

CHAPTER – V

RESEARCH METHODOLOGY

5.1. INTRODUCTION

The study has been conducted using a broad methodology framework which embraces both empirical - analytical formulations and normative deductive appraisals.

The interpretations that have been derived in various parts of the study have been based on statistical analysis. Mean, Standard deviation, Coefficient of Variance, Min and Max values (of claims/premiums) will help to assess the performance of the Asset (premium) and Liability (claims) portfolios of the States/Crops. Standard Error (SE) of the estimate will measure the uncertainty about the accuracy of the predicted values of the dependent variable (here claims/premium).

The coefficient of determination (r-squared) is the square of the correlation coefficient. Its value may vary from zero to one. It has the advantage over the correlation coefficient in that it may be interpreted directly as the proportion of variance in the dependent variable that can be accounted for by the regression equation.

The coefficient of variance is the degree to which a set of data points varies and it will be used to determine the variability in claim/premium data. Correlation is a measure of association between two variables which will be applied to measure the relationship between two states or crops.

The significance (probability) of the correlation coefficient can be determined by the application of the t-statistic. Beta distribution will be used to calculate Probability of ruin and maximum claim ratio. Beside these statistical tests various ratios are proposed to be formulated and examined to make a comparative analysis of different variables. One of major part of the proposed research study will be to build and design models by simulating different statistical tools all together.

The different methodologies used during the analysis and interpretations are independently discussed below.

5.2 STATISTICAL TECHNIQUES

Following statistical tests has been performed to asses the performance of the Asset (premium) and Liability (claims) portfolios of the States/Crops:

5.2.1 Basic Statistical Tools

Mean, Standard deviation, Coefficient of Variance, Min and Max values (of claims/premiums) help in assessing how the claims or asset (premium) portfolio of a State/crop is performing. Higher standard deviation indicates higher variability or Risk. Additional variability or risk should be adequately rewarded by higher premium. If premium data are used for the analysis then, the Mean value of the premium portfolio should be on the higher side if the standard deviation of the claims portfolio is high. If that is not the case then it can be interpreted that the state/crop portfolio under analysis is not performing as expected.

5.2.2 Standard Error

Standard Error (SE) of the estimate measures the uncertainty about the accuracy of the predicted values of the dependent variable (here claims/premium). SE will be low (relative to total variability) if the relationship between the variables (in this case year and claims/premium) is very strong and high if the relationship is weak.

5.2.3 R Square

R Square: The coefficient of determination (r-squared) is the square of the correlation coefficient. Its value may vary from zero to one. It has the advantage over the correlation coefficient in that it may be interpreted directly as the proportion of variance. For example, an r-squared value of .49 means that 49% of the variance in the dependent variable can be explained by the regression equation. The other 51% remains unexplained.

5.2.4 Coefficient of Variance

The coefficient of variance (CV) is the degree to which a set of data points varies. The larger the value of CV is, the greater the variability in claim/premium data. Lower the CV percentage, the better the precision between replicates. For example, if the standard deviations for 2 states/crops are same, it doesn't necessarily mean that the precision was the same.

5.2.5 Correlation

Correlation is a measure of association between two variables. The value of a correlation coefficient can vary from minus one to plus one. A minus one indicates a perfect negative correlation, while a plus one indicates a perfect positive correlation. A correlation of zero means there is no relationship between the two variables.

When there is a negative correlation between two variables, as the value of one variable increases, the value of the other variable decreases, and vice versa. In other words, for a negative correlation, the variables work opposite each other. When there is a positive correlation between two variables, as the value of one variable increases, the value of the other variable also increases.

5.2.6 Test of Significance (t-statistic)

The significance (probability) of the correlation coefficient is determined from the t-statistic. The probability of the t-statistic indicates whether the observed correlation coefficient occurred by chance if the true correlation is zero. In other words, it asks if the correlation is significantly different than zero (i.e. states/crops are uncorrelated).

5.3 DYNAMIC FINANCIAL ANALYSIS (DFA)

Major facet of the research study is to build and design a software based model by simulating different statistical tools all together. The model has been developed after modifying the widely used Dynamic Financial Analysis model of the actuarial science.

Dynamic Financial Analysis (DFA) is a systematic approach based on large-scale computer simulations for the integrated financial modeling of non-life insurance and reinsurance companies aimed at assessing the risks and the benefits associated with strategic decisions.

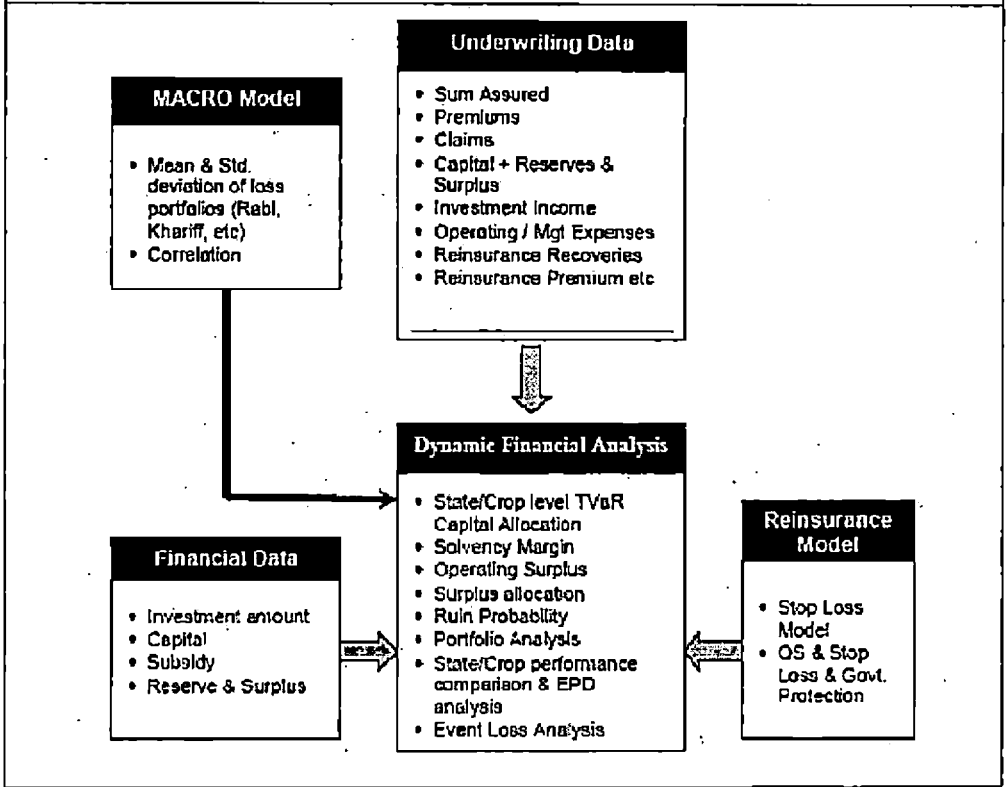
5.3.1 Objectives of Dynamic Financial Analysis

- ❖ It helps in identifying States/Crops which are performing well and which are performing poorly.
- ❖ It helps in allocating capital to lines based on the Risk associated with it and reflects its' contribution to the overall cost of capital.
- ❖ It helps to perform Event Loss (Draught, flood etc) Analysis
- ❖ It helps in comparing performance of states/crops.

The DFA Model

The following diagram (Figure: 5.1) shows data flow to the Dynamic Financial Analysis (DFA) model:

Figure 5.1
Flow Chart of DFA Model



Source: Constructed for the purpose of the study

5.3.2 STATE/CROPS CORRELATION ANALYSIS

Following are the steps involved in a typical correlation based insurance product designing:

1. Select a State or Crop
2. Check the overall underwriting results (loss ratio, combined ratio etc) for the selected state crop
3. Check claim correlations of this state/crop with other states/crops.

If claim correlation is significant and positive then design similar insurance schemes. On the other hand, if claim correlation is significant and negative, then design tailor made insurance scheme for the selected state or crop.

State correlation analysis helps in identifying highly correlated states and along with crop correlation analysis; it will help in creating less risky crop portfolio for the individual states.

Crop correlation analysis mainly helps in designing insurance products for the individual crops. Similar insurance scheme can be designed if the crops are positively correlated. This will reduce underwriting risk substantially. The benefit will also come in the form of reduced insurance product designing cost and effort.

5.3.3 Marginal Tail Value at Risk (VaR) and Capital Allocation Analysis

Many re-insurers assess the price of their business using some form of contract-level capital allocation -- e.g., ruin threshold, marginal Value at Risk (VaR), expected policyholder deficit (EPD), or tail conditional expectation (TCE). Practical application of any of these capital measures in contract pricing requires:

- (i) Stochastically modeled contract outcome distributions, and
- (ii) A selected "safety standard" for that risk measure (e.g., 99 % percentile for ruin threshold).

The more stringent the safety standard (confidence level), the more capital will be allocated. The DFA model uses tail VaR based capital allocation to losses. The basic underlying idea is to allocate capital to outstanding losses from prior years. In future years, the organization will need to allocate capital to outstanding losses from the current year. And it must fund the cost of that capital from the current year's premiums. The capital allocated to outstanding losses in future years will, in part, depend upon future underwritings.

While doing VaR based analysis it is assumed that future writings depend on the past experience. So it will not be wrong to infer that this allocation will be valid over the next year.

The DFA model uses the following major inputs to compute marginal Tail VaR and capital allocation % for States and crops:

- Mean Loss
- Standard deviation of Loss
- Confidence level

Mean loss is the average claim amount for a state/crop whereas Standard deviation of loss is the standard deviation of historic claim data. The macro model calculates mean loss and standard deviation of loss from available historic claim data. The DFA model uses this data to compute Marginal Tail VaR and Tail VaR allocation.

Tail VaR Calculation Process:

The process of calculation of Value at Risk (VaR) in DFA is discussed below.

- ❖ Total Tail VaR capital is the difference between Tail VaR and expected Loss.
- ❖ Sum of the Tail VaR Marginal Capital is equals to the sum of the Marginal Tail VaR capital of all the states/crops.
- ❖ The percentage of capital allocated to different states/crops is the ratio of Tail VaR capital of a state/crop and total marginal Tail VaR.

5.3.4 Underwriting Performance Analysis of the States and Crops

Underwriting analysis needs premium details of the states/crops. The portfolio model uses premium data coming from the Macro model. the model calculates the following underwriting performance parameters:

- Loss Ratio: ratio of Claims and Premium
- Underwriting Results
- Combined Ratio: defined below.

Combined ratio can be defined as:

Combined ratio = (expected loss + Acquisition cost + other expenses-surplus)/Premium

Combination ratio can be viewed as a combination of the claims ratio and the expense ratio. A combined ratio below 100% generally indicates profitable underwriting prior to the consideration of investment income. A combined ratio over 100% generally indicates unprofitable underwriting.

5.3.5 Underwriting Profitability and Financial Analysis

The DFA model provides the flexibility to select the basis of analysis e.g. Historic loss cost based analysis, Projected (for the next Financial Year) loss cost based analysis etc. The present analysis is based on AICI's 21 years historic loss cost information.

DFA model also needs mean and standard deviation of the Rabi, Khariff, weather and total portfolios as inputs. Once required inputs are provided the DFA model performs underwriting and financial analysis. The DFA model generates five scenarios. These are as under.

1. Rabi
2. Kharif
3. Stop Loss reinsurance
4. Quota Share Reinsurance
5. Stop loss + Quota Share Reinsurance

The DFA model uses Beta distribution to calculate Probability of ruin and maximum claim ratio. In probability theory and statistics, **Beta distribution** is a two-parameter family of continuous probability distribution defined in the interval [0, 1], with probability density function (pdf):

$$f(x) = \frac{(x-a)^{p-1}(b-x)^{q-1}}{B(p,q)(b-a)^{p+q-1}} \quad a \leq x \leq b; p, q > 0$$

Where p and q are the shape parameters, a and b are the lower and upper bounds, respectively, of the distribution, and $B(p,q)$ is the beta function. The mean and standard deviation of this distribution can be expressed by the following formulas:

$$\text{Mean: } \frac{p}{p+q}$$

$$\text{Standard Deviation: } \sqrt{\frac{pq}{(p+q)^2(p+q+1)}}$$

The DFA model takes mean and standard deviation as inputs and calculates the parameters of the distribution p and q . The model assumes standard beta distribution (i.e. $a=0$ and $b=1$): The variable, x in the distribution is referred to as 'Claim Ratio'.

From the definition of the beta distribution it appears that the chance of claims ratio greater than 100% is nil. Using the mean and standard deviation as inputs, 'Probability of Ruin' and maximum 'Claim Ratio' can be calculated by using the following formulas:

$$\text{Probability of ruin} = [1 - \text{BETADIST}(\text{Expense Ratio}, \text{Mean}, \text{Standard Deviation})]$$

Expense ratio can be defined as the expenses expressed as a percentage of the net received premium. And claim ratio can be defined as the claims paid expressed as a percentage of the net received premium.

Maximum claim ratio can be expressed as:

$$\text{Maximum claim ratio} = \text{BETAINV}(\text{Probability of Ruin}, p, q)$$

Solvency margin can be defined as the difference between Remains and Maximum Claim Ratio. This difference is an estimate of the margin left over and above the maximum possible claim at the calculated Probability of Ruin level.

Using the **expected policyholder deficit (EPD)** risk measure insolvency risk can be measured in such a way that standard minimum level of protection is applied to all classes of policyholders and insurers (all states/crops). The EPD measure can apply equally to all risk elements, whether assets (Premiums) or liabilities (Claims).

It is informative to compare the EPD ratio solvency criterion with the ruin probability notion. The relationship between the EPD ratio and the probability of ruin is not constant, even for the well-known normal distribution. And it is difficult to calculate Probability of Ruin at crop and state level due to the scarcity of relevant data. EPD ratio calculation is relatively easier and it gives enough indication about solvency nature of a crop.

5.4 APPLICATION OF COMPUTER BASED SOFTWARE

The interactive tool has been developed to evaluate the risk profile of AICI's entire insurance portfolio or any components thereof. Following are the basic characteristics:

- ❖ The interface is Microsoft Excel with a windows based tool Graphical User Interface (GUI).
- ❖ The development environment for the tool is the Visual basic Editor built-in Microsoft Excel and the open source DFA analysis software.

Requirements

The main aim of this interactive tool is to create user-friendly environment to load Block level data, view and edit the selected block data and show the crop yields using charts and layouts. The components included with user interface are explained below:

- ❖ The database must be stored in MS Excel
- ❖ The application directory structure of Folders should be followed properly to avoid any erroneous results.
- ❖ For supporting database system it requires MS Office to support .xls for storing, viewing and processing of the data.

Since the development environment of the tool is Microsoft Visual basic Editor (Macros) in Excel, it needs to be enabled before the tool can function properly. To enable macros the user would need to follow below mentioned steps:

***Start Menu Programs Microsoft Excel Tools Macro Security
Security Levels Tab***

After this we have three options available i.e.

- **High:** By choosing this option the macros which are not listed in Excel are automatically disabled. Thus, the tool will not run by choosing this option.
- **Medium:** User can choose whether or not to run a particular macro. In this case, every time the user starts the tool a message box will appear as shown below. By selecting Enable Macros the tool will run absolutely fine.
- **Low:** By selecting this option all the macros are automatically enabled and the user doesn't need to enable or disable any macros.

The user needs to select either the Medium or Low security option for the tool to run successfully.

The subsequent step will be to apply the DFA software along with other statistical tools of MS-Excel to simulate the desired results.

5.5 PORTFOLIO RISK ASSESSMENT MODEL

The computer based interactive tool will utilize stochastic simulations, scenario testing, financial modeling, covariance modeling, and sensitivity estimation to provide benchmark and quantitative measures of expected returns and risk components under alternative scenarios.

Step 1: Obtain all existing information including factors used in rating and exact methods used.

A substantial set of experience data has been assembled in the spread sheet (MS Excel). These data will form the basis of an analysis of the existing book of business. The data include statistics on historical payouts, liabilities, premiums, and expenses.

This will be coupled with data used to determine the rating of new weather insurance contracts. MS Excel and other widely available alternatives will be considered to conduct Monte Carlo simulations (or DFA Model) of the overall book of business.

This is not a trivial consideration at the outset since the models will be quite computationally intensive and the level of complexity will necessarily be dictated by the constraints on the computational platform.

Step 2: Estimate distributional properties of risk components and correlation structures across different lines and policies.

Parametric models of the distributional properties of the risks faced in the book of business will be estimated. Two important components will be estimated using the aforementioned data.

These are parameters for the appropriate distributions and Pearson or Spearman correlation coefficients for the entire correlation matrix pertaining to risks.

The analysis will also include the use of standard correlation analysis, parametric curve fitting, maximum likelihood analysis to derive estimates of the parameters.

Step 3: Conduct Monte-Carlo based simulation using the empirical estimates.

The model will use standard parametric-based simulation methods to provide a benchmark simulation (pertaining to the current book and the additions brought about by the weather insurance products).

The study will use the estimated correlation structure and parametric measures of risks in accordance with multivariate normal/uniform random number generators and probability cumulative distribution functions to simulate correlated experience realizations for the underlying risks.

5.6 SOURCES OF DATA

The proposed study covers intimate details of performance analysis of the agriculture insurance schemes initiated at the Government level from 1985 to 2006. Crop Insurance includes the CCIS and NAIS portfolio of AICI. It is spread over 2 seasons, 25 states and 52 crops.

The initiatives taken by the private sector companies in regard to agriculture crop insurance in India are very limited and insignificant. In order to maintain business secrets the private sector companies have not provided their business results.

Comparative analysis has been done on the basis of secondary data available from internet, published literature and Government reports. The data available in this respect are also inconsistent and uncorrelated. Therefore, they have been not taken in to account for overall analysis.

The study is based mainly on secondary data. The secondary sources in this respect include published reports and bulletins of the State and Central Government, Ministry of Agriculture, World Bank, and Government agencies like RBI, IRDA, GIC and AICI.

The details of financial performances for the present study have been collected from published financial statements, viz. the Profit and Loss account, Balance sheet, Directors report etc. Pertinent information has also been collected from the websites of the appropriate government and non-government organizations at the national as well as international levels.

Required data on crop insurance at the national level were collected from the office of the General Insurance Corporation (GIC) of India Ltd., Kolkata as well as from the office of Agricultural Insurance Company of India (AICI) Ltd., Kolkata.