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BONUS-MALUS SYSTEMS IN A DEREGULATED ENVIRONMENT: FORECASTING MARKET SHARES USING DIFFUSION MODELS

BY

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ABSTRACT

In a deregulated insurance market, insurance carriers have an incentive to be innovative in their pricing decisions by segmenting their portfolios and designing new bonus-malus systems (BMS). This paper examines the evolution of market shares and claim frequencies in a two-company market, when one insurer breaks off the existing stability by introducing a super-discount class in its BMS. Several assumptions concerning policyholders and insurers behavior are tested. Diffusion theory is used to model the spread of the information concerning the new BMS among prospective customers. A wide variety of market outcomes results: one company may take over the market or the two may survive with equal or unequal market shares, each specializing in a specific niche of the market. Before engaging in an aggressive competitive behavior, insurers should consequently be reasonably confident in their assumptions concerning the reactions of their policyholders to the new BMS.

KEYWORDS

Bonus-malus systems, rating freedom, competition, diffusion processes, external and internal communication coefficients.

1. INTRODUCTION

With the introduction of complete rating freedom in non-life insurance in the European Union (EU) in July 1994 (Third Directive 92/49/EEC), insurers have been given the opportunity to be innovative in their pricing decisions, to introduce more classification variables and to design new bonus-malus systems (BMS). The European Commission has sent a clear message that the use of a mandatory BMS by all insurers of a given country is a practice that violates competition regulation.

In countries like Italy and Portugal, companies have taken advantage of new conditions to engage in very competitive strategies, based in part on aggressive BMS. Following the EU Directive, Portuguese companies have moved very quickly from a simple, six-class BMS to widely differentiated systems, actively

promoted and advertised. A recent survey (Portugal, 2001) mentions no less
than 33 different BMS, with a number of classes that varies between 12 and
28 and maximum bonuses that range between 30% and 60%; the number of
claim-free years to reach the highest discount from start can be as low as two
and as high as 17. Many companies have reacted to their newly found freedom
by expanding the number of BMS classes, mostly the bonus classes. The cur-
rent average number of classes is 17, up from six in the old system. Only two
companies have kept the former maximum bonus of 30%. The vast majority
of insurers have moved to a maximum bonus of 50%, with several awarding
discounts of even 55% or 60%.

Insurers in other European countries have not reacted as aggressively as the
Portuguese to the EU Directive. They appear to compete mostly on the basis
of increased segmentation through the use of more *a priori* classification vari-
ables, rather than creative BMS design. Insurer associations in Belgium, France,
and Luxembourg have taken legal action to exclude BMS from the range of
application of the Directive and keep the idea of a uniform BMS mandatory
for all companies. France and Luxembourg have scored an unexpected victory
in court, and legal proceedings are still pending.

Belgian insurers have been successful in delaying BMS rating freedom by
enforcing the idea of a smooth landing, a progressive elimination of their manda-
tory BMS. It is only since January 1, 2004, that Belgian carriers are free to design
their own BMS. Policyholders switching companies must obtain from their
former insurer a certificate indicating their claims history over the last five years;
the new insurer may then use this information to determine the entry class
into its own BMS. As of November 2004, it appears that few companies have
taken advantage of rating freedom to introduce major deviations from the
former BMS that had 23 classes, premiums levels ranging from 54 to 200, a one-
class discount per claim-free year, and a five-class penalty per claim. One com-
pany has added two "super-bonus" classes at level 54. Another company has
created four "super-bonus" classes with higher discounts.

One reason for the lack of an aggressive BMS policy in countries like
Belgium or France could be insurer uncertainty concerning the outcome of
unbridled competition. Insurers do not know whether the introduction of
a more efficient BMS will attract good or bad drivers, or result in an increased
or decreased market share. Another reason could be policyholder information,
or lack thereof, in automobile insurance. The well-known assertion by Joskow
(1973): "There is no other product for which consumer ignorance is so preva-
lent" is still applicable today. While most European drivers know that their
premium depends on their car model and that they are subject to some form
of merit-rating, only a minority knows its BMS premium level and the num-
ber of penalty classes in case of an accident. It is much easier for insurers to
advertise immediate discounts for suburban female drivers than to explain that
a more efficient BMS will, in the long run, lead to decreased premiums for the
better drivers.

The introduction of a new BMS represents an innovation in an automobile
insurance market. In revising its system from a government-prescribed system,
an insurer chooses the number of classes, the premium levels, and the transition

rules, each of which affording much flexibility. Through its system construction, an insurer may try to implement certain marketing strategies: attract the better drivers, capture market share, improve profitability, etc.

A BMS is a sophisticated innovation for which the learning requirements for prospective customers are high. Developing the ability to compare these systems takes time and initiative. Some drivers may have a short-term view, only comparing their premium for the next period, while others may assess their future claim probabilities and choose an insurer and its BMS accordingly. Companies need to promote their BMS and inform future customers. Advertising is a highly effective marketing tool to spread information concerning a new product, but advertising alone is not enough to educate policyholders. Word-of-mouth among drivers and brokers is probably just as essential in getting a large segment of the population informed.

In this article we shall use diffusion theory, a tool that has been used minimally in actuarial science, to model the spread of information about a new BMS among policyholders. We shall explore market outcomes (evolution of market shares and claim frequencies) in a deregulated environment, using a variety of assumptions about policyholder behavior and insurers' strategies. In section 2, the main deterministic models of diffusion theory are introduced. A survey of the theory can be found in De Palma, Droesbeke, and Lefèvre (1991) and Mahajan and Wind (1986). In section 3, our basic model of the competition between two companies is provided. Section 4 presents the results of our benchmark scenario. In section 5, eight other scenarios are introduced. They lead to a wide variety of market outcomes. It is concluded in section 6 that the knowledge of a market and its consumers is crucial to the implementation of a successful BMS strategy. Note that, with the exception of an article by Fels (1995), there has been little research done on BMS in a competitive environment. This research extends a discussion by Subramanian (1998).

2. DIFFUSION THEORY

Deregulation in insurance markets provides a timely opportunity for the incorporation of models of diffusion theory into actuarial science. In a diffusion process, an innovation is communicated through certain channels over time among the members of a social system. Diffusion theory can model the spread of a new product from its manufacturer to ultimate users. Communication of information can occur through the combination of two processes: advertising and word-of-mouth. These two processes will be first considered separately before being integrated.

2.1. The Advertising Process

The simplest model representing the spread of information in a closed group of individuals formalizes an idea of Fourt and Woodlock (1960). Assume a group of N persons (N constant) is partitioned into two sub-groups: the group

$S(t)$ of people who have not yet heard about the new product by time t, and the group $I(t) = N - S(t)$ of people who have learned about the new product, the "informed". Uninformed individuals learn about the innovation only through sources external to the social group: radio and television ads, newspapers, billboards. Denote a as the *external communication coefficient*, $a \in [0, 1]$, the strength of those external influences. During time interval $(t, t + \Delta t)$, each individual in group $S(t)$ learns about the new product with probability $a\Delta t$, independently of all other individuals. During time interval $(t, t + \Delta t)$, the rate of transition from class $S(t)$ to class $I(t)$ is $a[N - I(t)]$. Then, the total number of informed individuals at time $t + \Delta t$ is

$$I(t + \Delta t) = I(t) + a[N - I(t)]\Delta t$$

Assuming that time is measured in fairly small time intervals, we can use a differential equation as an approximation. Dividing by Δt and taking the limit for $\Delta t \rightarrow 0$ leads to the linear differential equation

$$\frac{dI(t)}{dt} = a[N - I(t)]$$

with solution

$$I(t) = N - [N - I(t_0)]e^{-a(t - t_0)}$$

where t_0 is the time of introduction of the new product, and $I(t_0)$ represents the initial number of informed individuals, possibly 0. The number of informed people forms an increasing and concave curve. $I(t)$ asymptotically tends to the population size N. Consider a group of 1000 individuals, none of whom is informed at time 0. Figure 1-1 depicts the increase in informed individuals over time, for various values of a.

2.2. The Word-of-Mouth Process

Mansfield (1961) considers only the word-of-mouth effect in the spread of information. Assume that a population of size N lives in a volume V of dimension 1, 2, or 3, and that the N individuals are uniformly distributed in V. It is reasonable to assume that uninformed individuals from $S(t)$ can only learn from informed individuals $I(t)$ who live close to them. Suppose that only the individuals of group $I(t)$ from a given sub-volume ΔV can inform an individual in group $S(t)$ living in the same ΔV. The number of informed and non-informed in ΔV at time t are equal to $I(t)\Delta V/V$ and $[N - I(t)]\Delta V/V$, respectively. Consequently, there are $I(t)[N - I(t)](\Delta V/V)^2$ different pairs of informed/non-informed in ΔV. Assume that any individual can meet at most one other individual during time interval $(t, t + \Delta t)$. Let c be the rate of contact between an uninformed/informed pair in ΔV. As V contains $(V/\Delta V)$ sub-volumes ΔV, the total number of persons switching from S to I during $(t, t + \Delta t)$ is

$$I(t)[N - I(t)](\Delta V/V)^2 c\Delta t(V/\Delta V)$$

The transition rate from class S to class I is then

$$\frac{dI(t)}{dt} = I(t)[N - I(t)] c \Delta V / V = b I(t)[N - I(t)] / N$$

where $b = c \Delta V \rho$ and $\rho = N/V$ is the density of individuals in volume V. b is called the *word-of-mouth communication coefficient*, and, in the above formulation, is independent of N. Parameter b, $b \in [0, N]$, measures the effectiveness of word-of-mouth as an information spreader. It is a function of the degree of knowledge and interest that individuals possess as well as media intensity. The potential number of contacts between an informed and an uninformed is $I(t)[N - I(t)]$. Thus, b/N is the probability that an informed individual meets an uninformed *and* that the contact leads to information spread. This probability is affected by the population size; as N increases, the probability that this particular contact between an informed/uninformed takes place becomes smaller.

The solution of this Ricatti non-linear differential equation is

$$I(t) = \frac{N}{1 + \dfrac{N - I(t_0)}{I(t_0)} e^{-b(t - t_0)}}$$

This is the well-known logistic curve, which is increasing, first convex then concave, and tends asymptotically to N. The inflection point is $I(t) = N/2$. At first, the number of informed persons grows slowly, as few people know about the new product. Then a snowballing effect begins, culminating at the inflection point, the maximum rate of information spread, when exactly half the population is informed. A progressive saturation effect begins there, reducing the rate of information spread. The process has two stationary states, $I_S = 0$ and $I_S = N$. The first state is unstable: the process cannot start as long as nobody knows about the new product. As soon as one individual is informed, $I(t)$ will increase. The second state is stable: the entire population is informed.

Consider again a potential market of 1000 individuals, for which the word-of-mouth effect represents the only way for information to be spread. At the initial time, 25 individuals are informed. Figure 1-2 depicts the growth in the number of informed policyholders for various values of the word-of-mouth coefficient b.

2.3. Advertising and Word-of-Mouth

Bass (1969) combines both the advertising and word-of-mouth effects in the following non-linear differential equation, of the Ricatti type.

$$\frac{dI(t)}{dt} = [a + bI(t)/N][N - I(t)]$$

The solution of the equation is

$$I(t) = \frac{N - \dfrac{a[N - I(t_0)]}{a + bI(t_0)} e^{-(a + bN)(t - t_0)}}{1 + \dfrac{b[N - I(t_0)]}{a + bI(t_0)} e^{-(a + bN)(t - t_0)}}$$

The number of informed asymptotically grows to N. $I(t)$ has a concave shape if $b \leq a$, and a sigmoidal shape if $b > a$. The importance of the word-of-mouth effect constantly increases with time. External influences are mostly important at the beginning of the process. In particular, if $I(t_0) = 0$, only external influences will allow the information process to start.

Note these implicit assumptions in the above presentation:

1. Informed and non-informed individuals have a symmetrical role. This implies that the rate of information curve is symmetric with respect to the inflection point. This point is reached before half of the population is informed.
2. The population is homogeneous in its socio-economic characteristics, and uniformly spread in space.
3. Only two classes of individuals are considered. Steps in the information process are not considered. Informed people never forget.
4. The information process is not dependent on the existence of another, possibly similar product, on the market.
5. The model is deterministic. Randomness can be incorporated in the information process through a stochastic model (Bartholomew, 1982).

3. APPLICATION: TWO COMPANIES IN COMPETITION. THE BASIC MODEL.

Given that deregulation in insurance markets allows insurance companies to design their own BMS, how will aggressive or passive behavior affect market shares? The following exploratory model aims to identify the main parameters driving the evolution of market shares. A simple model of competition between two companies will be progressively refined to analyze the "shock" of the introduction of a new BMS in a market. While simplified, this model attempts to illustrate the observed behavior of Portuguese and Belgian insurers, where BMS competition has mostly led to the creation of more bonus classes, and an increase of the maximum discount. We consider a stable two-company market, and explore the consequences of a BMS "shock", the introduction of a "super-discount" class by one of the companies.

Assume that only companies A and B operate in a given market. They both apply the same BMS, a nine-class system described in Table 1. Each insurer has used this system for such a long time that the stationary condition has been attained. Each applies the same rates, so that each has a 50% market share. Each company has 10,000 policyholders (see among others Lemaire, 1995, for actuarial models to analyze BMS.)

We do not consider other classification variables in this analysis. Obviously, the design of a BMS cannot be considered independently of other rating variables

TABLE 1

INITIAL BONUS-MALUS SYSTEM

CLASS	PREMIUM LEVEL	TRANSITION RULES
9	200	* Starting Class: 6
8	160	
7	130	* Discount per claim-free year: 1 class
6	100	
5	90	* Penalty per claim: 3 classes
4	80	
3	70	
2	60	
1	50	

(Taylor, 1997, Gisler, 1996, Portugal, 2001.) A company using many rating variables has lesser need for a sophisticated BMS while a company using little segmentation needs to implement a tougher BMS. We thus assume that companies A and B use the same *a priori* variables, surcharges and discounts.

The distribution of the number of claims of each policyholder is assumed to follow a Poisson with parameter λ. The distribution of λ in the portfolio is a Gamma, hence the portfolio distribution of loss counts is a negative binomial. Assume that the mean of the negative binomial is 0.10, and its variance 0.1063, corresponding to a typical accident pattern of European drivers. For computational simplicity, the Gamma has been discretized. Ten values of λ, presented in Table 2, have been selected so that their mean and variance respectively amount to 0.10 and 0.0063 (this leads to a negative binomial mean of 0.10 and a variance of 0.1063. Note that with these values, the skewness and higher order moments are slightly underestimated; however, this is a third order effect.)

TABLE 2

SELECTED VALUES OF λ

GROUP	λ	PERCENTILE IN THE GAMMA DISTRIBUTION
1	0.01081	3.88%
2	0.02536	13.08%
3	0.03918	22.98%
4	0.05363	33.25%
5	0.06952	43.73%
6	0.08774	54.32%
7	0.10971	64.95%
8	0.13815	75.51%
9	0.17982	85.84%
10	0.28608	96.74%

TABLE 3

DISTRIBUTION OF POLICYHOLDERS AT TIME 0

CLASS	NUMBER OF POLICYHOLDERS
9	199.49
8	204.91
7	268.67
6	286.78
5	294.52
4	697.21
3	610.91
2	538.49
1	6,899.02
TOTAL	10,000.00

Further assume that the mean cost of an accident is $10,000, and that all expense and profit loadings have been incorporated into this figure. These assumptions lead to an annual premium income of $10 million for each insurer.

The initial 10,000 policyholders in each company are equally divided among these 10 groups; we assume that there is no improvement in any individual's driving ability. The steady-state or stationary distribution of policyholders, for each value of λ, can be obtained by calculating the left eigenvector of the transition matrix, corresponding to an eigenvalue of 1. Aggregating across all classes for each value of λ, we find the distribution of policyholders for each company, presented in Table 3.

Surveys of policyholders have consistently demonstrated some reluctance to switch insurers. 54% of 2,462 respondents to a survey by Cummins *et al* (1974) confessed never to have shopped around for auto insurance prices. To the question "Which is the most important factor in your decision to buy insurance?", 40% responded the company, 29% the agent, and only 27% the premium. A similar survey of 2,004 Germans (Schlesinger and von der Schulenberg, 1993) indicated that only 35% chose their carrier on the basis of their favorable premium, despite the fact that 67% of those responding knew that considerable price differences exist between automobile insurers. Therefore we will initially assume that, given the opportunity to switch for a reduced premium, one-third of the policyholders will do so.

4. BENCHMARK SCENARIO #1: COMPANY B INTRODUCES ANOTHER DISCOUNT CLASS. A DOES NOT REACT.

Assume that, at time 0, rating freedom is introduced in the market, and that all policies are renewed annually, at times $0, 1, 2, \ldots$ A few weeks before time 1, company B announces that it will introduce a new class, class 0, with a premium

level of 40. All other premium levels and the transition rules remain unchanged. Company A decides not to change its system. Neither company changes its basic premium – the dollar amount it charges at level 100 – at that time. Some of the class 1 policyholders of company A, who qualify for this super discount class by being in A's class 1 and having no claim during the period, will switch to company B to take advantage of the extra discount. This results in an overall premium decrease in the market, and both companies lose money. B loses money because of the discounted premiums in the new class while A loses money because the quality of its portfolio deteriorates: many of its best drivers, in profitable class 1, switch to B. Basic premiums are assumed to be adapted retrospectively, at time 2, in such a way that the financial balance is restored for the current portfolio. The first year loss is never recouped, a strategy common during price wars.

The same process is repeated annually: some policyholders switch, resulting in modified market shares and in a gain or loss for each company. These one-year gains or losses are never recouped, but each company adjusts premiums one year later, taking into account the new mean premium level and the new portfolio claim frequency. Income stability is, however, never achieved, as some insureds immediately take advantage of the new rate information to switch carriers. Table 4 summarizes the evolution of the portfolios over the first 10 years.

This scenario leads to a complete elimination of company A in a few years, as evidenced by figure 2-1, the evolution of the market shares. At time 1, one-third of the claim-free drivers from A's class 1 switch to B's class 0. B gains 2,140 new policyholders in the process. Moreover, these are better-than-average drivers, as B's claim frequency for year 2 drops from 10% to 9.47%. However, B's average premium level decreases from the steady-state 63.86 to 54.36 because of the extra discount. B has to increase its basic premium rate by 11.27%. A's average premium level has increased to 67.63, but its claim frequency is now 10.81%. A's basic premium needs to be increased by 2.12%.

As a result of these differentiated premium increases, B's rates at time 2 are higher than A's in all classes, except of course the new class 0. Consequently, while some claim-free policies from A's class 1 will switch to B's class 0, all others switches will go the other way: A receives new policyholders from B's other classes. As a result, market shares change negligibly, but a selection process is beginning to take place, with the best policyholders concentrating in B's portfolio. B's claim frequency drops to 8.62% while A's increases to 12.24%. A has to increase its basic rate by 4.07%, while B's rate hardly has to change.

A similar pattern of switches takes place at times 3 and 4. B attracts many of A's good drivers, and sends away some of its worst drivers. Market shares do not change appreciably, but A's portfolio progressively deteriorates. Company A needs important annual price increases. The improvement in B's portfolio allows a slight decrease in its premiums. At time 5, A's premiums become higher than B's in all classes. From that time on, one-third of A's policyholders switch to B every year, and A progressively disappears from the market. At time 15, its market share is under 2.8%. B has taken over the entire market, and only had to pay a reasonable price, as its surplus has been depleted by only $1,626,000. A's surplus has been reduced by nearly as much.

TABLE 4

SCENARIO #1

Time	t = 0		t = 1		t = 2		t = 3		t = 4	
Company	A	B	A	B	A	B	A	B	A	B
1. # of policies	10,000	10,000	7,859	12,141	7,625	12,375	7,469	12,531	7,365	12,635
2. Average Premium Level	63.86	63.86	67.63	54.36	73.55	49.39	76.73	46.61	78.34	45.04
3. Market Average Level	63.86		59.58		58.60		57.86		57.30	
4. Expected # of claims	1,000	1,000	850	1,150	933	1,067	989	1,011	1,026	974
5. Claim Frequency	10.00%	10.00%	10.81%	9.47%	12.24%	8.62%	13.24%	8.07%	13.94%	7.71%
6. Next Premium Increase			2.12%	11.27%	4.07%	0.17%	3.69%	-0.81%	3.06%	-1.13%
7. Premium income (000's)	$ 10,000	$ 10,000	$ 8,324	$ 10,335	$ 8,969	$ 10,648	$ 9,537	$ 10,193	$ 9,956	$ 9,851
8. Claims (000's)	$ 10,000	$ 10,000	$ 8,500	$ 11,500	$ 9,334	$ 10,666	$ 9,889	$ 10,111	$ 10,260	$ 9,740
9. Annual Profit (000's)	$ —	$ —	$ (176)	$ (1,165)	$ (365)	$ (18)	$ (352)	$ 82	$ (304)	$ 111

Time	t = 5		t = 6		t = 7		t = 8		t = 9		t = 10	
Company	A	B	A	B	A	B	A	B	A	B	A	B
1.	4,910	15,090	3,273	16,727	2,182	17,818	1,455	18,545	970	19,030	647	19,353
2.	76.49	50.54	75.25	52.85	74.41	53.91	73.77	54.42	73.28	54.65	72.91	54.76
3.	56.91		56.52		56.15		55.83		55.56		55.35	
4.	684	1,316	456	1,544	304	1,696	203	1,797	135	1,865	90	1,910
5.	13.93%	8.72%	13.93%	9.23%	13.93%	9.52%	13.93%	9.69%	13.93%	9.80%	13.93%	9.87%
6.	2.41%	0.82%	1.65%	1.21%	1.13%	1.10%	0.88%	0.86%	0.66%	0.68%	0.24%	-0.62%
7.	$ 6,679	$ 13,053	$ 4,486	$ 15,256	$ 3,006	$ 16,775	$ 2,009	$ 17,820	$ 1,342	$ 18,522	$ 896	$ 19,003
8.	$ 6,840	$ 13,160	$ 4,560	$ 15,440	$ 3,040	$ 16,960	$ 2,027	$ 17,973	$ 1,351	$ 18,649	$ 898	$ 18,886
9.	$ (161)	$ (107)	$ (74)	$ (184)	$ (34)	$ (185)	$ (18)	$ (153)	$ (9)	$ (127)	$ (2)	$ 117

Cumulated Profit $ (1,495) $ (1,626)

Figure 3-1 shows the evolution of the claim frequencies in the two portfolios, and further illustrates the two phases of this scenario. During phase 1 (up to time 4), B progressively improves its portfolio by attracting A's best drivers, and eliminating some of its own worst drivers. A has to increase its rates so much that it becomes more expensive than B in all classes from time 5 on. A is then eliminated from the market during this second phase.

OUTCOME: Company A is eliminated from the market in a two-phase process. B attracts A's profitable customers in phase 1, then takes over the market in phase 2.

5. OTHER SCENARIOS

5.1. Scenario #2: A reacts by creating a super-discount class.

Under Scenario #1, company A passively watches its portfolio being taken over by B, and never uses its surplus to engage in a competitive battle. In Scenario #2, we assume that, at time 5, A creates a super-discount class 0, with a premium level of 35. Figure 2-2 shows that A manages not only to recover its former market shares, but eventually succeeds in eliminating B from the market.

OUTCOME: B is eliminated from the market.

Under the first two scenarios, the most aggressive insurer eventually manages to drive its competitor out of the market. Before concluding that rating freedom will result in tougher BMS and less solidarity among policyholders, we must consider the effect of more realistic assumptions.

5.2. Scenario #3: Entry and Exit of Policyholders in the Market.

We now modify Scenario #1 by introducing entry and exit of drivers in the portfolios. In the above two scenarios, we assumed a closed market with 20,000 policyholders. Now we still consider a constant 20,000 drivers, however 5% or 1,000 drivers leave the market each year and 1,000 enter as new drivers. We assume that 5% of policyholders leave each class of the system in each λ group. Per the rules of this BMS, new policyholders enter at class 6. Maintaining the assumption that one-third of the policyholders compare premiums before choosing an insurer, one-third of newcomers chooses the company with the lower entry premium, while the remaining two-thirds are evenly split across the two companies. This entry and exit of policyholders occurs every period.

The evolution of market shares, shown in figure 2-3, reveals that both companies survive in the market and maintain almost equal market shares, a dramatically different result from Scenario #1. Company A, being cheaper than Company B in the early years, receives most of the new drivers, thus enabling it to stabilize its portfolio. There is no need for company A to react

by introducing a new class. Figure 3-2 shows the evolution of claim frequencies, demonstrating a niche effect: company A specializes in insuring the worst risks, at a higher price.

OUTCOME: Both companies survive with similar market shares, B attracting all good risks, A specializing in sub-standard risks.

5.3. Scenario #4: Threshold

We now examine the effect of a different modification to Scenario #1, the introduction of a threshold, an amount the premium difference between the two insurers must exceed to entice a policyholder to switch. In the Cummins *et al* (1974) survey, only 13% of respondents claimed that they would switch carriers for a premium decrease of less than 10%. 22% would switch for a decrease between 10% and 19%, 29% require a decrease in excess of 20%, and 35% were not sure. Changing companies involves search and switching costs. Search costs include the costs of time and effort taken in contacting various insurers and providing the necessary paperwork. Some of the monetary switching costs include, for instance, the loss of a family rebate or the loss of a discount for a combined auto-homeowners policy. Other costs are non-pecuniary, stemming from loyalty to a particular insurer or agent that has developed during a long-term relationship. Therefore, we will assume that, given the opportunity to switch for a lower premium, one-third of all policyholders will change, but only if the premium reduction is at least $100 (which corresponds to 10% of the expected cost of annual claims).

Market shares, shown in figure 2-4, indicate that company B still takes over the market, but at a slower pace. The switching of policyholders from A to B occurs almost uniformly over time, as B becomes cheaper than A each period for a growing group of classes.

OUTCOME: A threshold in policyholder decisions slows down the evolution of market shares.

5.4. Scenario #5: Expense Breakdown

We examine here the effect of allocating expenses to specific functions. We had assumed in all above scenarios that the $10,000 claim cost included all expenses. Now, we assume 35% of expenses broken down as follows:

   1/3 proportional to premiums collected (commissions, for example)
   1/3 proportional to claims (claim-related expenses)
   1/3 proportional to the number of policies (per policy expenses)

We expect that this would penalize company B, since now expenses are more closely linked with market share. Indeed, the addition of this assumption to the original Scenario #1 results in a marked slowdown in the evolution of market

shares, depicted in figure 2-5. Company B only begins to drastically take over the market at time 7, versus time 5 under Scenario #1.

OUTCOME: Expenses more linked to market shares slow down the evolution of market shares.

Our exploratory model illustrates the effects of several parameters that contribute to the evolution of market shares. Each of the scenarios presented considers separate introduction of more realistic assumptions. Incorporating various combinations of assumptions into the model lead to slightly different outcomes.

In the scenarios presented so far, it was assumed that given the opportunity to switch insurers for a more favorable premium, a random one-third insureds does so. This proportion represented the number of individuals who undergo the searching and switching process. More realistically, the number of individuals who learn about an innovation in the market is a function of the level of advertising as well as the degree of interpersonal contact. Information diffusion regarding the new BMS and its effect on the market are explored in the next four scenarios. We assume that expenses are allocated to specific functions, similar to the breakdown of Scenario #5.

5.5. Scenario #6. Scenario #1 with information diffusion, $a = 0.10$, $b = 0.25$.

Consider Scenario #1 where company B adds a class 0 with a premium level of 40 to its BMS. Policyholders learn about the new BMS through the media, an effect captured through parameter a of the Bass model. Parameter b denotes the word-of-mouth effect, mainly impacted by the level of policyholder sophistication and interest in BMS. We are essentially incorporating a discretized version of the Bass approach into the basic model, assuming $I(0) = 0$.

Keeping a constant 20,000 policyholders spread over the 10 different λ's, with $a = 0.10$, by time 1, $a*N = 2,000$ drivers become informed, 1,000 in each company. They undergo a search process, comparing the premium they would be charged by each company. We assume that an informed policyholder will certainly switch insurers for a more favorable premium. Since at time 1, premiums are identical across all classes except class 0, the only informed individuals who switch are those in company A, who qualify for B's class 0, about 642 drivers. The other 358 informed drivers in A remain with that company. B must raise its premiums 10.14% at time 2, while A's increase is a negligible 0.25%. At time 2, B is more expensive across all classes except in class 0, a position that remains over time. Thus, from time 2 onwards, those policyholders in B who become informed switch to A, while B progressively receives the best drivers. Figure 1-3 depicts the information diffusion process.

By time 10, over 90% of policyholders are informed about the innovation and base their insurer choice on premium comparisons. Market shares by company are presented in figure 2-6. Company B is achieving a niche effect, attracting the best drivers, while A manages to survive by servicing a portfolio with lesser quality drivers. Market shares appear to reach a steady-state.

Both insurers survive with substantial market shares, but with different portfolio compositions.

OUTCOME: Both companies survive. B has a larger market share with the better drivers. A manages to survive by servicing lesser-quality drivers.

5.6. Scenario #7. Scenario #1 with advertising shocks, $a(1) = a(2) = 0.30$, $a(t) = 0.10$ for $t \geq 3$, $b = 0.25$.

Company B can speed up the process to steady-state by increasing its advertising at times 1 and 2, logical times given that the new system is introduced then. $a(1)$ and $a(2)$ are set at 0.30. An advertising shock, increased media effort or agent persuasion, allows more policyholders to become informed initially. This speeds up the initial information process and facilitates increased interpersonal communication. Assume that a reverts to 0.10 at time 3 and remains at that level. As depicted in figure 2-7, similar switching behaviors occur and B achieves its steady-state position at a faster rate.

OUTCOME: Timely advertising enables B to achieve its objectives faster.

5.7. Scenario #8. Scenario #3 with information diffusion, $a = 0.10$, $b = 0.25$.

In Scenario #3, we incorporated into the basic model entry and exit of policyholders. Each year, 5% of policyholders leave the automobile insurance market. 1,000 new drivers enter in class 6. Movement into and out of the portfolios has implications on the proportion of informed individuals in the market. Each year, a portion of informed drivers ceases driving while 1,000 new uninformed drivers join the market. As Figure 2-8 shows, both companies co-exist with relatively equal market shares.

OUTCOME: Entries and exits slow down the information process, which helps company A maintain a market share near 50%.

5.8. Scenario #9. Scenario #3 with advertising shocks, $a(1) = a(2) = 0.30$, $a(t) = 0.10$ for $t \geq 3$, $b = 0.25$.

Again, company B can speed up the information process with increased advertising during the first and second periods, as shown in figure 2-9. Given that market shares become essentially equal, B must weigh the costs with the benefits of such an advertising shock.

OUTCOME: Advertising does not help company B in this case.

FIGURE 1. Informed Individuals

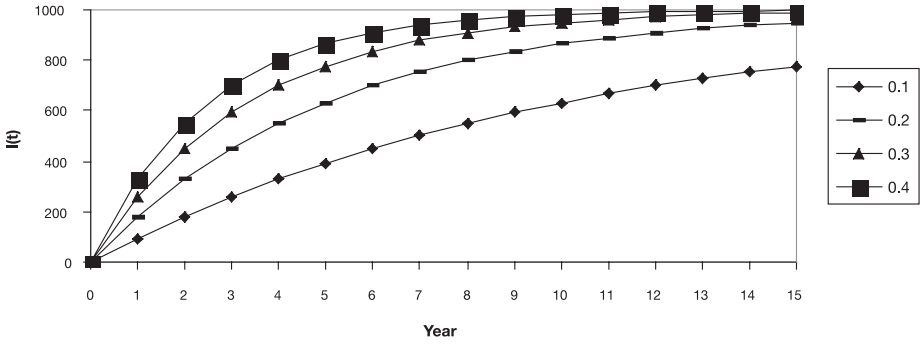FIGURE 1-1. Information Spread through Advertising

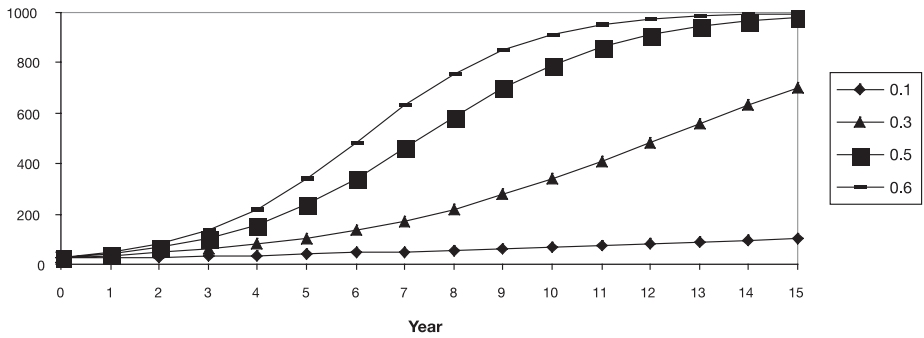FIGURE 1-2. Information Spread through Word of Mouth.
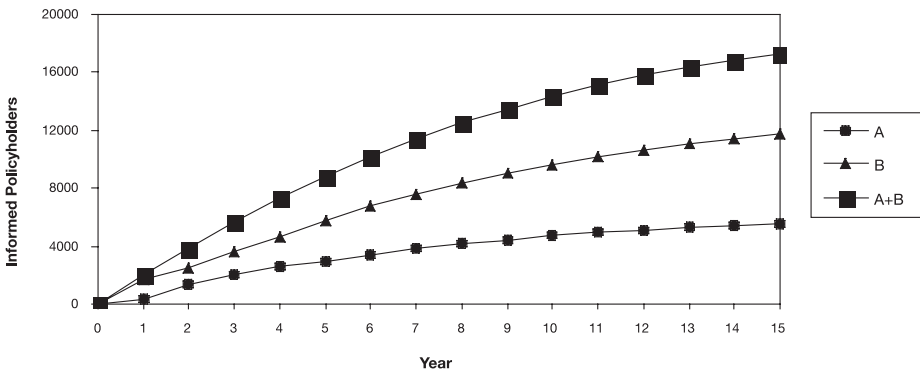

FIGURE 1-3. Scenario #6.

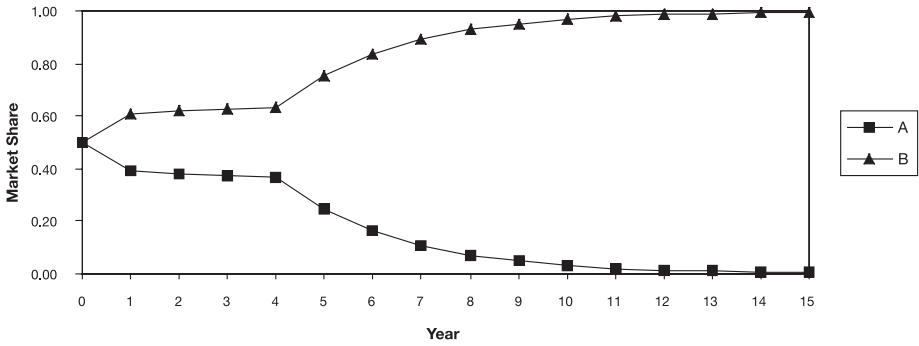FIGURE 2. Evolution of Market Shares.

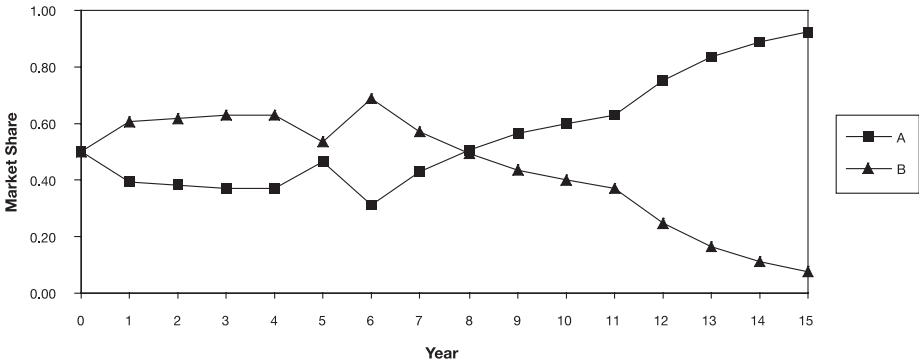FIGURE 2-1. Scenario #1.

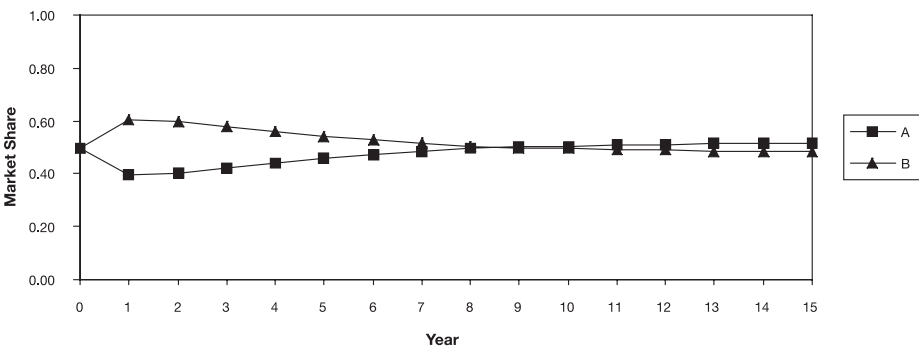FIGURE 2-2. Scenario #2.
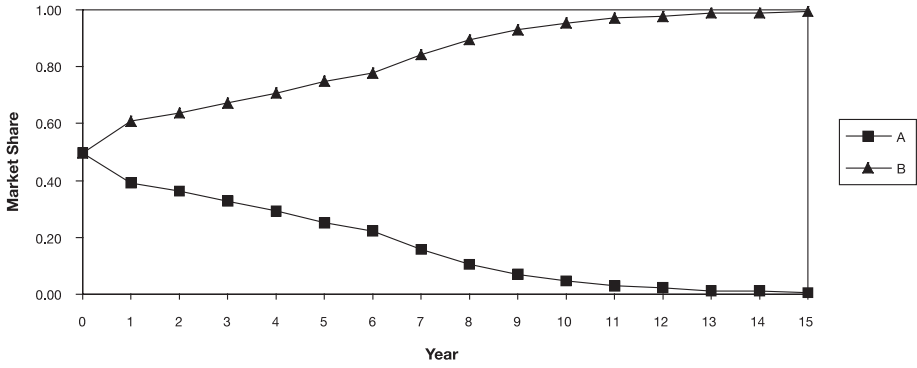

FIGURE 2-3. Scenario #3.
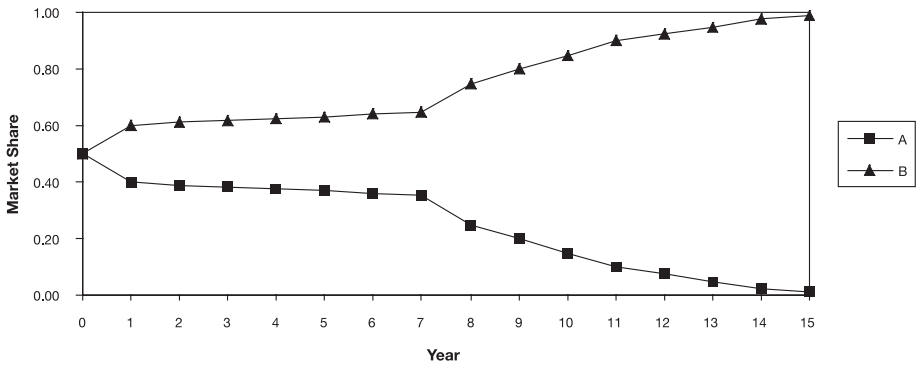
FIGURE 2-4. Scenario #4.
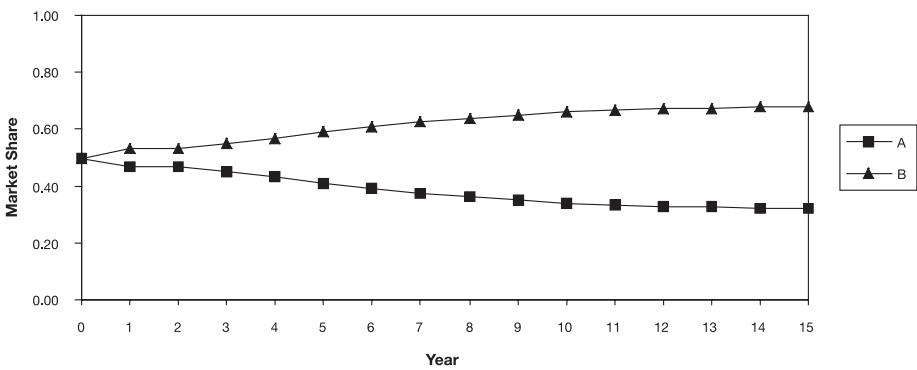

FIGURE 2-5. Scenario #5.
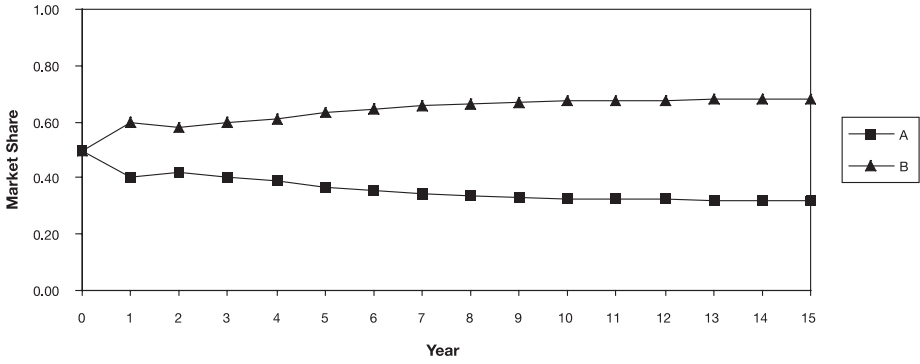

FIGURE 2-6. Scenario #6.

FIGURE 2-7. Scenario #7.

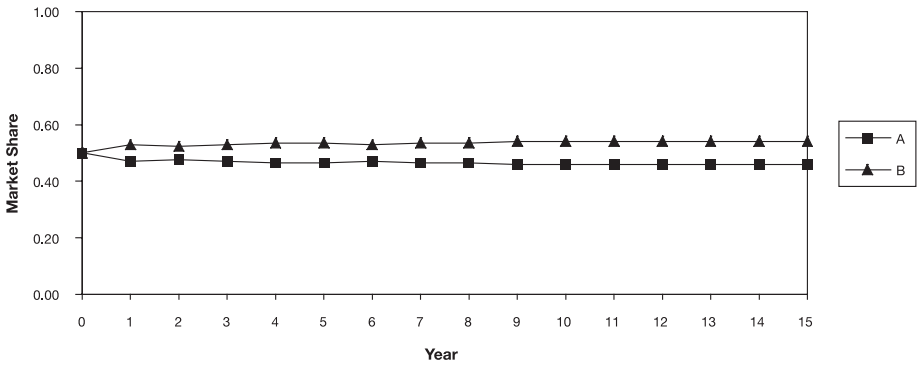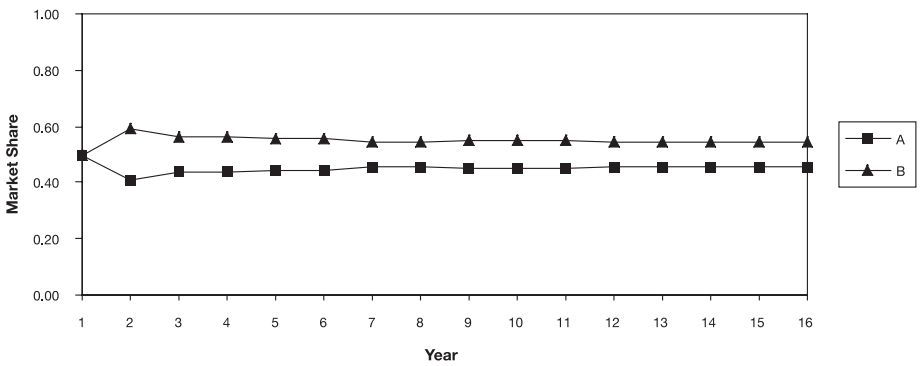FIGURE 2-8. Scenario #8.

FIGURE 2-9. Scenario #9.

FIGURE 3. Evolution of Claim Frequencies.
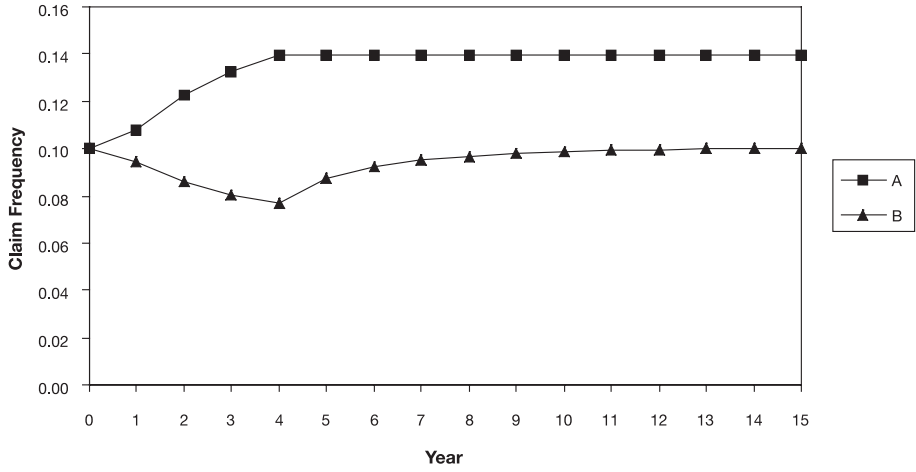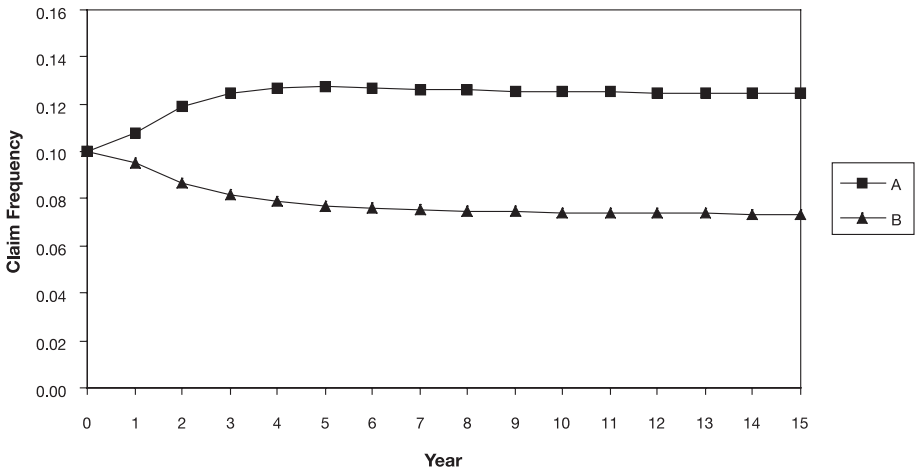
FIGURE 3-1. Scenario #1.

FIGURE 3-2. Scenario #3.

6. Conclusions

Many different scenarios concerning the diffusion of information among prospective consumers of a new BMS have been analyzed. Various assumptions concerning expenses, entries and exits in the markets, and policyholder purchasing decisions have been tested. Very different outcomes have resulted: one or the other company can be eliminated from the market; both companies can survive, with equal or different market shares. Portfolios after a competition war can be similar, or very different, as each company can find a niche by specializing in servicing some categories of drivers.

This extreme variety of market outcomes leads to an important conclusion: before engaging in BMS competition, a thorough knowledge of market conditions and policyholder behavior is essential. Companies should not adopt an aggressive strategy in the design of a new BMS unless they are reasonably confident about consumers' reactions. Surveys of policyholders seem essential prior to any aggressive competitive strategy.

Our simple model could be extended in a variety of ways:

- Diffusion theory belongs to the class of the so-called "first-purchase" models. Repeat-purchase models could be developed to incorporate the fact that, in insurance, there is a flow of new customers every year, but also a portfolio of existing customers who may base their renewal decision on other factors than newcomers.

- We have focused on insurers' market shares, without considering the evolution of surpluses. A more sophisticated model could include the cost of designing and advertising a new BMS, as well as the level of the companies' solvency margins, or even the level of prudence in claims reserving.

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