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From data to decisions: developing an innovative industry-wide statistical information system for credible pricing

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ABSTRACT

In today's globalised and competitive economic environment, insurance companies are continually faced with situation of risk where decisions are taken in the face of uncertainty. The variability of claim costs and the challenge of estimating the cost of insurance at inception of the policy make it necessary for companies to frequently assess the credibility upon which pricing, valuation and other product management decisions are made. The accuracy of estimated future claim costs plays a fundamental role in determining the underwriting profit of these insurers. This study proposed an industry-wide information based experience rating in a regulated and competitive Nigeria business environment for credible underwriting and profitability. The proposed structure incorporates various initiatives for having in place reliable, up-to-date, efficient and effective statistical system such as the Marrakech Action Plan for Statistics (MAPS), General Data Dissemination System (GDDS), Partnerships in Statistics for Development in the 21st Century (PARIS21), the Reference Regional Strategic Framework for Statistical Capacity Building in Africa (RRSF), National Strategies for the Development of Statistics (NSDS) and AFRISAT. It also integrates variation in expected claim costs from insurer to insurer in the industry, variation between expected claim costs from group to group for a given insurer, and variation from insured to insured within a group. Inferences can be made about the industry's average, companies' average and group-specific average.

Introduction

The Nigerian insurance market is bedeviled by series of challenges, one of which is unprincipled underwriting, which have led to its present abysmal state and in some cases leading to insolvency of insurance companies. Rivalry among the companies and bid to attract more customers and higher market share has resulted into rate cutting and premium purchases, resulting in inability to meet obligation to insurance consumers when the need arises. However, in today's globalised and competitive market environment insurance companies are continually faced with situation of risk where decisions are taken in the face of uncertainty. Correct pricing is the foundation of the existence of insurance contracts and special techniques and methods are developed to price the different insurance products. The rates determined by the insurance company are affected by present and past experiences of the insured, and should reflect not only some principles of fairness but also some business considerations. Accordingly, prices paid by the insured must be adequate, reasonable and equitable. If an insured has better loss experience than the average losses for its class but is still charged the manual rate, he pays more for the coverage than it should, while those insured with worse loss experience than the average for their class benefits by are having a subsidized rate. This makes it imperative to estimate future claim costs with much credibility and precision as the accuracy of these estimates are germane in determining the underwriting profits of insurance companies (Lamm-Tennant et al., 1992, 1996). A principal actuarial objective of experience rating is to facilitate the distribution of an equitable tariff structure within an industry classification in relation to each employer's expected future costs (WCIRB, 2008) among policyholders in the light of heterogeneity of risks insured otherwise the concept of adverse selection will undermine the solvability of the company. Rather than relying solely on company-specific claim experience, better estimates may be obtained by incorporating inter-company experience and using industry-wide claims data.

Reliable, timely statistics and efficient data dissemination system are essential keys for improving insurance penetration and credible underwriting as rightly noted in (Kiregyera, 2008) that 'Good statistics are absolutely vital to sensible, sound economic management, to good social policy and are as necessary to the nation as sound money and clean water'. This study proposed an industry-wide information based experience rating in a regulated and competitive Nigeria business environment for credible underwriting and profitability. The proposed structure incorporates various initiatives for having in place reliable, up-to-date, efficient and effective statistical system such as the Marrakech Action Plan for Statistics (MAPS), General Data Dissemination System (GDDS), Partnerships in Statistics for Development in the 21st Century (PARIS21), the Reference Regional Strategic Framework for Statistical Capacity Building in Africa (RRSF), National Strategies for the Development of Statistics (NSDS) and AFRISAT (Kiregyera, 2008). It also integrate variation in expected claim costs from insurer to insurer in the industry, variation between expected claim costs from group to group for a given insurer, and variation from insured to insured within a group.

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The remainder of this article is organized as follows: The next section describes credibility theory for experience rating. Sections 3 discuss the proposed methodology of a hierarchical experience data sharing system. Section 4 specifies the details of the proposed model and Section 5 provides the discussion and conclusion.

Credibility Theory

The premium charged by the insurer on a policy is expected to be determined by the risk level associated with the insured. Its calculation takes into account the policyholders' claims history to determine the risk of future claims. Credibility theory is essentially a technique of experience rating that allows the use of data in hand, together with the experience of others in determining rates and premium (Boland, 2007). It is a logical concept that seeks to use a weighted average for claims from the risk class and overall risk classes to predict future expected claims to address the problem of assessing the risk premium *m*, defined as the expected claims expenses per unit of risk exposed, for an individual risk selected from a portfolio of similar risks (Norberg 2004). The weight associated with the risk class under consideration is known as the credibility factor. The basic formula for calculating credibility weighted estimates is:

$$\overline{m} = z\widehat{m} + (1 - z)\mu$$

Although credibility is not a precise mathematical process but it is a statistical estimation procedure that requires informed judgment of assigning the degree of reliability on a particular data set (Klugman, 2007).

Modern credibility theory suggests an optimal weighted average of the current accounting period claims X_A, and the hypothetical industry claims obtained from the entire industry M_A as

$$Y_A = Z_A X_A + (1 - Z_A) M_A$$

where Z_A is the credibility factor for group A of the insured, and it is determined to minimize the mean square error of Y_A in estimating the true claims (Robinson, 2000).

Hence,

$$Z_A = \frac{MSE_X}{MSE_X + MSE_M}$$

Proposed Method

The increasing demand for more and better statistics has brought to the fore the importance of statistics as a strategic resource for industrial and economic development. We propose a Hierarchical experience data sharing system that requires experience to be collated, shared and integrated at the state, zonal levels and onward transfer to National Insurance Commission (NAICOM) at the center. It is expected that the data are derived from all insurance activities, including periodic information on claims frequency and size, and growth of the industry and development. Such statistics may be derived from NAICOM zonal offices records, sponsored research and surveys as well as from other insurance activities.

The Role of Data as a Corporate Asset

Timely, reliable and efficient data are central to insurance penetration and credible underwriting. A thorough underwriting process should involve the gathering and analysis of past and present claims reports and settlement, and communication of large quantities of information. The guidance that is drawn from this data is essential to the corporate solvency state and informed decision making process underlying risk underwriting. Adequate data gathering are required to monitor claims history, evaluate risks and the variability of claim costs, the condition and performance of different portfolio, develop and access performance of new products and measures, identify cost-effective investment strategies, and conduct valuation of assets. Information is also required to monitor and ensure the effective administration, supervision, regulation and control of insurance business in Nigeria. The data generated by NAICOM and various insurance companies constitute a major corporate asset which unlike other assets, is not necessarily limited. The reason being that data can grow and be reproduced almost without limit, and the quantity and quality of data at the disposal of any corporate entity determines the competitive edge that it will enjoy. Sharing and integrating the data from the various units within a data warehouse will enhance the sustainability and growth of the insurance industry.

Hierarchy of Experience Data Sharing

The required information to be forwarded to NAICOM include experience within group of a particular company (i.e. group specific experience of all companies) and experience of all groups of a particular company for a particular policy (i.e. company-wide experience for a policy). This information should be forwarded to zonal collation centers who then forward same to NAICOM. Collating at the zonal level would make it possible to assess the zonal experience as depicted in the Fig 1.

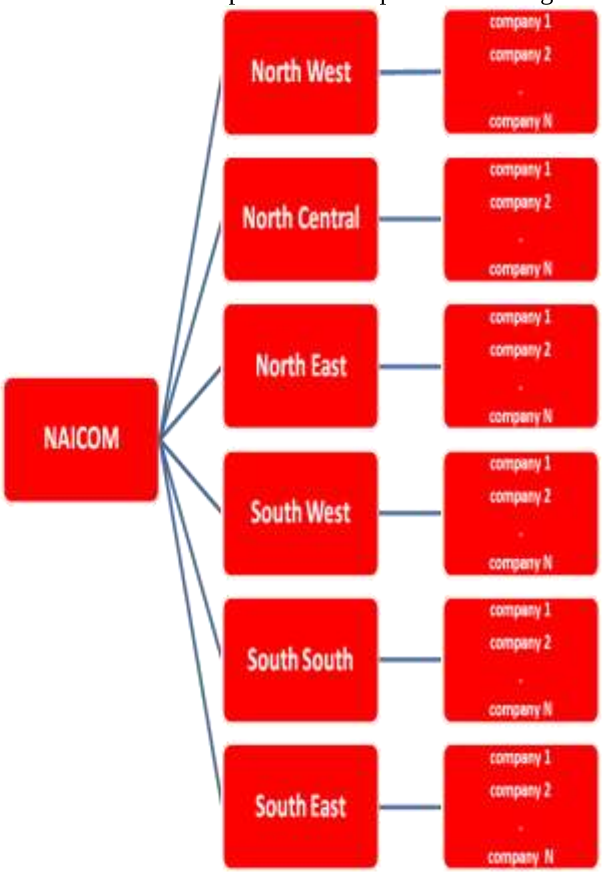

Fig1: Proposed Flowchart for Coordinating and Disseminating Experience Data for Industry-Wide Experience Rating

Proposed Models

Rather than relying solely on company-specific claim experience, better estimates may be obtained by incorporating inter-company experience and using industry-wide claims data to calibrate the credibility models in rate making. Suppose we are interested in estimating Group A's future claims based on the present experience alongside the industry-wide experience, the proposed credibility model for group A is of the form

$$Y_A = Z_A X_A + Z_B M_{ZA} + Z_C M_B$$

where

$$Z_C = (1 - Z_A - Z_B)$$

X_A – current observed claims for group A
M_{ZA} – current zonal-wide experience claims for group A
M_A – industry-wide experience claims for group A
The estimates of Z_A, Z_B and Z_C which produce the best linear combination of

$$Y_A = Z_A X_A + Z_B M_{ZA} + Z_C M_B$$

are respectively $\hat{Z}_A$, $\hat{Z}_B$ and $\hat{Z}_C$ where

$$\hat{Z}_A = \frac{\gamma - \alpha\left[\frac{\theta(\lambda)-\gamma(\alpha)}{\beta(\lambda)-\alpha^2}\right]}{k_1+k_2+2k_5}, \quad \hat{Z}_B = \frac{\theta(\lambda)-\gamma(\alpha)}{[\beta(\lambda)-\alpha^2]} \quad \text{and}$$

$$\hat{Z}_C = 1 - \left[\frac{\gamma - \alpha\left[\frac{\theta(\lambda)-\gamma(\alpha)}{\beta(\lambda)-\alpha^2}\right]}{k_1+k_2+2k_5}\right] - \left[\frac{\theta(\lambda)-\gamma(\alpha)}{[\beta(\lambda)-\alpha^2]}\right]$$

and

$$\lambda = k_1 + k_3 - 2k_5$$
$$\alpha = k_3 + k_4 - k_5 - k_6$$
$$\beta = k_2 + k_3 - 2k_6$$
$$\theta = k_3 - k_6$$
$$\gamma = k_3 - k_5$$

with

$$k_1 = Var(X_A), \quad k_2 = Var(M_{ZA}), \quad k_3 = Var(M_B),$$
$$k_4 = \hat{\rho}(X_A, M_{ZA})\sqrt{Var(X_A)Var(M_{ZA})},$$
$$k_5 = \hat{\rho}(X_A, M_B)\sqrt{Var(X_A)Var(M_B)},$$
$$k_6 = \hat{\rho}(M_{ZA}, M_B)\sqrt{Var(M_{ZA})Var(M_B)}$$

$\hat{\rho}(X_A, M_{ZA})$, $\hat{\rho}(X_A, M_B)$ and $\hat{\rho}(M_{ZA}, M_B)$ are the correlation coefficients between X_A and M_{ZA}, X_A and M_B and M_{ZA} and M_B respectively (see appendix for proof of results).
Whereas X_A can be considered to be a combination of random and fixed effects in the generalized model of the form

$$X_A = \alpha_A + \beta_A + \gamma_A + \varepsilon_A$$

α_A – is a fixed effect that denotes the true average of group A
β_A – is a random effect that denotes the realized value of the group effect for a particular company which insures group A
γ_A – is a random effect that denotes the realized value of the effect for group A
ε_A – is a sampling error for group A
The weight Z_A and Z_B are computed to minimize the mean square error of Y_A

Discussion and Conclusion

The importance of evaluating data credibility is emphasized in several insurance law and regulations relating to the use of company-specific claims experience (see ASOP, 2011). However, in Nigeria, data collection has been moribund as evidenced in non-production of relevant statistics for planning and absence of evidence-based information for policy formulation and evaluation. This proposal emphasized the need for the establishment of an integrated Statistical Information System for the entire insurance industry by NAICOM, (the regulatory body) to provide a legal framework for records collection of reliable and quality data from insurance companies for efficient planning and information for evidence-based pricing and policy decision making. By regular assessment of needs and resources, synchronizing needs and resources, coordination and integration of experiences, planning and standardization. Every insurer, should with the aid of relevant laws and regulations have unimpeded access to these records. The need for industry-wide claims data to properly implement and apply modern credibility theory for equitable and competitive pricing and profitability had been discussed. A new method based on the generalized linear model had also been proposed in addition to the experience data sharing structured proposal. This will facilitate computation of optimal blending weights (rate making) combining claim cost estimates based on the group-specific, company-specific and industry-wide experience (claim costs), allowing the actuary to make the most effective use of available data as well as equally assessing the reliability of the resulting estimates. Advancement in computational technology will make it practically possible to apply and implement the proposed model. Industry-wide experience rating engenders an incentive for safety and enhances market competition.

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Appendix

The estimates of Z_A, Z_B and Z_C which produce the best linear combination of

$$Y_A = Z_A X_A + Z_B M_{ZA} + Z_C M_B$$

are respectively $\hat{Z}_A$, $\hat{Z}_B$ and $\hat{Z}_C$ where

$$\hat{Z}_A = \frac{\gamma - \alpha\left[\frac{\theta(\lambda)-\gamma(\alpha)}{\beta(\lambda)-\alpha^2}\right]}{k_1+k_2+2k_5}, \quad \hat{Z}_B = \frac{\theta(\lambda)-\gamma(\alpha)}{[\beta(\lambda)-\alpha^2]} \quad \text{and}$$

$$\hat{Z}_C = 1 - \left[\frac{\gamma - \alpha\left[\frac{\theta(\lambda)-\gamma(\alpha)}{\beta(\lambda)-\alpha^2}\right]}{k_1+k_2+2k_5}\right] - \left[\frac{\theta(\lambda)-\gamma(\alpha)}{[\beta(\lambda)-\alpha^2]}\right]$$

Proof

Let

$$Y_A = Z_A X_A + Z_B M_{ZA} + Z_C M_B$$

$E(Y_A) = E[Z_A X_A + Z_B M_{ZA} + Z_C M_B]$
$= Z_A E(X_A) + Z_B E(M_{ZA}) + Z_C E(M_B)$
$Var(Y_A) = E[Y_A - E(Y_A)]^2$
$= Z_A{}^2 Var(X_A) + Z_B{}^2 Var(M_{ZA}) + Z_C{}^2 Var(M_B)$
$+2Z_A Z_B Cov(X_A, M_{ZA}) + 2Z_A Z_C Cov(X_A, M_B)$
$+2Z_B Z_C Cov(M_{ZA}, M_B)$
$= Z_A{}^2 Var(X_A) + Z_B{}^2 Var(M_{ZA}) + Z_C{}^2 Var(M_B)$
$+2Z_A Z_B \hat{\rho}(X_A, M_{ZA})\sqrt{Var(X_A)Var(M_{ZA})}$
$+2Z_A Z_C \hat{\rho}(X_A, M_B)\sqrt{Var(X_A)Var(M_B)}$
$+2Z_B Z_C \hat{\rho}(M_{ZA}, M_B)\sqrt{Var(M_{ZA})}Var(M_B)$

$\hat{\rho}(X_A, M_{ZA}), \hat{\rho}(X_A, M_B)$ and $\hat{\rho}(M_{ZA}, M_B)$ are the correlation coefficients between X_A and M_{ZA}, X_A and M_B and M_{ZA} and M_B respectively.

Let:
$k_1 = Var(X_A)$
$k_2 = Var(M_{ZA})$
$k_3 = Var(M_B)$
$k_4 = \hat{\rho}(X_A, M_{ZA})\sqrt{Var(X_A)Var(M_{ZA})},$
$k_5 = \hat{\rho}(X_A, M_B)\sqrt{Var(X_A)Var(M_B)}$,
$k_6 = \hat{\rho}(M_{ZA}, M_B)\sqrt{Var(M_{ZA})}Var(M_B)$
$Var(Y_A) = Z_A{}^2 k_1 + Z_B{}^2 k_2 + Z_C{}^2 k_3$
$+2Z_A Z_B k_4 + 2Z_A Z_C k_5 + 2Z_B Z_C k_6$
$= \varphi(Z_A, Z_B, Z_C)$

we minimize $\varphi(Z_A, Z_B, Z_C)$ subject to $Z_A + Z_B + Z_C = 1$ by applying the principle of Lagrange multiplier, we obtain
$\varphi(Z_A, Z_B, Z_C) = Z_A{}^2 k_1 + Z_B{}^2 k_2 + Z_C{}^2 k_3$
$+2Z_A Z_B k_4 + 2Z_A Z_C k_5 + 2Z_B Z_C k_6$
$+m(Z_A + Z_B + Z_C - 1)$

$$\frac{\partial \varphi^*}{\partial Z_A} = 2Z_A k_1 + 2Z_B k_1 + 2Z_C k_1 + m = 0$$

$$\frac{\partial \varphi^*}{\partial Z_B} = 2Z_B k_2 + 2Z_A k_4 + 2Z_C k_6 + m = 0$$

$$\frac{\partial \varphi^*}{\partial z_C} = 2Z_C k_3 + 2Z_A k_5 + 2Z_B k_6 + m = 0$$

on solving the above system of linear equations, we obtain

$$\hat{Z}_A = \frac{(k_3 - k_5) - (k_3 + k_4 - k_{5-} k_6)\left[\frac{k_3 - k_6(k_1 + k_3 - 2k_5) - k_3 - k_5(k_3 + k_4 - k_{5-} k_6)}{k_2 + k_3 - 2k_6(k_1 + k_3 - 2k_5) - (k_3 + k_4 - k_{5-} k_6)^2}\right]}{k_1 + k_2 + 2k_5},$$

$$\hat{Z}_B = \frac{k_3 - k_6(k_1 + k_3 - 2k_5) - k_3 - k_5(k_3 + k_4 - k_{5-} k_6)}{[k_2 + k_3 - 2k_6(k_1 + k_3 - 2k_5) - (k_3 + k_4 - k_{5-} k_6)^2]}$$

and

$$\ddot{Z}_C = 1 - \left[\frac{(k_3 - k_5) - (k_3 + k_4 - k_{5-} k_6)\left[\frac{k_3 - k_6(k_1 + k_3 - 2k_5) - k_3 - k_5(k_3 + k_4 - k_{5-} k_6)}{k_2 + k_3 - 2k_6(k_1 + k_3 - 2k_5) - (k_3 + k_4 - k_{5-} k_6)^2}\right]}{k_1 + k_2 + 2k_5}\right]$$

$$- \left|\frac{(k_3 - k_6)(k_1 + k_3 - 2k_5) - k_3 - k_5(k_3 + k_4 - k_{5-} k_6)}{[k_2 + k_3 - 2k_6(k_1 + k_3 - 2k_5) - (k_3 + k_4 - k_{5-} k_6)^2]}\right|$$