Optimizing the Financial Management of Electronic Companies using Goal Programming Model

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Abstract. The swift development and transformation of emerging technologies such as augmented reality, robotics, biometrics and 3D printing place varying degree of pressure to the electronic industry to play a trailblazing role in making the world a smarter place of living. The concept of smart city increases the demand for the upgrades and sophistication of electronic components. Shorter product life cycles of personal and commercial electronic products also keep the electronic companies in a never-ending loop for huge investments in materials, equipment and expertise. Electronic companies in Malaysia are still facing financial stress in their operations. Therefore, this paper aims to optimize the financial management of listed electronic companies, namely D&O, GTRONIC, UNISEM and VITROX with asset, liability, equity, earning, profit and optimum management item as the objectives using goal programming model. The benchmarks of all the goals are obtained by comparing the maximum and minimum values of the optimal values of these companies. The results of this study show that the goal programming model is able to generate the optimal solution for each company. Besides liability and earnings, all the goals have been attained by these companies upon analysis using goal programming. Possible refinement values particularly for liabilities for all the companies have been generated from this model to provide insights for these companies to benchmark for risk alleviation and strategic decision making.

Index Terms—Goal programming, optimal solution, potential improvement, financial analysis

1. Introduction

Smart city evolves around the usage of Internet of Things (IoT) applications including sensors, cameras, actuators, microcontrollers and various other electronic components to create a bridge between the real life and digital world [1]. These electronics, coupled with other technologies, facilitate the connection and exchange of the most valuable asset in IoT – data, over the Internet through live reporting and smart monitoring to enhance machine to machine communication and machine learning [2]. The concepts of Smart Dubai and Smart City Korea also place great emphasis on research and development which further develop the electronic industry as a basis to support urban development, government projects, business services and smart living [3-5]. Therefore, the electronic industry, which boomed since the third industrial revolution, has continued to enjoy the surging
demand with the rise of emerging technologies such as IoT, artificial intelligence, blockchain and augmented reality.

In the meantime, the government of Malaysia is also very keen in the concept of smart city as seen in the launching of Malaysia Smart City Framework in the end of 2019 to apply and adopt the smart city concept into the lives of the Malaysian citizens. Digital innovation and transformation with high reliance on the electronic industry is one of the main modules in this framework besides government reform and the city system [6]. The acknowledgement on the electronic industry can further be seen with tax incentives to support their operations right after the launch of the framework [7]. The electronic industry has also contributed more than RM370 billion in export in 2019, which was almost 40% of the overall export in 2019 with semiconductors, integrated circuits, transistors and automated data processing being among the topmost exported and imported electronic products in Malaysia [8].

Besides, since the end of the 20th century, there have been close to one billion desktops and laptops sold in the United States while these personal devices have increased in demand of more than 10% worldwide in the recent years [9]. The short product life cycles of the electronic products show that electronic companies pour in a huge sum of investment into research activities for product enhancement and innovation in the competitive digital world [10]. The introduction of 5G and 6G networks with unique millimeter wavelengths means that the production of electronics such as semiconductors will have to undergo specific transformation to have enhanced performance [11]. The upgrading of wireless connectivity also requires many other state of the art electronic components such as reconfigurable intelligent surfaces, high electron mobility transistors and power amplifiers which incur huge investments that may cause financial stress in electronic companies [12]. Nevertheless, the manufacturing processes in electronic industry is also constantly changing with additive manufacturing or 3D printing and various fabrication processes to produce transformative prototypes [13].

In the corporate world, companies implement various business information systems to streamline their work functions. These business information systems consist of various hardware, software and real time data to facilitate their decision making based on data processing and data analysis [14-15]. With industrial automation, more business functions will benefit from the electronic industry as electronics are the basis for robotics and autonomous devices [16]. The realization of the importance of the sustainment and growth of the electronic industry to support smart city and industrial automation has prompted the need to investigate the financial status of electronic companies. This is because the raw materials such as silicon, glass, metals and plastics and manufacturing equipment require high level of investment and maintenance in the electronic industry.

Hence, this paper aims to optimize the asset and liability management (ALM) problem to study the financial position of electronic companies in Malaysia with goal programming (GP) model. ALM is a risk management approach to identify sources of potential financial peril and help companies mitigate them to reduce cost of rectification by balancing assets and liabilities. ALM may assist electronic companies to optimize their financing and obtain adequate capital to reduce bankruptcy risks. ALM offers insights to facilitate electronic companies to maximize profitability, reduce insolvency and manage liquidity [17]. ALM is also widely applied in insurance companies [18-20] and portfolio investment [21-22].

GP is used for the optimization of various goals that involves multi-criteria decision making (MCDM) problem and the identification of benchmarks for companies which have yet to achieve optimized goals. MCDM model aims to determine the best solution based on multiple criteria [23-33]. In a study by Bal and Satoglu [34], GP was used in the optimization of electronic equipment waste to minimize cost, environmental effects and penalty. This paper showed that economic, social and sustainability goals are achievable with the GP optimization. An application of GP was also performed on the insurance sector in Turkey with financial goals such as return on assets, liquidity ratios, equity and capital adequacy ratio. This study has also found improvements for the insurance companies and assist them in decision making and strategy development [35]. In addition, GP was applied in logistics [36-37], energy [38-39] and staff planning [40].
Asset accumulation, liability minimization, equity, earning, profitability and optimum goal management were the goals of an optimization study in Nigerian bank from 2007-2011 [41]. Financial management of healthcare system was studied in India from 2010 to 2017 with weighted GP model. There are six goals in this study, namely asset accumulation, liability reduction, equity accumulation, earning accumulation, profitability increment and optimum management item [42, 43]. Hence, this paper will adopt these goals for the optimization of financial management of electronic companies in Malaysia. The next section of the paper will focus on data and methodology, then empirical results and conclusion.

2. Data and Methodology

The listed electronic companies, namely D&O, GTRONIC, UNISEM and VITROX are studied in this paper for a period from 2015 to 2019. Data analysis is performed based on the financial reports of these companies [44]. Six goals will be optimized in the study of financial management of electronic companies in Malaysia as shown in Table 1.

| Goal | Description |
|------|-------------|
| 1    | Maximizing asset |
| 2    | Minimizing liability |
| 3    | Maximizing equity |
| 4    | Maximizing profit |
| 5    | Maximizing earnings |
| 6    | Maximizing optimum management items |

Maximization of asset, equity, profit, earnings and optimum management item as well as the minimization of liability are the main goals of this paper. In MCDM problem, linear programming (LP) faces limitation as LP shall only carry a single objective with some constraints. However, companies may pursue several goals at a time. GP is able to supplement LP to optimize various objectives. The achievement function involves the minimization of non-achieving goals [38]. The goal achievement of GP is determined by the deviation value from the benchmark value. The greater the deviation, the lower the goal achievement, hence, smaller deviation is more favorable. The construction of the GP model for every electronic company to study the optimization of the financial status with the six goals of uniform weight is shown below:

\[
\text{min } z = w_1 G_1 + w_2 G_2 + \cdots + w_i G_i
\]  

subject to

Constraint 1 (Asset):

\[
\sum_{j=1}^{m} a_{ij} x_j + d_{1}^+ - d_{1}^- = g_1
\]

Constraint 2 (Liability):

\[
\sum_{j=1}^{m} a_{ij} x_j + d_{2}^+ - d_{2}^- = g_2
\]

Constraint 3 (Equity):

\[
\sum_{j=1}^{m} a_{ij} x_j + d_{3}^+ - d_{3}^- = g_3
\]

Constraint 4 (Profit):

\[
\sum_{j=1}^{m} a_{ij} x_j + d_{4}^+ - d_{4}^- = g_4
\]

Constraint 5 (Earnings):

\[
\sum_{j=1}^{m} a_{ij} x_j + d_{5}^+ - d_{5}^- = g_5
\]
Constraint 6 (Optimum Management Item):
\[ \sum_{j=1}^{m} a_{ij} x_j + d_{6}^- - d_{6}^+ = g_6 \]  
(7)

where
\[ z = \text{objective function} \]
\[ w_i = \text{weight for } i = 1, 2, 3, ..., n \]
\[ d_i^- = \text{negative deviation variables when } i = 1, 2, 3, ..., n \]
\[ d_i^+ = \text{positive deviation variables when } i = 1, 2, 3, ..., n \]
\[ a_{ij} = \text{weight of financial statement in year } j = 1, 2, 3, ..., m \]
\[ x_j = \text{amount of financial statement in year } j = 1, 2, 3, ..., m \]
\[ g_i = \text{benchmark value when } i = 1, 2, 3, ..., n \]

The comparison of the sum of the values of every goal among the electronic companies and determination of optimal values to serve as the benchmarks will be performed in this study [43, 45]. The benchmarks may serve as possible refinement of the current financial status of electronic companies. When a goal is being maximized, the goal is reached when \( d_i^- = 0 \). On the other hand, when a goal is aimed at being minimized, goal attainment is reached when \( d_i^+ = 0 \). Else, the possible improvement of the goals can be seen with other values of deviation variable. The model value is the optimal solution of every electronic company based on GP model. The computational work is performed using LINGO software. LINGO has been used in various studies to generate the results for linear, non-linear and integer programming models [46-54].

3. Empirical Results

The data analysis on the financial management of electronic companies is presented in Table 2.

Table 2. Data analysis on the financial management of electronic companies (RM trillion)

| Goal                  | D&O    | GRONIC  | UNISEM  | VITROX  |
|-----------------------|--------|---------|---------|---------|
| Asset                 | 2.596152 | 1.778821 | 8.898055 | 2.312921 |
| Liability             | 0.983256 | 0.335711 | 1.866776 | 0.616005 |
| Equity                | 1.612896 | 1.443110 | 7.031279 | 1.696916 |
| Profit                | 0.156136 | 0.263013 | 0.567567 | 0.377325 |
| Earnings              | 0.578710 | 0.436300 | 6.651413 | 1.456076 |
| Optimum management items | 5.927150 | 4.256955 | 25.015090 | 6.459243 |

Table 3 to Table 6 display the model values and goal attainments of the four electronic companies according to the optimal solution of GP model.

Table 3. Model value and goal attainment of D&O (RM trillion)

| Goal      | Benchmark value | Model value | Negative deviation | Positive deviation | Goal achievement |
|-----------|-----------------|-------------|--------------------|--------------------|------------------|
| Asset     | 8.898055        | 10.811302   | 0.000000           | 1.913247           | Achieved         |
| Liability | 0.335711        | 3.771158    | 0.000000           | 3.435447           | Not achieved     |
| Equity    | 7.031279        | 7.040143    | 0.000000           | 0.008864           | Achieved         |
| Profit    | 0.567567        | 0.804569    | 0.000000           | 0.237002           | Achieved         |
| Earnings  | 6.651413        | 2.587918    | 4.063495           | 0.000000           | Not achieved     |
From Table 3, D&O has achieved the goals on assets, equity, profit and optimum management item because these four goals, aimed at maximizing them, have zero negative deviation which implies that the model values are same as or more than the benchmark values. D&O performed greater than the benchmark value for asset, equity and profit by RM 1.913247 trillion, RM 0.008864 trillion and RM 0.237002 trillion respectively. The positive deviation value for liability indicates that D&O did not achieve the goal for liability. D&O has to reduce its liability by RM 3.435447 trillion in order to achieve the liability goal. D&O has also earned less than the expected value of RM 6.651413 trillion. Therefore, D&O has to increase its earnings by RM 4.063495 trillion.

Table 4. Model value and goal attainment of GTRONIC (RM trillion)

| Goal                  | Benchmark value | Model value | Negative deviation | Positive deviation | Goal achievement |
|-----------------------|-----------------|-------------|--------------------|--------------------|-------------------|
| Asset                 | 8.898055        | 30.351715   | 0.000000           | 21.453660          | Achieved          |
| Liability             | 0.335711        | 3.682799    | 0.000000           | 3.347088           | Not achieved      |
| Equity                | 7.031279        | 26.668909   | 0.000000           | 19.637630          | Achieved          |
| Profit                | 0.567567        | 4.017877    | 0.000000           | 3.450310           | Achieved          |
| Earnings              | 6.651413        | 6.651413    | 0.000000           | 0.000000           | Achieved          |
| Optimum management items | 25.015090    | 71.372710   | 0.000000           | 46.357620          | Achieved          |

From Table 4, GTRONIC has achieved the goals of asset, equity, profit, earnings and optimum management item as they have zero negative deviation values. GTRONIC has also obtained earnings equivalent to the benchmark value. The outperformance of goals can be seen in assets (RM 21.453660 trillion), equity (RM 19.637630 trillion), profit (RM 3.450310 trillion) and optimum management item (RM 46.357620 trillion). However, GTRONIC has not achieved the goal for liability as GTRONIC has RM 3.347088 trillion of liability in excess. A reduction of RM 3.347088 trillion in liability may be made to achieve the goal for liability.

Table 5. Model value and goal attainment of UNISEM (RM trillion)

| Goal                  | Benchmark value | Model value | Negative deviation | Positive deviation | Goal achievement |
|-----------------------|-----------------|-------------|--------------------|--------------------|-------------------|
| Asset                 | 8.898055        | 8.898055    | 0.000000           | 0.000000           | Achieved          |
| Liability             | 0.335711        | 1.764387    | 0.000000           | 1.428676           | Not achieved      |
| Equity                | 7.031279        | 7.133668    | 0.000000           | 0.102389           | Achieved          |
| Profit                | 0.567567        | 0.825522    | 0.000000           | 0.257955           | Achieved          |
| Earnings              | 6.651413        | 6.651413    | 0.000000           | 0.000000           | Achieved          |
| Optimum management items | 25.015090    | 25.273045   | 0.000000           | 0.257955           | Achieved          |

According to Table 5, the asset and earnings goals for UNISEM are well achieved at the benchmark values. Positive deviations of equity, profit and optimum management item show that UNISEM has
surpluses of RM 0.102389 trillion, RM 0.257955 trillion and RM 0.257955 trillion in equity, profit and optimum management item respectively. In addition, UNISEM has to reduce its liability by RM 1.428676 trillion to achieve the liability goal.

**Table 6.** Model value and goal attainment of VITROX (RM trillion)

| Goal                | Benchmark value | Model value | Negative deviation | Positive deviation | Goal achievement |
|---------------------|-----------------|-------------|--------------------|--------------------|------------------|
| Asset               | 8.898055        | 10.602515   | 0.000000           | 1.704460           | Achieved         |
| Liability           | 0.335711        | 1.932996    | 0.000000           | 1.597285           | Not achieved     |
| Equity              | 7.031279        | 8.669477    | 0.000000           | 1.638198           | Achieved         |
| Profit              | 0.567567        | 1.839214    | 0.000000           | 1.271647           | Achieved         |
| Earnings            | 6.651413        | 6.651413    | 0.000000           | 0.000000           | Achieved         |
| Optimum management items | 25.01509 | 29.695616 | 0.000000 | 4.680526 | Achieved |

Based on Table 6, VITROX has achieved five goals, namely for asset, equity, profit, earnings and optimum management item. Outperformances in asset, equity, profit and optimum management item have been detected at RM 1.704460 trillion, RM 1.638198 trillion, RM 1.271647 trillion and RM 4.680526 trillion respectively. On the contrary, VITROX underperformed in the liability goal as the company has an additional of RM 1.597285 trillion which has to be reduced to attain this goal.

The summary of the benchmark values and model values for all the electronic companies are performed in Table 7.

**Table 7.** Summary of benchmark and model values for electronic companies (RM trillion)

| Goal                | Benchmark value | Model value (D&O) | Model value (GTONIC) | Model value (UNISEM) | Model value (VITROX) |
|---------------------|-----------------|-------------------|----------------------|----------------------|---------------------|
| Asset               | 8.898055        | 10.811302         | 30.351715            | 8.898055             | 10.602515           |
| Liability           | 0.335711        | 3.771158          | 3.682799             | 1.764387             | 1.932996            |
| Equity              | 7.031279        | 7.040143          | 26.668909            | 7.133668             | 8.669477            |
| Profit              | 0.567567        | 0.804569          | 4.017877             | 0.825522             | 1.839214            |
| Earnings            | 6.651413        | 2.587918          | 6.651413             | 6.651413             | 6.651413            |
| Optimum management items | 25.01509 | 25.015090 | 71.372710 | 25.273045 | 29.695616 |

The deviations between benchmark and model values for all the four electronic companies are compared in Table 8. These deviations signify the underperformance of the respective goal with the benchmark values.

**Table 8.** Comparison of deviations of goals with the benchmark values (RM trillion)

| Goal    | D&O | GRONIC | UNISEM | VITROX |
|---------|-----|--------|--------|--------|
| Asset   | 0   | 0      | 0      | 0      |
| Liability | 3.435447 | 3.347088 | 1.428676 | 1.597285 |
| Equity  | 0   | 0      | 0      | 0      |
| Profit  | 0   | 0      | 0      | 0      |
From Table 8, four goals, namely asset, equity, profit and optimum management items are well achieved by all the electronic companies. D&O is unable to achieve the earnings goal with RM 4.063495 trillion in deviation. The goal to minimize liability is not achieved by all the electronic companies. As such, electronic companies are recommended to reduce their liability according to the values in Table 8 for goal achievement.

4. Conclusion
This study focuses on optimizing and comparing the multiple goal attainment for the data analysis of the financial management in electronic companies in Malaysia using GP model. The benchmark values of all the goals have been determined by comparing the maximum optimal values of asset, equity, profit and optimum management item and the minimum optimal values of liability for better benchmarking for possible refinement among the four electronic companies, namely D&O, GTRONIC, UNISEM and VITROX. Based on the optimal solution, all the electronic companies are able to attain the asset, equity, profit and optimum management item goals while possible refinements are also being determined for the liability goal for all the companies. This study has proven its significance as the desirable amount of asset, liability, equity, profit, earnings and optimum management item have been determined to fulfill the objective functions. The level of goal achievements and possible refinement have also been ascertained.

Conflict of Interest
The authors declare no conflict of interest.

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