ON THE PROPENSITY TO SURRENDER A VARIABLE ANNUITY CONTRACT: AN EMPIRICAL ANALYSIS OF DYNAMIC POLICYHOLDER BEHAVIOR

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ABSTRACT

We empirically analyze surrender behavior for variable annuity contracts using Japanese individual policy data. For traditional life insurance products, surrender behavior is typically explained by the interest rate and the emergency fund hypotheses. For variable annuities, the interest rate hypothesis is not directly applicable. For these products, we expect the value of the financial options and guarantees provided to the policyholder to drive surrender behavior. We define this expectation as the “moneyness hypothesis.” The statistical analysis confirms our moneyness hypothesis: the value of the embedded financial options and guarantees has the largest explanatory power for the surrender rate. The extent to which this finding holds depends on the single premium paid, which we consider a proxy for the policyholder’s financial literacy. Moreover, our data set weakly supports the emergency fund hypothesis for the case of variable annuities.

INTRODUCTION

The policyholders’ option to surrender their policy is an important risk factor for life insurance companies. This importance is reflected by the increasing amount of...
literature addressing this topic over the last decade, further intensified by the development of new regulatory regimes such as Solvency II (see Eling and Kiesenbauer, 2014). For companies that offer variable annuities, understanding surrender behavior is of particular importance because the value of the policyholder’s surrender option heavily depends on the development of the underlying fund and thus on the development of financial markets.

Variable annuities are essentially unit-linked products with guarantees. In contrast to other products, the guarantees are provided by the insurance company that manages the product, and they are separate from the underlying fund and not within it. For variable annuities, surrender assumptions are a substantial pricing factor that can have an impact on the rider fees. Previous studies found evidence that many insurance companies assume irrational surrender behavior for at least some of their policyholders (see, e.g., Milevsky and Salisbury, 2006; Bauer, Kling, and Russ, 2008; Chen, Vetzel, and Forsyth, 2008). Where surrender assumptions are used to reduce the rider fee (or the premium, for the traditional life insurance business), the business is called “lapse supported” (see Dickson, Hardy, and Waters, 2009, p. 259, for more details). If the actual surrender rates deviate from the surrender rates assumed for the valuation, the insurer may face significant economic losses. If the surrender value of a contract is less than the fair value of the contract, lower surrender rates than anticipated lead to insufficient reserves. If the surrender value of a contract exceeds the fair value of the contract, higher surrender rates than anticipated lead to insufficient reserves. During the lifetime of a policy, both situations may occur, so it is important to analyze the surrender behavior in this respect.

According to ING (2011), ING Groep N.V. incurred expenditures of EUR 0.9 billion to EUR 1.1 billion in 2011 for its closed block variable annuity business in the United States due to updated assumptions regarding policyholder behavior and mortality; “the most significant revision was from the adjustments of lapse assumptions.” Also, in third-quarter 2011, Manulife Financial lost CAD 309 million “related to updates to lapses and other policyholder behavior assumptions for segregated fund business” (see Manulife Financial, 2011), while Sun Life Financial reported major losses “which were reflected primarily in the individual life and variable annuity businesses in SLF U.S. Updates to . . . actuarial methods and assumptions . . . reduced net income by $203 million”¹ (see Sun Life Financial, 2011).

In several simulation studies, the importance of dynamic surrender behavior for solvency capital requirements (Kochanski, 2010) and for the effectiveness of hedging (Kling, Ruez, and Russ, 2010) has been shown. Swiss Re (2003) suggests that compared to traditional participating life insurance products, lapse rates will be higher and more volatile for unit-linked policies because policyholders are more sensitive with regard to changes in market conditions and the account value of the underlying fund.

However, to the best of our knowledge, there has been no empirical investigation of dynamic policyholder behavior for variable annuities to date (see Eling and Kochan-

¹Sun Life Financial reports in Canadian dollars.
ski, 2013). This article fills this gap by analyzing surrender behavior for a variable annuity product sold in the Japanese market. The policies contain a guaranteed minimum accumulation benefit (GMAB) that provides a guaranteed minimum payout at the maturity of the policy regardless of the account value and a guaranteed minimum death benefit (GMDB) that promises to pay a certain minimum amount in case of the policyholder’s death.

Prior research developed the “interest rate hypothesis” and the “emergency fund hypothesis” to explain lapses or the surrender of life insurance products. According to the interest rate hypothesis, the market interest rate can be seen as the opportunity cost of owning a life insurance policy. If interest rates go up, premiums for new policies usually fall. Therefore, policyholders might surrender their policy to purchase a new one, offering the same coverage for a lower premium or higher coverage for the same premium. However, policyholders have a low incentive to surrender the policy in times of falling interest rates (see Outreville, 1990; Kuo, Tsai, and Chen, 2003). The emergency fund hypothesis states that policyholders will surrender their life insurance policy when they need the surrender value as an emergency fund, e.g., due to unemployment or expenses for long-term care (see Outreville, 1990; Kuo, Tsai, and Chen, 2003). Several authors tried to find evidence for the interest rate hypothesis or the emergency fund hypothesis for different types of life insurance products and markets (see, e.g., Outreville, 1990; Kuo, Tsai, and Chen, 2003; Kim, 2005; Kiesenbauer, 2012; Russell et al., 2013). Eling and Kiesenbauer (2014), who analyze which policy features determine life insurance lapse in the German market, provide a descriptive and comprehensive overview of empirical studies on life insurance lapses. In their study, they analyze surrender behavior for different product types, including unit-linked contracts, with respect to different product and policyholder characteristics. Their analysis is based on a large data set covering a long observation period provided by a single life insurer. It is the first analysis on this subject that includes the distribution channel as an explanatory variable.

Our analysis is also based on individual policyholder data. While focusing on one product type, we have detailed information about options and guarantees embedded in the policies. Thus, we contribute to the literature on life insurance surrender in two ways. To the best of our knowledge, we conduct the first empirical study on surrender behavior for variable annuity products. Second, we provide empirical evidence for the influence of the value of options and guarantees on surrender behavior for unit-linked contracts. Our analysis also contributes to the more general literature on how

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2In the United States, the demand for variable annuities (and presumably surrender behavior as well) is to a large extent driven by tax considerations. Because this is not the case in Japan, analyzing a product sold in this market allows for a cleaner analysis of policyholder behavior. However, when adopting our results to other markets, it must be considered that institutional factors can drive policyholder behavior.

3For a more detailed description of variable annuities and the guarantees therein, see Brown and Poterba (2006) and Condron (2008).

4In contrast to lapsing, early surrender usually results in a cash payment to the policyholder. Nevertheless, the traditional measurement of lapse rates contains lapse and surrender. In the context of variable annuities, surrender is the correct term.
individuals perceive options embedded in financial contracts. We also find that the surrender rate increases with the attained age of the insured life, which we interpret as evidence for the emergency fund hypothesis. Before staying constant after the first year of the policy, surrender increases with the time that the policy has been in force. Interestingly, the influence of moneyness on the surrender rate depends on the size of the policy. We find that owners of large policies tend to behave more sensitively toward moneyness: compared to owners of small policies and all other things being equal, they have twice as high a probability of surrendering their policy if the guarantees are out of the money. As policy size might to some extent serve as a proxy for wealth and thus also for financial literacy, we interpret this as evidence that financial literacy increases the influence of the value of the embedded options and guarantees on surrender behavior. If the guarantees are in the money, no difference between small and large policies can be found.

The remainder of the article is organized as follows. In the “Dynamic Policyholder Surrender” section, we discuss the specifics of surrender behavior for variable annuities. The “Data” section first provides an overview of the variable annuity market in Japan, before we describe the data set. In the “Hypotheses” section, the hypotheses that we want to test are developed. After introducing our empirical model in the “Method” section, the results are presented and discussed in the “Findings” section. The “Conclusion” section concludes this article.

**Dynamic Policyholder Surrender**

When analyzing surrender behavior for variable annuities, the specifics of these policies need to be considered. The rationale behind the emergency fund hypothesis is also valid for variable annuity policies. However, since variable annuities are unit-linked products, the interest rate hypothesis cannot be directly applied. Kling, Ruez, and Russ (2010) state that surrender behavior for variable annuities can be considered to be optimal “if the policyholder decides to surrender the contract whenever the benefit from discounting the contract . . . exceeds the surrender fees.” For an expected value-maximizing policyholder, this case occurs if the surrender value of the policy exceeds its fair value. The surrender value is defined as the account value less the surrender charge, if any. The fair value of a variable annuity policy containing a GMAB and a GMDB rider as well as a surrender option, seen from the perspective of a policyholder, is determined by the following equation:

$$\text{Fair value} = \text{account value} + \text{present value of the guarantees}$$

$$- \text{expected present value of future guarantee fees}$$

$$+ \text{present value of the surrender option}.$$\(^5\)

\(^5\)To be precise, future surrender fees must be considered in the calculation of the present value of the surrender option. In a more general context, product features such as target levels/knockout features also need to be considered in the calculation of the fair value of the variable annuity policy.
The options and guarantees embedded in the contract are an important component of the fair value of the policy. The GMAB can be seen as the account value plus a European put option on the account value with the guaranteed value as the strike price (see Mahayni and Schneider, 2012). Because the payoff structure of the GMDB is between an American and a European option and is triggered by death, Milevsky and Posner (2001) name it a “Titanic option.” Gatzert (2009) classifies the surrender option as a Bermudan put option on the cash-flow stream of future expected insurance benefits with the surrender value as the strike price. According to Bacinello (2003), it is an American put option. Accordingly, Milevsky and Salisbury (2002) develop a model to value the surrender option for a GMAB/GMDB variable annuity policy by applying American option pricing techniques.

Taking transaction costs, tax considerations, or other regulatory reasons into account, it might be rational for individuals to not surrender their contract although the guarantees are not valuable. For example, favorable taxation rules may be linked to a minimum policy term. This linkage might prevent some policyholders from surrendering (see Kent and Morgan, 2008). Without transaction costs, it would be possible for policyholders to increase the guaranteed value while maintaining the account value by surrendering and instantly repurchasing the policy. In reality, this strategy usually involves transaction costs such as, for example, surrender fees or initial expense loadings. When taking risk preferences into account, one would thus expect to observe heterogeneous surrender behavior for out of the money policies. In a dynamic optimization model, Moenig and Bauer (2011) and Steinorth and Mitchell (2012) analyze the withdrawal behavior of risk-averse policyholders for a variable annuity product with a withdrawal guarantee, focusing on the U.S. market. Moenig and Bauer (2011) identify “value-maximisation as being the key driver. In particular, it does not seem to be the market incompleteness that is responsible for the divergence of actual observations and results from the actuarial literature, which relies on value-maximisation approaches. Rather, it appears to be a matter of perspective: While there, the calculations were carried out from the company’s position, the focus should be on the policyholder’s point of view.” Summing up, the value of the options and the guarantees embedded in the policy should be an important determinant of surrender behavior. We define this conjecture as the “moneyness hypothesis.”

However, prior research has found evidence for clearly irrational and reference-point-dependent behavior for employee stock option exercises (see Heath, Huddart, and Lang, 1999) and for the early exercise of exchange-traded options (see Poteshman and Serbin, 2003). The prepayment option for fixed interest rate mortgage contracts is similar to the surrender option in variable annuity policies and life insurance policies (see de Giovanni, 2010). Prior literature found that option pricing theory can to a large extent explain households’ prepayment behavior. However, to some extent, prepayment behavior appears to be irrational (see, e.g., Green and LaCour-Little, 1999; Deng, Quigley, and Order, 2000). Consistent with these findings, a survey by Kent, Legrand, and Morgan (2009) about dynamic policyholder behavior with respect to traditional participating life insurance products finds that life insurers do not usually
assume fully rational policyholder behavior.  

As the term “rational” is not clearly defined in this survey, one must be careful when interpreting these results.

A guaranteed annuity option gives the policyholder the option to annuitize the account value at the end of the accumulation phase at a predefined annuitization rate that can be higher than the market conditions on the annuitization date (see O’Brien, 2006).

In this article, a GMAB/GMDB single premium product is analyzed because of its simple product design. Hence, the extent to which policyholders exercise their option to surrender the policy should be a good indicator to test whether option pricing theory can describe surrender behavior.

According to the President’s Advisory Council on Financial Literacy (2008), financial literacy is “the ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being.”

The following section is based on Winkler (2009).
On the Propensity to Surrender a Variable Annuity Contract

Figure 1
Development of Variable and Fixed Annuity New Business Volumes and the 10-Year JPY Swap Rate in Japan

![Graph showing development of Variable and Fixed Annuity New Business Volumes and the 10-Year JPY Swap Rate in Japan](image)


the sales process more elaborate. Figure 1 shows the development of the variable annuity new business volumes in Japan from 2002 to 2010.

For the purpose of our study, it is worth noting that the sharp decrease in sales in 2010 is not, or at least not to a major extent, related to the consumers’ loss of trust in the financial stability of the variable annuity issuers in the aftermath of the financial crisis. Rather, the turmoil in the financial markets led to the market exit of some leading players (see, e.g., Asahi, 2009; Watson-Wyatt, 2009, for more details). These exits are related to the fact that increased market volatility and lower interest rates caused higher guarantee costs. Consequently, other types of investment became more appealing to investors. Figure 1 also illustrates this relationship between the interest rate and variable annuity sales.

In Japan, variable annuity products are almost exclusively sold via bancassurance.11 Most insured lives are rather mature and are looking for an investment possibility for their savings. So the products are predominantly single-premium products and have a strong savings character. Starting from the extremely low interest rates in Japan following the year 2000, savers began to invest in equity. Because the Japanese tend to be rather risk averse, they highly value investment guarantees in their variable annuities; usually a GMAB (in some cases an income guarantee) is combined with a GMDB. Many products contain a “target setting”: the policyholder determines

11Only approximately 1 percent of the policies are sold via insurance agents or brokers.
a target level for the investment (usually between 110 percent and 150 percent of
the premium). If the fund reaches this level during the policy term, the contract
is automatically terminated (“knockout”). Most of the products are invested in a
mutual fund consisting of domestic and foreign bonds as well as domestic and
foreign equity and do not allow for fund switches.

Product Characteristics
All of the policies in the data set contain both a GMDB and a GMAB rider. At inception
of the policy, the policyholder fixes a target value, expressed as a percentage of the
single premium. The considered portfolio only contains policies with a target level
of 110 percent of the premium. For each product, a knockout period is defined. Pro-
vided the knockout period has expired, the policy terminates automatically as soon
as its account value outranges its target value. These knockouts are not counted as
surrenders. Because the analyzed product has no surrender fee, a strong influence
from the chosen target level on surrender behavior is not to be expected. The consid-
erations of the policyholders regarding the optimal time to surrender (which could
include time to maturity) should not be strongly influenced by the chosen target level.
However, policyholders with the same target level could be more homogeneous in
terms of risk attitude than policyholders with different target levels. The company
charges an initial expense loading that effectively leads to an investment of less than
100 percent of the single premium. The guarantee fee is charged to the account value
of the policy on a daily basis. Table 1 summarizes the main policy characteristics.

Data Set
The data set consists of 15,180 distinct policies, of which we have observations from
June 1, 2009 up to and inclusive of November 30, 2010. For the analysis, we have
19,335.7 policy years of central exposure to risk at our disposal. The average period
of time that a random policy was under observation during the observation period is
19,335.7 / 15,180 ≈ 1.273 years, whereas the overall observation period is 1.5 years.

Not all policies were in force during the entire observation period: new business came
into force during the observation period and policies went out of force as a result of

12To be precise, only the variable annuity character of the policy is terminated. The contract is
transformed into a deferred annuity such that effectively the target level is locked in. Alter-
atively, the policyholder has the right to choose a lump sum that is equivalent to the target
level. There is no fee to the policyholder.
13A typical Japanese single premium variable annuity product either has an initial expense
loading and no surrender charge (and hence has an initial account value of less than the
single premium) or a surrender charge and no initial expense loading. A typical surrender
charge, expressed as a percentage of the account value, is as follows: year 1: 6 percent, year 2: 5
percent, …, year 6: 1 percent, year 7 onward: 0 percent. For the purpose of analyzing dynamic
policyholder behavior, a product of the first type is favorable because the policyholder’s
moneyness heuristic is not influenced by any surrender fee.
14For confidentiality reasons, we cannot state the precise values of the initial expense loading
and the guarantee fee.
Table 1
Main Policy Characteristics

<table>
<thead>
<tr>
<th>Product Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy term</td>
<td>10 years</td>
</tr>
<tr>
<td>Asset allocation</td>
<td>Different investment funds (each) consisting of investments in domestic and foreign bonds as well as domestic and foreign equity. The funds are reweighted periodically</td>
</tr>
<tr>
<td>GMAB</td>
<td>100% of single premium</td>
</tr>
<tr>
<td>GMDB</td>
<td>100% of single premium</td>
</tr>
<tr>
<td>Target level</td>
<td>110% of single premium</td>
</tr>
<tr>
<td>Knockout period</td>
<td>1 or 3 years</td>
</tr>
<tr>
<td>Surrender charge</td>
<td>None</td>
</tr>
<tr>
<td>Initial expense loading</td>
<td>Approximately 4% of single premium</td>
</tr>
<tr>
<td>Guarantee fee</td>
<td>Fixed percentage of account value, charged on a daily basis</td>
</tr>
</tbody>
</table>

the death of the insured life, knockout or surrender. Central exposure to risk is the period of time, measured in years, during which a policy is exposed to the risk of being surrendered. The central exposure to risk in June 2009 is, according to Table 3, 641.4 policy years. This amount can be thought of as approximately 7,804 (≈ 641.4 · 365/30) policies that were under observation for a period of 30 days. One year later, apparently, the portfolio under observation had increased due to new business coming into force. In June 2010, the central exposure to risk equals 1,172.7 years, which is equivalent to approximately 14,268 policies under observation for a period of 30 days.

At the beginning of each calendar month, data relating to the policies are available. The investigated data set contains policy exposure information and surrender counts as well as insured life and policy characteristics. These characteristics, collected at the policy level, are enumerated in Table 2. The precise dates of portfolio entries and decrements are available.

To determine the value of the policy as perceived by the policyholder, we define the variable “moneyness” as:

\[
moneyness = \frac{\text{surrender value (account value less surrender fees)}}{\text{guaranteed value}}.
\]

This heuristic is based on a method recommended by the American Academy of Actuaries (2005).\textsuperscript{15} The moneyness is measured at the end of the respective month or at the date at which the policy went out of force, provided that this event took place in the course of the respective month; we assume that moneyness remains constant.

\textsuperscript{15}The American Academy of Actuaries uses a “dynamic lapse multiplier” calculated at the valuation date (as the ratio of the account value and the guaranteed value). To model dynamic lapsing behavior, this factor is multiplied by the deterministic base lapse rate (see American Academy of Actuaries, 2005).
Table 2
Available Covariates

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Description</th>
<th>Data Granularity</th>
<th>Categorization in Final Model Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moneyness ( m )</td>
<td>Heuristic moneyness</td>
<td>Rounded to an integer multiple of 0.01 In months</td>
<td>Continuous</td>
</tr>
<tr>
<td>Curtate duration ( c )</td>
<td>Curtate duration of the policy</td>
<td>In months</td>
<td>Continuous</td>
</tr>
<tr>
<td>Attained age ( a )</td>
<td>Attained age of the insured life</td>
<td>In years</td>
<td>Continuous</td>
</tr>
<tr>
<td>Policy size ( s )</td>
<td>Single premium</td>
<td>In JPY</td>
<td>(&lt; 8\text{m JPY}/\geq 8\text{m JPY})</td>
</tr>
<tr>
<td>Gender</td>
<td>Gender of the insured life</td>
<td>Male/female</td>
<td>male/female</td>
</tr>
<tr>
<td>Knockout period</td>
<td>Knockout period</td>
<td>In years</td>
<td>1 year/3 years</td>
</tr>
</tbody>
</table>

during the respective month. Obviously, the heuristic does not completely reflect option pricing theory because it does not consider time to maturity, risk-free interest rate, or implied volatility. However, policyholders, having understood that they have a surrender option and that the value of their policy depends on the development of the account value, will presumably not calculate the exact fair value of the policy but will instead use some heuristic for their surrender decision. Because our primary goal is to analyze whether policyholders surrender dynamically, we proceed analogously and thus base our analysis on this heuristic.

Table 3 summarizes the central exposure to risk and surrender count by calendar month. For completeness, knockout and death counts are also displayed.

Figures 2–4 provide a short descriptive analysis of the data set.

Figure 2 illustrates that many policyholders of a single-premium product purchase their policy around retirement age, which is 60 in Japan.

Figure 3 shows that the moneyness distribution in our data set is well centered around the value 1.0. This range is relevant for testing the hypotheses presented in the “Hypotheses” section. It is important that both exposure for in the money policies and for out-of-the money policies is observed.

During the considered time frame, the observed portfolio was open for new business, as can be seen in Figure 4.

Hypotheses
Moneyness Hypothesis
The discussion in the “Dynamic Policyholder Surrender” section suggests assuming some type of functional relationship between surrender behavior and the development of the underlying fund. The evidence for the interest rate hypothesis found in prior research and the fact that option pricing theory can explain a large part of
<table>
<thead>
<tr>
<th>Month</th>
<th>Central Exposure to Risk (in Years)</th>
<th>Surrender Count</th>
<th>Knockout Count</th>
<th>Death Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun 2009</td>
<td>641.4</td>
<td>13</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Jul 2009</td>
<td>619.9</td>
<td>11</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Aug 2009</td>
<td>617.6</td>
<td>44</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Sep 2009</td>
<td>594.2</td>
<td>44</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Oct 2009</td>
<td>1,228.6</td>
<td>47</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Nov 2009</td>
<td>1,264.1</td>
<td>69</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Dec 2009</td>
<td>1,215.9</td>
<td>104</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Jan 2010</td>
<td>1,207.5</td>
<td>75</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Feb 2010</td>
<td>1,122.6</td>
<td>52</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Mar 2010</td>
<td>1,316.4</td>
<td>87</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Apr 2010</td>
<td>1,182.3</td>
<td>105</td>
<td>84</td>
<td>7</td>
</tr>
<tr>
<td>May 2010</td>
<td>1,214.7</td>
<td>48</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Jun 2010</td>
<td>1,172.7</td>
<td>32</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Jul 2010</td>
<td>1,170.2</td>
<td>13</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Aug 2010</td>
<td>1,246.5</td>
<td>37</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sep 2010</td>
<td>1,165.9</td>
<td>46</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Oct 2010</td>
<td>1,122.4</td>
<td>60</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Nov 2010</td>
<td>1,232.8</td>
<td>83</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>19,335.7</td>
<td>970</td>
<td>110</td>
<td>78</td>
</tr>
</tbody>
</table>

the prepayment behavior for fixed interest rate mortgages also suggests that fewer policyholders surrender their variable annuity policies if the guarantees are in the money than if they are out of the money. With regard to the definition of moneyness as presented in the “Data” section, a low value is associated with a high value of the provided guarantees and should thus lead to a low surrender rate and vice versa.

_Hypothesis 1: The probability that a policy is surrendered increases with its moneyness._

**Emergency Fund Hypothesis**

The emergency fund hypothesis provides a rationale to surrender a policy even if its guarantees are valuable.\(^{16}\) We cannot observe whether policyholders are in a situation in which they suddenly need a considerable amount of money. But there might be some observable determinants that potentially drive the probability of this type of situation. A GMAB is valuable if the account value is low. As the account value

\(^{16}\)This reason would not necessarily exist if a well-developed secondary market for variable annuities existed. At the moment, there is no well-developed secondary market for any of the existing variable annuity markets. Nevertheless, as secondary markets might develop in the future, surrender behavior might be subject to a considerable change (see Kent and Morgan, 2008).
depends on the development of stock prices and thus on the economic environment in general, the guarantee should be in the money in case of a poor economic situation (when stock prices go down). Because cases of financial distress tend to coincide with such situations (e.g., due to unemployment), it appears plausible that more policyholders surrender their policies due to emergency fund situations when moneyness is low. Unfortunately, we cannot test this hypothesis because we are not in a position to observe whether policyholders surrender their contract because of an emergency fund situation when the guarantees are out of the money. Instead, we use other variables as a proxy to test for the emergency fund hypothesis. As people grow older, medical emergencies and severe illnesses tend to occur more frequently. Because a considerable amount of money might be needed to cover health care or long-term care costs, the age of the insured life might be positively correlated with the probability of surrendering the policy.

_Hypothesis 2.1: Age is positively correlated with the probability of surrender._

Smaller policies might be an indication of a policyholder with lower income or wealth. As emergency fund situations are more likely if wealth and income are low, we hypothesize that policy size is negatively correlated with the probability of surrender:

_Hypothesis 2.2: Policy size is negatively correlated with the probability of surrender._
Figure 3
Figure 3: Moneyness Distribution in Data Set: High Exposure in the Range That Is Relevant to the Study

Central Exposure to Risk by Moneyness

Financial Literacy Hypothesis

Financial literacy is a crucial prerequisite to understand the basic character of the guarantees and the surrender option contained in the policy. Although we cannot directly observe the policyholders’ financial literacy, policy size is likely to be correlated with financial literacy. Behrman et al. (2010) find a positive correlation between wealth accumulation and financial literacy. Agnew (2006) finds that higher salaried employees show fewer behavioral biases and make significantly better choices concerning their 401(k) plans. Therefore, there is evidence that, on average, wealthier people have higher financial literacy. Because policy size should be a good proxy for the policyholder’s wealth, we suppose that surrender behavior for large policies is more sensitive toward the value of the embedded options and guarantees.

Hypothesis 3.1: If moneyness is greater than one, surrender rates are higher for large policies than for small policies.

Note that, strictly speaking, our data do not allow us to differentiate between the financial literacy of the policyholder himself and a financially literate advisor (or just the simple fact that the stakes—and hence the attention—are higher for large
policies\textsuperscript{17}). Also, institutional factors such as regulation and secondary markets might in theory distort the observation of the policyholder’s financial literacy.

Assuming a negative interaction between policy size and moneyness if the guarantees are in the money would also be clear evidence for the dependence of policyholder rationality on policy size. However, it appears to be rather easy to understand that surrendering a policy when the account value is lower than the guaranteed value would be a bad decision. Thus, we do not expect to observe such an effect.

\textit{Hypothesis 3.2: Surrender rates do not differ between small and large policies if moneyness is smaller than one.}

\section*{Method}

To test our hypotheses, we use a Poisson generalized linear model (GLM) with a logarithmic link function. This choice leads to a model for the rate of surrender. This method makes better use of the available data than a binomial GLM because it offers a more precise calculation of the time that a policy is at risk.\textsuperscript{18} This precision is partic-

\textsuperscript{17}For an easier assessment, we recall that large policies are policies with a single premium of more than JPY 8 million which, at the time of writing, is roughly equivalent to USD 80,000.

\textsuperscript{18}We recall that we derived the central exposure to risk.
ularly important for the analysis of portfolios that are open to new business. Please note that our data set consists of monthly data deliveries and even contains precise information about the date of the portfolio entries or decrements at the individual policy level.

The number of surrendered policies, $Y$, in a portfolio follows a Poisson distribution:

$$P(Y = y) = f(y, \lambda) = \frac{\lambda^y e^{-\lambda}}{y!},$$

where $y$ can take the values $0, 1, 2, \ldots$ and $\lambda = E(Y)$ is the expected number of surrendered policies in a specified time period, such as a year.

The parameter $\lambda$ depends on the size of the portfolio, the period of observation, and various characteristics of the policy or the insured life. This parameter can be modeled by

$$E(Y) = \lambda = E_\bullet \rho(x^T \beta),$$

where $E_\bullet$ is the central exposure to risk (in years) and $\rho(x^T \beta)$ is the surrender rate per policy per year (which depends on the policy characteristics described by the linear component $x^T \beta$).

The explorative statistical analysis in Figure 5 shows how the surrender rate increases with moneyness. The logarithmic scale has been used on the vertical axis. On this scale, the plot is approximately piecewise linear, suggesting that the relationship between the surrender rate and moneyness is approximately piecewise exponential. A similar structure can be observed in Figure 7 (surrender rate by curtate duration) and, to a lesser extent, in Figure 6 (surrender rate by attained age).

To find a functional form for the surrender rate, which depends on the policy characteristics, we use the Poisson distribution to model the number of surrendered policies. We deliberately did not directly model the logarithm of the surrender rate in the linear regression model, as this procedure would break down: for those combinations of policy characteristics for which we did not observe any surrender activity, the logarithm of the empirical surrender rate is not defined. This problem is particularly relevant for model points with little exposure or with a low surrender rate (i.e., for low values of moneyness). A recent application of GLM models for German life insurance lapse data can be found in Eling and Kiesenbauer (2014), who also provide a comprehensive overview on the use of different modeling approaches in the literature. Milhaud, Loisel, and Maume-Deschamps (2011) provide a more technical comparison of modeling approaches for surrender behavior. For further details on count regression analysis, we refer the interested reader to Cameron and Trivedi (1998) or Denuit et al. (2007). Implementations of the Poisson GLM approach are available in standard statistical software such as R (R Core Team, 2012), which we use for our analysis. The standard fitting procedure for GLMs is maximum likelihood estimation.

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19The different combinations of values for these characteristics are often referred to as model points.
Specifically, we use the following Poisson GLM with a logarithmic link function:

$$S_{m,c,s,a} \sim \text{Poisson}(E_{m,c,s,a} \cdot \mu_{m,c,s,a}),$$

whereas $\ln \mu_{m,c,s,a}$ has the following functional form:

$$\beta_0 + \beta_1(m - m_1)_+ + \beta_2(m - m_2)_+ + \beta_3 c I_{(c \leq 12)} + \beta_4 I_{(c > 12)}$$

$$+ \beta_5 a + \beta_6 I_{(c \geq 24 \land m < 1)} + \beta_7 I_{(s \geq 8 \land m > 1)}.$$

The functional form of this final model fit is related to the hypotheses that are to be tested. This relationship will be discussed in the “Findings” section in more detail. $S_{m,c,s,a}$ denotes the number of surrendered policies by moneyness $m$, curtate duration $c$ (in months), policy size $s$ (in million JPY), and attained age $a$ (in years). The term $E_{m,c,s,a}$ is an exposure constant that gives the length of time (in years) for which a policy has been under observation. $\mu_{m,c,s,a}$ denotes the surrender rate, that is the expected number of surrenders per policy year exposure to risk. $I$ denotes the indicator function. The final interaction term allows differentiating out of the money policies between the surrender behavior of policyholders with a large policy and those with a small policy. $m_1$ and $m_2$ are the points where the hockey stick functions change their slope. The values of these points are $m_1 = 0.93$ and $m_2 = 1.043$, respectively.\(^{20}\) A hockey stick function is a real-valued function, whose function value equals zero up to a certain point and then increases monotonically with a constant slope from this point onwards.\(^{21}\) That is, it is formally defined by

$$(m - m_1)_+ = \begin{cases} 0, & m < m_1 \\ m - m_1, & m \geq m_1. \end{cases}$$

The categorization of the covariates that is used in the analysis is provided in Table 2. The model-fitting process starts with a GLM that includes all covariates (in high granularity) and reasonable interaction terms. Because insignificant variables (and insignificant interaction terms) are taken out of the analysis, the results in the following section do not list all of these variables. Hypothesis testing is performed in the context of model fitting by defining a series of (nested) models corresponding to the different hypotheses. In this connection, overparameterization should be avoided. For more details on this method, we refer to Dobson (2002, section 2.3.5). The final model presented above is the result of this process. One characteristic of this approach is that, for example, the covariate policy size enters, after testing different categorizations and ways of modeling, the final model fit as a categorical variable even though more detailed information is available in the data set.

\(^{20}\)These values were determined such that $m_1$ and $m_2$ jointly minimize the model deviance and hence maximize the goodness of fit of the model to the data. These optimal values match the graph in Figure 5, which was used for explorative statistical analysis.

\(^{21}\)Thus, a combination of hockey stick functions enables an approximation of, e.g., exponential-like functions within a generalized linear model framework.
## Table 4
Parameter Estimates of Regression Model

<table>
<thead>
<tr>
<th>Regression Coefficient $\hat{\beta}$</th>
<th>Regression Coefficient Estimate</th>
<th>Standard Error</th>
<th>$z$-Value</th>
<th>$p$-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept $\hat{\beta}_0$</td>
<td>$-21.49$</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moneyness hockey stick 1</td>
<td>$\hat{\beta}<em>1(m - m_1)</em>+$</td>
<td>24.9828</td>
<td>1.6354</td>
<td>15.28</td>
</tr>
<tr>
<td>Moneyness hockey stick 2</td>
<td>$\hat{\beta}<em>2(m - m_2)</em>+$</td>
<td>$-20.5529$</td>
<td>5.2090</td>
<td>$-3.95$</td>
</tr>
<tr>
<td>Curtate duration $\beta_3 I(c \leq 12)$</td>
<td>0.1266</td>
<td>0.0247</td>
<td>5.14</td>
<td>0.0000</td>
</tr>
<tr>
<td>Curtate duration $\beta_4 I(c &gt; 12)$</td>
<td>1.4490</td>
<td>0.2465</td>
<td>5.88</td>
<td>0.0000</td>
</tr>
<tr>
<td>Attained age $\beta_5$</td>
<td>0.0093</td>
<td>0.0032</td>
<td>2.86</td>
<td>0.0042</td>
</tr>
<tr>
<td>Interaction term 1 $\beta_6 I(c &gt; 24 \land m &lt; 1)$</td>
<td>$-0.4446$</td>
<td>0.1976</td>
<td>$-2.25$</td>
<td>0.0245</td>
</tr>
<tr>
<td>Interaction term 2 $\beta_7 I(c \geq 8 \land m &gt; 1)$</td>
<td>0.7588</td>
<td>0.0858</td>
<td>8.84</td>
<td>0.0000</td>
</tr>
<tr>
<td>Null deviance</td>
<td>6673.1 on 36659 degrees of freedom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual deviance</td>
<td>5977.6 on 36652 degrees of freedom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>7865.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Findings
The results of our empirical analysis (as reported in Table 4) are largely consistent with our hypotheses. The key figures for the explanatory power of the statistical model reveal a reduction of the deviance of over 10 percent with seven regression coefficients. This result is satisfactory given the degrees of freedom of the model.

An analysis of the deviance with the analysis of variance (ANOVA) technique as presented in Table 5 reveals that the majority of the explained surrender behavior can be attributed to the moneyness of the policy. By means of the inclusion of seven parameters, $\beta_1, \ldots, \beta_7$, the deviance is reduced by 695.5. Of this reduction, 574.5 is related to moneyness as a main effect. Moneyness is followed first by the interaction between moneyness and policy size, second by curtate duration, and third by the attained age of the insured life.

The surrender rate is an increasing function in moneyness $m$, as both $\hat{\beta}_1 > 0$ and $\hat{\beta}_1 + \hat{\beta}_2 > 0$:

$$\ln \hat{\mu}(m) = \hat{\beta}_0 + \hat{\beta}_1(m - m_1)_+ + \hat{\beta}_2(m - m_2)_+$$

wherein $m_1 < m_2$. The policyholders take the value of the guarantees provided to them into account for their surrender decision. This result supports our moneyness hypothesis.

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22The parameter values for the intercept are removed for confidentiality reasons. This step derogates neither the qualitative conclusions of the analysis nor the quantitative conclusions about the relative size of the observed effects.
### Table 5
ANOVA Analysis of the Deviance Table

<table>
<thead>
<tr>
<th>Covariate Term</th>
<th>Regression Coefficient $\beta$</th>
<th>D. f.</th>
<th>Deviance</th>
<th>Residual D. f.</th>
<th>Residual Deviance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null</td>
<td>$\beta_0$</td>
<td></td>
<td>36,659</td>
<td>6,673.1</td>
<td></td>
</tr>
<tr>
<td>Moneyness hockey stick 1</td>
<td>$\beta_1(m - m_1)_+$</td>
<td>1</td>
<td>535.3</td>
<td>36,658</td>
<td>6,137.8</td>
</tr>
<tr>
<td>Moneyness hockey stick 2</td>
<td>$\beta_2(m - m_2)_+$</td>
<td>1</td>
<td>39.2</td>
<td>36,657</td>
<td>6,098.5</td>
</tr>
<tr>
<td>Curtate duration 1</td>
<td>$\beta_3I_{c \leq 12}$</td>
<td>1</td>
<td>3.3</td>
<td>36,656</td>
<td>6,095.2</td>
</tr>
<tr>
<td>Curtate duration 2</td>
<td>$\beta_4I_{c &gt; 12}$</td>
<td>1</td>
<td>35.8</td>
<td>36,655</td>
<td>6,059.5</td>
</tr>
<tr>
<td>Attained age 1</td>
<td>$\beta_5a$</td>
<td>1</td>
<td>8.5</td>
<td>36,654</td>
<td>6,050.9</td>
</tr>
<tr>
<td>Interaction term 1</td>
<td>$\beta_6I_{c \geq 24 \text{ and } m &lt; 1}$</td>
<td>1</td>
<td>6.0</td>
<td>36,653</td>
<td>6,044.9</td>
</tr>
<tr>
<td>Interaction term 2</td>
<td>$\beta_7I_{c \geq 8 \text{ and } m &gt; 1}$</td>
<td>1</td>
<td>67.4</td>
<td>36,652</td>
<td>5,977.6</td>
</tr>
</tbody>
</table>

Note: d. f. = degrees of freedom.

Figure 5\textsuperscript{23} shows that the surrender rate only increases slightly while the guarantees are in the money. Around a moneyness value of 1, the graph shows a sharp twist. Out of the money, the surrender rate increases exponentially at a higher rate than in the money. At both ends of the interval of the observed moneyness values, the precision of the estimation decreases due to a decreasing number of observations.

All other things being equal, the logarithm of the surrender rate increases linearly with the attained age of the insured life ($\hat{\beta}_5 > 0$). Hence, the surrender rate itself also increases with the attained age. This result, also illustrated by Figure 6, is consistent with our Hypothesis 2.1 and supports the emergency fund hypothesis.

The inclusion of policy size as a main effect proved to be not significant (i.e., the covariate policy size does not enter the linear predictor of the final regression model).\textsuperscript{24} Because we conjectured that policy size might be a proxy for the policyholder’s wealth or income and that emergency fund situations should be more likely if wealth and income are low, this result does not confirm Hypothesis 2.2, which had been derived from the emergency fund hypothesis. Thus, we altogether find mixed evidence with regard to the emergency fund hypothesis.

\textsuperscript{23}In the process of finding a suitable model fit, we used generalized additive models as explorative tools. Figures 5–7 are generated using this technique and are included here for illustrative purposes only.

\textsuperscript{24}If policy size is added to the regression model as a categorical variable, the corresponding coefficient is $-0.2519$ for small ($< \text{JPY 8 million}$) policies (large policies fall into the intercept) with a standard error of 0.1622, a z-value of $-1.553$, and a p-value of 0.1205. In this final model fit, all other coefficients (as well as their standard errors, z-values, and p-values) slightly deviate from the coefficients in the final regression model presented in Table 4 but stay significant. The explanatory power of this statistical model is described by a null deviance of 6,673.1 on 36,659 degrees of freedom, a residual deviance of 5,975.3 on 36,651 degrees of freedom, and an AIC of 7,864.9.
Curtate duration plays a significant role in explaining the observed policyholder behavior. For young policies (curtate duration \( \leq 12 \) months), the surrender rate increases linearly with the time the policy has been in force, as \( \hat{\beta}_3 > 0 \). After 1 year, the surrender rate remains more or less constant, as can be seen from \( \hat{\beta}_4 \approx 12 \cdot \hat{\beta}_3 > 0 \) as well as graphically in Figure 7. Note that the direction of this effect is contrary to what is generally observed for traditional participating life insurance policies (Renshaw and Haberman, 1986, p. 485). One might presume that consumers who buy a more complicated product such as a variable annuity policy put significant thought into their buying decision and hence prefer to stick to their decision for a certain period before this effect levels off. Another observation relating to curtate duration is that more mature policies (curtate duration \( \geq 24 \) months) are less likely to be surrendered if out of the money as \( \hat{\beta}_6 < 0 \). This observation might, however, be due to a selection effect as the insured lives that remain in the sample over the first 2 years may systematically differ from those insured lives that surrender earlier. Moneyness-sensitive policyholders have a high probability of reaching their surrender threshold level during the first 2 years. Hence, older policies still remaining in the sample have a high chance of being less sensitive to moneyness. 25 In general, there is another possible link

25Stanton (1995) and Deng, Quigley, and Order (2000) discuss the question of unobserved heterogeneity among fixed interest rate mortgage borrowers. They argue that surviving borrowers
between curtate duration and surrender probabilities. As the remaining policy term becomes shorter, an otherwise identical guarantee becomes less valuable (assuming an equal account value). At the same time, the future guarantee fees also decrease. If this double decrease had an effect, potentially in interaction with moneyness, on the policyholder’s propensity to surrender, we would expect to observe the effect particularly toward the approaching end of the policy term. As the analyzed portfolio is rather young (cf. Figure 4; the age of the oldest policy in the portfolio is 31 months) compared to the policy term of 10 years, it is too early to reasonably analyze such effects. This question remains for future research when the data for the full term becomes available.26

Regarding the interaction between the policy size and moneyness, both hypotheses are confirmed. For policies having a moneyness in excess of 1, we observe that the owners of large policies are more prone to surrender their policies as \( \hat{\beta}_7 > 0 \). Hence, Hypothesis 3.1 is confirmed: the owners of larger policies appear to react, by a factor

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26Further analysis not presented in this article found no evidence for the existence of a strong calendar-year effect in this data set.
of 2. More sensitively to the moneyness of their policy. This result is consistent with the expected higher financial literacy of these policyholders. However, for policies with a moneyness below 1 (no matter how far below), no differences can be found between small and large policies. Thus, we do not observe a (negative) interaction between policy size and moneyness if the guarantees are in the money. This finding supports Hypothesis 3.2. Not only should just a small number of policyholders surrender their in-the-money policies, the in-the-money surrenders should also be dominated by surrenders due to emergency fund situations. Figure 8 visualizes the

\[
\exp(0.7588) = 2.1357.
\]

If an interaction term for large policies with a moneyness below 1 is added to the regression model, the corresponding coefficient is 0.0026 with a standard error of 0.2198, a z-value of 0.012, and a p-value of 0.9906. In this nonfinal model fit, all other coefficients (as well as their standard errors, z-values, and p-values) slightly deviate from the coefficients in the final regression model presented in Table 4 but remain significant. The explanatory power of the statistical model is described by a null deviance of 6,673.1 on 36,659 degrees of freedom, a residual deviance of 5,977.6 on 36,651 degrees of freedom, and an AIC of 7,867.2.

The generalized linear model underlying the graphs in Figure 8 differs from that presented in Table 4 for illustrative reasons. The covariates are moneyness, policy size, and their interaction. The included raw observations are to be interpreted as the realized surrender probability on the aggregated exposure for all observations with the corresponding values for moneyness...
interaction effect between policy size and moneyness: the slope of the graph is steeper for large policies when moneyness is in excess of 1.

Several studies have shown that brokers, and distribution channels in general, potentially influence investor behavior. Poteshman and Serbin (2003) analyze the early exercising of exchange traded stock options. They find that customers of discount brokers and full-service brokers both exhibited a significant number of irrational exercises, while the traders at large investment houses did not conduct irrational early exercises. Shapira and Venezia (2001) compare clients making individual decisions with investors whose accounts were managed by brokerage professionals. They find that professionally managed accounts were better diversified and that the disposition effect was stronger for individual investors. Owners of large policies are presum-

30Weber and Camerer (1998) define the disposition effect as “the tendency to sell assets that have gained value (‘winners’) and keep assets that have lost value (‘losers’).” Usually, this effect is explained by the properties of the prospect theory’s value function: individuals exhibit risk seeking behavior for losses and risk averse behavior for gains relative to a reference point.
ably advised more intensely and by better agents or brokers and thus might better understand the value of the options in their policies; this could provide another explanation for a positive interaction between policy size and moneyness if the guarantees are out of the money. If nothing else, policyholders might just pay more attention to large policies because the stakes are higher for large policies.

As mentioned above, transaction costs, tax considerations, and risk preferences might prevent policyholders from surrendering their policy. If policyholders owning large policies differ from those owning smaller policies with respect to these characteristics, it might explain the differences in surrender behavior, in particular the positive interaction term between policy size and moneyness if the guarantees are out of the money. However, because all direct costs (especially the initial expense loading) for the analyzed product are charged as a certain share of the amount invested or the account value, differences in transaction costs cannot explain the observed surrender behavior. For the observed portfolio, there is also no difference in taxation between small and large policies in the case of surrender.31 Because the considered variable annuity product contains no surrender fees, risk preferences should not influence the surrender behavior of the policyholders that want to reinvest the surrender value in a different product. However, the propensity of policyholders to surrender their policy and instantly repurchase it might depend on individual risk preferences. Due to the up-front expense loading, the account value would decrease. At the same time, the value of the guarantees less the expected present value of the future guarantee fees would increase. Depending on risk preferences, this scenario might be more or less favorable. Therefore, if many policyholders wanted to maintain their policy, if those that surrendered their policy wanted to instantly repurchase it, and if the owners of large and small policies differ in their risk preferences in such a way that surrendering and repurchasing the policy is more attractive for the owners of large policies, it might to some extent explain the observed surrender behavior as well.

As an excursus, it shall be mentioned that the fact that financial literacy appears to drive surrender behavior and that insurance companies obviously base their prices for the guarantees on irrational surrender assumptions and offer lapse supported prices indicates that a “shrouded equilibrium”32 (Gabaix and Laibson, 2006) exists in

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31 The taxation rules in Japan are as follows: if surrendered within 5 years, the investment gain in the surrender value will be separated from the other income and will be taxed at 20 percent. This case applies to the observed portfolio (cf. Figure 4). If surrendered after 5 years, the investment gain in the surrender value will be added to the other income and will be taxed, after deductibles, at the income tax rate and residential tax rate. Taxation for the target hitting value is analogous. There is no tax on the capital gain in the separate account during the accumulation phase. For the maturity value, the income tax will be applied to the investment gain.

32 Gabaix and Laibson (2006) develop their model for products with hidden costs for expensive add-ons (e.g., cost of ink for printers or expensive phone calls from hotel rooms). In a shrouded equilibrium, some consumers are not aware of these hidden costs. Due to competitive pressure, the company will use the excess returns from the add-ons to reduce the price for the base product. If sophisticated consumers have the possibility to purchase cheaper substitutes instead of the expensive add-ons, competitors have no incentive to de-bias the uninformed
the market for variable annuities. In this equilibrium, sophisticated policyholders are cross-subsidized by uninformed customers that do not understand the complicated financial product they have purchased, and no market participant has an incentive to eliminate this cross-subsidization. In the market for variable annuities, there appears to be uninformed customers who do not optimally exercise the surrender option that is embedded in their policy and sophisticated policyholders who understand the surrender option they have and act accordingly. Hence, the insurance companies gain excess returns from the uninformed policyholders. However, the insurance company cannot distinguish between sophisticated and uninformed policyholders ex ante. Competition thus drives these excess returns away by reducing the guarantee fees for all policyholders. Of course, the sophisticated policyholders will not want the uninformed policyholders to become sophisticated. But also, none of the insurance companies offering these products has an incentive to inform the uninformed policyholders and offer a product with fairly priced guarantees. The sophisticated policyholders will not purchase this product because they would have to pay more. The uninformed policyholders, once they have been informed, have no incentive to purchase the product either; they now are sophisticated and will profit from cross-subsidization if they purchase the existing product. Hence, heterogeneity in policyholders’ surrender behavior is not only important for the pricing assumptions of the insurance company, but can, depending on who the sophisticated and the uninformed policyholders are, have important welfare implications as well.33

Conclusion

Surrender behavior constitutes a significant risk for life insurance companies offering variable annuity products because it influences the pricing of the options and guarantees within the policies, the solvency capital requirements, and the hedging effectiveness. Hence, it is important for insurers to understand what drives their policyholders’ surrender decisions. We analyzed this question empirically using data on a GMAB/GMDB product offered in Japan, the second largest market for variable annuities in the world.

First, we find that the moneyness of the policy is the most important driver for surrender behavior in our analysis. In addition, we identified a number of additional factors that explain the propensity to surrender.

Surrender rates increase with the attained age of the insured life. However, surrender rates are not correlated with policy size (as a main effect). Hence, we find mixed evidence for the emergency fund hypothesis. It might be reasonable to include unemployment and economic growth into a future analysis. Third, the influence of mon-

33Using an analogous rationale, Campbell (2006) discusses how a shrouded equilibrium with cross-subsidizations from uninformed to sophisticated mortgage holders might exist in the market for fixed interest rate mortgages. In this example, as well as in the case of variable annuities, the hidden costs arise from the failure of consumers to understand an option that would be advantageous to them.
eyness on the surrender rate depends on the size of the policy. We find that owners of large policies tend to behave more sensitively toward the moneyness of the policy. According to the existing literature, financial literacy is positively correlated with income and wealth. We interpret policy size as a proxy for wealth and thus also for financial literacy. The positive interaction term for policy size and moneyness thus indicates that financial literacy increases the influence of the value of the embedded options and guarantees on surrender behavior.

The data we analyzed cover a rather limited range of moneyness values. It remains open for future investigation to determine if policyholders behave differently should we gain access to a broader range of moneyness values. This investigation would be particularly important for regulatory considerations because the question of how much regulatory capital is needed to cover risks originating in dynamic policyholder behavior is especially relevant for tail events. The definition of moneyness used in this article only represents a simplifying approximation to measure the economic value of the guarantees contained in variable annuity products. Further research will be needed to evaluate whether results change if the economic value is taken into account more precisely.

**References**


