Accommodation or Obfuscation? Product Innovation in the Variable Annuities Market

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Abstract

Variable Annuity products, which make up a substantial part of retirement products sold by insurance companies, have become increasingly complex over the past decades. In this paper, we investigate the drivers for these product innovations. We distinguish "virtuous" innovations that complete the market and "obfuscating" innovations that increase complexity without benefitting consumers. We demonstrate that both forms are potentially relevant in the Variable Annuities market, both theoretically and empirically. In particular, we document a recurring pattern where innovative products that expand the scope of attainable consumption paths in retirement are followed by many more complex variants in the same product class.

Keywords: Variable Annuities, financial innovation, market completeness, obfuscation, retirement finance.

1 Introduction

The market for Variable Annuities (VAs) has grown tremendously over the past three decades, both with regards to total investments and the number of offered products. Along with an increase in the number, the offered annuity benefits have also become increasingly complex. In this paper, we investigate the drivers for product innovation in the VA market. Several recent studies analyze financial innovation in related markets for consumer financial products, generally finding questionable motives and merits for enhancing product complexity from the consumer perspective. Our analysis points to a more differentiated situation in the VA market: "virtuous" innovations that

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expand the scope of attainable consumption paths in retirement and "obfuscating" innovations that increases complexity to confuse and overcharge unsophisticated consumers appear to co-exist. In particular, we document that the aggregate increase in complexity is a result of a recurring pattern where substantial virtuous innovations are followed by a period of many similar obfuscating innovations that complicate the product landscape.

VAs are separate account life insurance contracts that are linked to a list of financial instruments. They offer policyholders the opportunity to invest in a combination of equities and bonds, while being protected by guarantees against downside risks. These guarantees provide minimum benefits (GMBs) upon the policyholder's death (Guaranteed Minimum Death Benefits, GMDBs) and/or survival (Guaranteed Living Benefits, GLBs). While sales in the US VA market have recently stagnated, they still present the largest component of life insurance liabilities, with 2020 sales totaling to roughly $90 billion down from $133 billion in 2015, and more than 70% containing one or more GLB. The total assets invested in the US VA market exceeded two trillion dollars in late 2017, making up for about a quarter of the total US insurance industry (US Department of the Treasury, 2016).

Understanding the drivers of product innovation in VAs is important given the size of the market and mixed reviews of their merits in the popular press. Indeed, famed personal finance expert Suze Orman declared: "I think variable annuities were created for one reason and one reason only—to make the advisor selling those variable annuities money." Similarly Jeff Rose, CFP and author of *Soldier of Finance*, provides "Five Reasons Why You Should Never Buy A Variable Annuity." Their voices are just two among many suggesting that VA providers solely aim at taking advantage of uninformed consumers, selling them products they do not need at unreasonably high prices.

This perspective aligns with evidence from recent literature and aggregate product trends. While some classical references on financial innovation point to the benefits of enhanced risk sharing (Allen and Gale, 1994; Duffie and Rahi, 1995), a growing theoretical literature emphasizes the link between negative product attributes and complexity (Carlin, 2009; Carlin and Manso, 2011; Gabaix and Laibson, 2006, among others). Analyses across different markets seem to corroborate this link (Célérier and Vallée, 2017; Ghent, Torous, and Valkanov, 2019; Henderson and Pearson, 2011; Vokata, 2020). In particular, evidence from retail structured products, which exhibit various similarities to VAs, documents increasing product complexity together with an increase in risk to the consumer and profitability for the issuers. As we demonstrate, aggregate product trends in the VA market track these observations: Over the past two decades, our measures of product complexity and fee levels in VA contracts have steadily increased. This provides prima facie evidence for a parallel view on the VA market—seemingly confirming the grim testimonials by Suze Orman, Jeff Rose, and company.

However, we illustrate that this simple, negative account of VA product development may be misleading—a more granular analysis of VA product trends provides a more differentiated picture. From the perspective of an issuer, a VA delivers pay-offs contingent on the future market evolution, much like a retail structured product. From the consumer's perspective, however, VAs are retirement products that protect their holders against a variety of risk factors. These products potentially provide value by expanding the set of attainable consumption paths. For instance, a so-called *Guaranteed Lifetime Withdrawal Benefit* (GLWB), the most recently introduced broad category of GLBs, provides protection against the *joint* event of a poor market performance and a long realized lifetime. More precisely, the GLWB provides the opportunity, against a substantial fee, to take annual guaranteed withdrawals starting at retirement age from the investment account for as long as the policyholder is alive—similarly to a life annuity—even if the account value drops to zero. Similarly, other GLBs provide payoffs that are difficult to replicate using existing savings and retirement products.

When analyzing product trends *within* major GLB categories, three rough features emerge. First, when a new category is first introduced, it is offered by relatively few providers and the products are *relatively simple*. Here *relatively simple* means that they are simple in relation to other products of the same category—of course, it may require more language to explain the basic payoff functionality of a new GLWB in comparison to a simpler rider such as a GMDB. Second, products in the same category that follow the new introduction are more and increasingly complex, although this increase in complexity stagnates after a few years. Hence, the aggregate trend of rising product complexity is composed of this recurring pattern of the introduction of a new category and a *temporary* increase in complexity within this category. Third, while generally higher product complexity is associated with higher fees, the newly introduced products—albeit simple—appear to be sold at relatively high charges.

These features can be rationalized in an equilibrium model of product complexity where "virtuous" product innovation that caters to a subgroup of consumers with differentiated product preferences co-exists with "obfuscating" innovation with increases in complexity that targets unsophisticated consumers. We present an extension of the model by Carlin (2009), where firms set prices and product complexity levels to attract consumers with different degrees of sophistication. As the key modifications, our consumers are heterogeneous, with some consumers preferring an alternate product to the one currently offered, and firms can engage in costly and uncertain—though profitable when successful—"virtuous" innovation realized in a second stage. We show that the successful firm offers the new product at a low complexity to enlarge the set of sophisticated consumers but at a high (monopoly) price, in line with the introduction of a new product category in the VA market. However, complexity will increase eventually to an equilibrium level in both product markets as copycats introduce products in the new category without bearing innovation costs in line with the arguments from Carlin (2009). This explains the increase—and stagnation—in complexity subsequent to the new introduction.

We test these predictions via regression analyses using our complexity measures and fee levels as dependent variables. Our results suggest that, controlling for firm fixed effects and product category dummies, product complexity is low initially and increases for four to five years after the introduction of the new category and stagnates thereafter. Fees increase in product complexity and over time, with a markup in the first year a new product category is introduced.

Hence, overall our results point to a mixed picture. Much of the added complexity and the accompanying fee increases in VAs indeed seem to serve the purpose of obfuscating unsophisticated consumers: "Complex variable annuities are oversold to individuals who don't understand them. They're frustratingly complex to comprehend."[1] However, the innovation pattern also suggests that VA providers come up with new products to serve individuals' retirement needs. They do so to reap the benefit of being the only game in town after the introduction, but clearly there are resulting benefits to sophisticated consumers that understand their own risk profile—particularly in the long run. Hence, our conclusion is in line with that of the Securities and Exchange Commission (2009): "Information is an investor's best tool." If a consumer purchases a VA contract, they should know why they are opting for their specific product.

Related Literature and Organization of the Paper

As indicated, there is a growing recent literature on financial product innovation. On the theoretical side, we extend the model for financial complexity presented by Carlin (2009). As Spiegler (2016) points out, Carlin's model—and our extension—are part of a class of models on choice complexity with similar features. In particular, within these models, complexity increases in market competition, which is also true in our context. On the empirical side, the most closely related paper is Célérier and Vallée (2017). We follow their approach in applying text analysis to assess product complexity and charges, and we also follow their ideas closely in defining our complexity measures. However, we focus on a different market and come to different conclusions.

While the more specialized literature on VAs primarily focuses on actuarial aspects (Bauer, Kling, and Russ, 2008; Ledlie et al., 2008, among many others), more recent papers emphasize the relevance of financial frictions in understanding the VA market and its relevance to other economic sectors (Koijen and Yogo, 2016). On the supply side, Ellul et al. (2018) and Koijen and Yogo (2020) explore the relevance of regulatory and financing frictions in explaining insurer characteristics and the industrial organization of the VA market. On the demand side, Moenig and Bauer (2016) emphasize the importance of tax advantages in explaining VA pricing and policyholder behavior. However, these papers do not document the evolution of VA product characteristics or provide insights on potential drivers of product innovation in this market more broadly. We close this gap in literature.

[1]See Forbes' "Annuities: The Good, The Bad and The Ugly," `https://www.forbes.com/sites/feeonlyplanner/2015/07/15/annuities-the-good-the-bad-and-the-ugly`.

The remainder of the paper is structured as follows. In Section 2, we provide background information on the VA market and descriptive evidence of product evolution. In Section 3, we introduce our model on the co-existence of different modes of product innovation, and discuss implications for VAs. We present our regression analysis in Section 4, and finally Section 5 concludes.

2 Product Innovation in Variable Annuity Markets

2.1 Background on Variable Annuities

A VA delivers pay-offs contingent on the future market evolution, much like a financial derivative. Typically the VA policyholder deposits a lump sum premium at the issue of the contract and receives a benefit upon death or survival until termination. Percentage fees are assessed at regular intervals (month, quarter, year), consisting of the VA charge, the benefit fee (if elected), and potential excess withdrawal penalties. The payoff of the product, on the other hand, depends on the benefits chosen, market performance, and the policyholder's actions and experience.

VA contracts are typically several hundred page long documents with a detailed description of all investment options, fees, and benefits. In particular, in contrast to other (life) insurance and retirement products, there is little standardization and generally products differ along several dimensions. To provide a broad overview of the (heterogeneous) products, in what follows are brief descriptions of five VA plus GMB combinations. We are not exhaustive on all the details but aim to provide a reasonable depiction of each contract's payoff mechanics:

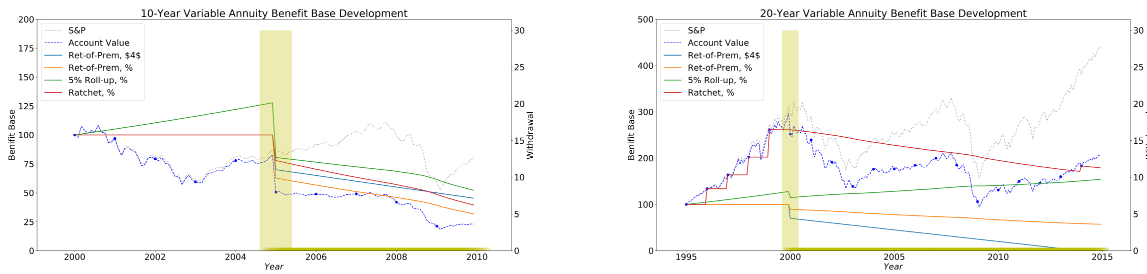
I. The "Guaranteed Protection Advantage 5" introduced by Pacific Life in 2003 is a Guaranteed Minimum Accumulation Benefit (GMABs), so the policyholders receive the maximum of the account value and the *benefit base* upon termination after a ten-year waiting period. The benefits base is the purchase payment, proportionally adjusted for possible early withdrawals (pro-rata), and allows for a step-up to the current account value on the 5th or subsequent anniversaries with a restart of the waiting period. The contract does not include a surrender fee, and a surviving spouse can continue the benefit. It is offered for a basic VA fee of 1.4% plus a rider fee of 0.25% initially, although it was gradually increased until the maximal rider fee of 0.75% (since 2011) as a proportion of the account value. The investment restrictions specify four types of portfolio choices and exclude the "aggressive growth" options.

II. The "Guaranteed Minimum Income Benefit (6.5%)" introduced by AXA Equitable in 2007 is a Guaranteed Minimum Income Benefit (GMIBs), so the policyholders receive the maximum of the account value and the benefit base upon annuitization at fixed annuity rates (e.g., a \$3.25 annuity per \$100 purchase price for a 65 year old male). The benefits base is the maximum of the largest account value at each previous anniversary (ratchet base) and the purchase payment compounded at 6.5% p.a. (roll-up base). The waiting period is ten years when purchased after age 50, with a possible step-up for the roll-up base restarting it. The ratchet base is adjusted for early withdrawals on a pro-rata basis, and the roll-up base is adjusted on a dollar-per-dollar up to a 6.5% withdrawal and on a pro-rate basis subsequently. Surrender fees in the first four years decrease linearly from 8% to 5%, with free withdrawals of 10% of the contract value p.a. The VA is offered for a fee of 1.65% of the account value with a current rider fee of 0.8% (maximal 1.1%) charged as a percentage of the benefit base.

III. The "SafeGuard Max" introduced by Jackson National in 2009 is a Guaranteed Minimum Withdrawal Benefit (GMWBs), so the policyholders can withdraw the purchase price (return-of-premium base) at regular installment free of charge, even if the account value is depleted. The maximal withdrawal percentage is based on the age of the owner and amounts to 7% below 75 years, to 8% below 80 years, and so on, up to 10% above 85 years. Manual step-ups to the current account value are allowed every five years. Spouses can continue the benefit with an automatic step-up. Guaranteed withdrawals reduce the benefit base and the account value dollar-for-dollar, as long as the latter remains positive. Excess withdrawals reset the benefit base to the lesser of contract value minus withdrawal or benefit base minus withdrawal, with a corresponding adjustment of the the guaranteed annual withdrawal amount. Excess withdrawals and surrenders in the first four years are charged surrender fees of 8%, 7%, 5.5%, and 3.5%, respectively. The VA is offered for a fee of 1.55% of the account value with a rider fee of 0.45% (maximal 0.8%) as a percentage of the benefit base.

IV. The "Polaris Income Builder" introduced by AIG in 2012 is a GLWB for individuals above the age of 65, allowing for a withdrawal of 5% of the maximum of the purchase premium and an annual ratchet base, with percentage step-ups of 8% simple interest in a year without withdrawals up to a maximum of 200% of the initial premium after 12 years. Excess withdraws reduce the benefits base proportionally. The surrender fee period is nine years, with fees amounting to 9%, 9%, 8%, 8%, 7%, 6%, 5%, 4%, 3% for years 1 through 9, respectively. The investment restrictions limit the available investments funds and require 20% in fixed interest account as of 2015. The VA is offered for a fee of 1.9% of the account value. The rider fee is minimally 0.6%, assessed against the benefit base, and may be adjusted based market volatility (VIX index) using a non-discretionary formula, with a maximum fee rate change per quarter of 0.25%. The current charge is 1.1% (maximal 2.2%).

V. The "GMDB Greater of Roll-Up or Step-Up" introduced by Prudential in 2004 is a GMDB that pays the maximum of an annual ratchet base and a 5% roll-up base in the event of death before the policyholder's 80th birthday. Withdrawals up to 5% reduce the roll-up base dollar-for-dollar, withdrawals in excess of that proportionately. Withdrawals reduce the ratchet base



(a) 10-year VA purchased in 2000

(b) 20-year VA purchased in 1995

Figure 1: Evolution of VA contracts linked to the S&P 500 index over different time periods as well as resulting evolution of different guarantee bases (return-of-premium, ratchet, and 5% roll-up) and withdrawal impact (proportionate or dollar-for-dollar). We assume a 1% fee charged as a percentage of the account value.

proportionately. The surrender fee period is seven year, with fees linearly decreasing from 7% to 1%. It is offered for a basic VA fee of 1.4% plus a rider fee of 0.35%, both as a percentage of the account value.

Thus, the benefit types (GMxBs) provide broad product categories, but the details of contracts within each of these categories differ substantially in various regards. Moreover, contracts may include multiple GMBs. For instance, the "Total Protection" by Security Benefit Life includes a GMAB and a GMWB component; the "Growth and Income Advantage" by Penn Mutual Life combines a GMWB, a GLWB, and a ratchet GMDB; etc. Indeed, most VA products include a basic return-of-premium GMDB at baseline financed by the basic VA charge, which consists of so-called mortality-and-expense (M&E) and administrative fees (see also Rosen (2019)). However, in some instances even more generous GMDB variants are included at no additional charge, such as the "Maximum Anniversary Death Benefit" ratchet-type GMDB offered by AIG.

To illustrate that this heterogeneity leads to meaningful differences in payoffs, in Figure 1 we plot the evolution of VA contracts linked to the S&P 500 index and corresponding benefits bases over two time periods (2000-2010 and 1995-2015). In constructing the plots, we assume an initial investment of \$100, a fee of 1% charged as a percentage of the account value, we assume that the policyholder makes a lump-sum withdrawal of \$30 after 5 years, and continuous withdraws of \$5 per year thereafter. We plot a return-of-premium benefit base, a ratchet benefit base, and a 5% roll-up base where we assume a proportionate impact of withdrawals, as well as a return-of-premium benefit base with a dollar-for-dollar (\$4\$) impact. As is evident, the dollar-for-dollar rule is more generous when the guarantee is in the money, whereas the proportionate impact is more generous if the guarantee is out-of-the-money. Most notably, the different bases lead to very different guarantee values at contract maturity, and thus to potentially very different payoffs if the guarantee is in-the-money as for the 2000-2010 period.

As annuity products in the US, VAs are regulated by state insurance commissioners. States generally adopt model laws created by the National Association of Insurance Commissioners (NAIC), who suggests requirements regarding capital, surplus, and monitoring. In addition, VAs are also governed at the federal level by the Securities and Exchange Commission (SEC) and the Financial Industry Regulatory Authority (FINRA) due to their security-like features. As part of their regulatory efforts, the SEC requires VA providers to file new product prospectus, which can be accessed publicly via the SEC EDGAR (Electronic Data Gathering, Analysis, and Retrieval) system.[2]

2.2 Dataset and Variable Construction

We rely on the commercial database *Morningstar Annuity Intelligence* (MAI), which gathers VA information directly from insurers. The information is still text-based similarly to the VA prospectus, but it is sufficiently structured for us to automate the data collection process using natural language processing techniques. We cross-checked this data set with the SEC EDGAR filings database (N-4 forms), and found that the matched contracts contain the same information.[3] In some instances, we hand-collected missing information in MAI based on the EDGAR filings.

The contract details are generally divided into two parts: plain VAs and add-on benefits. A firm may offer several plain VAs as well as add-on benefits, which are categorized into types of GMBs. Through mix and match, a firm can create many combinations of VA products. We carry out analyses at the VA-plus-benefit level and at the benefit only level. For both plain VAs and benefits, MAI collects not only numerical variables (such as maturity, fees, and conditional returns), but also text descriptions of the key features of the contract (for example, terminal payoff, special conditions, etc.). This textual description is crucial to our analysis as it allows us to measure product complexity.

We initially collect 2,302 plain VA contracts and 22,623 VA plus benefit combinations originating between 1994 and 2017 from the MAI database. We eliminate contracts with missing inception date, benefit description, and benefit charge, as these are crucial to our analysis, resulting in 15,757 observations. Since the contract information was reported by VA providers to Morningstar, and the primary intent is to provide a platform for intermediaries (brokers, dealers, and financial advisors) to view and compare products, we do not see significant selection bias affecting our sample. For our main analyses, we further focus on primary benefit types and exclude uncommon variants as well as bundles of various primary benefit types. This leaves us with 1,286 benefit-only observations and 15,757 VA-plus-benefit combinations.

[2]See `https://www.sec.gov/edgar`.

[3]Not all contracts are matched, as the SEC EDGAR only requires larger insurers to register and report. Also, the number of contracts in the Morningstar data set is a lot higher than the number in the SEC EDGAR filings system.

Contract	Type	Rating	Incept. Yr.	Length	# of Scenarios	Ben. Fee	Tot. Fee
I	GMAB	A+	2003	4,169	27	0.75%	2.15%
II	GMIB	A+	2007	5,884	31	0.80%	2.45%
III	GMWB	A+	2009	2,995	19	0.45%	2.00%
IV	GLWB	A	2012	5,588	28	1.10%	3.00%
V	GMDB	A+	2004	3,319	19	0.35%	1.75%

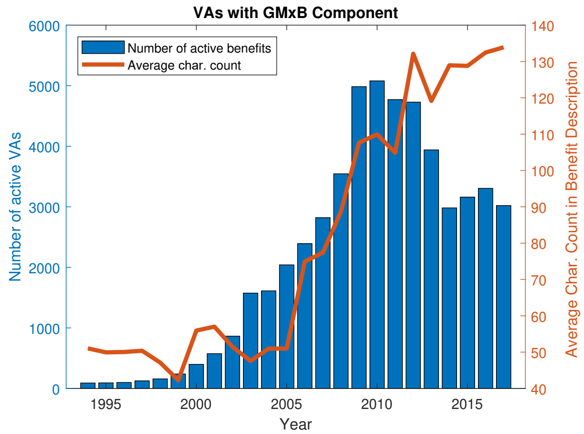
Table 1: Variables used in our analysis for the VA plus GMB products described in Section 2.1. Here inception year ("Incept. Yr."), benefit fee ("Ben. Fee"), and total fee ("Tot. Fee") are directly collected from MAI, whereas the complexity measures number of characters ("Length") and number of scenarios ("# of Scenarios") were collected using text mining techniques.

For each product (VA or benefit), we collect three main characteristics: the inception date, charges, and complexity measures. For VA charges, consumers potentially pay three kinds of fees: plain VA fees, benefit charges, and sub-account fees depending on their enrollments, which are all collected and stored in numerical form in our data set. We adopt two complexity measures following Célérier and Vallée (2017), which we compile at the VA and at the benefit level: (i) number of characters, and (ii) number of scenarios. The former measure is straightforward, as we just scrape text description from MAI and count the total number of characters used in the contract. The intuition is that with lengthier description being used in a VA contract, true complexity (e.g., with regards to the conditions in the payoff profile) as well as perceived complexity (consumers ability to comprehend the contract) will increase. For the latter measure of complexity, we define a bag of keywords, such as "if," "largest," "prior to (a date)," etc. These keywords represent potential sharp changes and generate the multi-dimensional nature in the payoff function of the products. Again, we collect it using text analytics. Both measures can make VAs more difficult to understand, and create room for insurers to advertise misleading conditional returns and shroud risks.

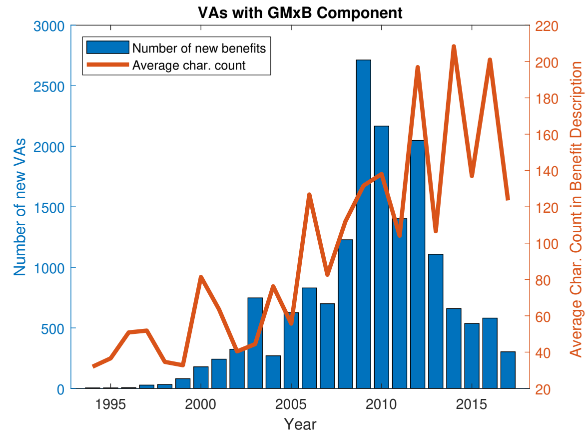
To illustrate the variable definitions, in Table 1 we provide the variables that we will use in our analyses for the five example contracts introduced in the previous section. In particular, we present inception year, our complexity measures, and our charge measures. As is evident, the benefit descriptions in MAI are relatively long and amount to between 3,300 and 5,800 characters. Furthermore, the ordering according to the description length (weakly) aligns with the number of scenarios. Benefit fees are between 35 basis points (bps) for the GMDB and 110 bps for the GLWB, with corresponding total VA fees between 175 and 300 basis points, respectively.

	Summary Statistics for Variable Annuity Contracts with Benefits					
	GMDBs	GMABs	GMIBs	GMWBs	GLWBs	Total
Number of Contracts	3,201	755	2,013	822	5,358	12,872
First Inception	1994	2002	1996	2002	2003	1994
Most Popular Year	1994	2004	2012	2002	2011	-
Median Opening Length	3	2	2	2	2	2
Mean Surrender Duration	4.7	5.4	4.4	4.9	4.6	4.7
Ratings (% of A- or above)	0.93	0.98	0.95	0.98	0.96	0.95
Concentration (HHI)	0.067	0.102	0.48	0.21	0.096	0.076
Length (1000 Characters)	2.7	3.1	5.7	3.4	5.1	4.2
Number of Scenarios	12	16	25	23	27	22
Total Fees (%)	1.65	2.2	2.35	2.1	2.55	2.2
s.d.	(0.62)	(0.46)	(0.49)	(0.42)	(0.45)	(0.61)
Benefit Charges (%)	0.2	0.65	1.05	0.65	1.1	0.875
s.d.	(0.5)	(0.39)	(0.36)	(0.35)	(0.28)	(0.51)

Table 2: Summary Statistics of Variable Annuity contracts with benefits. Row (1): number of new contracts during our observation period (1994-2017) for each benefit category; row (2): the year of each benefit type's first market inception; row (3): the annual popularity is defined as the number of new contracts with specific types of benefit over the number of all new contracts of the year, and the most popular year refers to the year that VA contracts with the specific type of benefit has the highest popularity compared to itself in other years; row (4): the median length of time that the VA contracts are offered in the market; row (5): the average length of duration that is considered as "early surrender"; row (6): share of VA contracts that are issued by firms with AM Best ratings no lower than A-; row (7): the concentration of VA contracts provided by insurers is measured by the Herfindahl-Hirschman Index; row (8)-(9): levels of complexity of the contracts measured by the length of description and number of scenarios; row (10)-(13): total fees and benefit charges of the contracts.



(a) Active Benefits and Average Character Count



(b) New Benefits and Average Character Count

Figure 2: Trend of active and new VA benefits. Each plot provides the number of contracts (ticks on the left-hand y-axis) and the corresponding average complexity (ticks on the right-hand y-axis) for each year.

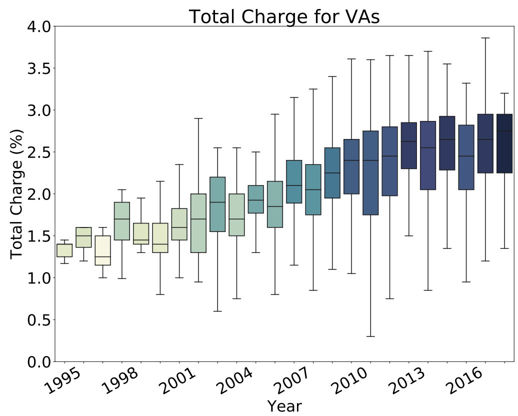
The last column in Table 2 collects summary statistics for our main sample. In line with our example contracts, the mean description length is roughly 4,200 characters with 22 scenarios. The correlation between the two complexity measures is 78.5%. Benefit fees and total fees are substantial with averages of 88 bps and 220 bps, respectively. As is evident, the vast majority of contracts is offered by companies with high rating, and the aggregate market appears fairly competitive with an Herfindahl-Hirschman Index (HHI) of 0.076.[4] On median, a product is only active for two years ("Median Opening Length").

2.3 Aggregate Product Trends

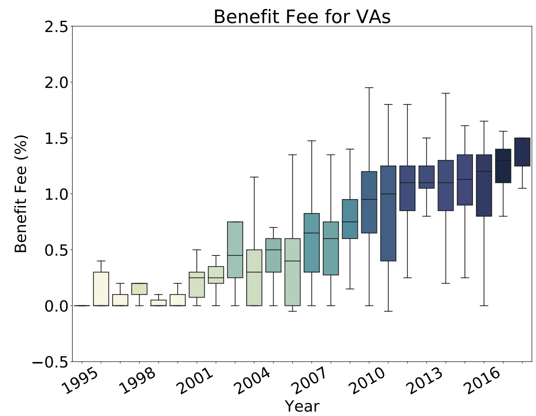
Figure 2 illustrates the evolution of the number of VA products and product complexity for all considered benefits.[5] The number of both active and new VAs increases sharply until 2008, but it exhibits a significant dip around the financial crisis as many insurers left the market or "de-risked," arguably due to supply side effects (Koijen and Yogo, 2016, 2020). Not only were products eliminated, but the development of new VAs has also stagnated since then. The number of new VAs in 2017 is less than 20% of the number in 2008 (see Figure 2b). Along with the increase in the number of offered products, we observe a sharp increase in complexity. The length of the average benefit description offered in 2017 is almost three times the average description length in 1995.

[4]We use the market share of number of supplied VA contracts to calculate the HHI.

[5]Here, complexity is determined at the *benefit* level, whereas the complexity statistics in Table 1 and 2 are at the VA-plus-benefit level. We show VA complexity evolution in Figure 5a.



(a) Total Fees of Variable Annuities



(b) Benefit Charges of Variable Annuities

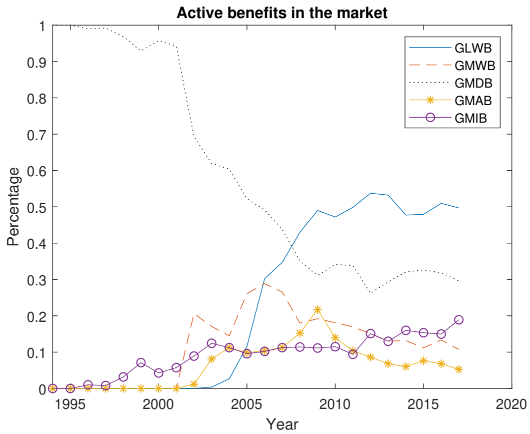
Figure 3: Trend of Variable Annuities total fees and benefit charges across year. Based on all active benefits available in a certain year.

Figure 3 shows the benefit charges and the total fees (including plain VA fee and benefit charge) of active VAs from 1994 to 2017. The total fees show a clear upward trend, indicating that VAs have become more and more expensive. The variance of the prices also increases over time, so it appears that firms offer various kinds of VA contracts.

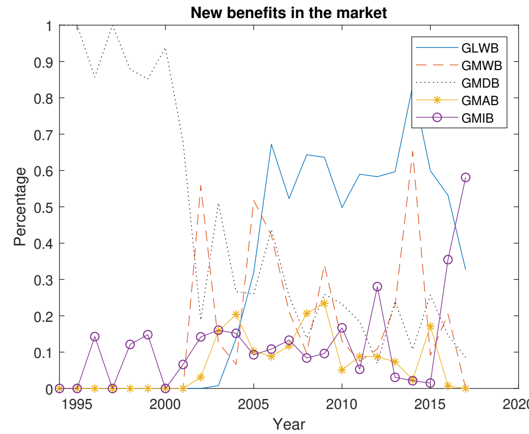
These observations track those in Célérier and Vallée (2017) for retail structured products: Complexity and charges for the contracts both have been increasing. This suggests that their findings, particularly that product innovations primarily serve the purpose of shrouding risk and obfuscating unsophisticated consumers, may also apply in the VA market. However, while there are various analogies between retail structured products and VAs, there are also important differences. First, investors in retail structured products may purchase them for a limited horizon, and many investors may be repeat-customers. This emphasizes the relevance of learning in this market, possibly along the lines of Carlin and Manso (2011). In contrast, VAs are long-term contracts, and many consumers hold a single product only. Most importantly, however, VAs are *retirement* insurance products. Thus, while VA providers may benefit from obfuscating and overcharging consumers for non-essential product features, product innovations may also expand the scope of attainable consumption paths in retirement—providing substantial benefits to consumers. We explore this perspective in what follows.

2.4 Granular Analysis of VA Products

Table 2 also provides aggregate statistics by primary benefit type. While some attributes such as the mean opening length and the mean surrender duration do not differ much between the



(a) Percentage of Benefits in the Market (Active)



(b) Percentage of Benefits in the Market (New)

Figure 4: Trend of active and new VA benefits. We plot the fraction of active products and the fraction of newly introduced products by benefit type.

benefit types, also because these are frequently specified in the plain VA description, others differ substantially. Some product categories are much more concentrated according to the HHI, as some types of benefits are mainly offered by only a few providers. For example, Lincoln National Life has offered 1,381 different GMIBs during our study period, contributing more than half of the total new GMIBs. Importantly for our analysis, the product complexity measures differ substantially across types of benefits: GMDBs are the simplest by design, and require the least characters (and scenarios) for description; GLWBs, being the latest and rather complex benefit, are at the other end of the spectrum. GMIBs also seems to be quite complex, which likely is due to additional information on the optional annuity at the maturity of VA contract. Similarly benefit and total fees vary across the benefit types, apparently tracking the complexity measures.

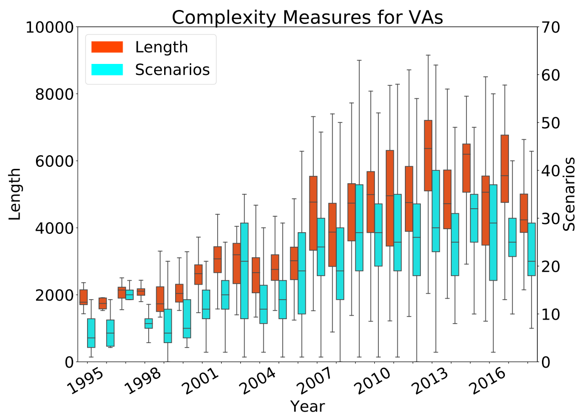
Figure 4a shows the proportion of each major type of benefit category relative to all offered products in the market place by year, where we also include product bundles. Consistent with our description above, GMDBs presented the lion's share of all benefits in the early period of the market, with GMIBs, GMABs, GMWBs, and GLWBs emerging thereafter. Since 2010, GLWBs are the most prominent benefit category making up roughly half of all the products offered. Figure 4b plots the corresponding proportion of each type of benefit in newly introduced contracts every year. Similar to the active benefits case, most new contracts developed in the early years are GMDBs. While GMABs and GMWBs both had been the most popular type of benefit for a period, GLWBs have been the most frequent new benefit for quite a long time. It is worth noting that the sum of the market share seems to exceeds one. This is because we include bundled benefits that belong to multiple types.

In contrast to many new product introductions in each category, the introduction of a new benefit category presents a more "radical" innovation. In particular, by providing a new contingency or bundling certain risks, these new benefit categories reduce market incompleteness and enhance the universe of attainable consumption paths. For instance, a GMDB combines flexible life insurance protection, where the level responds to changes in the investment portfolio. A GMAB provides a long-termed put option (investment protection) that is not available on options markets. Similarly, a GMIB provides protection against joint movements in equity and interest rate markets. As mentioned above, a GLWB bundles protection against states of the world where the policyholder experiences a long lifetime *and* the financial market performs poorly. And a GMWB provides an investment instrument that combines a financial and mortality premium, meanwhile allowing great flexibility with regards to withdrawals—and can thus help consumers manage access to emergency funds such as in the case of unemployment.

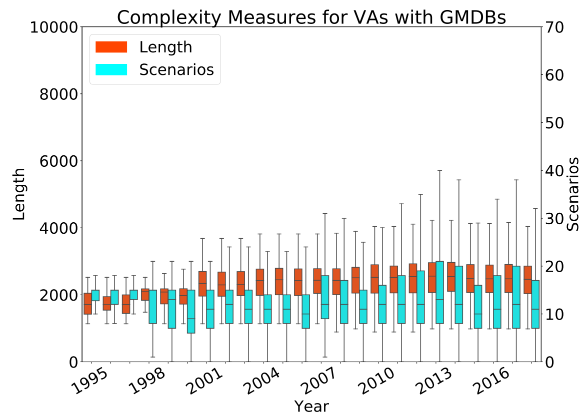
Analyzing product trends within each major product category, a different image emerges. Figure 5 shows the number of characters and scenarios used to describe VA contracts. While in the first panel we provide the aggregate trend, the following five panels show the changes of character counts for VAs with specific benefits, i.e. VAs with GMDB, GMAB, GMIB, GMWB, and GLWB. Comparing these figures, we find that (i) VAs with GMIBs and GLWBs seem to need significantly more words to describe, in line with the aggregate statistics, and (ii) for new VAs with a specific type of benefit, the character count seems to stay low for a few years after this type's market inception, increase for a few years, and finally stay at a higher level. In most cases, the within type variance for character count also increases with time. These patterns persist with our alternative "number of scenarios" complexity measure. Hence, the increase in aggregate product complexity appears to be the result of an aggregation of effects (i) and (ii). This points to an important distinction of financial innovation with regards to new product categories and innovations within each category.

Figure 6 illustrates the price measures (plain VA fee and benefit charge) charged for VAs with benefits in the market. A general increasing trend in the total fee as well as its variance can be observed in Figure 6a, which includes all types of benefits. Again, the following panels show price measures of VAs with a specific type of benefit. We can see that total fees for VAs with different types of benefits do not exhibit substantial differences. There is an upward trend for all types, although the intensity differs: VAs with GMABs, GMIBs, and GMWBs have higher total fees as time passes, while VAs with GMDBs and GLWBs do not change much. Similar observations emerge where we plot the benefit fee. One distinctive feature, particularly pronounced for GMWBs and GLWBs, is that the fees for newly introduced benefits seem high initially but then decrease.

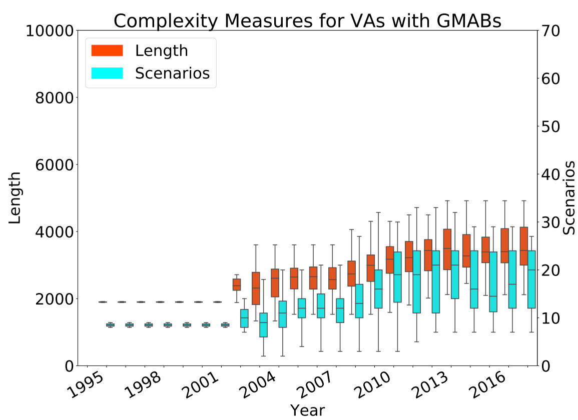
The next section aims at rationalizing these observations in the context of a model for product complexity.



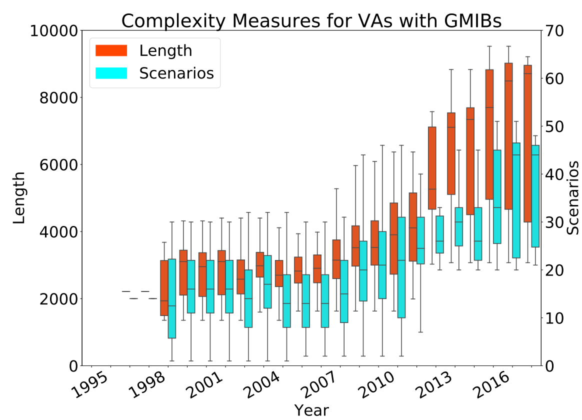
(a) Complexity Measures of VAs



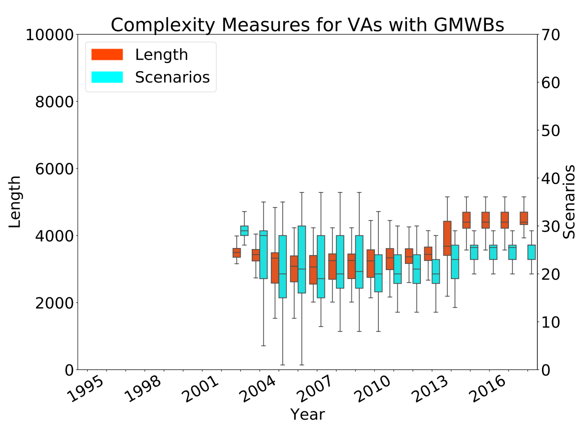
(b) Complexity Measures of VAs with GMDBs



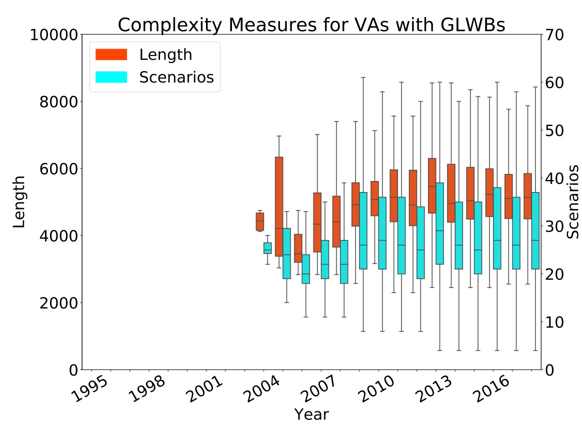
(c) Complexity Measures of VAs with GMABs



(d) Complexity Measures of VAs with GMIBs

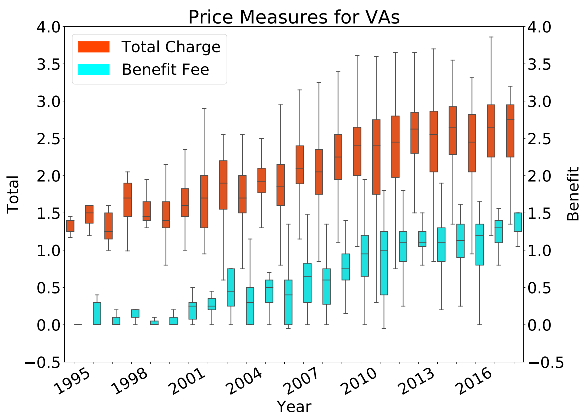


(e) Complexity Measures of VAs with GMWBs

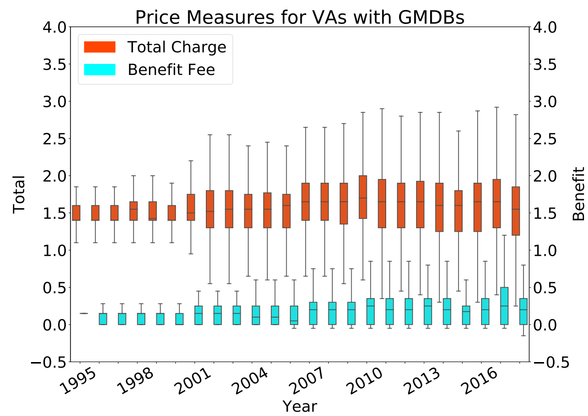


(f) Complexity Measures of VAs with GLWBs

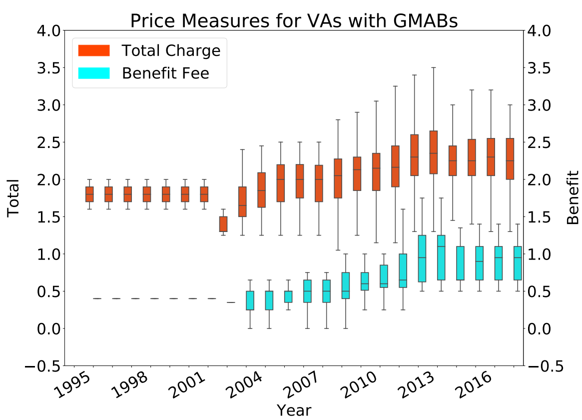
Figure 5: Complexity Measures for VAs with Benefits



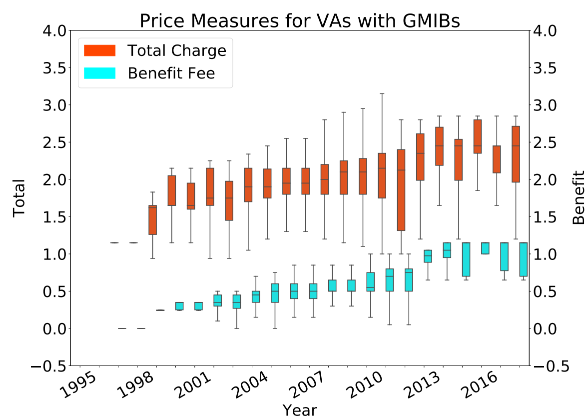
(a) Price Measures of VAs



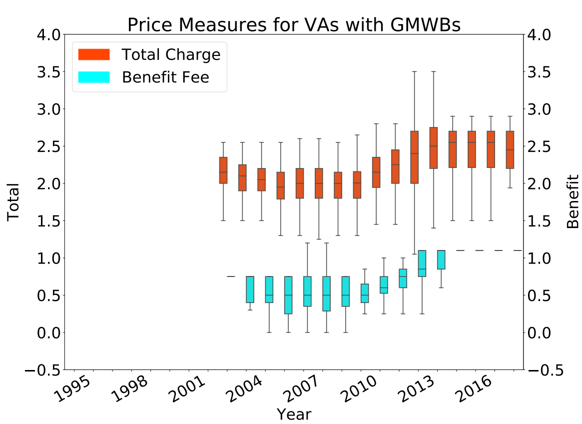
(b) Price Measures of VAs with GMDBs



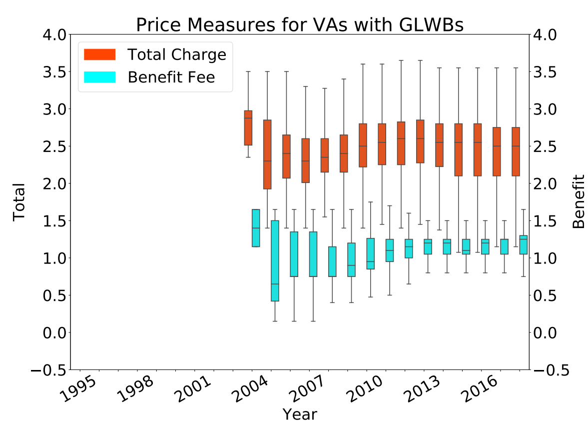
(c) Price Measures of VAs with GMABs



(d) Price Measures of VAs with GMIBs



(e) Price Measures of VAs with GMWBs



(f) Price Measures of VAs with GLWBs

Figure 6: Price Measures for VAs with Benefits

3 Virtuous and Obfuscating Product Innovation

The previous section illustrates a recurring pattern in each product category after "major" innovations of introducing a new type of benefit. In this section, we first introduce a model in which product design can be driven by different motives. We then discuss how the results align with the observed patterns in the VA market.

3.1 An Extended Carlin (2009) Model

Carlin (2009) presents a model for strategic price complexity in retail financial markets. As an important feature of his model, as competition increases, firms tend to offer more complex products although the value to consumers remains constant. We introduce an extension of the model for product complexity from Carlin (2009) where firms can additionally engage in "virtuous" product innovation.

As in his model, we assume that there are $N + 1$ homogeneous firms in the market, indexed by $j \in \{1, ..., n + 1\}$. They all have the technology to produce the default version of a good, and may participate in innovating an alternate product version with costly effort e_j. We call this type of innovation "virtuous" as it caters to consumers' valuations. The firms face zero cost to produce both the default and the alternative version—if the innovation is successful—of the goods, and choose product prices and levels of complexity (p_j, k_j) simultaneously. There is a unit mass of consumers in the market. They are either type I or II, at equal proportion, and their valuations of the two versions of the goods v is described as follows:

	Default	Alternative
I	1	0
II	0	1

Hence, engaging in financial innovation caters to type II consumers, who (only) value the new product. Extensions where both consumers get some value out of both products are possible but complicate the analysis.

Depending on the complexity levels of all products offered in the market, consumers are divided into two groups: sophisticated consumers (a portion of μ) and unsophisticated consumers $(1 - \mu)$. Sophisticated consumers know their own types and are fully aware of prices in the market. They choose the good that provides the highest utility for them. In contrast, unsophisticated consumers—not knowing their own types nor the product prices—choose random goods to purchase. There is no relationship between preference type and sophistication.

The two-stage innovation game proceeds as follows. In the first stage, firms choose their levels of effort e_j to develop the alternative version of products. One—and only one—among them will succeed. Let P_j denotes the probability of firm j being the successful innovator, which depends on the effort put in by said firm and its competitors:

$$P_j = \frac{e_j}{\sum_i e_i}, \qquad j \in \{1, 2, ..., n+1\}.$$

In the second stage, the result of the innovation is revealed. Unsuccessful firms choose price and complexity pairs (p_j, k_j) for the default version of products, while the successful firm decides which good to produce. The complexity levels of all products in the market jointly determine the portion of sophisticated consumers:

$$\mu = \Lambda(k_1, k_2, ..., k_{n+1}).$$

Following Carlin (2009), we assume that any firm may lower the portion of sophisticated consumers by increasing their product complexity ($\partial\Lambda/\partial k_j < 0$), and that the change of one firm's complexity does not inherently affect the evaluation difficulty of another firm's product (that is, $\partial\Lambda^2/\partial k_i \partial k_j = 0,\ i \neq j$).

After firms post their offers in the market, consumers choose one to purchase. Unsophisticated consumers choose randomly and receive expected utility, while sophisticated consumers choose to maximize their utility:

$$\begin{aligned} E[U_{unso}] &= \frac{1}{2} - \frac{1}{N+1} \sum_j p_j, \\ U_{so} &= \max_j \{v_j - p_j\}, \qquad v_j \in \{0, 1\}. \end{aligned}$$

Firms choose price and complexity to maximize profits. The profit for firm j is:

$$\max_{\{p_j, k_j\}} \ \pi_j = p_j \times Q_j,$$

with expected demand Q_j. Hence, successful innovators can compete for sophisticated type I consumers, sophisticated type II consumers, and unsophisticated consumers whereas unsuccessful firms are confined to competing for sophisticated type I consumers and unsophisticated consumers, similarly as in Carlin (2009).

In stage one, firms maximize their expected profits by choosing the optimal level of effort to develop new products. Holding other firms' actions fixed, the more effort a firm invests in product development, the more likely it will be the successful innovator and enjoy the reward, defined as the difference in profits. A firm's objective function can thus be written as:

$$\max_{e_j} \left\{ \frac{e_j}{\sum_i e_i} \times \text{Reward} - e_j \right\}.$$

The equilibrium of this price and complexity competition is described by the proposition below:

Proposition 1. *Assume N is sufficiently large. Then there exists a mixed-strategy Nash equilibrium in which firms maximize their expected profits by choosing the optimal level of effort to develop innovation:*

$$e^* = \frac{N}{(N+1)^2} \times \text{Reward},$$

where

$$\text{Reward} = \mathrm{E}[\pi(\text{successful})] - \mathrm{E}[\pi(\text{unsuccessful})].$$

The firm with successful innovation produces the alternative version product, chooses monopolistic price ($p = 1$), *lowest complexity ($k = \underline{k}$), and attracts all type II sophisticated consumers in equilibrium:*

$$\mathrm{E}[\pi(\text{successful})] = \frac{\mathrm{E}[\mu]}{2} \times 1 + (1 - \mathrm{E}[\mu]) \times \frac{1}{N+1},$$

where $\mathrm{E}[\mu]$ *is given in Equation* (A.1) *in the Appendix.*

Unsuccessful firms choose prices according to the distribution $F(p)$, either highest or lowest complexity levels, and compete for type I sophisticated consumers:

$$k(p) = \begin{cases} \underline{k}, & \textit{if } p < \tilde{p}, \\ \bar{k}, & \textit{otherwise}, \end{cases}$$

where:

$$\tilde{p} = F^{-1}\left(1 - \left[\frac{2}{N+1}\right]^{1/(N-1)}\right),$$

$F(p)$ is continuous and strictly increasing in p, and the expected profit $\mathrm{E}[\pi(\text{unsuccessful})]$ *is given in Equation* (A.2) *in the Appendix.*

The proof of Proposition 1 is given in the Appendix. The intuition is as follows. If a firm successfully developed the alternative version of the product, it will choose to offer the alternative products over the default version. This is intuitive since for any price and complexity combination (p, k) chosen for the default product, this firm can offer the same for the alternative version instead. This way, its market share of unsophisticated consumers stays the same, while the share of sophisticated consumers will either be unchanged (if its price is already the lowest in the market) or increase (not the lowest), leading to potential profit without any risk of loss. The firm will also charge the monopolistic price for its new product, since Type II sophisticated consumers will always (weakly) prefer the alternative goods. The firm can attract half of the sophisticated consumers, while only $\frac{1}{N+1}$ of the unsophisticated (these consumers do not know their own type, and always select randomly among the $N + 1$ goods), so it will choose the lowest level of product complexity to have as many sophisticated consumers in the market as possible.

For firms with unsuccessful innovation, they can only compete in the default product market and choose prices from a distribution $F(p)$. The higher the price a firm picks, the more profit it gains from unsophisticated consumers; the lower the price, the more likely it is for them to offer the lowest price in the market and attract all Type I sophisticated consumers. If the price is higher than a threshold $\tilde{p}$, then the profit from unsophisticated consumers dominates the latter, and the firm chooses the highest level of complexity to have more unsophisticated consumers in the market. We call this behavior "obfuscating." If the price is lower than the threshold, the firm chooses the lowest level of complexity to attract more Type I sophisticated consumers.

The reward for innovation success reflects in the difference between the expected profits. Combining this with the lottery-like likelihood of being the successful innovator, firms engage in a Tullock's game with N+1 players in stage one (Tullock, 1980).

It is worth noting that while $\tilde{p}$ is decreasing in N and therefore aggregate product complexity increases in competition, the relation between competition and financial literacy depends on the form of Λ. As Carlin shows in his paper that $\partial\mu/\partial N$ can be positive or negative. As a consequence, the sign of $\partial e^*/\partial N$ is unclear, meaning we cannot make a conclusive statement on whether innovation effort decreases as competition intensifies. However, we know the effort will eventually go to zero as the market approaches perfect competition, since the reward is bounded.

3.2 Discussion and Relevance for VAs

The extended model exhibits several properties that are in line with our descriptive analysis from the previous section. When a new product is first introduced into the market, the successful innovator chooses a low level of complexity to advertise the product to consumers who will benefit from the product. Hence, product complexity of a specific type of benefit is low at first, then increases as the number of the same type benefits goes up due to competition.

The successful innovator charges a high price for the new product. This innovation is nonetheless "virtuous" in the same sense as introducing a new benefit type in the VA market is virtuous. While there may be a high charge at first, in the long run the types of consumers that value the newly introduced product will be better served. After other providers learn of the new benefit type and engage in competition in this new market, the price of the simple product goes down whereas complex products are introduced at a high price.

Of course there are various simplifications in the model. There may not only be a single successful innovator, consumers may be getting value from both products, and indeed a different benefits within one category will yield a different—and not a uniform—valuation. However, the model rationalizes the product level trends, and particularly the differences between complexity *within* and *across* benefit types. We explore the predictions in the context of regression analyses in the next section.

4 Regression Analysis

To study the heterogeneity in product design for VA benefits in both aggregate and type specific VA markets, we explore how benefit complexity and prices differ across benefit types and particularly the time since their inception. We carry out these analyses at the benefit level, as otherwise regression results may be affected by the number of plain VA contracts that the benefits could be added onto. We start with the same broad benefit categories we use in the descriptive analysis in Section 2.4 but then also consider the MAI definition of (twelve) product categories that provide product refinements as an alternative.

In general, we run regressions of the type:

$$\text{Complexity}_i = \beta_0^C + \text{Co. Fixed Effect}_i^C + \beta_{type}^C \,\text{Benefit Type}_i + \beta_X^C \, X_i + \varepsilon_i, \tag{4.1}$$

$$\text{BenefitFee}_i = \beta_0^F + \text{Co. Fixed Effect}_i^F + \beta_{type}^F \,\text{Benefit Type}_i + \beta_X^F \, X_i + \varepsilon_i, \tag{4.2}$$

at the newly introduced benefit level i controlling for company fixed effects and fundamental differences between the benefit types, where we use our complexity and price measures as the dependent variables. We vary the feature set X_i between the different analyses. As we describe in Section 2.2, we work with 1,286 individual benefit introductions.

We test three primary hypotheses that are inspired by the model from the previous section: That product complexity is relatively low for newly introduced benefits (H1); that product complexity is increasing for each benefit types but levels off eventually (H2); and that while price is increasing in complexity, early product introductions—albeit being relatively simple—are offered at a relatively high price (H3). We analyze hypotheses H1 and H2 in the context of our complexity regressions (4.1) while we test hypothesis H3 using the fee regressions (4.2).

4.1 Analyses for Basic GMB Categories

Tables 3 and 4 show the results for our complexity regressions (4.1) when using the benefit description length and the number of scenarios as complexity measures, respectively. Table 5 provides the results for our fee regressions (4.2). The different columns use different sets of independent features X_i. We control for company fixed effects and include benefit dummies in all regressions (omitting fixed effects will yield similar results but the R-squared decreases by about 10%).

Several observations across the regressions are in line with descriptive analyses from Section 2. First, GLWBs are the most complex and the most expensive products, and all living benefits are more complex than the guaranteed death benefit (GMDB, baseline). GMABs are the simplest type of living benefit, but not the cheapest one. This is not surprising as the GMAB will pay in any case if the benefit is in the money, whereas a GMIB only pays upon annuitization and GMWBs/GLWBs

	Product Complexity Measured by Length (1,000 char.)				
	(1)	(2)	(3)	(4)	(5)
Early 5%	-0.322^{***}	-0.3649^{***}	-0.2983^{**}	-0.2389^{*}	-0.188
	(0.112)	(0.107)	(0.125)	(0.133)	(0.141)
InterestRate	-0.002	-0.0347^{**}	-0.0044	-0.0082	-0.0061
	(0.018)	(0.017)	(0.019)	(0.018)	(0.018)
Year	0.0377^{***}	0.0113			
	(0.008)	(0.009)			
Year 0			0.0681	0.0975^{*}	0.0996^{**}
			(0.071)	(0.051)	(0.04)
Year 3			-0.0316		
			(0.073)		
Year 4				-0.0632	
				(0.054)	
Year 5					-0.066
					(0.042)
GMAB	0.2092^{*}	-0.4198	0.5131^{***}	0.527^{***}	0.5456^{***}
	(0.107)	(0.364)	(0.125)	(0.125)	(0.126)
GMIB	1.2681^{***}	-1.3976^{***}	1.3406^{***}	1.3357^{***}	1.3324^{***}
	(0.087)	(0.249)	(0.089)	(0.089)	(0.089)
GMWB	0.3612^{***}	-0.4993	0.667^{***}	0.6959^{***}	0.7285^{***}
	(0.112)	(0.456)	(0.132)	(0.135)	(0.138)
GLWB	1.8037^{***}	2.6678^{***}	2.1342^{***}	2.1202^{***}	2.1225^{***}
	(0.06)	(0.238)	(0.082)	(0.082)	(0.08)
GMAB $\times$ Year		0.0424^{*}			
		(0.025)			
GMIB $\times$ Year		0.2026^{***}			
		(0.018)			
GMWB $\times$ Year		0.0704^{*}			
		(0.037)			
GLWB $\times$ Year		-0.0481^{***}			
		(0.014)			
Company FE	Yes	Yes	Yes	Yes	Yes
Observations	1286	1286	1286	1286	1286
Adj. R^2	0.618	0.663	0.618	0.618	0.619

Table 3: Product complexity regression results using description length. Column (1): Basic regression on dummy of earliest 5% innovations, interest rate, time trend, and benefit type dummies; column (2): Regression with interaction terms between benefit types and time trend; column (3)-(5): Basic regression with 3-5 years lagged time trend (Eq. (4.3)). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Product Complexity Measured by Number of Scenarios				
	(1)	(2)	(3)	(4)	(5)
Early 5%	-2.7666^{***}	-3.4691^{***}	-2.5241^{**}	-2.1367^{*}	-1.4959
	(1.014)	(1.014)	(1.127)	(1.197)	(1.272)
InterestRate	0.4752^{***}	0.364^{**}	0.4509^{***}	0.4283^{***}	0.4361^{***}
	(0.16)	(0.16)	(0.167)	(0.167)	(0.162)
Year	0.251^{***}	0.281^{***}			
	(0.073)	(0.085)			
Year 0			0.5625	0.7048	0.838^{**}
			(0.637)	(0.465)	(0.363)
Year 3			-0.3235		
			(0.657)		
Year 4				-0.4795	
				(0.485)	
Year 5					-0.6265^{*}
					(0.379)
GMAB	4.1278^{***}	1.8224	6.1614^{***}	6.2603^{***}	6.4679^{***}
	(0.969)	(3.452)	(1.125)	(1.13)	(1.14)
GMIB	6.6873^{***}	1.8437	7.1603^{***}	7.1301^{***}	7.0846^{***}
	(0.788)	(2.367)	(0.806)	(0.806)	(0.806)
GMWB	6.4861^{***}	5.3491	8.5389^{***}	8.7465^{***}	9.1196^{***}
	(1.013)	(4.331)	(1.192)	(1.215)	(1.246)
GLWB	12.6763^{***}	23.1241^{***}	14.8479^{***}	14.7641^{***}	14.7432^{***}
	(0.542)	(2.262)	(0.737)	(0.736)	(0.724)
GMAB $\times$ Year		0.1519			
		(0.234)			
GMIB $\times$ Year		0.3802^{**}			
		(0.168)			
GMWB $\times$ Year		0.1123			
		(0.348)			
GLWB $\times$ Year		-0.6277^{***}			
		(0.135)			
Company FE	Yes	Yes	Yes	Yes	Yes
Observations	1286	1286	1286	1286	1286
Adj. R^2	0.516	0.527	0.515	0.516	0.516

Table 4: Product complexity regression results using scenarios. Column (1): Basic regression on dummy of earliest 5% innovations, interest rate time trend, and benefit type dummies; column (2): Regression with interaction terms between benefit types and time trend; column (3)-(5): Basic regression with 3-5 years lagged time trend (Eq. (4.3)). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

only pay upon sufficient withdrawals. The two complexity measures generally yield similar conclusions with the exception of the GMIB coefficients, which is relatively more complex according to the "description length" measure than when using the "number of scenarios" measure. This is potentially due to the description of the guaranteed annuity rates within the income benefits. Columns (1) in the tables show that both complexity and price have markedly increased over time—the coefficient for "Year" is positive and highly significant. Again, this shows the aggregate product trends track observations from the market for retail structured products (Célérier and Vallée, 2017). The results for "InterestRate", measured as the 3-Month Treasury Bill [6], are not consistent between the two complexity measures: while it is mostly insignificant for description length, the coefficients for the number of scenarios are positive. The reason may be dissimilar residual time trends in the complexity measure, as interest rates generally decreased (but non-linearly so) over the observation period.

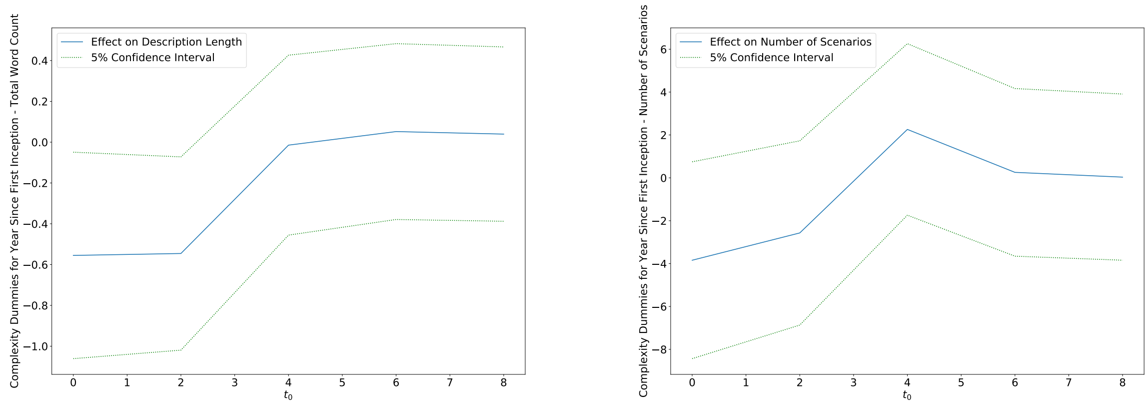
To test our hypothesis H1 for a low complexity level for newly introduced benefits, we include a dummy variable for the first five percent of products of a newly introduced benefit type. Columns (1) in Tables 3 and 4 show the corresponding coefficients ("Early 5%"). As is evident, in line with our hypothesis, we obtain negative and highly significant coefficient. This observation also persists if we include more refined or benefit-specific time trends, the results for which are shown in the following columns.

To analyze how complexity evolves over time after introducing a new benefit, and particularly to test our hypothesis H2 of increasing but stagnating complexity at the benefit level, we first introduce benefit-specific time trends in the regressions (Columns (2) in Tables 3 and 4). For the GMAB, GMIB, and GMWB the benefit dummies decrease, and we obtain positive and mildly significant benefit-specific time trends—in line with hypothesis H2. However, the results go in the opposite direction for the GLWB, which was introduced in the early 2000s. One possible explanation for this exception is the 2008-2009 financial crisis and the associated "de-risking" of VA benefits.

Given such idiosyncrasies, we analyze the product cycle across the benefit types. In Figure 7, we show dummies for each two-year period following the introduction of a new benefit, including 95% point-wise confidence intervals, when using the description length as the complexity measure in the left-hand panel and when using the number of scenarios as the complexity measure in the right-hand panel. We observe that the products offered in the early years are relatively simple although complexity increases until about year four after the introduction, stagnating afterwards. This pattern is in line with hypothesis H2 predicted by our theoretical model.

Regression analyses confirm this pattern. To capture a temporary pattern, we introduce two trend variables, one starting on the first inception date of each benefit and a second lagging x years

[6] See https://fred.stlouisfed.org/series/TB3MS.



(a) Dummy coefficients, description length

(b) Dummy coefficients, number of scenarios

Figure 7: Coefficients for dummy variables for each two year period after the inception of a new benefit in the complexity regressions, using description length and number of scenarios as the complexity measures, including 95% point-wise confidence intervals.

behind. Formally, denote by t_0 the number of years between each product's first inception year and the earliest inception year of the first product of the same type. And denote by t_x the non-negative part of t_0 lagging x years:

$$
\begin{aligned}
t_{0i} &= \text{Inception}_i - \min_{\{type_j = type_i\}} \text{Inception}_j, \\
t_{xi} &= \max\{t_{0i} - x, 0\}.
\end{aligned}
\tag{4.3}
$$

Columns (3) to (5) in Tables 3 and 4 show the regression result when including t_{0i} and t_{xi} in the feature set for choices of x ranging from 3 to 5 ("Year x"). While only mildly significant, the two coefficients generally have opposing signs, the first being positive and the coefficient for the lagged variable being negative, with similar magnitudes essentially offsetting each other after the five year time frame. Hence, the resulting pattern is similar to the payoff profile of a collar, increasing linearly and then leveling off, which again is in line with hypothesis H2.

To test hypothesis H3 of product price increasing in complexity and of an extra premium for early product introductions, we turn to our fee regressions (4.2) with the results displayed in Table 5. One caveat here is that financial engineering costs of a certain benefit not only depend on its complexity, but also on the level of generosity, which is not directly captured in our regressions. For instance, two benefits could be almost identical but one could offer a substantially higher percentage guaranteed maturity benefit than the other, leading to a much higher fee. While this does not yield obvious biases, this effect likely inflates variation.

We include both complexity measures in the regression as independent variables, and the coefficient for "Length" is positive and significant while the coefficient for "# of Scenarios" is in-

	Benefit Charges of Variable Annuities			
	(1)	(2)	(3)	(4)
Early 5%	0.0184	0.0562		
	(0.058)	(0.058)		
First			0.1455	0.2254*
			(0.126)	(0.127)
InterestRate	−0.0172*	−0.0195**	−0.0156*	−0.0167*
	(0.009)	(0.009)	(0.009)	(0.009)
Year	0.0297***	0.0188***	0.0305***	0.0194***
	(0.004)	(0.005)	(0.004)	(0.005)
Length	0.121***	0.1174***	0.121***	0.1167***
	(0.02)	(0.022)	(0.02)	(0.022)
# of Scenarios	−0.0005	0.0004	−0.0006	0.0002
	(0.002)	(0.002)	(0.002)	(0.002)
GMAB	0.2579***	−0.404**	0.2539***	−0.4539**
	(0.055)	(0.197)	(0.055)	(0.199)
GMIB	0.2211***	0.0743	0.2218***	0.0784
	(0.048)	(0.139)	(0.048)	(0.139)
GMWB	0.1667***	−0.3425	0.1634***	−0.3835
	(0.058)	(0.247)	(0.058)	(0.248)
GLWB	0.3922***	−0.0905	0.3921***	−0.0656
	(0.04)	(0.135)	(0.04)	(0.132)
GMAB × Year		0.0469***		0.0501***
		(0.013)		(0.013)
GMIB × Year		0.0104		0.0103
		(0.01)		(0.01)
GMWB × Year		0.0404**		0.0434**
		(0.02)		(0.02)
GLWB × Year		0.0302***		0.029***
		(0.008)		(0.008)
Company FE	Yes	Yes	Yes	Yes
Observations	1286	1286	1286	1286
Adj. R^2	0.464	0.473	0.464	0.474

Table 5: Variable annuity benefit charge regression results. Column (1): Basic regression on dummy of earliest 5% innovations, interest rate, time trend, two complexity measures, and benefit type dummies; column (2): Regression with interaction terms between benefit types and time trend; column (3)-(4): Regression results with dummy of first inception instead. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

significant. However, we obtain a positive and significant coefficient when only including a single complexity measure. Therefore, our regressions strongly support the idea that the fee is increasing in complexity. Even when controlling for complexity, a positive time trend persists—the coefficients for "Year" and also the benefit-specific time trends are positive (now also for the GLWB). This is potentially due to supply-side aspects, particularly in the aftermath of the financial crisis (Koijen and Yogo, 2016).

We also include a dummy variable for the first five percent of products of a newly introduced benefit type ("Early 5%"), in analogy to the complexity regressions. While the corresponding coefficients come back positive—in line with hypothesis H3 that there is an extra premium for early product introductions—they are not significant. One potential explanation is that the first 5% comprise too many benefits, and only the very first introductions are able to reap the novelty premium. Therefore, instead of using a dummy for the first 5% of introduced benefits, we use a dummy for only the products that were introduced in the first year a certain benefit was available ("First"). In this case, we still obtain positive coefficients and now they are mildly significant. Thus, our regressions provide at least some support for hypothesis H3.

4.2 Analyses for MAI Rider Categories

We rerun our analyses for the product categories defined in MAI. MAI distinguishes 12 different types of VA riders, which include some of our basic benefit types but also several refinements. A list of the benefit types as well as their mapping to our basic benefit categories from the previous section is provided in Table 6. Since the product database MAI distinguishes them as distinct riders, we interpret their inception as *major* "virtuous" innovations and following innovations within these categories as "obfuscating."

We run complexity and fee regressions (4.1) and (4.2) in direct analogy to the previous subsection. The results are displayed in Table 7 for product complexity as measured by description length as the dependent variable, and in Table 8 when using the benefit fee charge as the dependent variable. Again, there are differences between the benefits, with "Lifetime GMWB" (Type 8) corresponding to a GLWB being among the most complex and expensive riders, and the "Account Value only Death Benefit" included at baseline being the least complex and the cheapest guarantee. As before, per Columns (1) in the tables, aggregate complexity and fees are increasing over time when not allowing for product-specific time trends. Product-specific time and fee trends (Columns (2)) are again mostly positive, even for the GLWB, but not all are significant.

The results in view of our three hypotheses are qualitatively identical to the coarser benefit categories from the previous subsection. The "Early 5%" coefficient in the basic complexity regressions from Table 7 are negative and significant, indicating that product complexity is relatively low for newly introduced benefits (H1). The benefit-specific time trends are mostly positive; and

Name	Variable	Index	Mapping
Account Value only Death Benefit	- (Baseline)	-	GMDB
Add-on benefit for i4LIFE	Type 1	1	GMIB
Earnings Enhancement Benefit	Type 2	2	GMDB
GMAB	Type 3	3	GMAB
GMIB	Type 4	4	GMIB
GMWB	Type 5	5	GMWB
Highest Anniversary Value and Return of Premium Death Benefit	Type 6	6	GMDB
Hybrid Income Guarantee	Type 7	7	GMIB
Lifetime GMWB	Type 8	8	GLWB
Percentage Increase and Return of Premium Death Benefit	Type 9	9	GMDB
Percentage Increase, Highest Anniversary Value and Return of Premium Death Benefit	Type 10	10	GMDB
Return of Premium Death Benefit	Type 11	11	GMDB

Table 6: MAI product categories.

when including the time trend specification from Equation (4.3) using the variables "Year 0" and "Year 3"/"Year 4"/"Year 5" in the complexity regressions, we again obtain offsetting results yielding an increasing but then leveling-off pattern of complexity (H2). From Table 8, the benefit fee is increasing in complexity ("Length") and, via the "First" dummy variable, there seems to be an extra premium for very early product introductions (H3).

5 Conclusion

We analyze product innovation and drivers of product complexity in the VA market. On the theoretical side, we extend Carlin's model for product complexity by allowing for "virtuous" product innovation, which in the VA market represent product introductions that reduce market incompleteness. In equilibrium, "virtuous" and "obfuscating" firm behavior co-exist. Firms engage in costly virtuous innovation in hope to succeed and enjoy monopolistic market power, and those who fail will participate and increase complexity to attract a larger share of unsophisticated consumers.

On the empirical side, we use VA product level data between 1994 to 2017 to assess drives for financial innovation in the VA market. Using text mining techniques, we obtain measures of product complexity and prices. We find support for the theoretical model's predictions. In particular, while product complexity in aggregate has been increasing, we find that this appears to be a result of trends within categories of benefits. Hence, while type-specific increases in complexity likely are a result of obfuscating behavior, the introduction of new benefit categories—while complicating the product landscape—are driven by the potential profitability of "virtuous" innovation.

These findings are in contrast to other related markets, and they have repercussions for con-

	MAI Product Complexity Measured by Length (1,000 char.)				
	(1)	(2)	(3)	(4)	(5)
Early 5%	-0.1998^{***}	-0.2364^{**}	-0.176	-0.1203	-0.0746
	(0.102)	(0.096)	(0.112)	(0.118)	(0.123)
InterestRate	-0.0003	-0.0297^{*}	-0.0029	-0.0067	-0.0045
	(0.016)	(0.015)	(0.017)	(0.017)	(0.016)
Year	0.0443^{***}	-0.0342			
	(0.008)	(0.04)			
Year 0			0.0772	0.1057^{**}	0.107^{***}
			(0.064)	(0.047)	(0.036)
Year 3			-0.0342		
			(0.066)		
Year 4				-0.0651	
				(0.049)	
Year 5					-0.0671^{*}
					(0.038)
Type1	1.6103^{***}	3.013	1.6966^{***}	1.6897^{***}	1.6877^{***}
	(0.367)	(1.963)	(0.367)	(0.367)	(0.366)
Type2	1.1009^{***}	0.2749	1.0974^{***}	1.0936^{***}	1.0921^{***}
	(0.206)	(0.735)	(0.206)	(0.206)	(0.206)
Type3	1.2658^{***}	-0.171	1.6217^{***}	1.6345^{***}	1.6515^{***}
	(0.185)	(0.745)	(0.201)	(0.201)	(0.202)
Type4	2.1534^{***}	-1.6462^{**}	2.2378^{***}	2.2319^{***}	2.2268^{***}
	(0.18)	(0.712)	(0.183)	(0.183)	(0.183)
Type5	1.5065^{***}	-0.2708	1.8644^{***}	1.8926^{***}	1.9234^{***}
	(0.19)	(0.785)	(0.208)	(0.209)	(0.211)
Type6	1.0585^{***}	0.1623	1.0568^{***}	1.0544^{***}	1.0528^{***}
	(0.174)	(0.696)	(0.174)	(0.174)	(0.174)
Type7	3.9464^{***}	2.0251^{*}	4.0344^{***}	4.0324^{***}	4.0349^{***}
	(0.25)	(1.165)	(0.251)	(0.25)	(0.25)
Type8	2.8581^{***}	2.7808^{***}	3.2469^{***}	3.2323^{***}	3.2341^{***}
	(0.162)	(0.699)	(0.179)	(0.179)	(0.178)
Type9	1.3572^{***}	0.7396	1.3588^{***}	1.3614^{***}	1.3573^{***}
	(0.215)	(0.73)	(0.216)	(0.215)	(0.215)
Type10	1.8201^{***}	-0.0454	1.818^{***}	1.8149^{***}	1.8119^{***}
	(0.181)	(0.712)	(0.181)	(0.181)	(0.181)
Type11	0.7876^{**}	-0.158	0.7884^{***}	0.7901^{***}	0.7917^{***}
	(0.173)	(0.697)	(0.173)	(0.173)	(0.173)
Type1*Year		-0.0666			
		(0.102)			
Type2*Year		0.0396			
		(0.045)			
Type3*Year		0.0871^{*}			
		(0.045)			
Type4*Year		0.2863^{***}			
		(0.043)			
Type5*Year		0.1223^{**}			
		(0.051)			
Type6*Year		0.049			
		(0.041)			
Type7*Year		0.1069			
		(0.065)			
Type8*Year		0.0033			
		(0.041)			
Type9*Year		0.0159			
		(0.046)			
Type10*Year		0.1266^{***}			
		(0.043)			
Type11*Year		0.0531			
		(0.041)			
Company FE	Yes	Yes	Yes	Yes	Yes
Observations	1286	1286	1286	1286	1286
$Adj.R^2$	0.679	0.724	0.679	0.679	0.679

Table 7: Product complexity regression results for MAI categories measured by description length. Column (1): Basic regression on dummy of earliest 5% innovations, interest rate time trend, and benefit type dummies; column (2): Regression with interaction terms between benefit types and time trend; column (3)-(5): Basic regression with 3-5 years lagged time trend (Eq. (4.3)). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	MAI Benefit Charges of Variable Annuities			
	(1)	(2)	(3)	(4)
Early 5%	0.0218	0.0576		
	(0.056)	(0.056)		
First			0.1465	0.1896*
			(0.102)	(0.103)
InterestRate	−0.0161*	−0.0188**	−0.0144	−0.0165*
	(0.009)	(0.009)	(0.009)	(0.009)
Year	0.0333***	−0.0095	0.0344***	−0.0069
	(0.004)	(0.023)	(0.004)	(0.023)
Length	0.0931***	0.0891***	0.0928***	0.088***
	(0.023)	(0.024)	(0.022)	(0.023)
# of Scenarios	−0.0008	0.0004	−0.0009	0.0003
	(0.002)	(0.002)	(0.002)	(0.002)
Type1	0.933***	−1.187	0.9109***	−1.3886
	(0.203)	(1.147)	(0.203)	(1.154)
Type2	0.5524***	0.4522	0.5593***	0.4771
	(0.115)	(0.429)	(0.114)	(0.428)
Type3	0.6039***	−0.6014	0.6087***	−0.5982
	(0.104)	(0.435)	(0.104)	(0.434)
Type4	0.5741***	−0.0208	0.5842***	0.0216
	(0.105)	(0.417)	(0.105)	(0.417)
Type5	0.5401***	−0.5506	0.5464***	−0.5412
	(0.109)	(0.459)	(0.108)	(0.458)
Type6	0.2776***	−0.1959	0.2869***	−0.1527
	(0.097)	(0.406)	(0.097)	(0.406)
Type7	0.7047***	−0.0104	0.7027***	−0.0637
	(0.154)	(0.68)	(0.154)	(0.68)
Type8	0.7787***	−0.2356	0.7867***	−0.165
	(0.1)	(0.41)	(0.1)	(0.412)
Type9	0.4496***	−0.1953	0.4545***	−0.1769
	(0.12)	(0.426)	(0.12)	(0.426)
Type10	0.5181***	−0.2547	0.5269***	−0.2135
	(0.104)	(0.415)	(0.104)	(0.416)
Type11	0.2787***	−0.4667	0.2852***	−0.4349
	(0.096)	(0.407)	(0.096)	(0.407)
Type1*Year		0.1147*		0.1235*
		(0.059)		(0.06)
Type2*Year		−0.0089		−0.01
		(0.026)		(0.026)
Type3*Year		0.0774***		0.0778***
		(0.026)		(0.026)
Type4*Year		0.0325		0.0305
		(0.026)		(0.026)
Type5*Year		0.074**		0.0742**
		(0.03)		(0.03)
Type6*Year		0.0241		0.0219
		(0.024)		(0.024)
Type7*Year		0.0425		0.0452
		(0.038)		(0.038)
Type8*Year		0.06**		0.0564**
		(0.024)		(0.024)
Type9*Year		0.0378		0.0374
		(0.027)		(0.027)
Type10*Year		0.0476*		0.0455*
		(0.025)		(0.025)
Type11*Year		0.0454*		0.0438*
		(0.024)		(0.024)
Company FE	Yes	Yes	Yes	Yes
Observations	1286	1286	1286	1286
Adj. R^2	0.481	0.495	0.482	0.496

Table 8: Variable annuity benefit charge regression results for MAI categories. Column (1): Basic regression on dummy of earliest 5% innovations, interest rate, time trend, two complexity measures, and benefit type dummies; column (2): Regression with interaction terms between benefit types and time trend; column (3)-(4): Regression results with dummy of first inception instead. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

sumers, firms, and policy. For consumers, a more complex product may not necessarily be worse, but the purchase of a VA with an intricate rider should be assessed carefully. In particular, articulating the risk one is attempting to protect and a (self-)assessment how much one is willing to spend are key considerations.

For providers, understanding customers' needs is crucial when engaging in virtuous innovation. In particular, it is of key importance to assess risks that cannot be covered within the existing universe of retirement products and how large the corresponding market is. An interesting question, which we leave for future research, is what companies are likely to engage in virtuous innovation. One possible hypothesis is large providers with large market shares, steady research teams, and multiple distribution channels may be particularly engaged.

The co-existence of virtuous and obfuscating firm behavior makes it difficult for policy to respond. While regulators can facilitate contract standardization, making it easier for consumers to understand and compare products, this may stifle virtuous product innovation, with ultimately negative welfare consequences.

Appendix

A Proofs and Technical Material

Proof of Proposition 1. We proceed by backward induction.

The firm with successful innovation chooses monopolistic price $p_j = 1$. This is because (i) assuming unsophisticated consumers know the maximum utility they can get from products, the firm has no incentive to choose $p_j > 1$, as this will cause it to lose all consumers; and (ii) the firm can never attract type I sophisticated consumers with the alternative version, so choosing $p_j < 1$ will not increase its demand, leading to less profit. Then, it is clear that the firm will choose the lowest complexity $\underline{k}$. The firm wants more sophisticated consumers in the market, since for every unit unsophisticated consumers becoming sophisticated due to the reduction of product complexity, the firm loses $\frac{1}{N+1}$ market share of unsophisticated consumers and gain $\frac{1}{2}$ market share of sophisticated consumers.

Given that firms with unsuccessful innovation compete only for type I sophisticated consumers, they are in a similar situation as in Carlin (2009), with several exceptions: (i) N firms with unsuccessful innovation compete for default version market share; (ii) offering the lowest price only attracts half of the "experts" (type I); and (iii) they face a modified complexity functional where the successful firms choice is set to $\underline{k}$. Nevertheless, we can follow the same arguments as in Proposition 1 of his paper to derive the optimal price/complexity mix. In particular, let F denote the price distribution for the (symmetric) firms. Then firm j's profit is:

$$\pi_j = p_j \frac{1}{2} \mathrm{E}[\mu|p_j, k_j] \underbrace{[1 - F(p_j)]^{N-1}}_{\mathrm{P}(p_i > p_j \, \forall i)} + \frac{1}{N+1} (1 - \mathrm{E}[\mu|p_j, k_j])$$

so that:

$$\frac{\partial \pi_j}{\partial k_j} = p_j \frac{\partial \mathrm{E}[\mu|p_j, k_j]}{\partial k_j} \left\{ \frac{1}{2} [1 - F(p_j)]^{N-1} - \frac{1}{N+1} \right\}$$

where $\frac{\partial \mathrm{E}[\mu|p_j,k_j]}{\partial k_j} < 0$ due to the assumptions on Λ. Thus, if:

$$\frac{1}{2} [1 - F(p_j)]^{N-1} > \frac{1}{N+1} \Leftrightarrow p < \tilde{p},$$

the optimal choice $k_j = \underline{k}$, and similarly $k_j = \bar{k}$ for $p > \tilde{p}$

Given the optimal actions for both successful and unsuccessful innovators in stage two, we can solve for their expected profits. The profit for the firm with successful innovation is straightforward:

$$\mathrm{E}[\pi_j(\text{successful})] = 1 \times Q_j(\text{successful}) = \frac{1}{N+1}\mathrm{E}[\mu] + \frac{1}{2}\mathrm{E}[\mu] = \frac{1}{N+1} + \frac{N-1}{2(N+1)}\mathrm{E}[\mu]$$

where:

$$\mathrm{E}[\mu] = \sum_{m=0}^{N} \frac{N!}{m!(N-m)!} \lambda(m) \left(\left[\frac{2}{N+1} \right]^{1/(N-1)} \right)^m \left(1 - \left[\frac{2}{N+1} \right]^{1/(N-1)} \right)^{N-m} \tag{A.1}$$

with:

$$\lambda(m) = \Lambda(\underline{k}, \underbrace{\underline{k}, \ \underline{k}, \ ..., \ \underline{k}}_{\text{m}}, \underbrace{\bar{k}, \ \bar{k}, \ ..., \ \bar{k}}_{\text{N-m}})$$

The expected profit for the firm with unsuccessful innovation, in turn, is:

$$\begin{aligned}
\mathrm{E}[\pi_j(\text{unsuccessful})] &= \mathrm{E}[p_j \times Q_j] \\
&= \mathrm{E}\left[p_j \times \left(\frac{\mu_{k_j}}{2} + (1 - \mu_{k_j}) \frac{1}{N+1} \right) \right] \\
&= \int \int p_j \times \left(\frac{\mu_{k_j}}{2} \left[1 - F(p_j) \right]^{N-1} + \frac{1 - \mu_{k_j}}{N+1} \right) dF \, d\mathrm{P}_{\mu_{k_j}} \\
&= \frac{1}{N+1} \int_0^1 p_j \, dF \\
&\quad + \int \mu_{\underline{k}} \int_0^{\tilde{p}} p_j \times \left(\frac{[1 - F(p_j)]^{N-1}}{2} - \frac{1}{N+1} \right) dF \, d\mathrm{P}_{\mu_{\underline{k}}} \\
&\quad + \int \mu_{\bar{k}} \int_{\tilde{p}}^1 p_j \times \left(\frac{[1 - F(p_j)]^{N-1}}{2} - \frac{1}{N+1} \right) dF \, d\mathrm{P}_{\mu_{\bar{k}}} \\
&= \frac{1}{N+1} \mathrm{E}[p] + R_1 \times M_u(\bar{k}) + R_2 \times M_u(\underline{k}), \qquad \text{(A.2)}
\end{aligned}$$

where:

$$R_1 = \int_0^{\tilde{p}} p_j \times \left(\frac{[1-F(p_j)]^{N-1}}{2} - \frac{1}{N+1} \right) dF,$$
$$R_2 = \int_{\tilde{p}}^{1} p_j \times \left(\frac{[1-F(p_j)]^{N-1}}{2} - \frac{1}{N+1} \right) dF,$$

$$M_u(x) = \sum_{m=0}^{N-1} \frac{(N-1)!}{m!(N-1-m)!} \lambda(m,x) \left(\left[\frac{2}{N+1} \right]^{1/(N-1)} \right)^m \left(1 - \left[\frac{2}{N+1} \right]^{1/(N-1)} \right)^{N-1-m},$$
$$\lambda(m,x) = \Lambda(\underline{k},\ x,\ \underbrace{\underline{k},\ \underline{k},\ ...,\ \underline{k}}_{\text{m}},\ \underbrace{\bar{k},\ \bar{k},\ ...,\ \bar{k}}_{\text{N-1-m}})$$

Now we have the difference of expected profits between the two, or the reward of innovation success, firms actions in stage one can also be solved. In stage one, firms maximize their expected profits by choosing optimal level of effort to develop innovation, with the objective, probability, and reward of success as:

$$\max_{e_j} \quad \left\{ \frac{e_j}{\sum_i e_i} \times \text{Reward} - e_j \right\},$$
$$\text{Prob} = \frac{e_j}{\sum_i e_i}, \qquad i \in \{1, 2, ..., n+1\},$$
$$\text{Reward} = \text{E}[\pi_j(\text{successful})] - \text{E}[\pi_j(\text{unsuccessful})].$$

This is a Tullock's game with N players, and there is a symmetric Nash equilibrium where

$$e_i^* = \frac{N}{(N+1)^2} \times \text{Reward}$$

To ascertain that unsophisticated consumers will participate in the game, we need to ensure that their expected payoff exceeds the expected price, $\text{E}[p] < \frac{1}{2}$. The existence of such $F(p)$ is not guaranteed for arbitrary Λ. However, as N goes to infinity, $\Lambda^N = 1$ regardless of $k_i's$. Since consumers will always be sophisticated and choose the firm offering the lowest price, competition will drive the price to zero in equilibrium, resulting in $\text{E}[p] = 0 < \frac{1}{2}$ in the limit. Hence, $\text{E}[p] < \frac{1}{2}$ for sufficiently large N.

$\square$

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