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Research Article

FINANCIAL AND TECHNICAL ANALYSIS OF INSURANCE SECTOR WITH GOAL PROGRAMMING MODEL

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ABSTRACT

In today's business environment, management decision making in many insurance agencies and banks has become a complex task. Profit maximization or cost minimization are not always the only objects that a firm sets for. For these firms a variety of goals influence the decisions. Goal programming, one of the methods used to solve multi-objective linear programming models, can solve decision problems involving multiple goals. In this paper two different goal programming models are constructed for Turkey's non-life insurance sector to find an optimal solution with different goals for financial and technical analysis. In the first model five different financial ratios and in the second model four different technical ratios are used. The five years data is considered in these models. All goals which are set in the models are fully achieved. These models can be used as a guideline for insurance companies in their agency management and financial modeling.
Keywords: Goal programming, management, decision making, insurance sector, multiple goals.

1. INTRODUCTION

There are many goals that companies have to set and achieve to be financially strong. It is important to set the right targets for an effective asset-liability management. These targets may be profit optimization, risk minimization, or reaching the desired liquidity ratio, for financial institutions.

Goal programming is capable of handling decision problems involving multiple goals. A four-decade-old concept, it began with the work of Charnes and Cooper [1] and was refined and extended by Ingnizio [2]. Since then, goal programming techniques has been applied to many areas such as agriculture planning [3], scheduling [4], tourism [5], plant nutrient management [6], healthcare planning [7], engineering [8], transportation problems [9] and many more.

In the case of typical decision making, targets selected by management can be achieved by compromising other objectives. It is necessary to establish an order of importance among these targets. In this way, less important goals can be sought after achievement of more important goals. Since it is not always possible to achieve each goal, the goal programming will try to achieve as many multiple targets as possible.

Banks need to create strategies to make efficient use of funds and analyze the various goals such as minimizing risk and ensure security for an efficient asset-liability management. In the

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literature there are several examples that goal programming has been applied in banking and financial institutions area [10-15].

Rapid changes in the business environment have forced insurance agencies to re-examine their objectives and goal-programming has been used as an agency decision-making tool for these agencies [16]. It also has been used for optimum allocation of assets [17], capital budgeting [18], insurance agency management [19] and pension fund management [20]. Although goal programming is a well-known and useful technique to model multiple objective problems and applied to many different subject areas, in recent years there is relatively little literature published in actuarial / insurance field. One of them is the study of Heras et al in 2004 [21]. They used linear goal programming methodology to design Bonus-Malus premium scales with some interesting theoretical and practical attributes.

In this study two different goal programming models are set up to conduct financial and technical analysis for the entire non-life insurance sector, not for a single company. Some of the financial and technical ratios are selected as goals. These ratios are thought to affect the sector and it is considered useful to include these constraints into the model. The goals suggested in these models are neither all-encompassing nor constant among agencies or among the other countries' insurance sectors. The agencies can add different goals into the model in line with their own needs. "Republic Of Turkey Prime Ministry Under secretariat Of Treasury", the regulatory and supervisory authority for insurance companies in Turkey, publishes annual reports on insurance and private pension activities each year. The data from these reports is used in this study.

The purpose of this study is to make a financial and technical analysis in non-life insurance sector. The proposed models can be used as a guideline for life insurance sector or insurance agencies in making decisions and develop strategies to deal with various economic scenarios.

This paper is organized as follows: Goal programming methodology is presented in section 2. Section 3 "Application", consists of model formulations for financial analysis and technical analysis. In section 4, results for the models are presented. Section 5 concludes the study with the comments and certain suggestions for further research.

2. METHODOLOGY

Goal programming is an analytical approach devised to address decision-making problems where targets have been assigned to all the attributes and where the decision-maker is interested in minimizing the non-achievement of the corresponding goals. In other words, the decision maker seeks a Simonian satisficing solution (i.e., satisfactory and sufficient) with this strategy [22].

In typical decision making situations, the goals set by management can be achieved only at the expense of other goals. Since it is not always possible to achieve every goal to the extent the decision maker desires, goal programming attempts to reach a satisfactory level of multiple objectives [23].

The procedures for structuring a linear programming model are similar to those for a goal programming model. But the main difference between them is the objective function. While linear programming tries to find the best possible outcome for a single object and tries to maximize or minimize the objective function, goal programming minimizes the deviations between the target values of the objectives and the realized results.

$$\min z = \sum_{i \in n} \left(d_i^+ + d_i^- \right) \text{ , subject to } \sum_{j=1}^{m} \left(a_{ij} x_j - d_i^+ + d_i^- \right) = b_i \text{ ,} \quad x_j, d_i^+, d_i^- \geq 0$$

where x_j is the decision variable for j=1,…,m; a_{ij} represents the decision variable coefficients; b_i is the aspiration level; d_i^+ is the positive deviation variable from overachieving the i_{th} goal and d_i^- is the negative deviation variable from underachieving the i_{th} goal for i=1,…,n. If the management is unconcerned about whether there is an overachievement of the target, d_i^+ can be omitted from the object function, vice versa. In other words, b_i the aspiration level which is needed to be achieved is chosen for each of the objectives thus the undesired deviations from the given set of goals are minimized by using the achievement function z (total deviation function/object function). In Table 1 for different acceptable situations such as overachievement or underachievement of b_i the deviation variables to be minimized are summarized.

Table 1. General structure of goal programming model

Goal	Acceptable situation	Deviation variable to be minimized
$a_{ij}x_j \le b_i$	Underachievement	d_i^+
$a_{ij}x_j \ge b_i$	Overachievement	d_i^-
$a_{ij}x_j = b_i$	Exactly achievement	$d_i^+ + d_i^-$

When underachievement of b_i is the acceptable situation this implies anything below the aspiration level b_i is acceptable so the overachievement of the target d_i^+ should be minimized to 0. For overachievement situation anything below the aspiration level b_i should be driven to zero and if the management seeks to attain the aspiration level exactly both d_i^+ and d_i^- must appear in the object function.

As not all goals have the same importance, several variants have been conceived to weight goals differently [24]. There are two main variants/methods of goal programming; weighted goals programming and pre-emptive (lexicographic) goal programming. These two methods do not give the same results for the same problems and neither is one method is superior to the other method. They are designed to satisfy certain decision makers' preferences. In weighted goal programming model, weights are assigned to the goals that measure their relative importance and then finds a solution that minimizes the weighted sum of the deviations from the targets. In pre-emptive (lexicographic) goal programming model, the decision maker ranks the goals in order of importance. He must rank his goals from the most important one to the least important. This method is used when decision maker has a clear preference order for satisfying the goals. These two variants of goal programming are studied in Charles et al [25] Schniederjans and Kwak [26], Tamiz and Jones [27], Crowder and Sposito [28], Tamiz et al. [29], and many others. Solving a problem by assigning weights to the deviational variables easy to implement but in practice it is not easy to come up with precise weight for each goal. Therefore, the pre-emptive method is used for this study.

In this method priorities (P_i's) are assigned to each deviational variable in object function, with ranking that P_1 is the most important goal, P_2 the next most important goal and so on. The model is given as;

$$\min z = \sum_{i=1}^{n} P_i \left(d_i^+ + d_i^- \right) \text{ subject to } \sum_{j=1}^{m} \left(a_{ij} x_j + d_i^+ - d_i^+ \right) = b_i \,,\; x_j, d_i^+, d_i^- \geq 0.$$

3. APPLICATION

Turkey non-life insurance data is used for the case study. The five years data is obtained from the annual reports about insurance and private pension activities that Republic of Turkey Prime Ministry Under secretariat of Treasury published between 2011 and 2015.

3.1. Model Formulation for Financial Analysis

Financial ratios are used to make a holistic assessment of financial performance of the entity, and also help evaluating the entity's performance vis-à-vis its peers within the industry. For financial analysis of non-life insurance sector 5 different financial ratios are used; premium/shareholders' equity (total shareholders' equity calculated based on solvency requirement method), shareholders' equity/technical reserves, capital adequacy ratio, liquidity ratio, return on assets.

It is very important for insurance companies to have enough financial strength to fulfill their obligations to policyholders. The amount of equity capital is an important indicator to measure the financial strength of an insurance company. "Capital adequacy ratio" measures the adequacy of the capital available in the insurance and shareholders' funds of the insurer to support the total capital required and it is one of the most important indicators. "Premium/shareholders' equity ratio" and "equity/technical reserves ratio" are the other important indicators for assessing the capital adequacy of insurance companies. They both show the insurance company's exposure to underwriting risk. Liquidity ratios show the relationship of a company's cash and other current assets to its current liabilities [30]. One of the important and frequently used liquidity measure of non-life insurance companies is "liquidity ratio". "Return on assets" is the ratio of annual net income to average total assets of a business during a financial year. It measures efficiency of the business in using its assets to generate net income. It is one of the most important profitability measures for non-life insurance companies and an insurer naturally prefers a high return on assets ratio.

Table 2. Financial Ratios

Financial ratios (Goal)	Year					Priority
	2011	**2012**	**2013**	**2014**	**2015**	
Return on assets	0.4	-3.38	4.19	3.36	-1.46	P_1
Liquidity ratio	67.57	68.61	77.21	81.92	76.06	P_2
Capital adequacy ratio	128.46	107.63	125.01	136.4	106.2	P_3
Shareholders' equity/technical reserves	59.73	47.9	52.51	52.23	38.75	P_4
Premium/shareholders' equity*	246.68	285.24	251.38	232.09	285.65	P_5

*total shareholders' equity calculated based on solvency requirement method.

The decision variables; x_i's are the performance of financial ratios respectively for the year from 2011 to 2015 for i=1,…,5. The goal for the insurance sector is to exceed the average financial ratio values of the last 5 years. The priorities among goals are arbitrarily determined in this analysis and decision maker can change these priorities according to their needs. For example if the company's primary objective is to improve capital adequacy then first three priorities should be assigned to "capital adequacy ratio", "Premium/shareholders' equity ratio" and "equity/technical reserves ratio".

The goal constraints can be stated mathematically as follows:

$0.4x_1-3.38x_2+4.198x_3+3.36x_4-1.46x_5\geq0.622$ (return on assets constraint)
$67.57x_1+68.61x_2+77.21x_3+81.92x_4+76.06x_5^- \geq 74.274$ (liquidity ratio constraint)
$128.46x_1+107.63x_2+125.01x_3+136.4x_4+106.2x_5^- \geq 120.74$ (capital adequacy ratio constraint)
$59.73x_1+47.9x_2+52.51x_3+52.23x_4+38.75x_5\geq50.22$ (shareholders' equity/technical reserves c.)
$246.68x_1+285.24x_2+251.38x_3+232.09x_4+285.65x_5\geq 260.208$ (premium/shareholders' equity c.)
$x_1, x_2, x_3, x_4, x_5^- \geq 0$ (non-negativity constraint)

Now we can state our model as a goal-programming model using priorities;

Minimize total deviation$=P_1(d_1^-)+P_2(d_2^-)+P_3(d_3^-)+P_4(d_4^-)+P_5(d_5^-)$ (objective function)
$0.4x_1-3.38x_2+4.198x_3+3.36x_4-1.46x_5-d_1^+ + d_1^- =0.622$ (return of assets constraint)
$67.57x_1+68.61x_2+77.21x_3+81.92x_4+76.06x_5-d_2^+ +d_2^-= 74.274$ (liquidity ratio constraint)
$128.46x_1+107.63x_2+125.01x_3+136.4x_4+106.2x_5-d_3^+ +d_3^-=120.74$(capital adequacy ratio constraint)
$59.73x_1+47.9x_2+52.51x_3+52.23x_4+38.75x_5-d_4^+ +d_4^-=50.22$ (shareholders' equity/technical reserves c.)
$246.68x_1+285.24x_2+251.38x_3+232.09x_4+285.65x_5-d_5^+ +d_5^-= 260.208$ (premium/shareholders' equity c.)
$x_1, x_2, x_3, x_4, x_5, d_1^+, d_1^-, d_2^+ +d_2^-, d_3^+, d_3^-, d_4^+, d_4^-, -d_5^+ +d_5^- \geq 0$ (non-negativity constraint)

3.2. Model Formulation for Technical Analysis

For technical analysis of non-life insurance sector 4 different technical ratios are used; premium growth rate, technical profitability ratio, loss ratio, expenses ratio.

"Loss ratio" is one of the most important underwriting profitability and technical analysis measures for non-life insurance companies. This ratio demonstrates the effectiveness ofthe underwriting activities of the companies [31]. Loss ratio is calculated by dividing incurred losses by earned premiums [32]. There is a reverse relationship between loss ratio and financial performance [33]. Consequently, a low loss ratio is preferred by insurers. Another important underwriting profitability measure is technical profitability ratio. "Technical profitability ratio" assesses the effectiveness of the core insurance activities of the insurance company [34], and is calculated by dividing technical profit by gross written premiums. "Expense ratio" shows the percentage of the net earned premium paid out in the course of acquiring, writing and servicing the insurance payments in other words it is the ratio of underwriting expenses to net premiums written.

Table 3. Technical Ratios

Technical ratios (Goal)			**Year**			**Priority**
	2011	**2012**	**2013**	**2014**	**2015**	
Premium growth rate	21.57	19.1	21.65	8.43	20.43	P_1
Technical profitability ratio	0.42	-3.53	4.1	4.68	-1.79	P_2
Loss ratio	69.76	74.54	68.57	69.37	79.57	P_3
Expenses ratio	26.24	25.12	24.26	23.17	22.56	P_4

The decision variables; x_i's are the performance of technical ratios respectively for the year from 2011 to 2015 for i=1,…,5. The goal for the insurance sector is to exceed the average premium growth rate and technical profitability ratio values of the last 5 years and fall below the average loss ratio and expenses ratio values of the last 5 years. The priorities among goals are arbitrarily determined in this analysis and decision maker can change these priorities according to their needs. The goal constraints can be stated mathematically as follows:

$21.57x1+19.1x_2+21.65x_3+8.43x_4+20.43x_5 \geq 18.236$ (premium growth rate constraint)
$0.42x_1-3.53x_2+4.1x_3 +4.68x_4-1.79x_5 \geq 0.776$ (technical profitability ratio constraint)
$69.76x_1+74.543x_2+68.57x_3+69.374x_4+79.57x_5 \leq 72.362$ (loss ratio constraint)
$26.24x_1+25.12x_2+24.26x_3+23.17x_4+22.56x_5 \leq 24.27$ (expenses ratio constraint)
$x_1, x_2, x_3, x_4, x_5 \geq 0$ (non-negativity constraint)

Now we can state our model as a goal-programming model using priorities;

Minimize total deviation$=P_1(d_1^-)+P_2(d_2^-)+P_3(d_3^+)+P_4(d_4^+)$ (objective function)
$21.57x1+19.1x_2+21.65x_3+8.43x_4+20.43x_5-d_1^+ + d_1^- =18.236$ (premium growth rate constraint)
$0.42x_1-3.53x_2+4.1x_3 +4.68x_4-1.79x_5-d_2^+ +d_2^-=0.776$ (technical profitability ratio constraint)
$69.76x_1+74.543x_2+68.57x_3+69.374x_4+79.57x_5-d_3^+ +d_3^-=72.362$ (loss ratio constraint)
$26.24x_1+25.12x_2+24.26x_3+23.17x_4+22.56x_5-d_4^+ +d_4^-=24.27$ (expenses ratio constraint)
$x_1, x_2, x_3, x_4, x_5, d_1^+ , d_1^- , d_2^+ +d_2^-, d_3^+, d_3^-, d_4^+, d_4^- \geq 0$ (non-negativity constraint)

4. RESULTS FOR THE MODELS

The optimal solutions for these two goal programming models are found by LINGO software and results show all goals are fully achieved.

Table 4. Results for Financial Ratios

Goals Priority	Goals Achievement	d_i^-	d_i^+
P_1	Fully Achieved	0	0
P_2	Fully Achieved	0	30.79735
P_3	Fully Achieved	0	79.01530
P_4	Fully Achieved	0	42.65615
P_5	Fully Achieved	0	123.3794

Table 4 shows from the first to fifth priority all goals are achieved for financial ratios since all negative deviations d_1^-, d_2^-, d_3^-, d_4^- are equal to zero. After fully achieving these goals first positive deviation d_1^+ is equal zero, meaning that we do not expect changes in the return of assets. For goal 2 (P_2) the value of d_2^+ is 30.79735 so liquidity ratio can be increased by 30.79735 per year. For goal 3 (P_3) the value of d_3^+ is 79.01530 and this indicates an increase in capital adequacy ratio by 79.01530. Similarly, for goal 4 (P_4) and for goal 5 (P_5) we have overachievements of targets. We expect the increase in both shareholders' equity/technical reserves ratio and premium/shareholders' equity ratio by 42.65615 and 123.3794, respectively.

Table 5. Results for Technical Ratios

Goals Priority	Goals Achievement	d_i^-	d_i^+
P_1	Fully Achieved	0	0
P_2	Fully Achieved	0	0
P_3	Fully Achieved	13.55034	0
P_4	Fully Achieved	2.323530	0

Table 5 shows from the first to the fourth priority all goals are achieved for technical ratios since the first two negative deviations d_1^-, d_2^- and last the two positive deviations d_3^+, d_4^+ are equal to zero. The first two positive deviations are also equal to zero, meaning that we do not expect changes in premium growth rate and technical profitability ratio. For goal 3 (P3), the value of d_3^- is 13.55034. This shows loss ratio can be decreased by 13.55034. Since the sector is only concerned with the overachievement of the loss ratio constraint and wants to minimize the d_3^+ the result is satisfactory. Besides, this is also satisfactory that the fourth negative deviation, d_4^- takes the value 2.323530 the expected value for expenses ratio for 2016 is 21.94647 with this model.

5. CONCLUSION

Decision-making helps decision-makers to improve systematic thinking and achieve results in the face of simple or complex problems. It is not always possible to reach the optimum result with the increase in goals. In this case, the decision-making process will be difficult and the decision maker will try to reach a solution with certain sacrifices. Multi-criteria decision methods which are developed to help decision making against multiple objectives or alternative problems have been started to be used in all systems over time. These methods, which are often used in the financial and insurance systems, provide optimum results for decision makers.

In this study goal programming which is an important class of multi-criteria decision models is used to analyze financial and technical performance of Turkey's non-life insurance sector. In the application we used five different financial ratios; premium/shareholders' equity, shareholders' equity/technical reserves, capital adequacy ratio, liquidity ratio, return on assets, that are important for financial analysis and four different technical ratios; premium growth rate, technical profitability ratio, loss ratio, expenses ratio, that are important for technical analysis of non-life insurance sector. All the goals that have been examined in the models are achieved by LINGO software. The results show there will be an improvement in the financial and technical performance of Turkey's non-life insurance sector and we can reach our inspiration levels of our goals in two models with the priorities that we set.

The proposed models can serve as a guideline for insurance agencies in making decisions and developing strategies to dial with various situations involving multiple, often conflicting goals. In order to use goal programming an insurance company first has to determine its goals or objectives. Different goals may be important to different companies. By regulatory and supervisory agencies and rating agencies in any country, additional goals can be added into the models in the line with their needs.

Finally, these models with the same ratios or different ones will also be helpful for life insurance sector and the priorities of the goals can be changed and this leads to a change in the results.

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