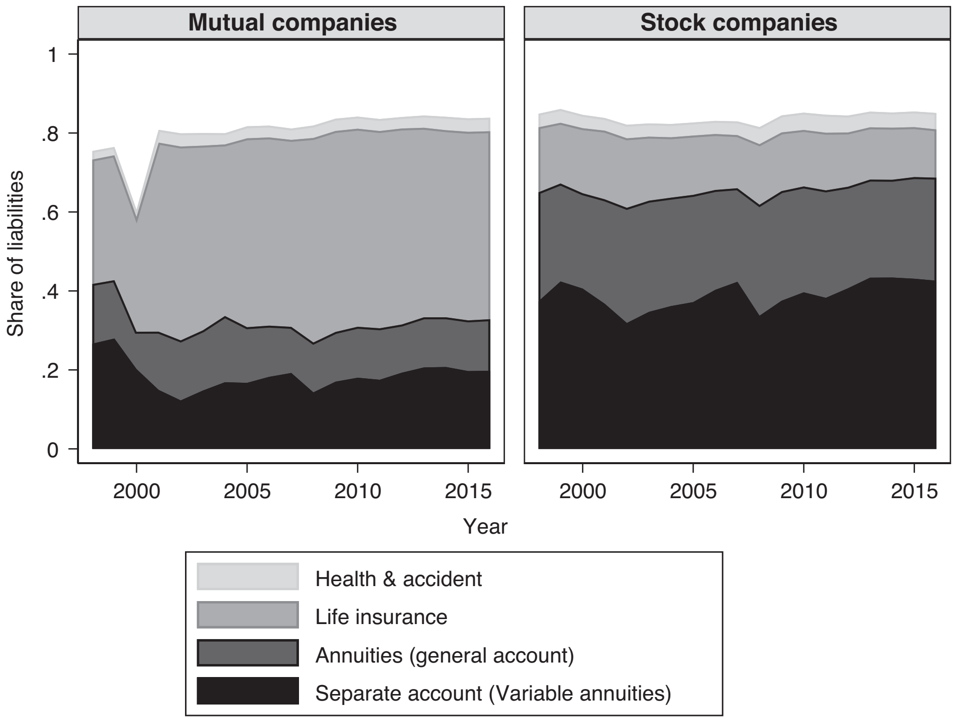

FIGURE 1.7. Composition of Life Insurers' Liabilities by Ownership Structure. Authors' tabulation based on the *Best's Statement File* for 1998 to 2016 (A.M. Best Company, 1999–2017).

and portfolio risk by holding non-agency mortgage-backed securities (MBSs) instead of highly rated corporate bonds.

1.2 Insurance Products

We describe the insurance products that we cover in the empirical work throughout the book. We also define the actuarial value of life insurance and fixed annuities. An insurer that issues life insurance or a fixed annuity must buy a portfolio of Treasury bonds to replicate its future cash flows. A portfolio of corporate bonds, for example, does not replicate the cash flows because of credit risk. Therefore, the law of one price implies that the Treasury yield curve is the appropriate cost of capital for the valuation of life insurance and fixed annuities.

1.2.1 *Life Insurance*

Term life insurance pays a death benefit upon the death of the insured during a fixed maturity of M years. The policy is in effect as long as the policyholder pays an annual premium while the insured is alive. The policy is lapsed if the policyholder stops paying the annual premium before maturity or the death of the insured. Let $y_t(m)$ be the zero-coupon Treasury yield at maturity m and time t. Let π_n be the one-year survival probability at age n. The actuarial value of M-year term life insurance at age n per dollar of death benefit is

$$V_t(n, M) = \left(1 + \sum_{m=1}^{M-1} \frac{\prod_{l=0}^{m-1} \pi_{n+l}}{(1+y_t(m))^m}\right)^{-1} \left(\sum_{m=1}^{M} \frac{\prod_{l=0}^{m-2} \pi_{n+l}(1-\pi_{n+m-1})}{(1+y_t(m))^m}\right). \tag{1.1}$$

The first term in parentheses is the present value of the premiums divided by the annual premium. The second term in parentheses is the present value of the death benefits. This formula does not account for the potential lapsation of policies. There is currently no agreed-upon standard for lapsation pricing, partly because lapsations are difficult to model and predict.

Guaranteed universal life insurance provides lifetime coverage at a constant guaranteed premium and accumulates no cash value. Thus, guaranteed universal life insurance is essentially term life insurance without a fixed maturity. The actuarial value of guaranteed universal life insurance is a special case of equation (1.1) when $M = N - n$, where N is the maximum attainable age according to the appropriate mortality table.

We briefly mention other types of life insurance that are not a focus of this book. Universal life insurance without a constant guaranteed premium as well as whole life insurance provide lifetime coverage and accumulate cash value. These types of policies can be thought of as a combination of life insurance and a savings account. Variable life insurance also provides lifetime coverage and accumulates cash value in a subaccount that is essentially an equity or bond mutual fund.

1.2.2 *Fixed Annuities*

A term annuity pays an annual income for a fixed maturity of M years. Since term annuities have a fixed income stream that is independent of survival, they are straight bonds rather than longevity insurance. The actuarial value of an

M-year term annuity per dollar of income is

$$V_t(M) = \sum_{m=1}^{M} \frac{1}{(1+y_t(m))^m}. \tag{1.2}$$

A life annuity with an M-year guarantee pays an annual income for the first M years regardless of survival, then continues paying income thereafter until the death of the insured. Let π_n be the one-year survival probability at age n, and let N be the maximum attainable age according to the appropriate mortality table. The actuarial value of a life annuity with an M-year guarantee at age n per dollar income is

$$V_t(n,M) = \sum_{m=1}^{M} \frac{1}{(1+y_t(m))^m} + \sum_{m=M+1}^{N-n} \frac{\prod_{l=0}^{m-1} \pi_{n+l}}{(1+y_t(m))^m}. \tag{1.3}$$

A life annuity without a guarantee is a special case when $M=0$.

1.2.3 Variable Annuities

A variable annuity is a mutual fund with longevity insurance and a potential tax advantage that is sold through an insurer. For an additional fee, the insurer offers an optional minimum return guarantee on the mutual fund. Thus, a variable annuity with a minimum return guarantee is a retail financial product that packages a mutual fund with a long-maturity put option on the mutual fund. To illustrate how variable annuities work, we start with an example of an actual product.

MetLife Investors USA Insurance Company (2008) offers a variable annuity called MetLife Series VA, which comes with various investment options and guaranteed living benefits. In 2008:3, one of the investment options was the American Funds Growth Allocation Portfolio, which is a mutual fund with a target equity allocation of 70% to 85% and an annual portfolio expense of 1.01%. One of the guaranteed living benefits was a Guaranteed Lifetime Withdrawal Benefit (GLWB). MetLife Series VA has an annual base contract expense of 1.3% of account value, and a GLWB has an annual fee of 0.5% of account value. Thus, the total annual fee for the variable annuity with a GLWB is 1.8%, which is on top of the annual portfolio expense on the mutual fund.

To understand the GLWB, we first describe a standalone investment in the mutual fund and the withdrawals that it would enable for retirement income. Suppose that a policyholder were to invest in the American Funds Growth

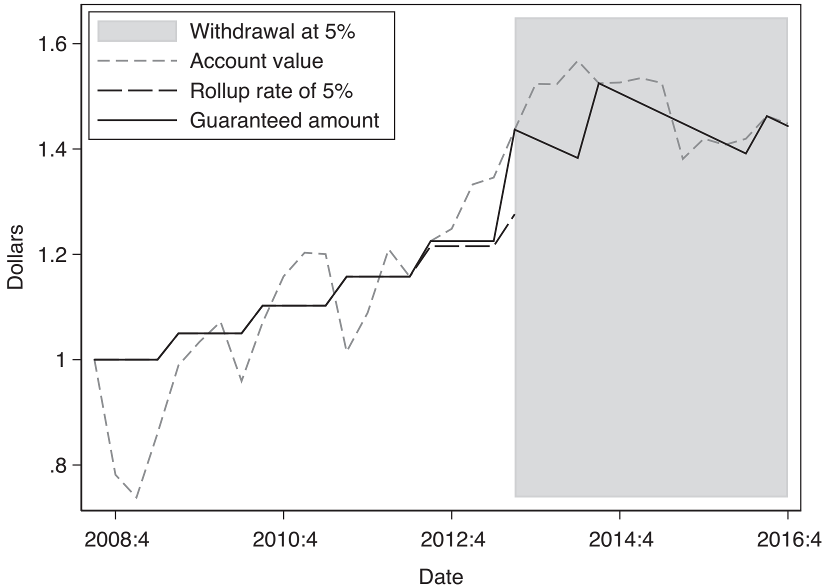

FIGURE 1.8. An Example of a Guaranteed Living Withdrawal Benefit. This example shows the evolution of account value and the guaranteed amount for MetLife Series VA with a GLWB from 2008:3 to 2016:4. The investment option is the American Funds Growth Allocation Portfolio. The policyholder is assumed to annually withdraw 5% of the highest guaranteed amount after 2013:3. For simplicity, this example abstracts from the impact of fees on account value and the guaranteed amount.

Allocation Portfolio in 2008:3. After 2013:3, the policyholder withdraws a constant dollar amount each year that is 5% of the highest account value ever reached. This behavior describes a policyholder who invests in a mutual fund five years before retirement and subsequently spends down her wealth by consuming a constant dollar amount each year. Figure 1.8 shows the path of account value per $1 of initial investment with the shaded region covering the withdrawal period after 2013:3. The account value fluctuates over time because of uncertainty in investment returns.

The same policyholder could purchase a GLWB from MetLife and guarantee her investment returns. A GLWB has an annual rollup rate of 5% before the first withdrawal, which means that at each contract anniversary, the guaranteed amount steps up to the greater of the account value and the previous guaranteed amount accumulated at 5%. Thus, a GLWB is a put option on the mutual fund that locks in each year to a strike price that accumulates at an annual rate of 5%. Figure 1.8 shows that the guaranteed amount can only increase during the five-year accumulation period, protecting the policyholder from downside market risk.

When the policyholder enters the withdrawal period, she can annually withdraw up to 5% of the highest guaranteed amount ever reached. In our example, the guaranteed amount in 2013:3 is $1.44, which means that the policyholder can withdraw up to $\$1.44 \times 0.05 = \$0.072$ per year. Each withdrawal gets deducted from both the account value and the guaranteed amount. A GLWB is a lifetime guarantee in that the policyholder receives income (i.e., $0.072 per year) as long as she lives, even after the account is depleted to zero. During the withdrawal period, the guaranteed amount steps up to the account value at each contract anniversary. In Figure 1.8, these step-ups occur in 2014:3 and 2016:3 because of high investment returns.

Because the annual rollup rate is 5% and the annual fee is 0.5%, one may be tempted to conclude that the guaranteed return on the variable annuity is 4.5% during the accumulation period. This logic turns out to be incorrect because the guaranteed amount of $1.44 in 2013:3 is only payable as an annual income of $0.072 over 20 years (or until the policyholder's death). Because of the time value of money, the present value of $0.072 per year over 20 years is worth substantially less than $1.44. Koijen and Yogo (2022a, appendix A) show the empirical relevance of this contract feature based on the historical term structure of interest rates.

A GLWB is the most common type of guaranteed living benefit. The three other types of guaranteed living benefits are a Guaranteed Minimum Withdrawal Benefit (GMWB), a Guaranteed Minimum Income Benefit (GMIB), and a Guaranteed Minimum Accumulation Benefit (GMAB). A GMWB is similar to a GLWB, except that the policyholder does not receive income after the account is depleted to zero. A GMIB is similar to a GLWB, except that the guaranteed amount at the beginning of the withdrawal period converts to a life annuity (i.e., fixed income for life). A GMAB provides a minimum return guarantee much like the accumulation period of a GLWB, but it does not have a withdrawal period with a guaranteed income.

If a policyholder were to die while the contract is in effect, her estate would receive a standard death benefit that is equal to the remaining account value. For an additional fee, the insurer offers four types of guaranteed death benefits (highest anniversary value, rising floor, earnings enhancement benefit, and return of premium) that enhance the death benefit during the accumulation period.

Even without minimum return guarantees, variable annuities may be attractive to policyholders because of a potential tax advantage in nonqualified accounts. Earnings on variable annuities can be deferred and accumulate tax free if the first withdrawal occurs after age 59.5. However, all earnings, including the capital gains, are taxed at the ordinary income tax rate, which is higher than the capital gains tax rate. Therefore, the tax advantage can justify the variable annuity fees only if the accumulation period is sufficiently long. In an illustrative example, Brown and Poterba (2006, table 5.2) show that the accumulation period must be longer than 40 years to justify an annual fee of 0.25% under the 2003 tax rates and an 8% pre-tax return (with 2% from dividends and 6% from capital gains).

1.3 Insurance Data

We describe the data on financial statements and insurance prices, much of which we use throughout the book.

1.3.1 Financial Statements

US insurers prepare annual financial statements according to the statutory accounting principles and file them with the National Association of Insurance Commissioners (NAIC). In addition to the balance sheets and the income statements, these data contain variable annuities in General Interrogatories Part 2 Table 9.2, portfolio holdings in Schedule D, derivatives in Schedule DB, and reinsurance in Schedule S. The National Association of Insurance Commissioners (1994–2019) sells the financial statements to academic researchers at a discounted price. The A.M. Best Company and SNL Financial also sell the same financial statements in a processed and cleaned format that may be easier to use.

The A.M. Best Company offers two products that contain the financial statements and rating information. *Best's Insurance Reports* contain highlights from the financial statements that are the most relevant to ratings and are available since 1992 (A.M. Best Company, 1993–2012). *Best's Statement File* contains the complete financial statements and is available since 1999 (A.M. Best Company, 1999–2017).

Based on the financial statements, we construct insurer characteristics that we use throughout the book. They are log assets, log liabilities, asset growth, leverage, and net equity flow. We also use insurer characteristics that the

A.M. Best Company constructs as part of the rating process. They are the A.M. Best rating, risk-based capital, current liquidity, return on equity, and the A.M. Best financial size category. We provide a complete definition of these insurer characteristics in Appendix A.2.

GENERAL INTERROGATORIES

General Interrogatories Part 2 Table 9.2 reports the total related account value, the gross amount of variable annuity reserves, and the reinsurance reserve credit on variable annuities. The total related account value is the market value of the mutual funds. The gross amount of variable annuity reserves is the accounting value of the minimum return guarantees net of hedging programs.

We define *variable annuity liabilities* as the total related account value plus the gross amount of variable annuity reserves minus the reinsurance reserve credit on variable annuities. For each insurer, we define its *reserve valuation* as the ratio of the gross amount of variable annuity reserves to the total related account value. The reserve valuation measures the value of the minimum return guarantees per dollar of underlying mutual funds. In the cross section, the reserve valuation is higher for insurers that have sold more generous guarantees. In the time series, the reserve valuation increases when the stock market falls, interest rates fall, or volatility rises. We define the *reinsurance share of variable annuities* as the ratio of the reinsurance reserve credit on variable annuities to the gross amount of variable annuity reserves.

SCHEDULE D

Schedule D reports all fixed income and equity holdings at the CUSIP level. Other than insurers, mutual funds and exchange-traded funds (ETF) are the only other US institutional investors who report fixed income holdings. The importance of insurers in the corporate bond market and the availability of holdings data create an opportunity to study the impact of institutional investors on corporate bond prices, following the demand system approach in Koijen and Yogo (2019). In fact, recent research takes the corporate bond literature in this direction (Bretscher et al., 2021; Yu, 2021; Siani, 2022).

SCHEDULE DB

Schedule DB reports all derivatives, including futures, options, and swaps, at the contract level. Such detailed data are not available for US banks. The data are ideal for studying the hedging and risk-shifting motives of insurers (e.g., Cummins, Phillips, and Smith, 2001; Sen, 2022).

SCHEDULE S

Our data on life and annuity reinsurance agreements are from Schedule S for 2002 to 2013 (A.M. Best Company, 2003–2014). The relevant parts of Schedule S are Part 1.1 (Reinsurance Assumed), Part 3.1 (Reinsurance Ceded), and Part 4 (Reinsurance Ceded to Unauthorized Companies). The data contain all reinsurance agreements (both ceded and assumed) at each fiscal year-end for any operating company or authorized reinsurer. An authorized reinsurer is subject to the same reporting and capital requirements as an operating company in its state of domicile, whereas an unauthorized reinsurer is not. In particular, the data contain reinsurance ceded by an operating company to an unauthorized reinsurer, such as a domestic captive or a foreign reinsurer. However, we do not observe reinsurance ceded by unauthorized reinsurers that do not report to the NAIC.

For each reinsurance agreement, we observe the identity of the reinsurer, the type of reinsurance, the effective date, the reserve credit taken (or reserves held), and the modified coinsurance reserve. The sum of the reserve credit taken and modified coinsurance reserve is the total amount of reinsurance ceded. We know the identity of the reinsurer up to its name, domicile, whether it is affiliated with the ceding company, whether it is authorized in the ceding company's domicile, and whether it is rated by the A.M. Best Company. We define *shadow reinsurers* as affiliated and unauthorized reinsurers without an A.M. Best rating. Our definition is stricter than "captives" because some captives are actually authorized.

CONSOLIDATED FINANCIAL STATEMENTS

Compustat contains the consolidated financial statements under the generally accepted accounting principles (GAAP) for publicly held holding companies. These financial statements are not as detailed as the financial statements for the subsidiaries under the statutory accounting principles. Reconciling the financial statements of the holding company and its subsidiaries is a daunting task because of differences in accounting standards, captive reinsurance, and non-insurance subsidiaries without public financial statements. However, Compustat data may suffice for some empirical applications in which only information at the holding company level is necessary.

INTERNATIONAL FINANCIAL STATEMENTS

The A.M. Best Company offers separate products that contain the financial statements for global insurers, European insurers reporting under Solvency II, and Canadian insurers. The Securities Holding Statistics of the European Central Bank contain all fixed income and equity holdings of European insurers at the ISIN level (Koijen et al., 2021).

1.3.2 Insurance Prices

LIFE INSURANCE

Our data on life insurance premiums are from Compulife Software (2002–2012), which is a computer-based quotation system for insurance agents. In Chapter 4, we focus on guaranteed universal life insurance for males and females aged 30 to 80 (every 10 years in between). We pull monthly quotes from January 2005 to July 2011 for all states at the regular health category and a face amount of $250K.

In Chapter 5, we focus on 10-year guaranteed level term life insurance for males aged 30 as representative of the life insurance market. However, we have also examined 20-year policies and older age groups for robustness. We pull quotes at the end of June of each year from 2002 to 2012 for all states at the regular health category and a face amount of $1 million.

We calculate the actuarial value of life insurance based on equation (1.1), the appropriate mortality table from the American Society of Actuaries, and the zero-coupon Treasury yield curve (Gürkaynak, Sack, and Wright, 2007). We use the 2001 Valuation Basic Table before January 2008 and the 2008 Valuation Basic Table since January 2008. These mortality tables are derived from the actual mortality experience of insured pools, based on data provided by various insurers. Thus, they account for adverse selection such that an insured pool has a lower life expectancy than the overall population. We smooth the transition between the two vintages of the mortality tables by geometric averaging.

FIXED ANNUITIES

Our data on term and life annuity prices are from the WebAnnuities Insurance Agency, which has published quotes from the leading insurers at a semiannual frequency since January 1989 (Stern, 1989–2011) and at a monthly frequency from January 2007 to August 2009 (Stern, 2007–2009). We focus on single premium immediate annuities in nonqualified accounts, for which only the interest is taxable. These policies cannot be lapsed because the premium is paid up front as a lump sum. For term annuities, we have quotes for 5- to 30-year maturities (every five years in between). For life annuities, we have quotes for "life only" policies without guarantees as well as those with 10- or 20-year guarantees. These quotes are available for both males and females aged 50 to 85 (every five years in between).

We calculate the actuarial value of term annuities based on equation (1.2) and the zero-coupon Treasury yield curve. We calculate the actuarial value of life annuities based on equation (1.3), the appropriate mortality table from the American Society of Actuaries, and the zero-coupon Treasury yield curve. We use the 1983 Annuity Mortality Basic Table before January 1999 and the 2000 Annuity Mortality Basic Table since January 1999. These mortality tables are derived from the actual mortality experience of insured pools, based on data provided by various insurers. Thus, they account for adverse selection such that an insured pool has a higher life expectancy than the overall population. We smooth the transition between the two vintages of the mortality tables by geometric averaging.

VARIABLE ANNUITIES

Based on Morningstar (2016a), we construct a comprehensive panel data set on the variable annuity market at the contract level since 1999. The data contain quarterly sales and a textual summary of the prospectus for each contract, from which we extract the history of fees and contract characteristics. The key contract characteristics are the base contract expense, the number of investment options, and the types of guaranteed living and death benefits that are offered.[1] For each guaranteed living benefit, the key characteristics are the type (i.e., GLWB, GMWB, GMIB, or GMAB), the fee, the rollup rate, and the withdrawal rate. Morningstar provides the open and close dates for each contract and guaranteed living benefit, from which we construct the history of when different benefits were offered.

Sales are available at the contract level but not at the benefit level. Therefore, we must aggregate fees and rollup rates over all guaranteed living benefits

1. We use assets under management by subaccount from Morningstar (2016b) to compute a measure of investment options that adjusts for the nonuniform distribution of assets across subaccounts within a contract. Our measure is the inverse of the Herfindahl index over the subaccount shares within each contract, which equals the number of investment options when the subaccounts are uniformly distributed.

that a contract offers to construct a panel data set on sales, fees, and characteristics at the contract level. For each date and contract, we first average the fees and the rollup rates by the type of guaranteed living benefit. We then use the average fee and rollup rate in the order of GLWB, GMWB, GMIB, and GMAB, based on availability. For example, if a contract does not offer a GLWB but offers a GMWB, we use the average fee and rollup rate on the GMWB. Because a GLWB is the most common type of guaranteed living benefit and a GMWB is the closest substitute for a GLWB, our procedure yields a representative set of fees and rollup rates that are comparable across contracts.

We merge the Morningstar data and the annual financial statements by company name. The annual financial statements are from the *Best's Statement File*, which is merged with NAIC's General Interrogatories Part 2 Table 9.2 by the NAIC company code. The final data set is a quarterly panel on the variable annuity market from 2005:1 to 2015:4, where the start date is dictated by the availability of the NAIC data. For the summary statistics that only require the Morningstar data, we use a longer sample that starts in 1999:1.

1.4 Institutional Background

Since the McCarran Ferguson Act of 1945, states have regulated US insurers, and there is no national insurance regulator. States regulate many aspects of the insurance business, including the coverage requirements for policies, the premiums for some types of insurance such as health, revisions in the premiums of existing policies, the accounting standards for financial reporting, and the capital requirements to ensure solvency. Although the regulation can vary across states, most states adopt the model regulation established by a coordinating organization known as the NAIC.

1.4.1 State Guaranty Associations

Since the Life and Health Insurance Guaranty Association Model Act in 1970, all states have established guaranty associations to cover insurance claims in case of default. The maximum coverage varies across states and types of policies. For example, California covers up to $250K for annuities and $300K for life insurance. Guaranty associations assess the surviving companies to pay off the defaulted insurance claims. All states cap annual guaranty association assessments, typically at 2% of recent life insurance and annuity premiums.

State taxpayers indirectly bear the cost of defaulted insurance claims because the assessments are tax deductible.

On the one hand, guaranty associations protect policyholders, who may not be informed or coordinated enough to monitor their insurer. On the other hand, guaranty associations create a risk-shifting motive for managers and shareholders (Lee, Mayers, and Smith, 1997). Therefore, state regulators must set and enforce capital requirements to limit excessive risk taking. As we have seen, the insurance sector was already large and functioning as a relatively unregulated system before 1970. It is unclear whether the insurance sector is better off in the current system of capital regulation protecting guaranty associations.

Although the US government does not explicitly guarantee insurers, it did bail out AIG, Hartford, and Lincoln Financial through the Troubled Asset Relief Program (TARP) during the global financial crisis. Other insurers such as Allstate, Genworth Financial, and Prudential Financial applied for TARP but were ultimately rejected or withdrew their application. In the aftermath of the global financial crisis, the Financial Stability Oversight Council designated AIG, Prudential Financial, and MetLife as systemically important financial institutions to enforce higher capital requirements that would prevent future bailouts. However, all three insurers have successfully challenged this decision and are no longer designated systemically important as of October 2018.

1.4.2 Risk-Based Capital Regulation

Since the Risk-Based Capital for Insurers Model Act in 1993, insurance regulators have used risk-based capital as an important metric of an insurer's financial strength. Rating agencies also use risk-based capital as an important metric for assigning credit ratings. Risk-based capital is the ratio of accounting equity to required capital:

$$\text{RBC} = \frac{\text{Assets} - \text{Reserves}}{\text{Required capital}}. \tag{1.4}$$

Reserves in the numerator are an accounting measure of liabilities that may not coincide with the market value. Required capital in the denominator is a measure of how much equity could be lost in an adverse scenario. Although the exact formula for computing the required capital is complex, it is helpful to think of it as proportional to reserves and increasing in the riskiness of the liabilities, as we discuss below. For a sufficiently high risk-based capital ratio, insurance regulators view equity capital as adequate to meet the insurer's existing liabilities, even in an adverse scenario.

To avoid a rating downgrade or regulatory action, an insurer may behave as if there were a risk-based capital constraint. There are four levels of risk-based capital that trigger regulatory action. When the risk-based capital ratio falls below the "company action level" of 2, the insurer must submit a plan of corrective actions. When the risk-based capital ratio falls below the "regulatory action level" of 1.5, the insurance regulator examines the insurer and orders corrective actions. When the risk-based capital ratio falls below the "authorized control level" of 1, the insurance regulator has the authority to place the insurer under regulatory control. When the risk-based capital ratio falls below the "mandatory control level" of 0.7, the insurance regulator places the insurer under regulatory control.

An economic risk constraint works similarly to a risk-based capital constraint. For example, let ϵ be a multiplicative shock to the leverage ratio with a cumulative distribution function $F(\epsilon)$, which arises from a risk mismatch between assets and liabilities. Consider a value-at-risk constraint under which the probability that assets cover liabilities must exceed a threshold:

$$\Pr\left(\frac{\text{Liabilities}}{\text{Assets}}\epsilon \leq 1\right) = F\left(\frac{\text{Assets}}{\text{Liabilities}}\right) \geq \kappa. \tag{1.5}$$

We can rewrite this constraint as

$$\frac{\text{Assets} - \text{Liabilities}}{(F^{-1}(\kappa) - 1)\text{Liabilities}} \geq 1. \tag{1.6}$$

Comparing the left side of this equation with risk-based capital (1.4), required capital must be a fraction $F^{-1}(\kappa) - 1$ of reserves for the two equations to be equivalent. An insurer with more conservative risk management has a higher $F^{-1}(\kappa)$ due to a higher κ or lower risk reflected in the cumulative distribution function. The horizon over which a value-at-risk constraint matters for life insurers is presumably much longer than that for banks and property and casualty insurers, given the long-term and less runnable nature of their liabilities.

1.4.3 *Accounting Standards*

An insurance holding company consists of operating companies that sell insurance and reinsurers that specialize in reinsurance. An operating company reports financial statements according to the statutory accounting principles, based on the NAIC's model regulation. A reinsurer that is not licensed to sell insurance reports financial statements under GAAP. The holding company reports consolidated financial statements under GAAP. European insurers report under Solvency II, which is different from GAAP. However, the European Union allows insurers to operate outside of the European Union under the home country's solvency regime under Solvency II equivalence.

Reserve valuation is the valuation of an insurance liability under an accounting standard for the purposes of financial reporting, and it is important because higher reserves reduce risk-based capital (see equation (1.4)). The reserve valuation of life insurance differs substantially between the statutory accounting principles and GAAP. This difference in accounting standards creates an incentive for life insurers to use shadow insurance, which we discuss in Chapters 2 and 5. We also discuss the statutory accounting principles for variable annuities, which is important for Chapter 4.

LIFE INSURANCE

In January 2000, the NAIC adopted Model Regulation 830 (commonly known as Regulation XXX) for the reserve valuation of term life insurance. In January 2003, the NAIC adopted Actuarial Guideline 38 (commonly known as Regulation AXXX) for the reserve valuation of universal life insurance with secondary guarantees. By increasing the reserve valuation, the new regulation forced insurers to hold more capital on newly issued life insurance policies.

The new regulation was a matter of the statutory accounting principles and does not apply to GAAP. The reserve valuation under GAAP is much lower and closer to the actuarial value. Therefore, an operating company that reports under the statutory accounting principles could cede reinsurance to either an affiliated or unaffiliated reinsurer that reports under GAAP to reduce overall reserves. In practice, unaffiliated reinsurance can be expensive because of capital market frictions and market power (Froot, 2001).

CAPTIVE LAWS

South Carolina introduced new laws in 2002 that allow insurers to establish captives, whose primary function is to assume reinsurance from affiliated companies for the purpose of reducing overall reserves. States compete for captive business to increase employment and tax revenue (Cole and McCullough, 2008). Furthermore, the captive's state of domicile does not directly bear risk because the liabilities go back to the operating company (and ultimately the guaranty associations of states in which the policies were sold) when a captive fails. A captive structure that has proven especially successful is the special purpose financial captive, which is a type of special purpose vehicle that was introduced by South Carolina in 2004 and Vermont in 2007. Twenty-six states have adopted a version of the captive laws, eight of which have defined special purpose financial captives (Captives and Special Purpose Vehicle Use Subgroup, 2013).

Captives differ from traditional reinsurers in several important ways. First, captive reinsurance can be less expensive than unaffiliated reinsurance, especially after the fixed costs of entry have been paid. Second, captives can operate with less equity because they report under GAAP and are not subject to risk-based capital regulation. For example, captives in Vermont are required to have only $250K in equity and could count letters of credit as admitted assets (Captives and Special Purpose Vehicle Use Subgroup, 2013). Third, captives have a more flexible financial structure that allows them to fund reinsurance transactions through letters of credit or securitization. Finally, their financial statements are confidential to the public, rating agencies, and even regulators outside their state of domicile.

US tax laws disallow reinsurance for the primary purpose of reducing tax liabilities. However, it can be an important side benefit of captive reinsurance that motivates where an insurer establishes its captives. Life insurance premiums are taxable at the state level, and the tax rates on premiums vary across states (Cole and McCullough, 2008). In addition, profits are taxable at the federal level, so an operating company can reduce the overall tax liabilities by ceding reinsurance to an offshore captive. Bermuda, Barbados, and the Cayman Islands are important captive domiciles for this purpose.

Operating companies are ultimately responsible for all liabilities that they issue, even those that they cede to reinsurers. Moreover, captives typically do not transfer risk to outside investors through securitization (Stern et al., 2007). These facts together imply that captives do not transfer risk outside the insurance group and exist only for the purpose of capital and tax management. Thus, captives have a function similar to asset-backed commercial paper conduits with explicit guarantees from the sponsoring bank (Acharya, Schnabl, and Suarez, 2013), before the regulatory reform of shadow banking (Adrian and Ashcraft, 2012).

VARIABLE ANNUITIES

Variable annuity liabilities enter both reserves and required capital in risk-based capital (1.4). As summarized by Junus and Motiwalla (2009), Actuarial Guideline 43 has determined the reserve value of variable annuities since December 2009, and the C-3 Phase II regulatory standard has determined the contribution of variable annuities to required capital since December 2005. Actuarial Guideline 43 is a higher reserve requirement than its precursor Actuarial Guideline 39, so insurers were given a phase-in period through December 2012 to fully comply with the new requirement.

To compute reserves and required capital, insurance regulators provide various scenarios for the joint path of Treasury, corporate bond, and equity prices. Insurers simulate the path of equity deficiency for their variable annuity business (net of hedging programs and reinsurance) under each scenario and keep the highest present value of equity deficiency along each path. Insurers then compute reserves as a conditional mean over the upper 30% of equity deficiencies (called CTE 70). This conditional tail expectation builds in a degree of conservatism that is conceptually similar to a correction for risk premia, but reserves do not coincide with the market value of liabilities. Insurers use the same methodology for required capital, except that they compute a conditional mean over the upper 10% of equity deficiencies (called CTE 90).

More generous guarantees with higher rollup rates or better coverage of downside market risk relative to fees require higher reserves and more capital. Moreover, minimum return guarantees are long-maturity put options on mutual funds, whose value increases when the stock market falls, interest rates fall, or volatility rises. Therefore, both reserves and required capital increase in an adverse scenario like the global financial crisis, which puts downward pressure on risk-based capital.

In contrast to the conditional tail expectation under Actuarial Guideline 43, GAAP allows insurers to record variable annuity reserves at market value. As a result, variable annuity reserves under the statutory accounting principles could increase relative to those under GAAP after a period of high volatility (Credit Suisse, 2012). Moreover, an insurer that implements a hedging program under GAAP could actually increase the volatility of accounting equity under the statutory accounting principles. For these reasons, insurers have an incentive for captive reinsurance of variable annuities either to increase risk-based capital or to implement a hedging program under GAAP.

1.5 A Baseline Model of Insurance Pricing

Traditional theories of insurance markets assume that insurers operate in an efficient capital market and supply policies at actuarially fair prices. Consequently, the market equilibrium is primarily determined by the demand side, either by life-cycle demand (Yaari, 1965) or informational frictions (Rothschild and Stiglitz, 1976). In contrast, we present a baseline model in which financial frictions and market power are the primary determinants of insurance prices.

We build on the baseline model in the subsequent chapters. In Chapter 3, we extend the insurance pricing model to multiple types of policies to explain pricing across policies with different statutory reserve requirements. In Chapter 4, we extend the insurance pricing model to contract design with an application to the variable annuity market. In Chapter 5, we extend the insurance pricing model to reinsurance to explain shadow insurance and its impact on the retail market. In Chapter 6, we extend the insurance pricing model to portfolio choice to explain why insurers are the largest institutional investors of corporate bonds.

1.5.1 Insurance Market

For simplicity, we assume that an insurer sells just one type of policy (e.g., annuities or life insurance). Insurers compete in an oligopolistic market and have market power because of product differentiation along policy characteristics other than the price, which we parameterize through a differentiated product demand system in Section 4.3.1. For now, we assume that the insurer faces a demand function that depends on its own price and the prices of its competitors. The demand function is continuously differentiable and strictly decreasing in its own price.

In period t, the insurer chooses the price P_t per policy and sells Q_t policies. The actuarial value per policy is V_t. The reserve value per policy is $\widehat{V}_t$. As we discuss in Section 1.4.3, the reserve value depends on the statutory accounting principles and could be greater or less than the actuarial value.

1.5.2 Balance Sheet Dynamics

We describe how the sale of policies affects the balance sheet. Let A_{t-1} be the assets at the beginning of period t, and let $R_{A,t}$ be an exogenous gross asset return in period t. The assets at the end of period t, after the sale of policies, are

$$A_t = R_{A,t} A_{t-1} + P_t Q_t. \tag{1.7}$$

The insurer must also record reserves on the liability side of its balance sheet. Let L_{t-1} be the reserves at the beginning of period t, and let $R_{L,t}$ be an exogenous gross return on reserves in period t. The reserves at the end of period t, after the sale of policies, are

$$L_t = R_{L,t} L_{t-1} + \widehat{V}_t Q_t. \tag{1.8}$$

We define statutory capital as equity minus required capital, which is proportional to reserves:

$$K_t = \underbrace{A_t - L_t}_{\text{equity}} - \underbrace{\phi L_t,}_{\text{required capital}} \tag{1.9}$$

where $\phi > 0$ is a risk charge on liabilities under risk-based capital regulation. In comparison to equation (1.4), we specify statutory capital as a difference (rather than a ratio) of equity and required capital to simplify the derivation of the optimal insurance price. However, we could scale statutory capital by lagged liabilities without substantively altering the results. Substituting equations (1.7) and (1.8) into equation (1.9), the law of motion for statutory capital is

$$K_t = R_{K,t} K_{t-1} + \left(P_t - (1+\phi)\widehat{V}_t\right) Q_t, \tag{1.10}$$

where

$$R_{K,t} = \frac{A_{t-1}}{K_{t-1}} R_{A,t} - \frac{(1+\phi)L_{t-1}}{K_{t-1}} R_{L,t} \tag{1.11}$$

is the return on statutory capital.

1.5.3 *Financial Frictions*

Following the discussion in Section 1.4.2, low statutory capital could lead to a rating downgrade or regulatory action, which have adverse consequences in both retail and capital markets. Moreover, financial frictions make equity issuance costly. We model the cost of financial frictions through a cost function:

$$C_t = C(K_t). \tag{1.12}$$

This cost function is continuous, twice continuously differentiable, strictly decreasing, and strictly convex. The cost function is decreasing because higher statutory capital reduces the likelihood of a rating downgrade or regulatory action. The cost function is convex because these benefits of higher statutory capital have diminishing returns. An alternative interpretation of the cost function is that the insurer has an economic risk constraint, such as the value-at-risk constraint in Section 1.4.2.

1.5.4 *Optimal Pricing*

The insurer's profit from selling policies is

$$D_t = (P_t - V_t)Q_t. \tag{1.13}$$

A simple interpretation of this profit function is that for each policy that the insurer sells for P_t, it can buy a portfolio of Treasury bonds that replicates its expected claims for V_t. For term annuities, this interpretation is exact because the future claims are deterministic. For life annuities and life insurance, we assume that the mortality risk is idiosyncratic and that the insured pool is sufficiently large for the law of large numbers to apply.[2] The insurer chooses the price P_t to maximize firm value, which is the profit minus the cost of financial frictions:

$$J_t = D_t - C_t. \tag{1.14}$$

We could specify firm value as the present value of profits, but we opt for the simpler presentation because the key insights do not depend on dynamics.

To simplify the exposition, we present the optimality condition for a single insurer with the understanding that all insurers have the same optimality conditions in a Nash equilibrium. To simplify the notation, we define the demand elasticity as $\epsilon_t = -\partial \log(Q_t)/\partial \log(P_t)$. We also define the marginal cost of capital as

$$c_t = -\frac{\partial C_t}{\partial K_t} > 0. \tag{1.15}$$

The marginal cost of capital represents the importance of financial frictions, which decreases in statutory capital by the convexity of the cost function.

2. For life insurance, we also assume that the policy is annually renewable or that the lapsation risk is idiosyncratic.

The first-order condition for the price is

$$\begin{aligned}\frac{\partial J_t}{\partial P_t} &= \frac{\partial D_t}{\partial P_t} + c_t \frac{\partial K_t}{\partial P_t} \\ &= Q_t + \frac{\partial Q_t}{\partial P_t}(P_t - V_t) + c_t \left(Q_t + \frac{\partial Q_t}{\partial P_t} \left(P_t - (1+\phi)\widehat{V}_t \right) \right) \\ &= (1+c_t)Q_t + \frac{\partial Q_t}{\partial P_t} \left((1+c_t)P_t - V_t - c_t(1+\phi)\widehat{V}_t \right) = 0. \qquad (1.16)\end{aligned}$$

We rearrange this equation to solve for the optimal price:

$$P_t = \left(1 - \frac{1}{\epsilon_t}\right)^{-1} \frac{1 + c_t(1+\phi)\frac{\widehat{V}_t}{V_t}}{1+c_t} V_t. \qquad (1.17)$$

The optimal price is the product of three terms. The first term is the markup that is inversely related to the demand elasticity. This term decreases to one as demand becomes perfectly elastic (i.e., $\epsilon_t \to \infty$). The second term arises from financial frictions. This term approaches one as the marginal cost of capital decreases to zero. The third term is the actuarial value or the frictionless marginal cost.

1.5.5 Empirical Implications

Because $c_t > 0$, the optimal price (1.17) satisfies an inequality:

$$P_t \gtrless \left(1 - \frac{1}{\epsilon_t}\right)^{-1} V_t \text{ if } \frac{(1+\phi)\widehat{V}_t}{V_t} \gtrless 1. \qquad (1.18)$$

When $(1+\phi)\widehat{V}_t/V_t$ is high, the capital regulation is conservative through a high risk charge ϕ on liabilities or a high reserve valuation $\widehat{V}_t$ relative to the actuarial value V_t. In this case, statutory capital decreases when the insurer sells more policies. Thus, the optimal price is higher than the frictionless price if the insurer is financially constrained (i.e., high $c_t > 0$).

This case describes property and casualty insurance. The capital regulation for property and casualty insurers is conservative to ensure an adequate capital buffer against tail risk. Thus, the supply contracts and prices increase when property and casualty insurers are financially constrained after a severe weather event that causes operating losses (Gron, 1994; Froot and O'Connell, 1999). This case also describes variable annuities, as we discuss in Chapter 4. It is also related to the banking literature, which shows that the loan supply contracts when banks are financially constrained (e.g., Peek and Rosengren, 1997).

When $(1+\phi)\widehat{V}_t/V_t$ is low, the capital regulation is aggressive through a low risk charge on liabilities or a low reserve valuation relative to the actuarial value. In this case, statutory capital increases when the insurer sells more policies. Thus, the optimal price is lower than the frictionless price if the insurer is financially constrained (i.e., high $c_t > 0$). When the reserve value is less than the actuarial value, the insurer can raise accounting equity as long as the price is above the reserve value, even if the economic profit is negative because the price is below the actuarial value. Although this case is less common, it describes fixed annuities and life insurance during the global financial crisis, as we discuss in Chapter 3.

INDEX

Page numbers in *italics* indicate figures and tables.