Modeling Anti-selective Lapse and Optimal Pricing in Individual and Small Group Health Insurance

by Andrew Wei

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1. Introduction

The task of determining the optimal rate increase for a block of individual or small group health (ISH) insurance policies presents a special challenge for actuaries. A key complicating factor is that a rate increase often leads to *anti-selective lapse*—a tendency that healthy lives lapse at a higher rate than impaired lives—resulting in an adverse change in the health mix of insureds. (For brevity, the term *insured* or *life* is used throughout this paper to refer to an individual, a family or a small group). In addition, a profit maximizing optimal rate increase solution needs to take into account the market price or the prevailing competitive prices in the market. In traditional actuarial models, anti selective lapse is simply assumed and market price not explicitly considered. In this article, we present a new model in which anti selective lapse emerges endogenously, as a result of rate restriction and market competition, and an optimal pricing solution can be obtained.

Many of us have an intuitive understanding of how anti selective lapse occurs. A distinguishing feature of the ISH market is *differential rate restriction.* Specifically, there are strict regulatory limits on how much renewal rates may vary within a class of insureds to reflect each insured's current health status or claim risk, although renewal increases applied at the block level are generally not restricted. (These limits exist because in the absence of these limits, insureds with serious long term illnesses are vulnerable to selective high renewal rate increases.) As a consequence, within a block, impaired lives' renewal rates are subsidized by healthy lives. On the other hand, new business rates are not subject to the same strict limits. Insurers are allowed (or at least, with much less restriction) to medically underwrite and rate new policies. If an insured decides to switch insurers, his new policy rates will be set according to his current risk. It is then natural that when there is a large renewal rate increase, insureds would shop around; those who could find lower price alternatives in the market would likely lapse, and those who could not would likely stay. The former are disproportionately healthy lives and the latter impaired lives. One key task in this new model is to formalize this intuition.

In the following, we present the model with minimal technical details. Our focus is on the concepts, relations, and implications of the model. We first describe the individual behavior of an insured and then the aggregate behavior of a block. *(The mathematical details of the model can be found in a paper by this author in the 2009.1 issue of the ARCH available on the SOA Web site.* http://soa.org/library/proceedings/arch/2009/arch-2009-iss1-wei.pdf. *A quick note on notation: In the detailed paper, log transformed variables were extensively used for technical reasons. In this article, only standard variables are used for the sake of readability.)*

2. Individual Model

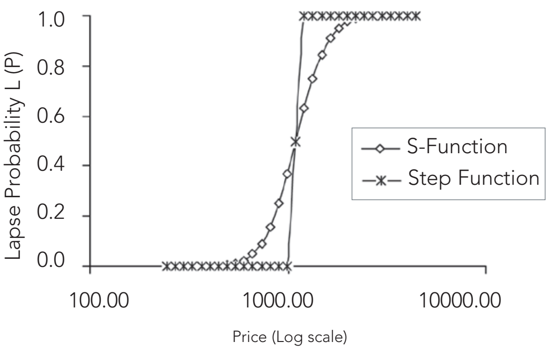
Individual Lapse Behavior

We first consider individual lapse behavior arising from an insured switching from the current insurer to another insurer for a lower price in the market (We shall ignore, for simplicity, other types of lapse). The probability of price induced lapse L due to switching for insured x is expressed as a function of adjusted price P' and market price M

$$L = S(P' / M).$$

Adjusted price P'=P/A, where P is price or premium rate and A is a *premium adjustment factor* for switching cost and product quality differences. So we can alternatively write $L = S((P/A)/M)$. Market price M is specific to insured x and calculated as $M = \sum_j w_j \cdot P_j$, a weighted average of competitor prices P_j for insured x. Significantly, it can be shown under certain conditions that if P'=M, then L=1/2 and vice versa. S is an "s"-shaped monotonically increasing function with properties: $S(z) \to 0$ as $z \to 0$, $S(z) \to 1$ as $z \to \infty$ $S(z) = 1/2$ if z=1. A special case for S is a step function with $S(z)$=0 if z <1, $S(z)$ =1 if z >1 and $S(z) = 1/2$ if z=1 (Figure 1).

FIGURE 1
LAPSE FUNCTIONS



To illustrate, consider a policy with premium rate P= \$1000, the cost of switching equal 10 percent of premium, and a product quality (which can be either higher or lower than average competition) commanding an extra 5 percent of premium. Then the premium adjustment factor A= (1+10%)*(1+5%) =1.155. The adjusted price P'= \$1000/1.155 = \$865. Suppose that the market price M is also \$865, then the lapse probability for this policy $L=S(1)$=1/2. The insured is indifferent. In this case, when L=1/2, P > M, due to the existence of switching cost and a positive quality premium.

The "s"-shape of function S is intended to capture the fact that a homogeneous class of insureds tends to exhibit heterogeneous lapse response to price and any prediction of lapse will have a non zero variance. If we could predict individual lapse perfectly, with a zero variance, then S is reduced to a step function. The step lapse function often leads to greatly simplified models.

Let's consider how we might estimate market price M and premium adjustment factor A. Note the relation that if L = ½ then P'=M or P/A =M. So if M is known and L=1/2, we can calculate A=P/M. M is initially calculated as a weighted average of competitive prices. In many cases, we may reasonably assume that A is the same for all policies in a block. Once A is known, M can be subsequently calculated from lapse L and price P using the inverse lapse function. This is convenient as the detailed competitive prices for many types of policies are often not available. Function S is derived from historical relationship between lapse L and price P.

Setting Premium Rates

In this market, insurers are assumed to set price P based on the insured's expected cost C plus a margin, but there are three exceptions: 1) deviation of renewal rate from cost due to rate restriction, 2) insurers' inability to accurately forecast medical cost trend, and 3) strategic pricing in which the price is set above or below the cost (for profit or market share).

When the new business rate is unrestricted, it turns out that market price M is proportional to cost C for all insureds in a block.

Excess risk

A central notion of this model is excess risk. Conceptually, excess risk is the portion of market price which is not in the actual price, because of rate restrictions. Consider a block of heterogeneous insureds. Let x be an insured with adjusted premium rate P', cost C, and market price M, x_0 a standard life with adjusted premium rate P'_0 , cost C_0, and market price M_0 , and x_1 an impaired life with adjusted premium rate P'_1, cost C_1, and market price M_1. Define *excess risk* V for x, expressed relative to a standard life, as

$$V = (M / M_0)/(P' / P'_0)$$

For impaired life x_1, it is easy to see that $P'_1 / P'_0 < M_1 / M_0$ due to the subsidy received by x_1. The excess risk $V_1 = (M_1 / M_0)/(P'_1 / P'_0) > 1$. For standard life x_0, the excess risk $V_0 = (M_0 / M_0)/(P'_0 / P'_0) = 1$. To illustrate, suppose P'_0=\$900, M_0=\$1000, P'_1=\$1100 and M_1 =1500, then V_1= (1500/1000)/(1100/900) =1.227. V_1 represents the extra market price not reflected in the insured's premium rate due to rate restriction.

If M is proportional to C, we have an alternative formula for excess risk $V = (C / C_0)/(P' / P'_0)$.

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When the new business rate is unrestricted, it turns out that market price *M* is proportional to cost *C* for all insureds in a block.

Anti-selective Lapse

Note that $V = (M/M_0)/(P'/P'_0)$ implies that $P'/M = P'_0/(M_0 \cdot V)$. Now the lapse function $L = S(P'/M)$ for an insured with excess risk V can be rewritten as:

$$L = S(P'_0/(M_0 \cdot V))$$

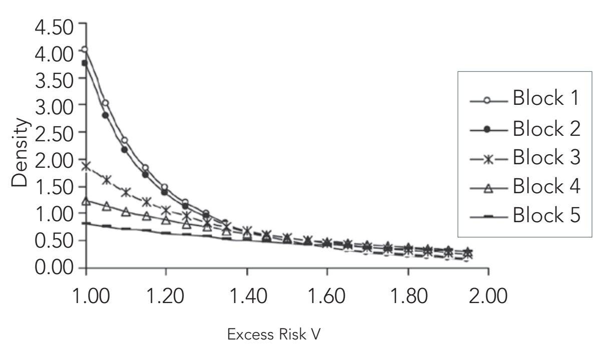
For $V_0 < V_1$, the fact that S is monotonically increasing implies that $S(P'_0/(M_0 \cdot V_0)) > S(P'_0/(M_0 \cdot V_1))$, thus $L_0 > L_1$ or healthy life x_0 lapses at a higher rate than impaired life x_1. So the above equation is a formula for anti-selective lapse. Note that anti-selective lapse is not assumed, but emerges naturally within the model.

3. Aggregate Model

Next we consider the aggregate behavior of a block of policies. Specifically, we want to determine the aggregate lapse, loss ratio, and profit using several representative blocks.

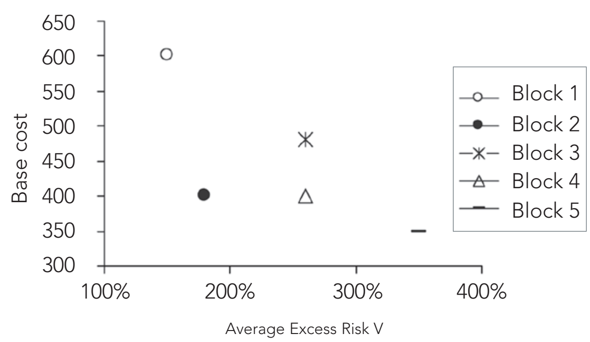
Consider five representative blocks that vary in the health mix of insureds and cost structure. The health mix of insureds in a block can be characterized using *f(V)*, a density distribution of insured excess risk for the block. Figure 2 shows the excess risk distributions for these five blocks. Intuitively, Blocks 1 and 2 have the highest proportion of healthy lives, Blocks 4 and 5 the lowest proportion of healthy lives, and Block 3 the medium proportion of healthy lives. In practice, we can obtain excess risk distribution *f(V)* by aggregating insureds by excess risk *V* over a block.

FIGURE 2
EXCESS RISK DISTRIBUTION BY BLOCK



In addition to their differences in excess risk, these five blocks also vary by base cost. The base cost of a block reflects the provider discount as well as the general expense of an insurer. Figure 3 positions these five blocks in a two dimensional map of average excess risk vs. base cost. In particular, Block 1 has low excess risk but high base cost and, in contrast, Block 5 high excess risk but low base cost. In the real world, Block 1 represents an insurer that is good at underwriting but not good in obtaining provider discount and managing expenses, and block 5 represents the opposite.

FIGURE 3
AVERAGE EXCESS RISK AND BASE COST BY BLOCK



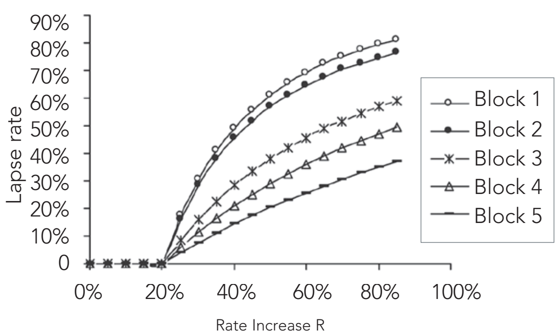
Now let x_0 denote a standard insured in a block, P'_0 the adjusted premium rate for x_0, and M_0 the market price for x_0. We shall refer P'_0 *as premium rate level* and M_0 *as market price level*. Let R denote the percentage of rate increase. Let $P'_0(R)$ denote P'_0 as a function of rate increase R. Then $P'_0(0)$ is initial premium rate level for x_0 when R= 0. Define $R_0 = M_0 / P'_0(0) - 1$. Then $P'_0(0) \cdot (1+R_0) = M_0$ Intuitively, R_0 is the percentage rate increase needed to bring P'_0 to match M_0.

For ease of comparison, initial premium rate level $P'_0(0)$ is assumed to be 20 percent below the market price level for all blocks. In other words, for all blocks, if R=20%, then $P'_0 = M_0$ or the premium rate level matches the market price level. So R_0=20% for all blocks.

Within a block, initial premium rates vary by insureds' benefits and risk load. All insureds within a block are assumed to receive the same percentage rate increase (This is not restrictive because the risk load can vary). Furthermore, the step lapse function is used for simplicity.

Applying the lapse formula $L=S(P'_0(R) / (M_0*V))$ to each insured in a block, we calculate the aggregate lapse rate of the block as a function of rate increase R (Figure 4).

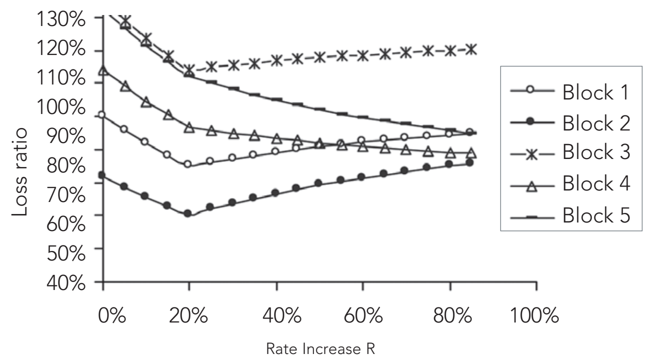
FIGURE 4
AGGREGATE LAPSE BY BLOCK



We make a few observations. When $R < R_0$ (R_0=20%), the premium rate level $P'_0(R)$ < market price level M_0, and aggregate lapse rate =0 in all blocks. When $R \geq R_0$, then $P'_0(R) \geq M_0$, and aggregate lapse rate is increasing with R. These blocks show different lapse sensitivity to price. Blocks 1 and 2, with the highest proportion of healthy lives, exhibit the steepest increases in lapse, and Blocks 4 and 5, with the lowest proportion of healthy lives, exhibit the slowest increases. The rate increase-induced lapses in these blocks are necessarily anti-selective in nature.

Next we calculate the aggregate loss ratio as a function of rate increase for each block (Figure 5).

FIGURE 5
LOSS RATIO BY BLOCK



Several loss ratio patterns emerged among these blocks. When R=0, the initial loss ratios differ considerably. When R < R_0 (R_0=20%), loss ratio is decreasing with *R* in all blocks When $R \geq R_0$, loss ratio is decreasing with *R*, at a slower rate, in Blocks 4 and 5, but is increasing with R in Blocks 1, 2, and 3. The loss ratio trajectory experiences a sudden shift at the point where lapses begin to rise. The various loss ratio patterns reflect the different impacts of anti-selective lapses as well as the different cost structures in these blocks.

Assessment spiral

The loss ratio behavior in Block 2, incidentally, provides an illustration for the assessment spiral phenomenon. Note that if a large renewal rate increase, *R*=85%, is given, the loss ratio after the increase, 76 percent, is actually higher than the loss ratio before the renewal increase, 72 percent.

Figure 6 shows the aggregate profit as a function of rate increase for these blocks.

The aggregate profit patterns mirror those of loss ratio in these blocks. When *R*=0, the initial profits vary considerably. When R < R_0 (R_0=20%), profit is increasing with R in all blocks. When $R \geq R_0$, profit is increasing with *R* in Blocks 4 and 5, but decreasing with *R* in Blocks 1, 2, and 3. Likewise, the different profit patterns reflect the changes in the mix of insureds and the cost structures in these blocks.

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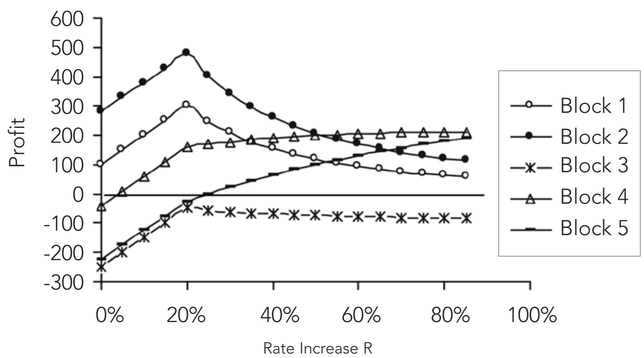
FIGURE 6

AGGREGATE PROFIT BY BLOCK



4. Optimal Pricing

Two distinct optimal pricing strategies emerged. First, for Blocks 4 and 5, the two blocks with the least healthy mixes of insureds, the optimal strategy is to maximize rate increase R (to the extent possible within the limits of the rating law). Second, for Blocks 1, 2, and 3, which have healthier mix of insureds, the optimal strategy is to set $R=R_0$ or set $P'_0 = M_0$, i.e., set the premium rate level to the market price level.

Sustainable blocks

Blocks 1 and 2 belong to an important class of blocks called sustainable blocks, which are characterized by

- A high proportion of healthy lives
- Profit is maximized when $R=R_0$ or $P'_0=M_0$
- At optimal price, the price-induced lapse is zero

Note that these blocks are theoretically sustainable as it is in the insurer's self-interest to keep rate increases moderate and lapses minimal. Setting $R=R_0$ amounts to giving only the trend increases in the long run.

5. Profit Drivers

Define *profit capacity* as maximum profit attained (at optimal price) in a block. It turns out that for sustainable blocks, profit capacity can be expressed as a function of internal drivers and an underwriting cycle index:

$$\text{Profit Capacity} = \text{Policy Inforce} \cdot \tilde{C} \cdot (A \cdot \Phi - B \cdot \bar{V})$$

A is the price adjustment factor described before, B is a firm-specific cost factor, $\bar{V}$ is average excess risk for a block, $\tilde{C}$ is market cost level or a weighted average of all competitors' cost for a standard life, Φ is an underwriting cycle index (Φ = market price level / market cost level),

The formula captures what we intuitively know. To increase profit capacity, an insurer can employ three basic strategies: 1) raise A: increase perceived quality and the cost of switching; 2) reduce B: lower cost and obtain better provider discount, 3) lower $\bar{V}$: improve underwriting and risk assessment. Φ is outside the insurer's control, and profit capacity fluctuates with Φ. Due to leveraging, small changes in A, B, $\bar{V}$, or Φ lead to large swings in profit capacity.

To illustrate, suppose *Policy Inforce* =100,000, $\tilde{C}$ = \$2,000, Φ =1.5, A=1.0, $\bar{V}$=1.4, B= 1.0, we can calculate profit capacity = \$20,000,000. Furthermore, a 1 percent change in any of the drivers A, B, $\bar{V}$, or Φ produces a 14 percent–15 percent swing in profit capacity.

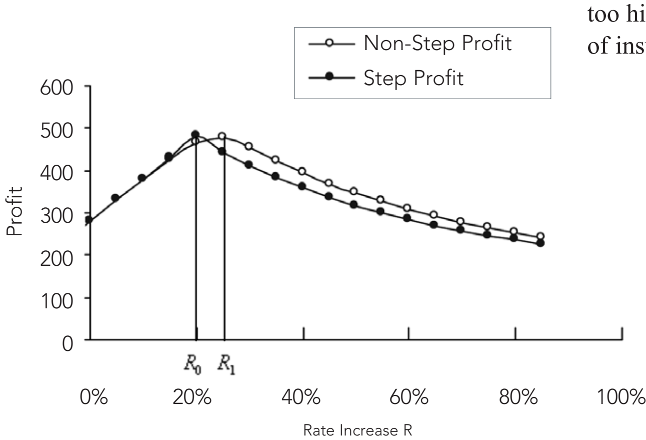
6. Non step Lapse Effect

So far, the step lapse function was used. As a result, we were able to obtain a simplified model with easy to understand results. In the real world, we cannot predict individual lapse perfectly, so a non-step lapse function is more realistic. Let's look at an example which illustrates how a non-step lapse function might affect the model.

Figure 7 compares the two methods of calculating aggregate profit function for Block 2. When the non step function is used, the overall effect is a shift of the aggregate profit curve to the right. The optimal rate increase shifted from $R=R_0$ to $R=R_1$ where R_1 is somewhat higher than R_0. But the essential characters and general results of the aggregate profit function remain unchanged.

The non step function has similar effects on aggregate lapse and loss ratio behavior.

FIGURE 7
AGGREGATE PROFIT WITH NON-STEP LAPSE RESPONSE



7. Conclusion

We developed a model in which anti selective lapse emerges naturally as a result of differential rate restriction and market competition. We applied the model to determine optimal rate increases in representative blocks with different mix of insureds and cost structures. The model has several practical applications and yielded new insights into the behavior of ISH insurance in a competitive market.

One key insight is that for a class of sustainable blocks, insurers can maximize profit while keeping rate increases moderate and lapses low. Sustainable blocks are good for both insurers and insureds. This could have implications for product design as well as regulation. A potential implication is that a disciplined insurer could offer contractually, at no extra cost, a renewal rate guarantee linked (within a small range) to a broad market price index, or alternatively, linked to, as a proxy, a medical cost index.

It may be worth mentioning some additional practical implications or potential rules for optimal pricing. These rules, though model based, can be used independently: 1) make sure to track competitive prices by market; 2) for optimal pricing, lapse is as important as cost or risk; 3) build a good lapse model; 4) monitor different types of lapse, especially base lapse vs. price-induced lapse; 5) if lapse rates exceed a base level, then prices are probably too high; and 6) set a target lapse rate for each class of insureds.

Finally, the model can be generalized. The excess risk distributions used can be easily extended to a general form. The basic framework of the model also allows new businesses to be incorporated. The model structure lends itself well to computer modeling. ■

The model has several practical applications and yielded new insights into the behavior of ISH insurance in a competative market.