Behavioral Simulations

Using agent-based modeling to understand policyholder behaviors

By Louis Lombardi, Mark Paich, and Anand Rao

Editors' Note: *This is part two of a two-part series on behavioral simulations. Part one was published in the June 2014 issue of* Product Matters.

Simulation

Modeling Process

The following exhibit is a high-level overview of the modeling process:

Exhibit 16: Overview of Modeling Process

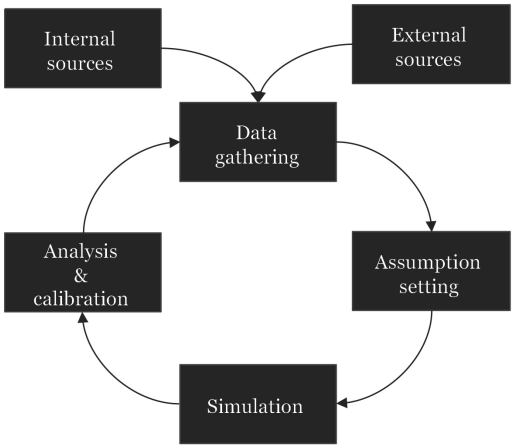
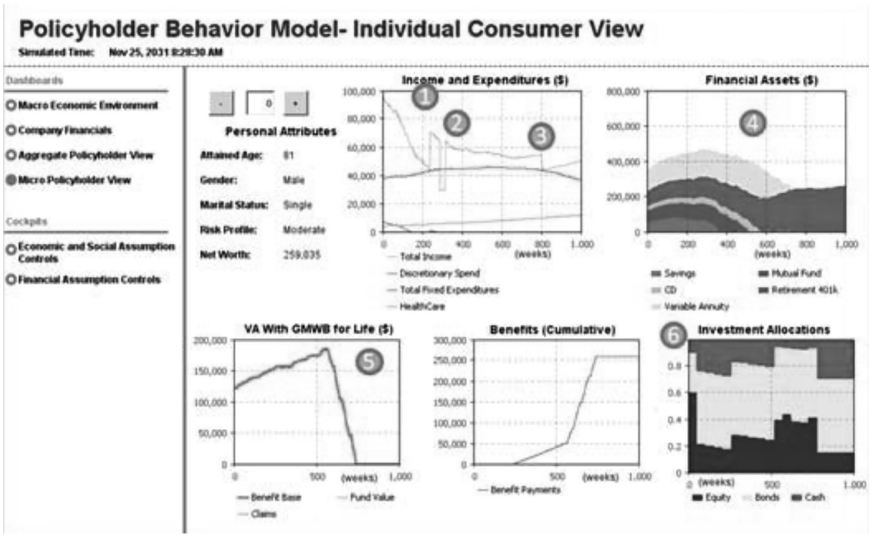


Exhibit 17: Micro Policyholder View



This exhibit divides the modeling process into four major segments:

1. Data gathering
2. Assumption setting
3. Simulation
4. Analysis & calibration.

The data gathering process is more extensive than traditional modeling techniques. In addition to accessing internal company sources for such items as policy data, plan data and claims data, external resources are needed for such items as:

1. Demographic data
2. Economic data
3. Household data.

Often this data needs to be supplemented with surveys and focus groups.

Similarly, the assumption-setting process is much more extensive than traditional modeling techniques. In addition to setting assumptions for such items as morbidity, mortality and lapses, assumptions must be specified for such items as:

1. Gross domestic product (GDP) growth rate
2. Unemployment rate
3. Inflation rate
4. Wage growth
5. Household expenses.

Further, these assumptions are integrated with interest rates investment returns and the state of the economy.

To give some indications of the intricacies of the simulation process, Exhibit 17 is a micro view of a particular policyholder.

The policyholder is a single male who was 60 years old at the start of the simulation.

The Income and Expenditures graph shows his income, nondiscretionary expenses, discretionary expenses and health care costs. The number 1 circle highlights that he:

1. Slowly started to retire at age 60;
2. Started to receive Social Security at age 65; and
3. Went back to work part time to have enough income to cover his expenses.

The number 2 circle indicates he tried to fully retire again, but returned to part-time work. The number 3 circle indicates his full retirement.

The Financial Assets graph shows the type of financial assets he owned and how their value changed over time. The number 4 and 5 circles indicate that he was making withdrawals from his variable annuity and his other investments prior to his retirement to cover his expenses. Finally, the Investment Allocations graph shows how he allocated his investments among equities, bonds and cash.

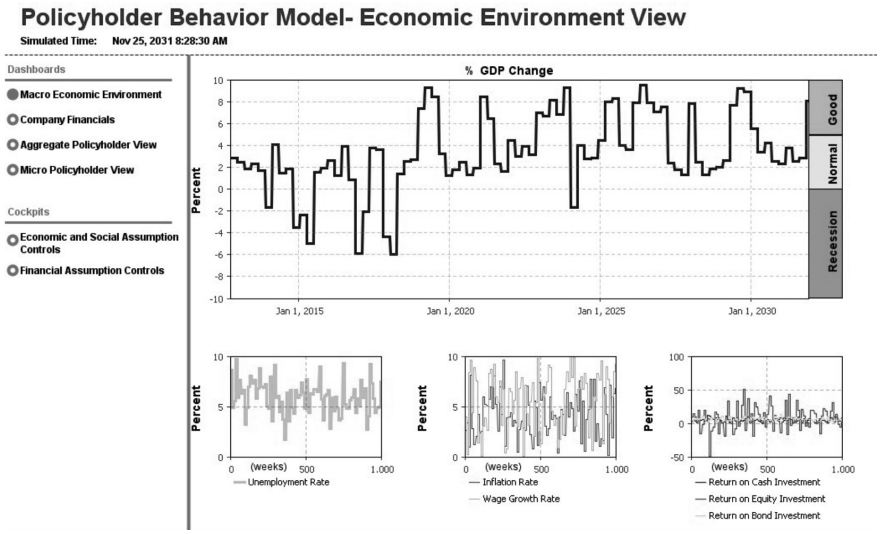
The Exhibit 18 is a macro view of the economic environment that led to some of the above behaviors.

The % GDP Change graph is the percentage change in the real gross domestic product for this particular simulation. It also shows the regime. Below this graph are three other graphs. The left graph is the unemployment rate; the middle graph is the inflation rate and wage growth; and the right graph is the return on equities, bonds and cash.

Exhibit 19 shows the macro view of all policyholders included in the simulation.

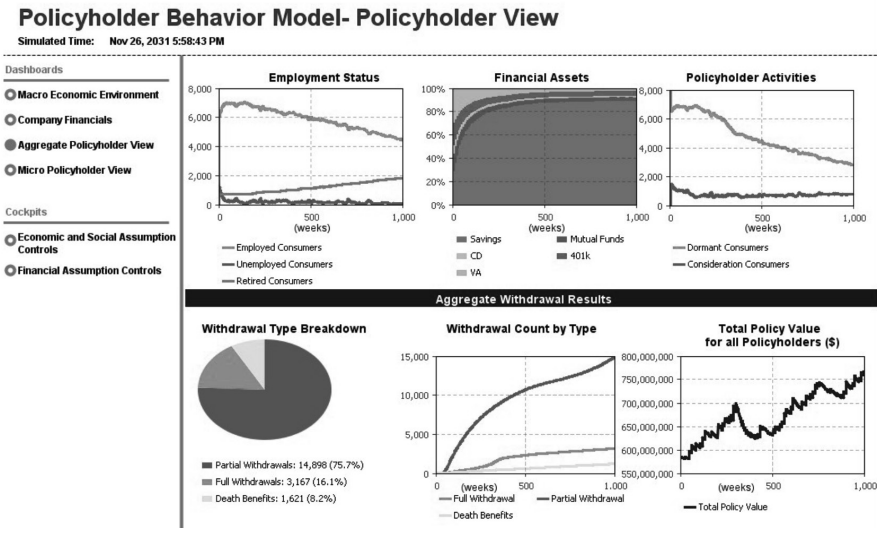
The Employment Status graph shows the number of policyholders that are employed, unemployed and retired. The Financial Assets graph shows the aggregate value of the five asset classes during the simulations. The Policyholder Activities graph shows the number of dormant policyholders and active policyholders. The pie chart shows the percentage of partial withdrawals, full

Exhibit 18: Macro View of Economic Environment



withdrawals and death benefits. The Withdrawal Count by Type graph shows the number of full withdrawals, partial withdrawals and deaths. The Total Policy Value chart shows the aggregate amount of the policy value in force.

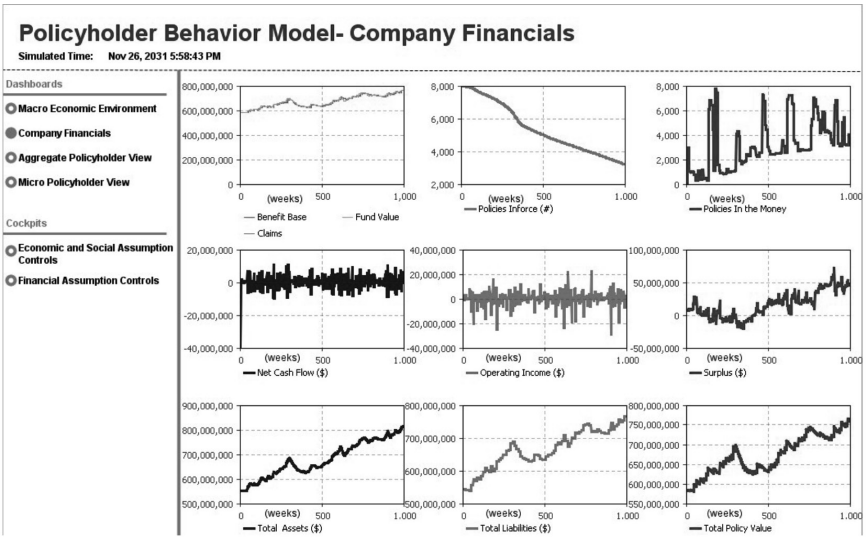
Exhibit 19: Macro View of Policyholders



CONTINUED ON **PAGE 22**

Finally, Exhibit 20 shows a macro view of the life insurance company.

Exhibit 20: Macro View of Company Financial



The above exhibit shows the graph of the following financial information on a statutory basis:

1. Net cash flow
2. Operating income
3. Surplus
4. Total assets
5. Total liabilities
6. Total policy value.

Case Study

An agent-based model can be used for a variety of applications such as:

- **Asset retention:** Test strategies to improve persistency and retention of account balances.
- **Pricing/product design:** Design products that better address the needs of the policyholder as conditions change.
- **Distribution strategy:** Train the distribution channels on how to address their clients' needs under a variety of circumstances.
- **Strategic analysis:** Allows insurance executives to have a better chance of achieving their strategic goals under various scenarios.
- **Risk management:** Enables risk officers to identify emerging risks due to the complex interactions of numerous factors.

The remainder of this paper discusses how an agent-based model can be used to test an asset retention strategy for a block of variable annuity contracts with a guaranteed minimum withdrawal benefit.

In the mid-1990s, LIMRA International initiated a study of workers eligible for a lump-sum payment from their companies' retirement plans. The purpose of this study was to assist their members in developing products and services that would help employees preserve their retirement benefits. Several companies have used this study to develop asset retention strategies for their retirement services business. These asset retention strategies have increased retentions from less than 10 percent to over 50 percent for many of these companies.

LIMRA's MarketFacts, November/December 1997.

Prior to this study, the behavior of many companies did not focus on asset retention. Specifically, when employees changed jobs or retired, they would call the company and ask for "their money." The customer service representative was trained to process the request as efficiently as possible.

One of the behaviors this study changed was how the companies responded to these types of requests. When former employees call, instead of narrowly focusing on processing the request as efficiently as possible, the customer service representative will transfer them to a sales representative. The sales representative will explain the various products and services the company will continue to provide should they leave their money with the company.

With this asset retention study in mind, consider a policyholder who owns the following investments:

1. Savings (i.e., checking, money market)
2. CDs
3. Mutual funds
4. Variable annuities
5. 401(k), 403(b) and IRAs

Now consider the question, "Which investment would he tap first to make regular withdrawals?"

In 2009, LIMRA published The Retirement Income Reference Book. In this book, they cite a survey they conducted of 942 retirees aged 55 to 80 with at least $200,000 in household investable assets. The survey revealed an interesting answer to the above question. In particular, the survey noted that "... taxes top the list of reasons that retirees defer tapping specific investments." However, when owned, "annuities top the list as the first investment for regular withdrawals."

What are some of the implications of this behavior? Generally, policyholders should first withdraw from their taxable account (i.e., savings, CD and mutual funds) and let their tax-deferred accounts (i.e., variable annuities and retirement accounts) accumulate. Accordingly, they need "nudging" from their advisors and the life insurance company on withdrawal strategies that help maximize their after-tax withdrawals.

With these LIMRA studies as background, assume you are the head of the strategy department of a large life insurance company. Your company has three major business segments:

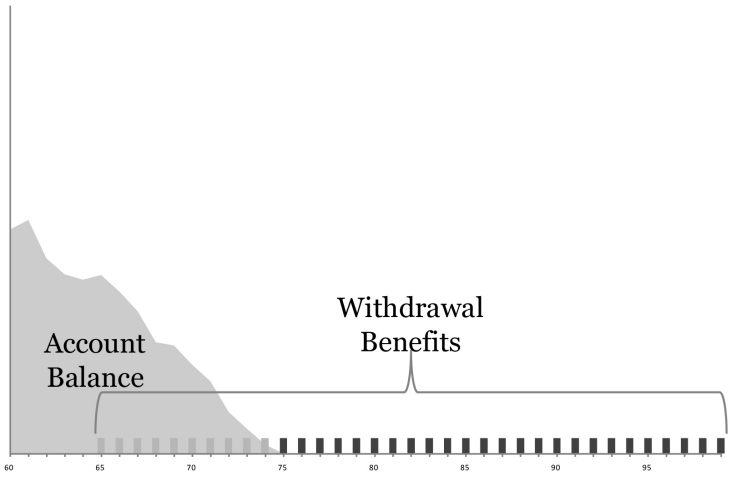
1. Life insurance
2. Annuities
3. Retirement services.

You are currently working with your marketing and customer service department on an asset retention strategy for your annuity operations.

Internal studies have shown that a significant number of policyholders begin taking regular withdrawal payments from their variable annuity contract around age 65.

Exhibit 21 shows a policyholder who elects to exercise a guaranteed withdrawal benefit for life at age 65. The account balance is deleted at age 75 so the contract is "in-the-money" thereafter.

Exhibit 21: Current Situation



CONTINUED ON **PAGE 24**

Thus, one of the objectives of your asset retention strategy is to delay when policyholders begin making regular withdrawals.

The expectation is that this would better align the interests of the company with those of the policyholder. By delaying when they make regular withdrawals, the policyholder would benefit by:

1. Deferring paying taxes;
2. Receiving a larger withdrawal benefit; and
3. Having an account balance that lasts longer.

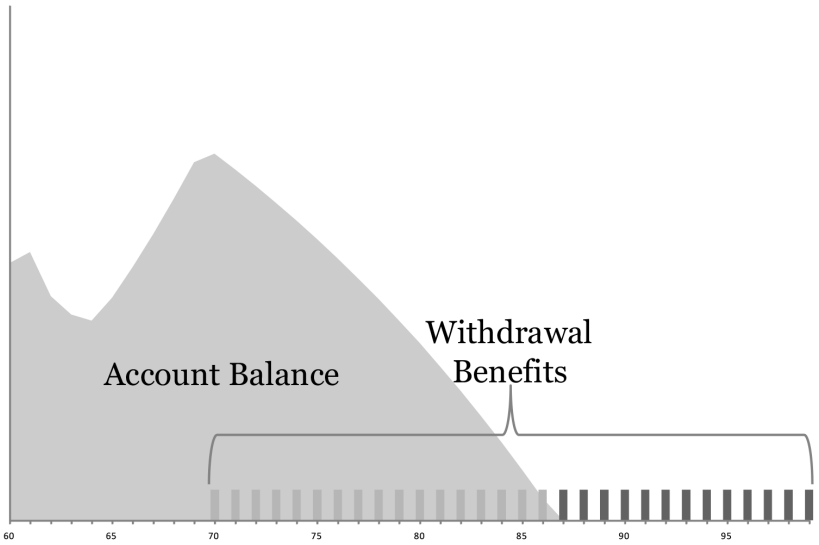
The life insurance company would benefit by:

1. Collecting higher fees for a longer period of time; and
2. Lowering expected cost of guaranteed withdrawal benefits.

Your asset retention strategy centers on influencing the order in which a policyholder makes withdrawals when he owns the following investments:

1. Savings (i.e., checking, money market)
2. CDs
3. Mutual funds
4. Variable annuities
5. 401(k), 403(b) and IRAs.

Exhibit 22: Objectives

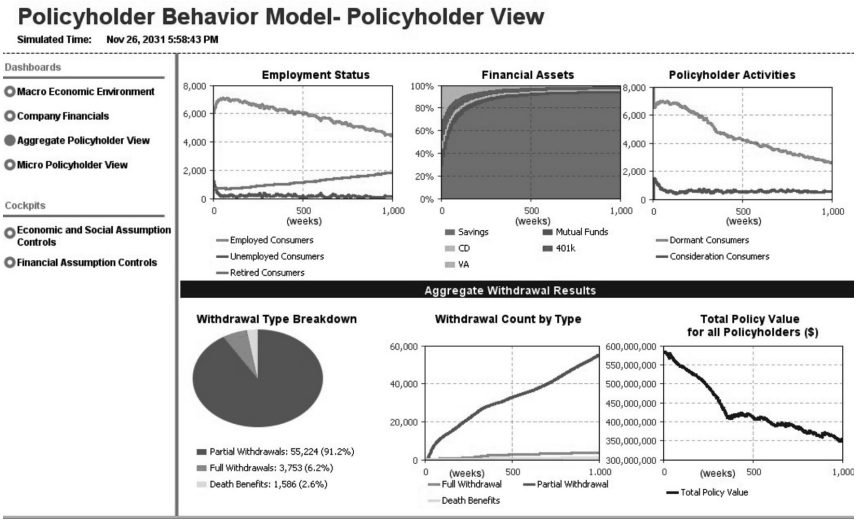


Simulation Results

First, a simulation was performed assuming that when policyholders make withdrawals from their financial assets they use the following withdrawal hierarchy:

1. Variable annuities
2. Savings (i.e., checking, money market)
3. CDs
4. Mutual funds
5. 401(k), 403(b) and IRAs.

Exhibit 23: Variable Annuities Are First in the Withdrawal Hierarchy



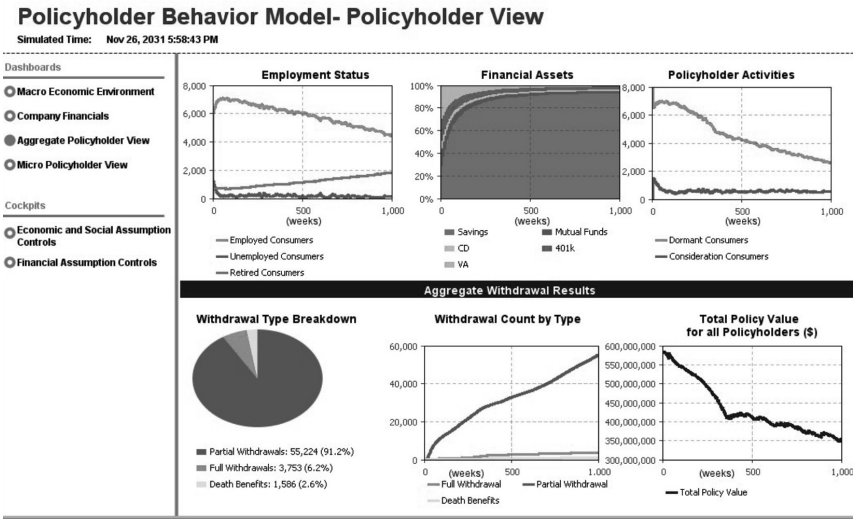
With this hierarchy, policyholders made 55,224 partial withdrawals, and the policy value at the end of the projection period was approximately $350 million.

Next, a simulation was performed assuming that when policyholders make withdrawals from their financial assets they use the following withdrawal hierarchy:

1. Savings (i.e., checking, money market)
2. Mutual funds
3. CDs
4. Variable annuities
5. 401(k), 403(b) and IRAs.

Exhibit 24 shows the macro view of this policyholder behavior.

Exhibit 24: Variable Annuities Are Fourth in the Withdrawal Hierarchy



With this hierarchy, policyholders made 14,898 (versus 55,224) partial withdrawals, and the policy value at the end of the projection period was approximately $760 million (versus $350 million).

Conclusion

Understanding and modeling policyholder behavior is critical to insurers; it is a key aspect of the full spectrum of the business, ranging from product design and pricing to reserving and risk management.

Either through deterministic approach or stochastic modeling, traditional techniques of modeling policyholder behavior present two major drawbacks. They focus primarily on the financial drivers and do not take into account other important factors such as social, cognitive and emotional factors. In addition, these approaches do not take into account different behaviors among policyholders, and accordingly the aggregate level results are not refined.

Having embraced behavioral economics and predictive modeling, more recent development has brought policyholder behavior modeling to an advanced level. However, these approaches still face fundamental challenges in modeling individual policyholder behaviors and also in capturing the causal structure of individual decision making.

Behavioral simulation, as presented in this paper, combines individual decisionmaking rules and artificial intelligence (AI) based software agent modeling to model policyholder behavior. Advances in AI allow insurers to simulate behavior at an individual level and then analyze the outcomes at an aggregate level.

Agent-based modeling promotes more sophisticated business solutions and can be used for a variety of business applications, such as product management and asset retention, pricing and product design, distribution strategy, capital and risk management, and strategic analysis.

We encourage insurers and insurance professionals to explore this unique approach, and we believe that this new technique will bring significant advancement to the policyholder behavior modeling and broad actuarial modeling for the industry.

CONTINUED ON **PAGE 26**

Louis Lombardi, FSA, MAAA, is principal at PricewaterhouseCoopers LLP in Hartford, Conn. He can be reached at louis.lombardi@us.pwc.com.

Mark Paich, PhD, is a director in the PWC Analytics Practice. He can be reached at mark.paich@us.pwc.com.

Dr. Anand S. Rao is principal, Advisory Services at PricewaterhouseCoopers LLP in (city, state). He can be reached at anand.s.rao@us.pwc.com.

Bibliography

Axelrod, Robert. 1997. *The Complexity of Cooperation.* Princeton University Press.

Baker, Kent H. 2010. *Behavioral Finance.* John Wiley & Sons.

Boatright, John R. 2010. *Finance Ethics.* John Wiley & Sons.

Consumer Expenditure Survey. Rep. N.p.: Bureau of Labor Statistics, 2011, *http://www.bls.gov/cex.*

Ehrentreich, Norman. 2008. Agent-Based Modeling. Springer-Verlag Berlin Heidelberg.

Federal Reserve Bank of St. Louis, Bureau of Economic Analysis and Yahoo Finance, Economic data and S&P 500 data, http://research.stlouisfed.org, *https://www.bea.gov and http://finance.yahoo.com.*

Gadenne, François and Michael Zwecher. How to Benefit from the View Across the Silos: From Investment Management to Retirement Income and Retirement Management. N.p.: RIIA Publishing, 2010. Print. Body of Knowledge for RIIA's Retirement Management Analyst (RMA) Designation.

Grimm, Volker and Steven F. Railsbark. 1997. *Agent-Based and Individual-Based Modeling.* Princeton University Press.

Macal, Charles M. and Michael J. North. 2007. *Managing Business Complexity.* Oxford University Press.

Page, Scott E. 2011. *Diversity and Complexity.* Princeton University Press.

Rao, Anand S. and Ron Mastrogiovanni. 2012. How Life Insurers Can Help Their Customers Remain Healthy, Wealthy and Wise. *The Retirement Management Journal SM, vol. 2, no. 2, summer.*

Salamon, Tomas. 2011. *Design of Agent-Based Models.* Tomas Salamon.

Schelling, Thomas C. 2006. *Micro Motives and Macro Behavior.* W.W. Norton & Company.

Sunstein, Cass R. and Richard H. Thaler. 2008. Nudge. Caravan.

Survey of Income and Program Participation (SIPP), Rep. N.p.: National Bureau of Economic Research, 2011, *http://www.nber.org/data/survey-of-income-andprogram-participation-sipp-data.html.*

The Retirement Income Reference Book. 2009. LIMRA.

Turner, Elvin. 2012. "Introduction to RIIA's Market Insight Research Program." *The Retirement Management Journal SM*, vol. 2, no. 2, summer.

University of Michigan Panel Study of Income Dynamics, Rep. N.p.: University of Michigan, 2008, *http://psidonline.isr.umich.edu.*

"Will they take the Money and Run?" Market Facts, November/December 1997, LIMRA.