ABSTRACT

Lapse rate modelling is an important topic for life insurers. Changes in such lapse rate can potentially lead to material losses or to liquidity problems.

Yet lapses prove difficult to model because they can be influenced by large number of parameters including the policyholder's behavioral characteristics, the product's specificities or the financial markets and macro-economic environment.

Specifically the modeling of interest rate dependency proves both critical (as lapses could be driven by increasing interest rates) and difficult to calibrate (historical data offer for instance limited information as rates decreased almost continuously over the recent decades).

In this white paper we review market practices in the Belgian market with regard to the modeling of lapses.

We further propose a pragmatic way to model and calibrate the interest rate dependency of lapse rates.
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Introduction

Lapse rate\(^1\) modelling is an important topic for life insurers. Changes in such lapse rate can potentially lead to material losses or to liquidity problems. Yet lapses prove difficult to model because they can be influenced by large number of parameters including the policyholder’s behavioral characteristics, the product’s specificities or the financial markets and macro-economic environment.

Particularly, with the currently low rate environment, one could expect that lapses could become materially more sensitive to interest rates if these ones were increasing again leading to quite significant losses for life insurers. Indeed, in case of interest rates hikes, for a set of products with either fixed guaranteed rate either income-driven profit sharing features (i.e. trailing behind interest rates movements due to their dependency on previously invested portfolios), clients may have an economical interest to surrender their contracts anticipatively. As we illustrate it at the end of this paper, the effect of changing lapses due to a mere 0.5% increase in interest rates over the next 3 years could prove sufficient to wipe out pretty material proportions of life’s business profitability.

In 2015, Reacfin has conducted a survey regarding lapse models used by Belgian Life insurers with a specific focus on interest rate dependent models. We observed that only a limited number of companies foresee interest rate dependency in their lapse model. One of the reasons explaining this small number is that more than 75% of the Belgian insurance companies do not yet consider lapse risk as a major threat to their profitability (in comparison with other risks). An additional reason is the fact that such a lapse model was not really needed in the past few years. Indeed, because of a prolonged low interest rates’ environment, the lapse rates observed on the insurance and more especially on savings market were very low.

But what if interest rate increased in the future? How would the lapse rates in life insurance be impacted?

Because of the lack of representative historical data, it is difficult to perform the calibration and the modelling of the lapse behavior, more specifically of the interest rate dependent behaviour.

This paper addresses the topic of lapse modelling and calibration for life insurance. While the first chapter presents some general characteristics of lapse modelling (as proposed in the literature and as practically implemented by European insurance companies), the second chapter focuses on the link between lapses and interest rates and proposes a pragmatic way to define interest rate dependent models for lapses and calibrate them.

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1 percentage of life policies surrendered prior to their normal maturity or contract boundary
HOW ARE LAPSES MODELLED?

This section contains a description of the variables and type of models used for lapses modelling in the literature and on the Belgian market.

Models

In the academic and practitioner's literature, a large number of articles suggest modeling lapses using the well-known Generalized Linear Models (GLM) because they

- capture an important number of risk factors
- capture interactions between variables
- account for correlations between variables

In this framework, the logistic regression is the most popular one. In this case, the lapse probability \( \pi \) is expressed as

\[
\text{logit}(\pi) = \ln \left( \frac{\pi}{1 - \pi} \right) = \beta_0 + \sum \beta_i x_i,
\]

where \( x \) represent the explanatory variables (age, interest rates, ...)

On the Belgian market, our survey showed that market practices rather consisted in splitting the lapse model in 2 main components:\(^2\):

- A model component dependent on financial markets and macro-economic conditions (the "dynamic lapse component"). In most cases these consider interest rates only. Such component is only developed and calibrated by about half of our respondents.
- A "market independent" lapse component (which will rather depend on the characteristics of contract and of the policyholder) and was developed by a majority of our survey's respondents.

The 2 components are often separated and developed rather independently. The total lapse probability is then simply the sum of these two components.

A disadvantage of such approaches is that the calibration of the "market independent" component is based on historical data, which one may say already depends on the interest rates (and other market parameters). It means that the rate dependency is partially taken into account in the static component and should ideally be isolated from the historical data. Implicitly Belgian insurers seem thus to assume that, given interest rates decrease quite consistently over the last several decades, they didn't have any impact on the lapse rate.

In most cases surveyed, the "dynamic lapse component" has the following characteristics:

- Fairly simple model: linear or quasi-linear
- Depending on the difference between
  - A market reference interest rate (see section on "variables" hereafter)
  - A return paid to clients. Typically expressed as a guaranteed rate plus an average historical profit sharing rate.
  - The larger the difference between the rate of return offered by the company and the alternative rates on the market, the higher the lapse probability.
- In most case, no floor or caps effects are considered. This means that
  - The interest rate dependent effect occurs as soon as there is a difference (even very small) between the market rate and the total return paid to the client
  - There is no limit to the influence of this delta rate; the bigger the difference, the bigger the impact
- In most of the case, the calibration of the dynamic lapse component is done on the basis of expert judgment:
  - This is mainly due to the lack of representative market conditions in recent decades (i.e. rising rates)

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2 Which we further detail later in this paper
Variables

In the academic and practitioner’s literature, variables typically quoted to explain lapses are listed in the exhibit below.

Product’s characteristics are key determinants of lapse rates. Mechanisms such as Market Value Adjustment (“MVA”) clauses or profit sharing features can be set up to limit the lapse rate dependencies to interest rates. Indeed, a policyholder would be incentivized to surrender his contract anticipatively if such surrender would result in a net financial gain. Such net gain may be computed by considering the delta between the rate of the contract and the rate offered on the market for equivalent products. However, if the surrender charges are variable (increasing with interest rates hikes) or if the profit sharing rates proposed on the market are lower, the policyholder will be more reluctant to lapse.

From our survey we observed that in Belgium, next to market rates, life-insurers may use a large variety of variables explain the intensity of lapses (see chart hereunder). Half of them considering at least the tax treatment of the product for the policyholders, the type of product, the age of the contract and the remaining life of the contract.

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3 “Market Value Adjustment” clauses are variable surrender penalties depending on the evolution of market rates and making thus lapses less sensitive to interest rates hikes (as rates would increase so would surrender penalties charged to clients willing to anticipatively redeem their contract.

4 Taking into account impact of taxes, surrender penalties and possible costs or charges.
Next to that a set of Belgian insurers surveyed (about half) use interest rates dependent models. For such models a key modeling assumption proves to be the choice of reference rate (which is to model market rates). Our survey hints that Belgian Life Insurers typically consider:

- Either the **Belgian rate for sovereign Bonds** (i.e. the Belgian “OLO” rate). This is typical of models which were already developed before the introduction of Solvency II and rather a practice for pure “Belgian Players”
- Either **inter-banking swap rates**. This is typical practice within International insurance groups or for Life insurers having developed their rate-dependent lapse model during the introduction of Solvency II).
HOW TO MODEL THE INTEREST RATES’ DEPENDENCY?

As mentioned in the introduction, the historical data available in Europe to model interest rate dependency is of limited significance given the consistent decrease of interest rates in the recent years.

Two possible solutions

A first solution could be to use data from other regions of the world. While quite limited, there are a few recent historical cases where lapses on Life & Saving products showed dependency to rising interest rates. An example here of is the case of South Korea during the late 1990's.

These findings should however be nuanced for insurance:

- Different markets typically prove challenging to compare as they involve very different customers habits, different commercialization practices, etc.
- Analysis published in academic or practitioner’s literature typically not only includes insurance products but also (short and long) term deposit products which showed materially higher sensitivity to interest rates (insurance contracts ~1.5-2 times less sensitive than other long term saving products)
- Lower sensitivity of insurance lapses is challenging to explain but could possibly be an effect of the “Emergency Fund Assumption”\(^5\) often mentioned by academic papers\(^6\). This assumption contends that policyholders use cash surrender values of life insurance as emergency funds when facing personal financial distress.

Hence, in the course of recent studies, Reacfin has proposed some of its clients to consider a second solution to model and calibrate interest rates dependent lapse rates. Our suggestion is to consider as proxies products for which the surrender rate is rather increasing during periods of reducing interest rates (i.e. for which the hike in surrender rates could be historically observed over the recent years).

\(^5\) i.e. the assumption that policy holders consider their life insurance policy as an ultimate buffer of money for real distressed situations hence one of the last once to be “actively managed” in their own private portfolio

Fixed rates residential mortgages are for instance typical candidates. Indeed, such mortgages are also dependent on interest rates but the relation is reverted: mortgage prepayments in Belgium tend to increase when borrowing rates are decreasing as the prepayment charge is mostly fixed (equal to 3 months interest rates payment). The advantage of this approach is that there are a lot of historical data related to mortgages allowing an easier calibration.

Our proposed method thus consists in translating the model used for residential mortgages so that it can be applied to the insurance world.

In practice, we typically assume (like many Belgian banks do) that residential mortgages prepayment rates can be modelled with an S-shaped curve. Note however that the methodology could be applied to mostly any other function.

The mortgage prepayment-proxy offers key advantages:

- **Evidences**: grounded in observable retail clients behaviour
- **Comparable approaches**: the S-shaped is “locally” a quasi-linear model similar to common models used for lapses
- **Implementable**: mortgages prepayment models can be logically transformed into a lapses risk proxy using a Net Present Value (NPV)-based approach (see hereafter).
NPV-based approach

The models used in Belgium for residential mortgages usually express the prepayment rate as a function of interest rates differential: the difference between the current mortgage rate and an alternative market rate.

Just “reverting” the rate relation would be an over-simplistic approximation and could result in misleading conclusions. Indeed, the prepayment rate of mortgages rather depends on the estimation of the gain (in net present value terms) that the borrower will make by refinancing its loan. It is thus not only the rate differential that matters but rather the value that the borrower can extract from the prepayment. Parameters such as penalties or remaining life of the contract will also be taken into account by the borrower.

Such idea can be used to adequately convert mortgages prepayment models into interest rates dependent lapse models. We propose to express the lapse rate as a function of a rate differential (in this case the difference between a market rate and the expected rate on the life insurance contract) but in a way which also considers the surrender costs, the penalties and the remaining duration of the contract. This can for instance be achieved by assuming that insurance policyholder will have the similar surrender behaviours as mortgage borrowers given their benefit in Net Present value terms is equivalent.

For example, let’s consider two different contracts A & B having exactly the same characteristics except that the surrender costs of the contract A are much higher than the surrender costs of contract B. It is reasonable to assume that, for a same rate differential, the probability to lapse will be higher for contract B than for contract A.
Calibrating the model

Let’s assume that the S-shaped function used to model lapses is the following:

\[ f(\Delta r) = a + b e^{-c e^{-d \Delta r}} \]  \hspace{1cm} (1)

The calibration will consist in adequately determining the values of these four parameters \(a, b, c\) and \(d\) by taking into account the lapses’ specificities.

Minimum lapse rate (parameter “a”)

From formula (1), we can easily see that \(f(-\infty) = a\), which means that the parameter \(a\) is the minimum lapse rate. In other words, it corresponds to the market independent part of the lapse rates model. As explained above, this market independent part is typically modelled by Belgian life-insurers using, for example, GLM (which is also aligned with suggestions to be found in international academic and practitioners papers).

Maximum lapse rate increase (parameter “b”)

From formula (1), we can also observe that \(f(+\infty) = a + b\). The sum of these two parameters gives thus the maximum possible lapse rate and \(b\) can thus be interpreted as the maximum increase in lapse rate as a result of interest rates hikes. In practice we believe it is critical that the determination of this rate should ultimately be done on the basis of expert judgment.

However, some facts may help for this expert calibration: one could indeed expect a lower sensitivity of insurance lapses to interest rates than mortgages:

- In contrast to other financial products, customers buy life insurance policies for long-term purposes and do not generally expect liquidity at any given time.
- Academic studies suggest the possibility of a relevant “Emergency Fund Hypothesis”.
- Mortgages are debts (hence often commercialized to populations which more prove more sensitive to potential gains), while life insurance are investment products largely commercialized to people with less financial constraints and who do actively manage investment portfolios (e.g. portfolios of securities) themselves.

On the basis hereof we could provide our clients with substantiated rationale for specific calibrations of the parameter \(b\).

Steepness accounting for surrender costs, penalties and duration (parameters \(c\) and \(d\))

Once these minimum and maximum lapse rates have been determined, it remains the estimation of parameters \(c\) and \(d\). The underlying idea is to use the NPV-based approach described here above. Therefore, one needs to determine the remaining duration, the penalties and costs (taxes,…) for mortgages and insurance products. One should also determine the relation between the \(\Delta r\) for mortgages and the \(\Delta r\) for lapses or, in other words, to translate the probability to prepay into a probability to lapse.

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7 see Belgium market practices in previous chapter
8 as international comparisons (e.g. the South Korean case elaborated above hints life insurance lapses can be materially less affect by interest rates changes than other financial products commercialized to retail clients.
Relevance of developing an interest rate dependent lapse model

Many insurers still hesitate on developing interest rate dependent lapse models. Similarly many retail bankers had hesitated to develop interest rate dependent model for the prepayment of residential mortgages. In Belgium such prepayment rate on residential mortgage inflated from their historical 3-4% stable levels to over 40% in some cases. Those bankers who had modelled it could anticipate the hike, adapt their offering and / or (partially) hedge out such risk.

An insurer that would currently have to ensure 0.75% guaranteed return on new business in life insurance product would today probably have to invest in very long term bonds. If for instance its operation costs and cost of capital only amounts to 0.75% it would mean that overall the investments of the insurer should ensure at least 1.5% return, which under current market conditions would probably mean investments (benchmarked on swap rates) up to 20 years.

In such case, if you assume that within 5 years (i.e. when the rates residual maturities of investments is of about 15 years),
- 15 years rates increase back to their value of Jan-2014 (i.e. around 2% and thus the residual duration of the invested bonds would be of about 13.5y);
- As a result lapse rates increase by a mere 15%,

then the loss for the insurer when liquidating his portfolio would be in excess of 100 bps (=13.5*0.5*15%), that is €1Mn loss for each €100Mn policies commercialized.

For In-Force life insurance books, where the guaranteed rates are typically higher and the clients have the option to stay invested the issue could only be worse, materially worse.

Conclusions

To conclude, while highly relevant, lapse modelling remains a quite tricky subject.

From our recent survey, we observed the issue is still widely underestimated by Belgian insurers, while basic interest rates mathematics show it could easily mean the difference between profitable and unprofitable business overall.

We believe rather simple modelling approaches based on relevant proxies are quite straightforward to implement. The “market independent” component of lapse rates can be calibrated using historical data and Generalized Linear Models. Next to that, comparisons with mortgages prepayments may prove interesting proxies to model the interest rate dependent component of lapses rate.

Doing so, insurance companies will be better able to assess the actual interest rate risks they are facing and to adapt their portfolio (both on assets and liabilities side) accordingly.
Reacfin’s Support

Reacfin is a consulting firm specialized in Risk Management, Actuarial Science, Portfolio Modeling and Quantitative Finance. We regularly support financial institutions in the development, the implementation and the validation of their new models.

With this White Paper we aim at illustrating the themes of some of our recent missions and research work.

We deeply believe that risk taking & innovation are inherent to the business models of financial institutions yet only scrupulous & systematic approaches can ensure the adequacy and robust implementation of new models.

To that extend Reacfin offers unrivalled modeling and validation support which combines the academic excellence of our consultants with high-end benchmarking services.

We look forward having the opportunity to also serve your company soon.

In the following exhibits, we elaborate on our focus and our company.
Reacfin s.a. is a Belgian-based actuary, risk & portfolio management consulting firm.

We develop innovative solutions and robust tools for Risk and Portfolio management.

The company started its activities in 2004 as a spin-off of the University of Louvain, focused on actuarial consultancy to Belgian insurers, pension funds and mutual organizations. Rapidly, Reacfin expanded its business internationally and broadened its scope to various aspects of quantitative & qualitative risk management, financial modeling and strategic advice to financial institutions.

Spread over its 3 offices in Louvain-La-Neuve, Antwerp and Luxembourg, Reacfin employs a team of high-end consultants most of which hold PhD’s or highly specialized university degrees.

We put great emphasis at strictly articulating our work around 5 fundamental driving values:

**Excellence: our outstanding feature**
To deliver more than is expected from us, we attract the best people and develop their skills to the most cutting-hedging techniques supported by a robust and rigorous knowledge management framework.

**Innovation: our founding ambition**
Leveraging on our profound academic roots, we are dedicated on creating inventive solutions by combining our extensive professional experience with the latest scientific research.

**Integrity: our commitment**
We put work ethics, client's best interest and confidentiality as the foundation of our work. We are fully independent and dedicated at telling the truth.

**Solution-driven: our focus**
We produce for our clients tangible long-term sustainable value. We help our clients not only to reach the top, we help them reaching the stable top.

**Reliability: our characteristic**
We never compromise on the quality of our work, the respect of deadlines & budgets and our other commitments. We don’t produce reports, we deliver results!
Reacfin’s 4 core fields of expertise:

**Risk & Portfolio Management**

**ALM, Portfolio Management & Quantitative Finance**
- Implementation and calibration of stochastic models for valuation, trading and risk Management purposes
- Times series analysis & modelling
- Pricing of financial instruments & development of ALM models
- Design/review/implementation of systematic trading & hedging strategies
- Business intelligence in ALM or Portfolio Management
- Tools development (Valuation, Pricing, hedging, portfolio replication, etc.)
- Design of Capital Management solutions

**Operations, restructuring & qualitative risk management**
- Organization & Governance
- Businesses restructuring & change management
- Implementation and industrialization of processes
- Internal & regulatory reporting (KRI’s & KPI’s dashboards)
- Model Review frameworks
- Model Documentation

**Insurance specialties**

**Life, Health and Pension**
- DFA* Models
- Capital Requirement assessment
- Business valuation support
- Product development (pricing, profitability, ...) & Reserving
- Model validation

**Non-Life**
- Reserving: triangle methods, individual claims modelling
- Pricing: frequency and severity modelling, large claims analysis, credibility methods, commercial constraints
- DFA models: cash-flows projection, calibration of models
- Reinsurance: modelling covers, optimal reinsurance programs

(*) DFA = Dynamic Financial Analysis
## What we deliver

### State of the art technical skills
- Expertise in most advanced quantitative modelling & academic excellence of a spin-off
- All our consultants hold multiple masters or Phd.
- Best-in-class qualitative risk management leveraging on highly experienced senior consultants
- Hands-on implementation solutions, tested for real-world conditions

### Balanced and pragmatic approach
- Client-centric solutions focussed on deliverables
- Respecting the principle of proportionality
- Cost efficient within tight pre-agreed budgets

### No black box Solutions
- We deliver results, not reports!
- Open source solutions
- Close cooperation with our clients

### Clearly structured processes
- Lean & efficient tailored project management
- Regular progress reviews
- Close cooperation with our clients

### Documentation, coaching & training
- Clear & comprehensive documentation compliant existing or upcoming regulation
- Adapted trainings at all levels of the organisation
- Coaching support for implementation and operationnalisation of processes
Examples of recent assignments

Of our center of excellence for **Life, Health and Pension**

- Interest rate dependent modelling for lapses
- Improvement of the allocation of the life technical profits to sources of profits
- Enhancement of projection models run-time
- Best Estimate net of reinsurance in Life and Non-Life Insurance
- Multi-state model in Health Insurance
- Dental Care Insurance Pricing Model
- Development of a worker’s compensation model
- Actuarial function in health insurance

Of our center of excellence for **Non-Life**

- Pricing model in Motor Insurance
- Validation of premium risk partial internal model
- Undertaking specific parameters (USP) application file
- Modeling and deployment of segmented price increase
- Premium risk model using timeseries
- Reserving model review for Legal Expense business
- Model testing framework set up
- Actuarial function in non-life insurance

Of our center of excellence for **ALM, Portfolio Management & Quantitative Finance**

- Advanced Mortgage Valuation Models in PROPHET
- Development of Economic Scenario Generators
- Strategic Asset Allocations
- Development of ALM models compliant with Solvency II
- Design of Solvency II compliant loans & credit investment products
- Pricing of a complex OTC balance derivative

Of our center of excellence for **Operations, restructuring & qualitative risk management**

- Definition of Comprehensive Risk Management Policies
- Development and deployment of model management scheme
- Risk appetite framework definition
- Overall design of Risk management framework
- ORSA organization and process
- Validation of internal model qualitative aspects
- Dependency modeling and testing
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