A practical model for pricing optimization in auto insurance

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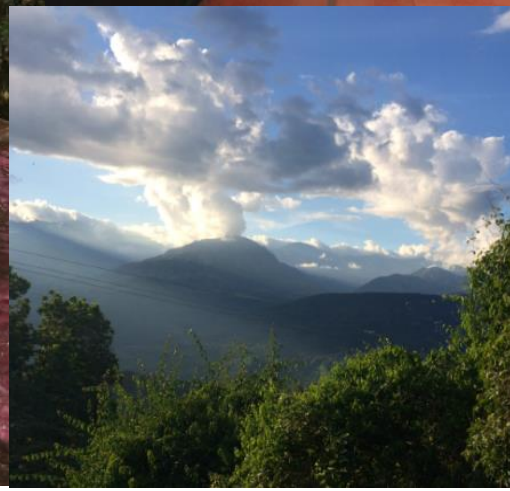

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Objective

A methodology to calculate the optimal premium for auto insurance

Uses statistical tools to estimate:

(i) the potential value of auto insurance customers

(ii) their price elasticity of demand

(iii) and simple optimization algorithms to simulate results.

Background for the application of the proposed methodology

The sensitivity of car insurance customers to price and how this affects their retention has been a subject of intense analysis in the insurance market research literature.

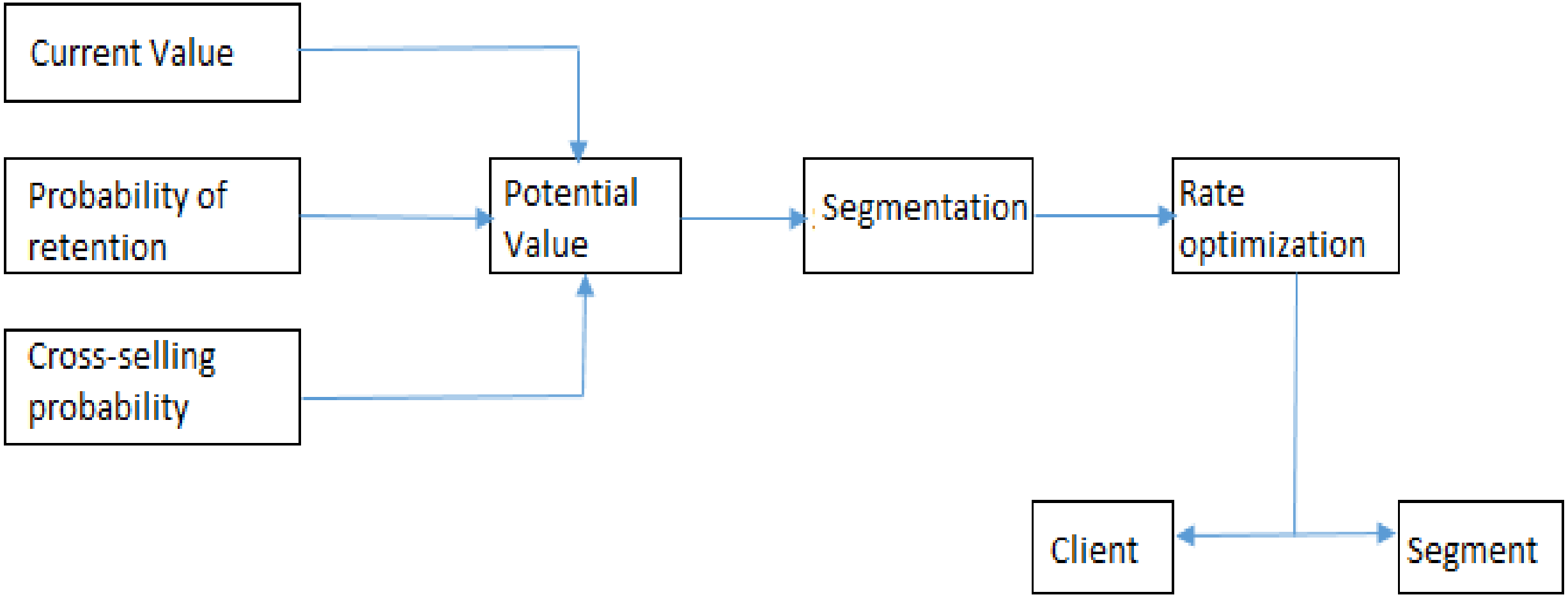
Different methodologies to determine the most valuable customer groups in an insurance company with application of models for estimating the potential value of customers

Given their price elasticity, it would be profitable to offer differential rates for keeping them as clients of the insurance portfolio.

Background for the application of the proposed methodology

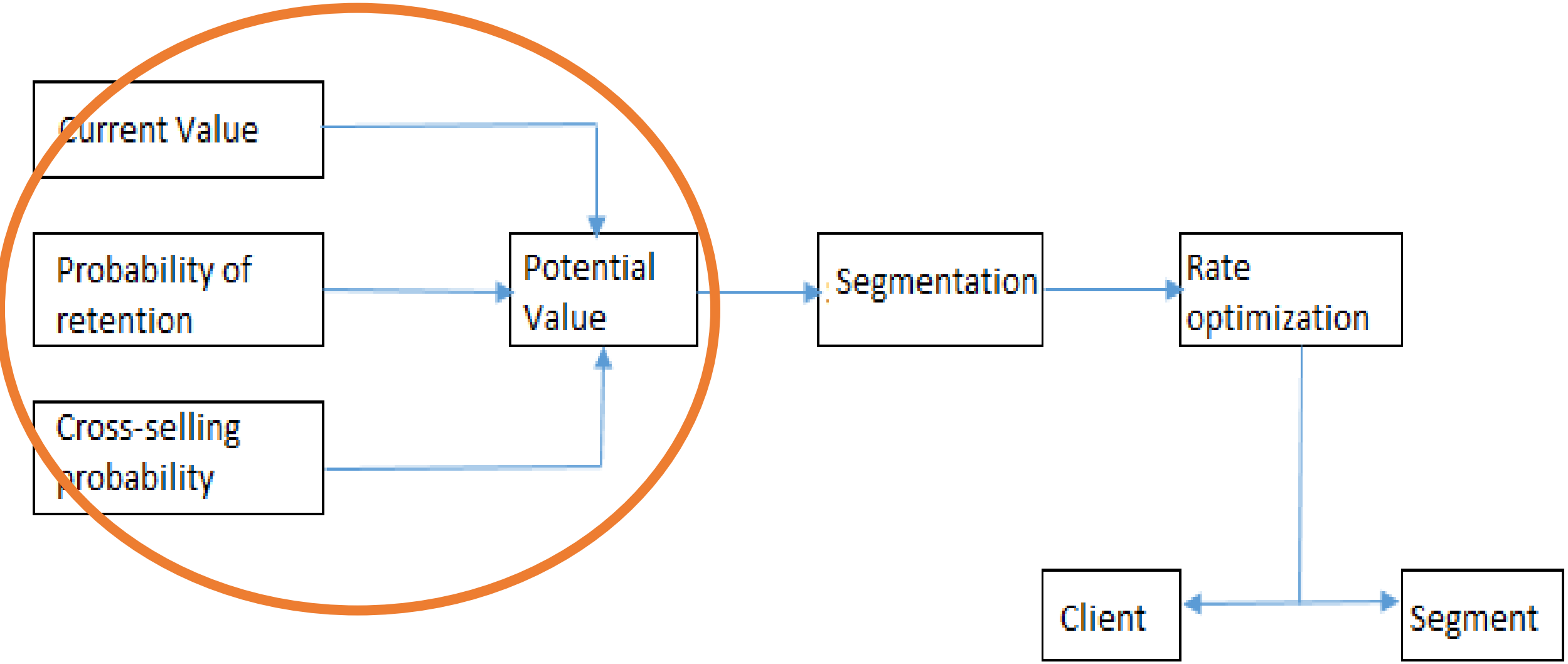
- The use of data mining tools for client segmentation in insurance portfolios.
- Analyse the relationship between price elasticity and customer retention probability with duration models.
- We propose the application of different statistical and actuarial tools available in a unified framework.

Client Value and Optimization Methodology



Let’s go to work!

First Step:


Current Value
Probability of retention
Cross-selling probability
Potential Value
Segmentation
Rate optimization
Client
Segment

Current Value of a Costumer:

Sum of the premiums paid during the entire relationship with the insurance company for all the insurance products

less

the sum of the claims incurred during the same period (adjusting values by the effect of inflation) and the acquisition and issue expenses of these same insurance policies.

Some of the customers who hold individual auto coverage will have other additional products with the same company .

Future Value of a Costumer

The expected value of the margin that the client will leave in his future relationship with the company (premiums less expected losses, expenses and commissions)

average premiums of the customers of a specific segment

multiplied

by the probability that the customers will acquire it

each adjusted to the likelihood that the client will maintain his relationship with the insurance company.

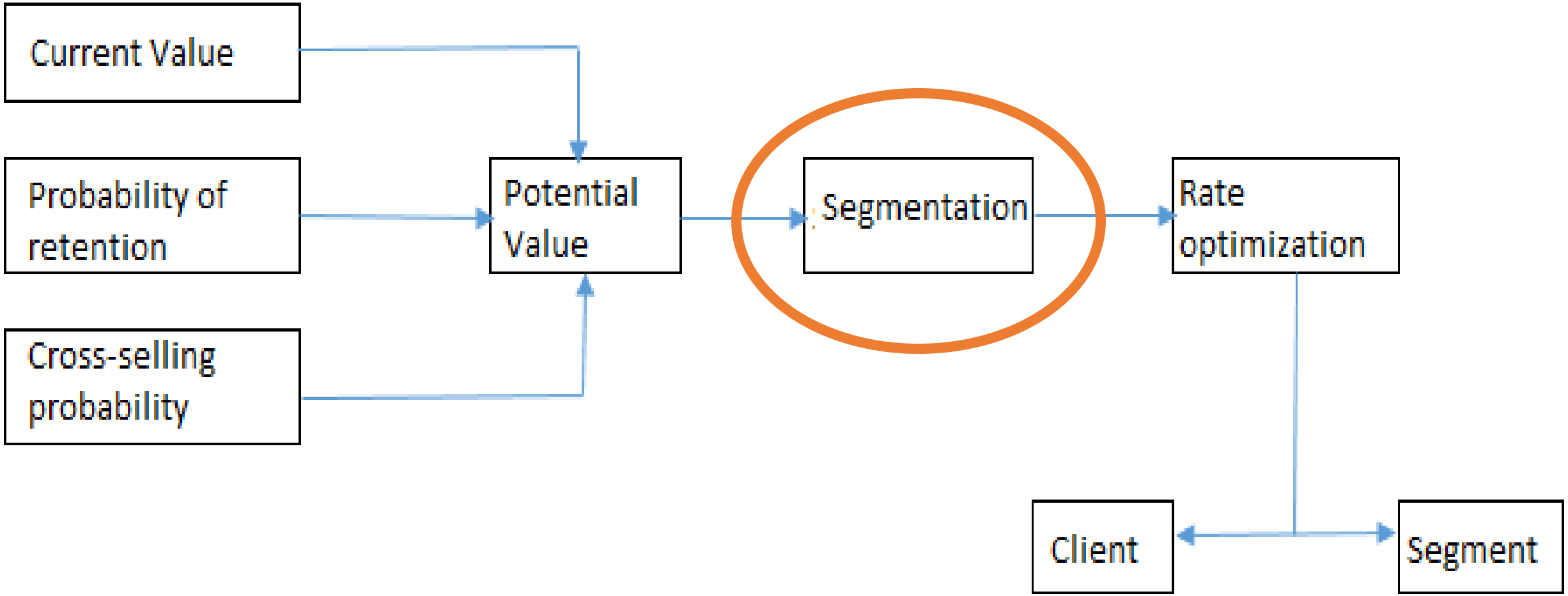
Estimation of the Potential Value of the Client

$$= current\ valor\ + \sum_{j=1}^{k}(p_j margin_j) \sum_{t=1}^{T}\left(\frac{1}{1+r}\right)^t \left(\frac{l_t}{l_0}\right)$$

Coss-sell probability using a MULTINOMIAL LOGIT model.

Survival function auto insurance client estimation with a Kaplan-Meier function

Second Step:


Current Value
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Second Step: Segmentation

Once the potential value variable for each client is calculated:

to analyse which segments or relevant variables may be used to cluster the clients with the highest potential value.

The final objective is to find those characteristics of the clients or particular clusters of clients that allow to determine groups of high potential value.

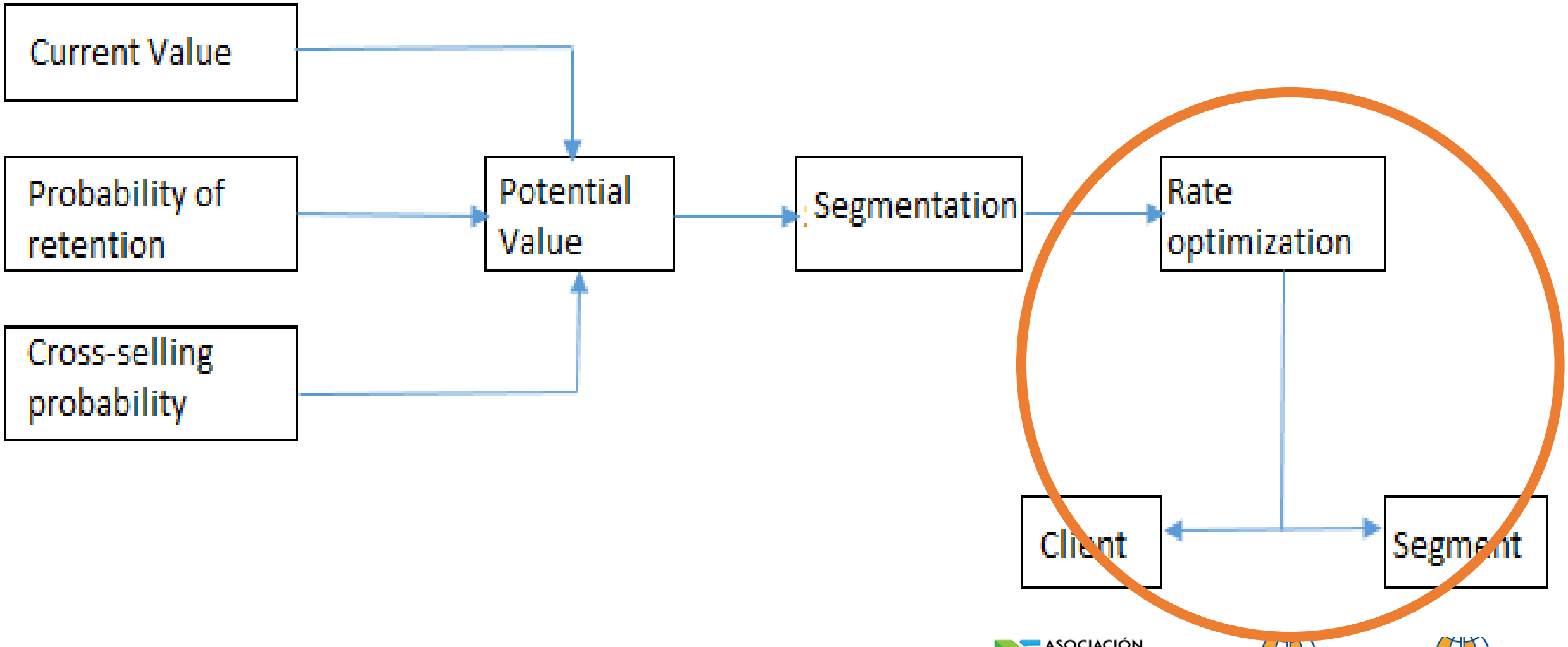
Second Step: Segmentation

To find the differences between the average potential value of clients by sex, insured, vehicle brand, broker or duration in customer years.

To present graphically the proportion of customers with more than one product that has been acquired in the Company.

To find the proportion of customers with a high potential value per branch.

Third Step:


Current Value
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Segmentation
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Optimization

To estimate the optimal renewal increment that should be applied to each customer or predefined cluster of customers.

To calculate the optimum increase it is necessary to account for two relevant factors:

- Margin, defined as the expected net premium of expected claims, commissions and associated expenses.

- Retention rate of the client portfolio

Optimization

The objective of the mathematical optimization program is to maximize the margin, subject to two constraints:

(i) The portfolio retention rate should be maintained above a predefined value.

(ii) The optimal increment for each customer (or group of customers) must be kept within a predefined range.

Optimization

The optimization program maximizes the margin of the portfolio renewal rate, denoted as *r* and equivalent to the probability that the client does not renew the policy, let *r* be greater than a defined value and the optimal percentage increase of the premium (*d*) in a pre-established range:

$$Max\ \pi_i = f(r_i, d_i)$$

$$\text{s.a.}\ \ r_i \geq \bar{r}$$

$$d_{min} \leq d_i \leq d_{max}$$

$$\pi_i = premium_{t,i}(1 + d_i) - E(losses) - E(expenses\ and\ comissions\ )$$

Optimization

The final result of the process will be the optimal increase to be charged on the next renewal to each car insurance customer.

This optimal increase will be the one that the commercial or subscription area will offer in the renewal of the *i*th client to offer to each client.

The optimization algorithm proposed in this exercise is a static optimization application by simulation

Optimization

Demand Function

Estimate the price elasticity of the customer portfolio analysed

GAM-LOGIT model that estimates the probability that the customer renews, according to relevant explanatory variables.

It is mandatory that one of these explanations be the premium

Optimization Algorithm

Once the demand function (or demand functions by client cluster) is estimated, the proposed static optimization algorithm is applied

Demand Function

The first step of the premium optimization algorithm is to estimate the demand function,

It will estimate the price elasticity of the customer portfolio analysed.

The demand function corresponds to a GAM-LOGIT model that estimates the probability that the customer renews with the company, according to relevant explanatory variables.

The GAM models correspond to an extension of the GLM models.

Optimization Algorithm

The optimization algorithm by simulation can be constructed such that it is correlated with the company's probability of renewal

Customers with lower price sensitivity will have a greater increase in their premium.

However, it is possible that the optimization algorithm allocates the optimum rate increase differentially for each segment, keeping the renewal rate constant between segments.

The utility of this second alternative is that the user may consider it relevant to analyse different classifications of the client portfolio.

Optimization Algorithm

From a theoretical viewpoint, the optimization model seeks to affect the retention rate of a client portfolio.

It starts generating random numbers (for each individual or each cluster) with the distribution chosen by the user (by default, uniform) between the lower limit and upper limit of the defined premium increase ranges.

With the *i*th iteration of premium growth rates, the proposed renewal premium is estimated, when this is used the estimated demand function is evaluated. The result of evaluating the demand function will be the probability of renewal for each individual in the given segment.

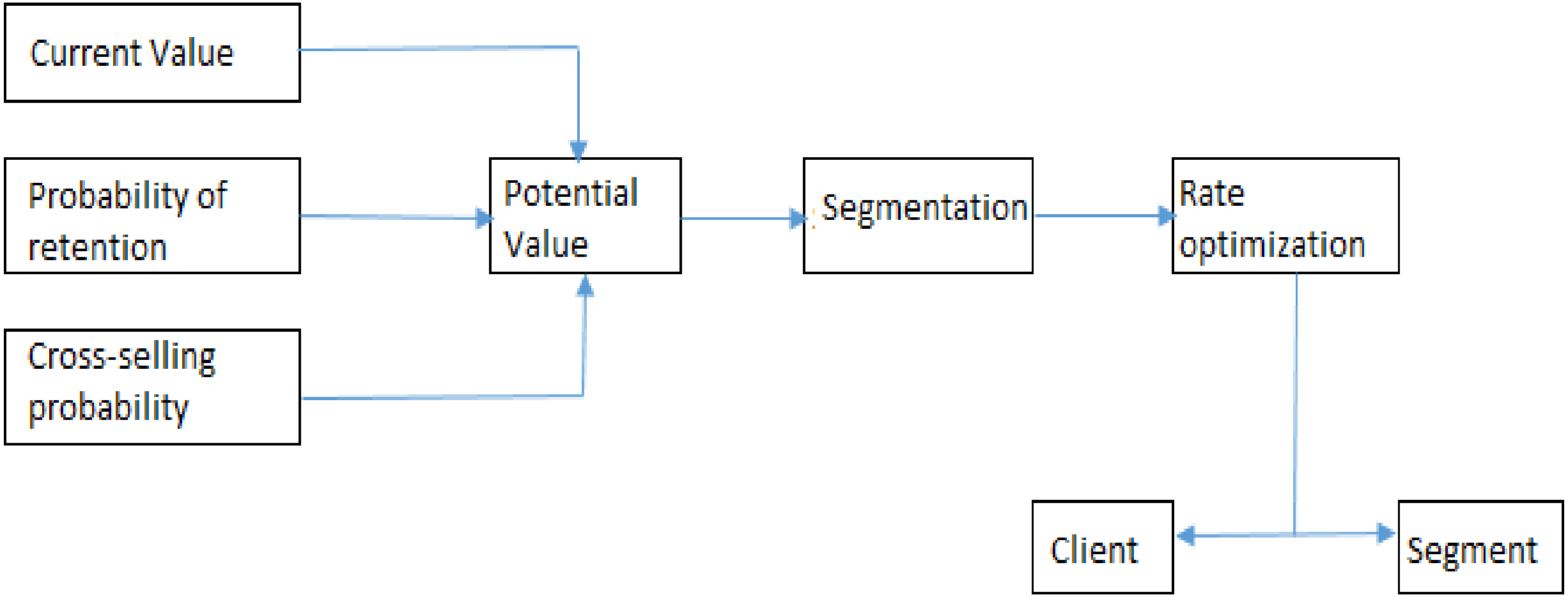
Optimization Algorithm

If the probability of the portfolio renewal or that of the determined estimated clusters by the demand function is lower than that required by the model, the algorithm passes to the next iteration.

In case that the renewal rate exceeds the required threshold, this renewal premium evaluates the objective function, which is the sum of the margin of all policyholders in all segments of the insurance portfolio.

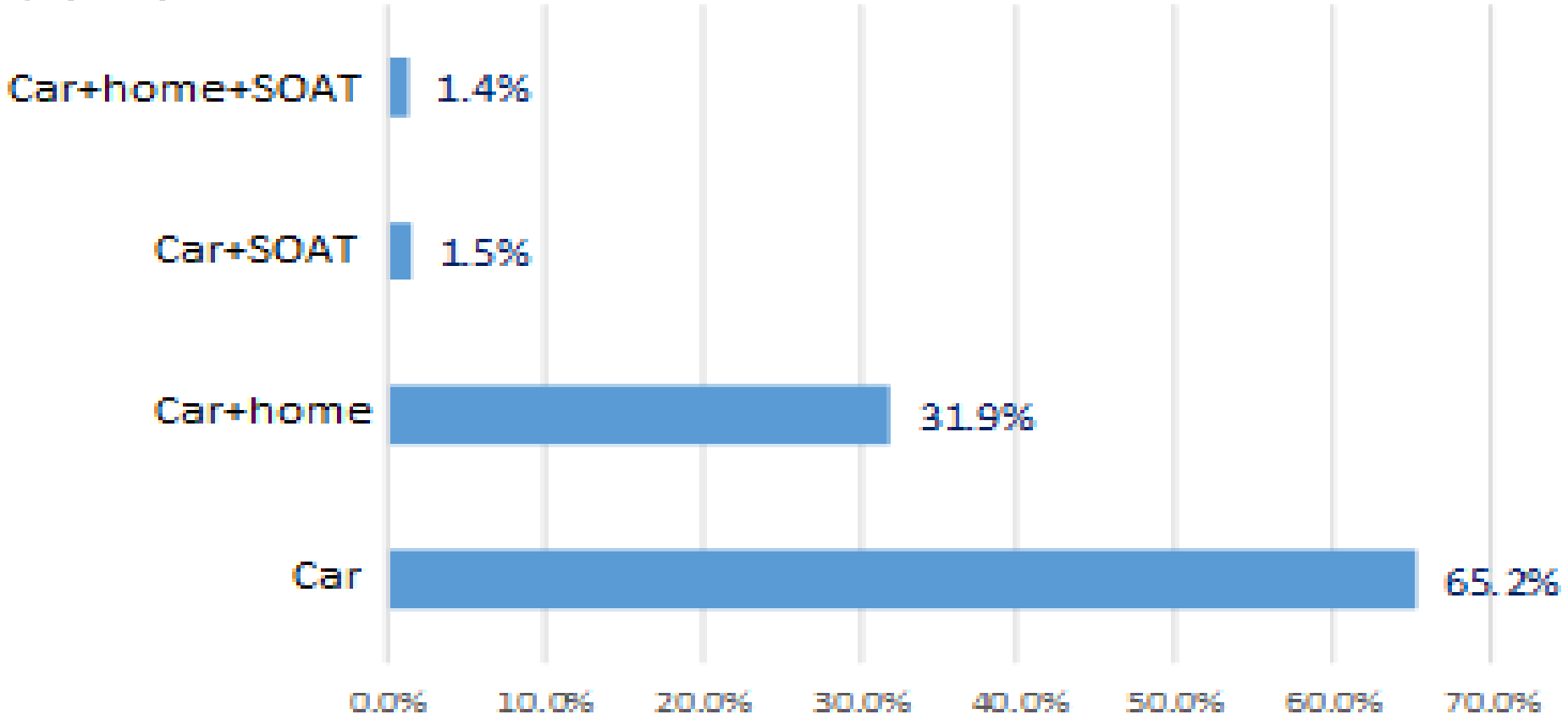
This procedure is repeated *n* times. The optimal renewal premium results from multiplying the current premium by the optimal increased premium, such that it generates the highest margin value of all iterations of the algorithm

Application of Methodology



Application of the Methodology

A portfolio of 57,246 clients of car insurers, of which some had household products or compulsory civil liability insurance (SOAT), was taken in the following proportion



SOAT : Obligatory Insurance of Traffic Accidents

Application of the Methodology

Survival function of costumers:

Interval		Beg. Total	Deaths	Lost	Survival
0	1	57246	5161	119	0.9098
1	2	51966	15743	6092	0.6170
2	3	30131	7592	3410	0.4522
3	4	19129	4225	2672	0.3448
4	5	12232	2245	2901	0.2730
5	6	7086	1032	1744	0.2277
6	7	4310	160	4150	0.2114

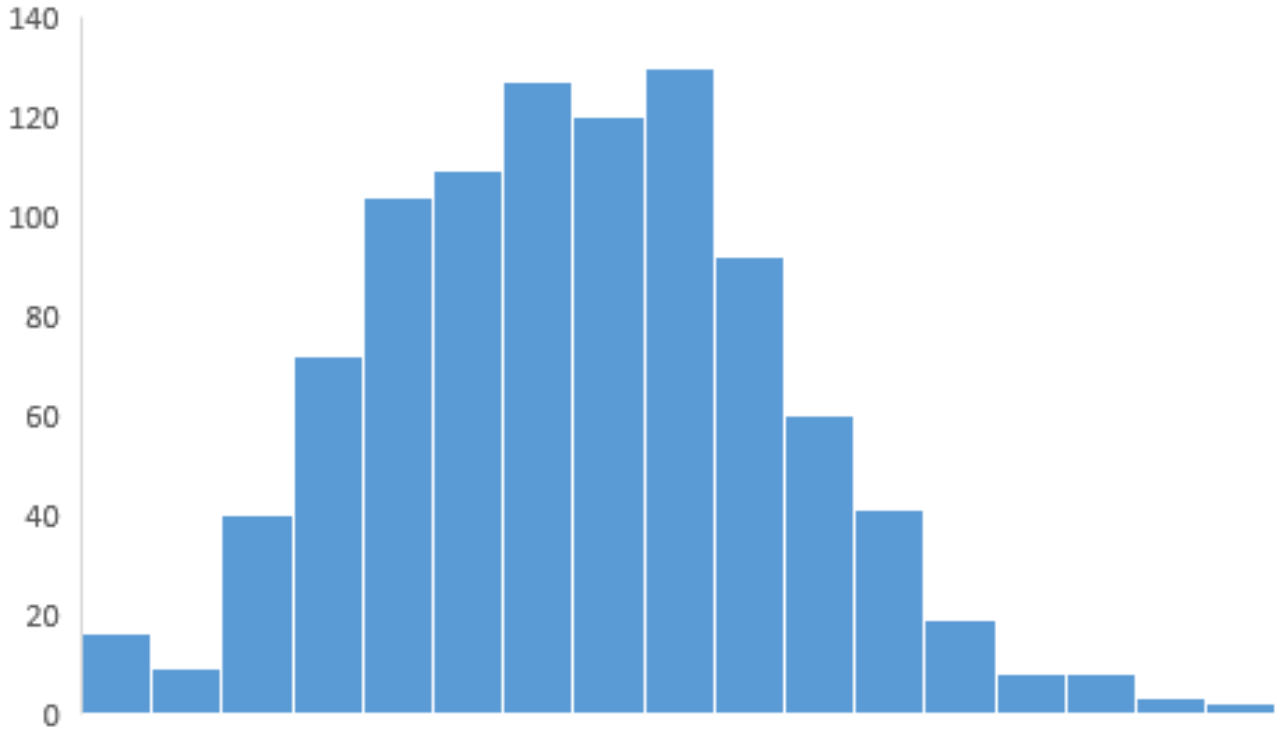
SOAT : Obligatory Insurance of Traffic Accidents

Application of the Methodology – Model LOGIT MULTINOMIAL

Estimated Odds of Cross Selling

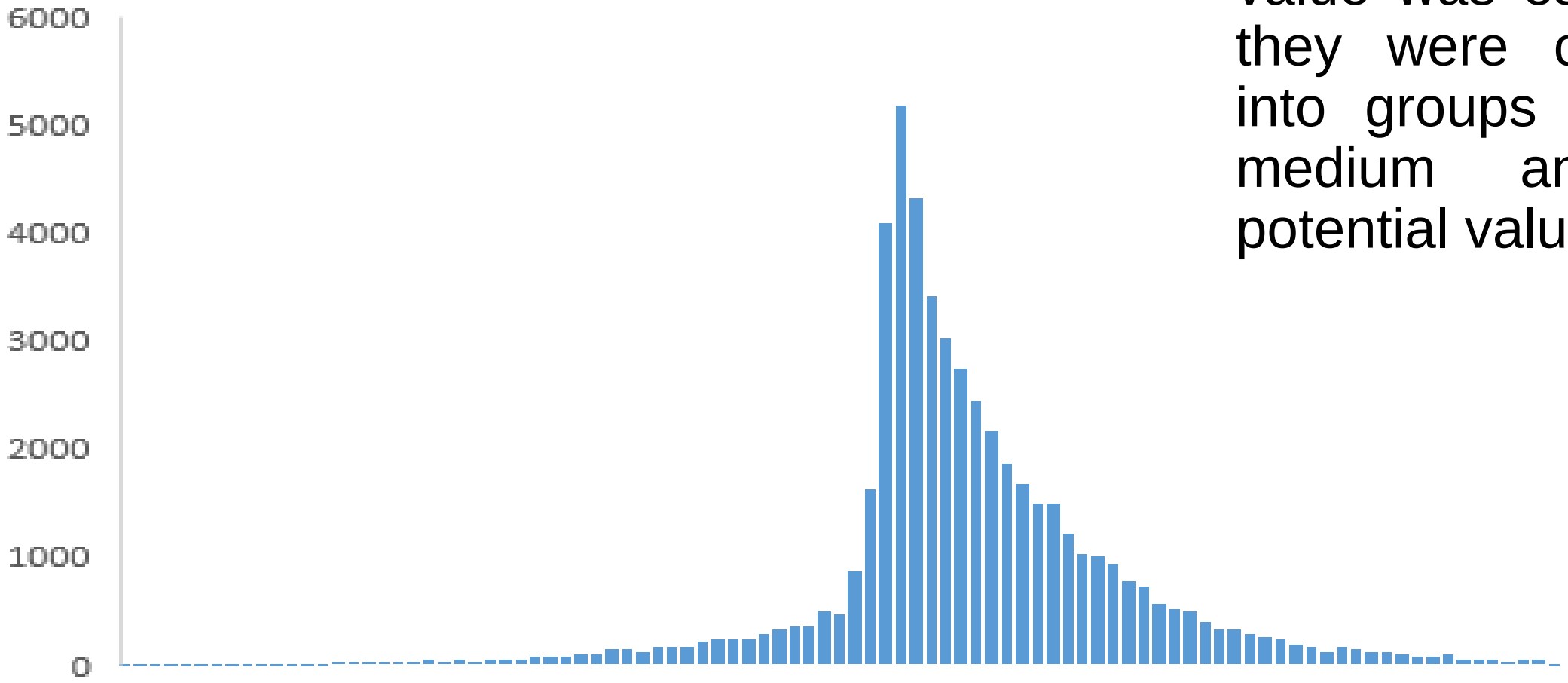
CATEGORY	P(Y=1/X)	P(Y=2/X)	P(Y=3/X)	P(Y=4/X)
1	77%	1%	22%	1%
2	47%	21%	20%	12%
3	45%	1%	53%	2%
4	26%	11%	39%	24%

Average Probability of Cross-Selling by Broker



Application of the Methodology – Costumer Value

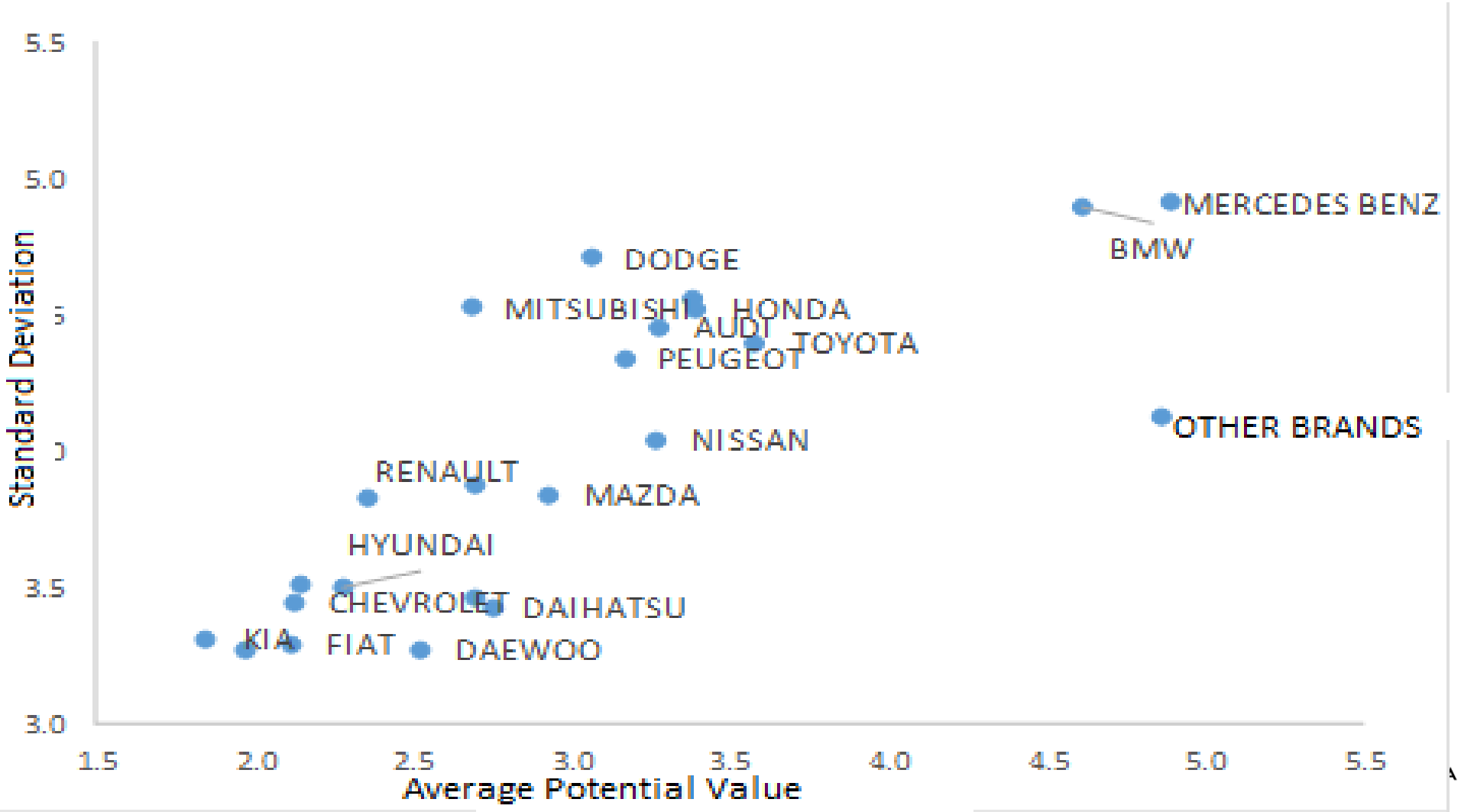
Customer Potential Value Histogram



Once the customer's value was estimated, they were clustered into groups of high, medium and low potential value

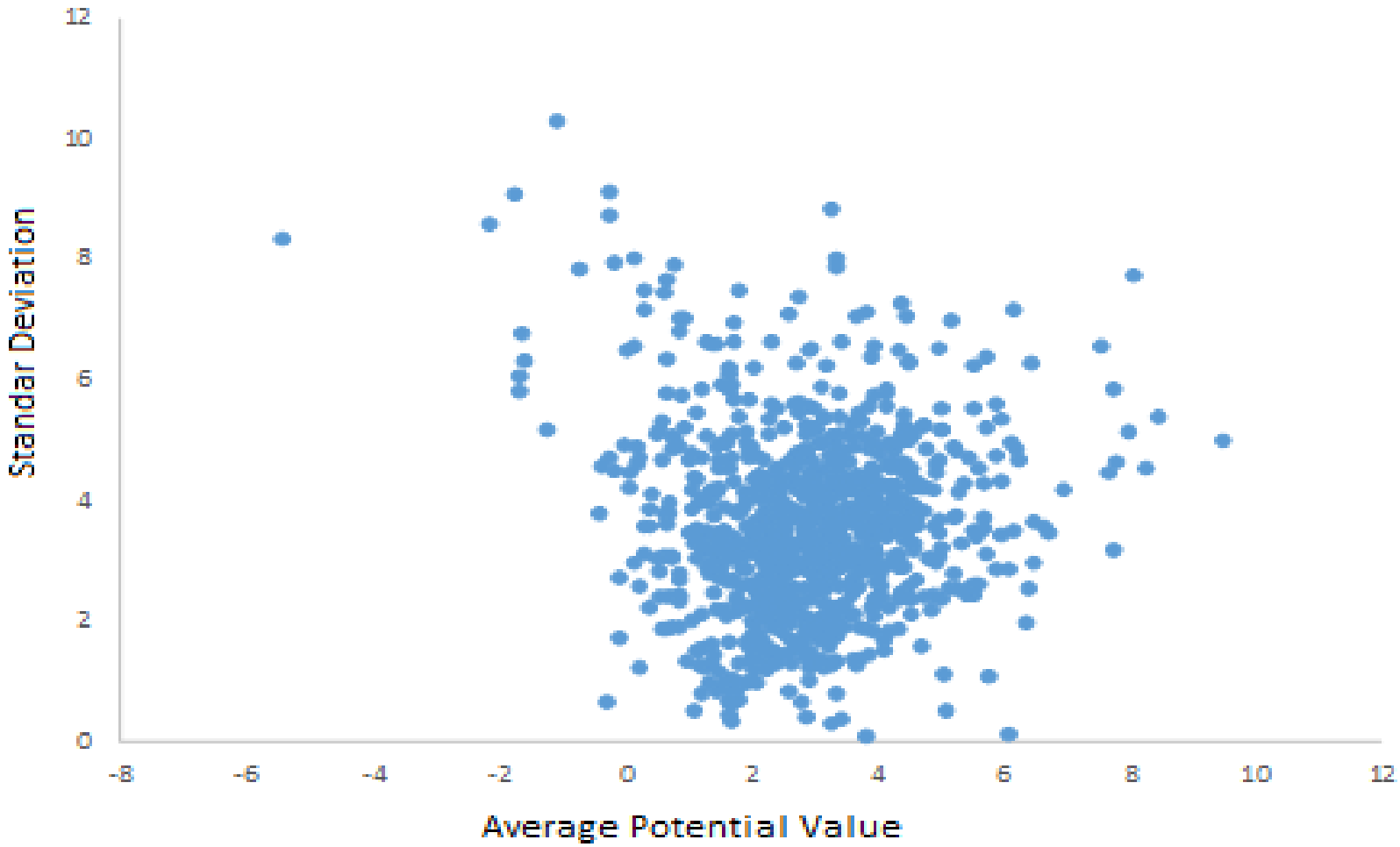
Application of the Methodology – Costumer Value

Average / sd of Potential Value of Customers - By Vehicle Brand



Application of the Methodology – Model LOGIT MULTINOMIAL

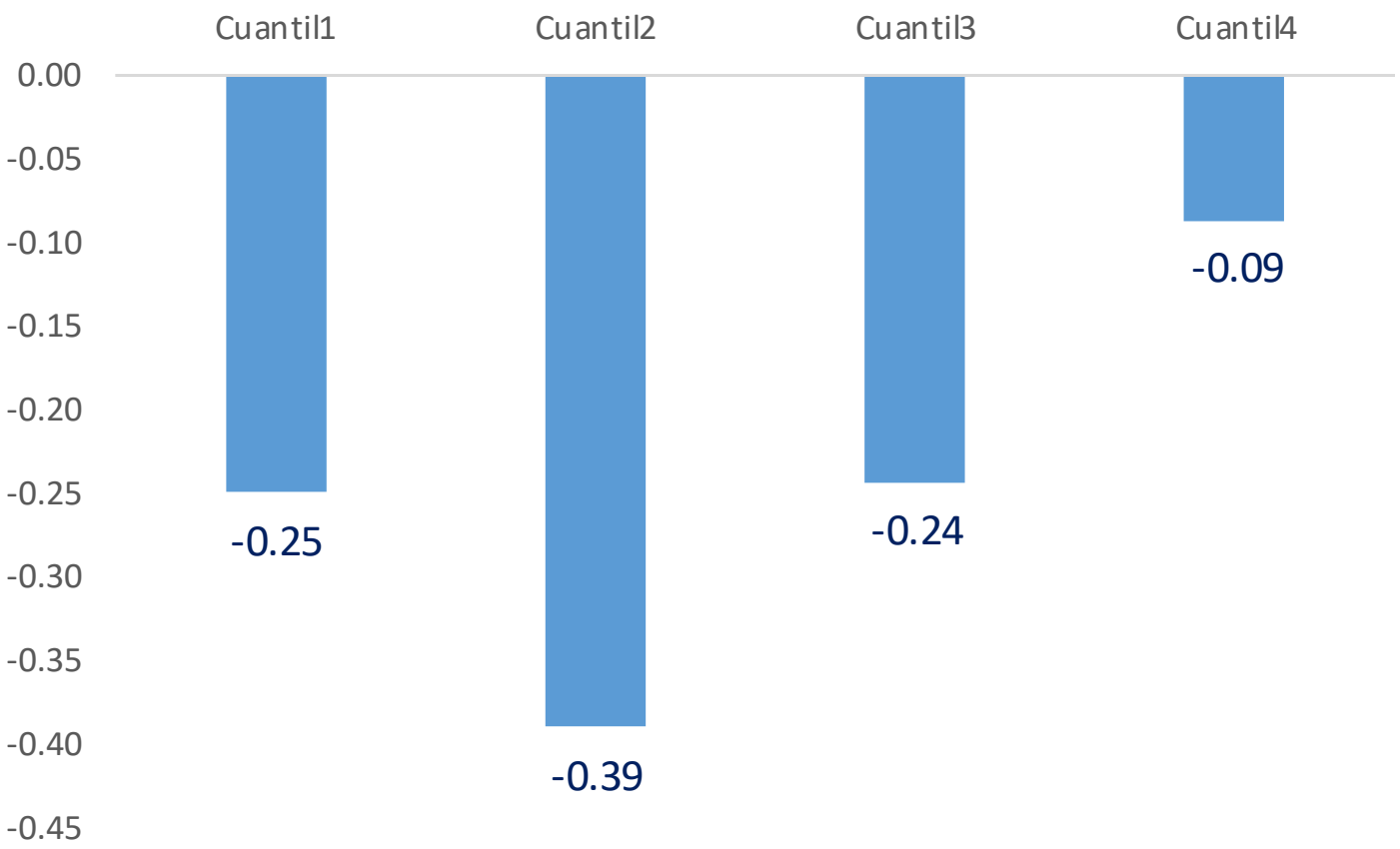
Average / sd of Potential Customer Value - By Broker



Demand Function

Once the customer's value was estimated, they were clustered into groups of high, medium and low potential value

timated Elasticity of Retention (GAM-LOGIT Model Coefficient)



The dependent variables

- 1: if the customer is in effect
- 0: if the customer has cancelled the policy in the last 24 months

One of independent variables

- The premium of his last renewal

Demand Function

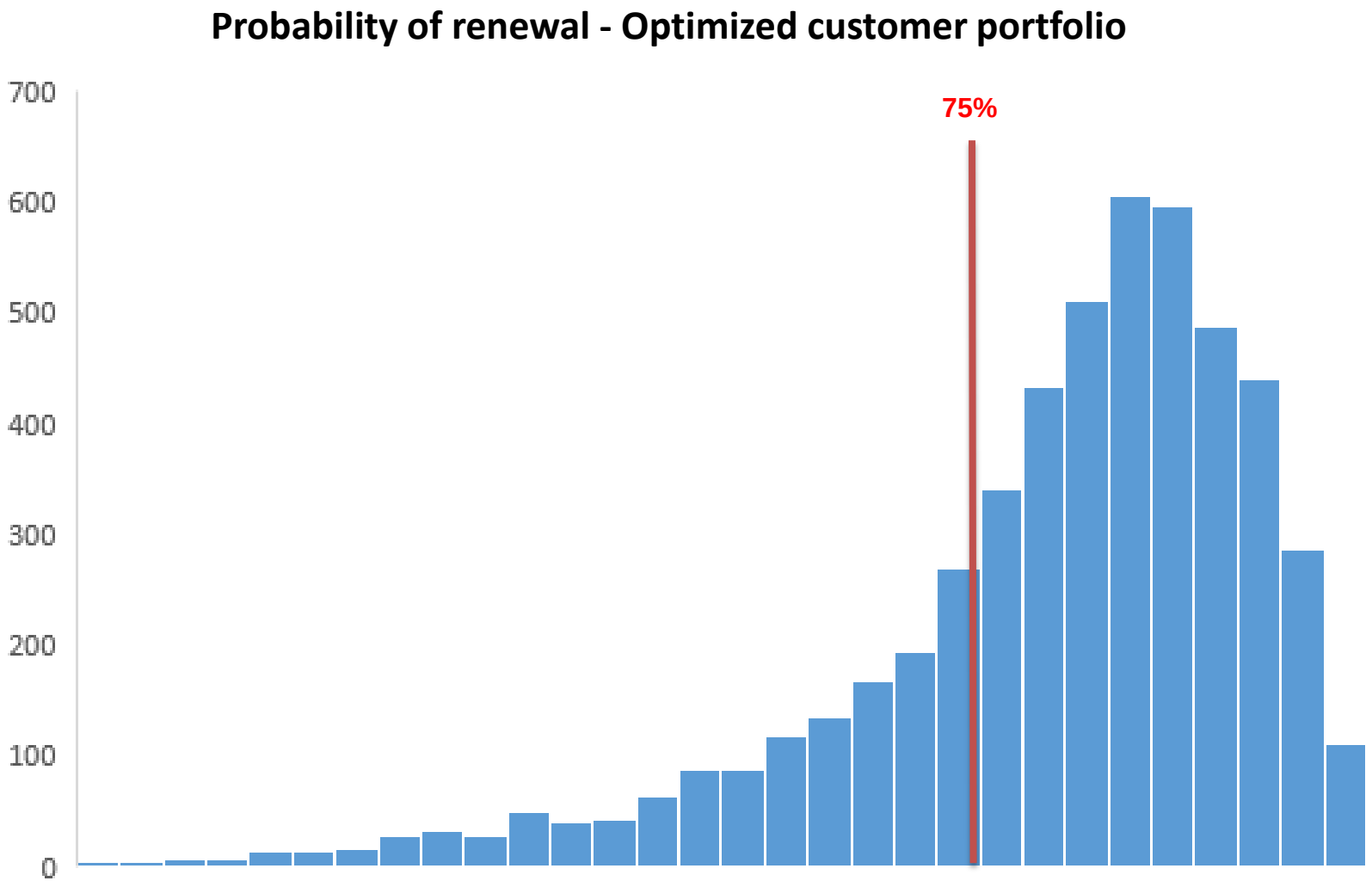
The algorithm was restricted to generate optimal increments between 3% and 13% and a renewal rate that was at least 75%.

The optimization algorithm by simulation was constructed to allocate the largest increase in the renewal premium to customers of lower potential value (first quartile).

Optimum Rate Increase by Clients Cluster

		Probability of renewal	
Segment	Optimal Increase	Average	Standard Deviation
Quartile 1	12.4%	0.76	0.16
Quartile 2	9.1%	0.75	0.16
Quartile 3	8.2%	0.76	0.16
Quartile 4	5.8%	0.76	0.17

Optimal Renewal given ncrease price rate by costumer



By construction, the retention rate is maintained constant in customer clusters and the optimal growth in the premium is decreasing for the different clusters chosen.

CONCLUSIONS

- Based on the applications described, a methodology for estimating the potential value of customers and premium optimization is presented.
- The methodology accounts for the likelihood that customers will maintain the current relationship with the company and the cases where there are cross-selling options and, through the estimation of a demand function for different client clusters, estimates the optimal increase of the renewal premium issued for these clusters.
- Through simulation optimization tools it is possible to generate different optimization algorithms for client clusters that are correlated with the potential value of the customer or that maintain the expected renewal rate of the portfolio under analysis

Now video! … I hope it woks!!!

Demand Function

Optimization

Thank you for your attention.