The main purpose of this paper is to propose a sustainable model in the Financial Planning discipline, by applying a multi-objective optimization process when setting the different corporate objectives. With this purpose, a mathematical programming model is proposed, valid for determining optimal global strategies based on a general set of objectives as asset optimization, return, cash flows or shareholder dividend, where decision variables are the changes in the patrimonial masses of the balance sheet. Given the great number of possible strategies to fit this model, an optimal subset of this set is selected by formulating an extension of the optimal Compromise Programming approach, where instead of optimizing one by one each different objective and looking for an iterative approach to target all objectives, it optimizes all objectives at the same time within the problem limits, by looking for optimum and sustainable compromise solutions regarding all objectives. The applicability of this process is illustrated with an example corresponding to a Spanish company listed in IBEX35 stock index.

1. Introduction

The problem of the corporate financial planning and its optimization in a Multi-Criteria Programming context is an issue which has been initially addressed throughout the 1980’s and 1990’s, and in which techniques based on Goal Programming (GP) have been generally
used for its solution. The recent progress of the computer industry in the late 2000’s simplifying the calculation hardware needs has allowed to ease the calculation of complex optimization models of Compromise Programming (CP) with simple personal computers allowing the possibility of calculating optimum approaches in several fields.

A classical approach to this problem has been to express quantitatively the corporate goals and objectives in terms of a financial plan in order to provide its managers a better understanding of the company and make better decisions to the organization (Hayen, 1983 and Zopounidis et al., 2013). The quantitative expression of these criteria can initially be formulated in terms of the future pro-forma financial statements. In some occasions, it is possible go further and develop a balance scorecard, including some other non-financial strategic objectives in the way that proposed Kaplan et al. (1996) to control and review the main business decision variables in a single record.

One of the first studies associating the problem of financial planning with Multi-Criteria programming techniques was that of Kvanli (1980), who noticed that the task of optimizing this problem was highly complex due to the existence of multiple constraints in conflict, leading to mathematical models in which the objectives were not simultaneously optimizable. For gathering a numerical solution, this author proposes a satisfying a Goal Programming model approach (Charnes et al., 1965) generating “good-enough” solutions (Simon, 1955), but not really Pareto-Optimal ones (Romero, 1993 and Ballestero et al., 1998). Some other practical examples of this topic can be found in Batson (1989), resolved also with Goal Programming; in Diakoulaki et al. (1992), showing different sectorial exercises; and more recently in Ballestero et al. (2012) and Trenado et al. (2014), in terms of social responsibility.

The aim of this paper is to advance in the optimum resolution of this issue, looking for optimal Pareto-Efficient solutions in a sustainable financial planning context. As a consequence, a mathematical model is formulated and solved with Compromise Programming model (Zeleny, 1973) for calculating optimum solutions, but adapted with the Extended Compromise Programming (ECP) approach (André et al., 2008) to ease the calculation process. For our financial planning environment, this ECP technique ensures that a numerical solution can be calculated (Romero et al., 2015 and Martín et al., 2011) as the problem is formulated with linear relationships on its objectives, allowing a great computational efficiency for solving this task.

For the mathematical modeling of the problem, instead of the four objectives raised in the Kvanli model (sales, profits, number of employees and size of the balance sheet), the study proposes a model based on a financial balance sheet structure with net assets and net liabilities (Fernandez., 2010) leading as general objectives profitability, cash flow, net asset optimization and dividend to fit for SME/large companies requirements. Sustainability is accomplished by limiting the maximum reduction of solvency or book value creation ratios allowing certain management flexibility and a soft evolution of the model.

The article has been organized as follows. In Section 2, the model inputs (parameters and decision variables) are defined. In Section 3, a multi-objective programming problem will be mathematically formulated, which will allow an efficient calculation of optimal financial planning strategies. Then a calculation methodology centered on ECP techniques is presented. Next, in Section 4, the model proposed will be applied in a business example, comparing the solutions obtained with the real results followed by the company. Finally, Section 5 will show the conclusions derived from this research and possible future lines of investigation.
2. Definition of the model inputs

2.1 Parameters

E .......... Equity or shareholder funds.
C .......... Share capital.
DN......... Net debt, i.e. bank loans less cash.
WK......... Working capital, i.e. net account receivables, plus stock minus net account payables.
NFA........ Net fixed assets.
REV........ Revenue.
EBITDA.... Gross operations result, i.e. earnings before interests, taxes, depreciations and amortizations.
EM......... EBITDA margin i.e. EBITDA/REV.
EBIT...... Net operations result, i.e. earnings before interests and taxes.
T.......... Tax rate.
Kf........ Financial cost in terms of net debt.
NP........ Net profit or net result after taxes.
μ.......... Minimum payout ratio: minimum amount of net profit to be distributed as dividend.
ω.......... Minimum acceptable solvency level.
θ.......... Minimum acceptable level for the book value of the company shares.
γ.......... Maximum level of new capital.
σf......... Minimum level of amortization according to net fixed assets.
σg......... Maximum level of amortization according to net fixed assets.
π.......... Maximum level of working capital reduction in days.
ρ1......... Minimum level of return of investment ratio (ROI).
ρ2......... Minimum level of return of equity ratio (ROE).
α1......... Minimum level of CAPEX investment according to net fixed assets.
α2......... Maximum level of CAPEX investment according to net fixed assets.

2.2 Decision variables

In the context of this document, the value of the turnover expected and the gross operational result (EBITDA) will be considered as starting point. Thus, will be assumed that the manager’s task would be to define the necessary financing structure, calculating the increases in the balance sheet and the expected investment in operations and from long-term assets. Thus, the decision variables considered are:

X1........... Annual increase of non-distributed reserves
X2........... Annual increase of external share capital
X3........... Annual increment of accumulated depreciation
\( X_4 \)......Annual reduction of net debt i.e. bank loans minus cash.
\( X_5 \)......Investment in fixed assets (CAPEX).
\( X_6 \)......Annual distributed shareholder dividend
\( X_7 \)......Annual reduction of working capital
\( \mathbf{X} \)......\((X_1,X_2,X_3,X_4,X_5,X_6,X_7)\) = Vector of decision variables

The constraints in the calculation of the multi-criteria optimization models imply that these decision variables are always positive. Taking into account that in corporate finance, asset growth or financial optimization strategies can apply depending on the economic cycle, in the context of this document, the objective of financial optimization will be considered as dominant. Thus, \( X_4 \) is defined as the reduction of the net debt and \( X_7 \) as the value of working capital optimization. On the other hand, if other expansive contexts were considered, and net debt or working capital may require a positive capital investment, those decision variables should be considered as increases and not as reductions.

3. Formulation of the model

3.1 Set of Objectives

The following general criteria seem to be reasonable as main indicators in the financial planning context of a large company (Ross, 2010).

1. Maximizing the optimization of the asset side in the balance sheet, which leads to the following objective function with reduction of working capital and growth of asset investment:
   \[
   \text{Max } f_1(\mathbf{X}) = X_7 - (X_5 - X_3)
   \] (1)

2. Maximizing the solvency of the company measured in terms of the equity over net debt position, which leads to the following objective function:
   \[
   \text{Max } f_2(\mathbf{X}) = \frac{E + X_1 + X_2}{DN - X_4}
   \] (2)

3. Maximizing the value creation for shareholders, using the book value ratio measured in terms of equity (share capital and reserves) over invested capital, which leads to the following objective function:
   \[
   \text{Max } f_3(\mathbf{X}) = \frac{E + X_1 + X_2}{C + X_2}
   \] (3)

4. Maximizing the dividend or shareholder remuneration, which leads to the following objective function:
   \[
   \text{Max } f_4(\mathbf{X}) = X_6
   \] (4)
5. Maximizing the cash flow from operations, as an indicator of the operational efficiency of the company, which leads to the following objective function:

\[ \text{Max } f_5(X) = N \cdot P + X_3 + X_7 \]  

(5)

6. Maximizing the free cash flow of the company, as a key element of the enterprise valuation and corporate management, which leads to the following objective function:

\[ \text{Max } f_6(X) = EBIT \times (1 - T) + X_3 - X_5 + X_7 \]  

(6)

7. Maximizing the return on equity (ROE) measured as net profit over initial equity as an indicator of the shareholder return, which leads to the following objective function:

\[ \text{Max } f_7(X) = \frac{NP}{E} \]  

(7)

### 3.2 Set of Constraints

The following constraints have been considered as being reasonable for maintaining the sustainability and long-term balance of any business project and thus satisfying the financing structure of the company:

1. The company’s solvency should be higher than a level of \( \omega \), which gives the following inequality:

\[ \frac{E + X_1 + X_2}{DN - X_4} \geq \omega \]  

(8)

2. The book value ratio should be higher than a lower level \( \vartheta \), which gives the following inequality:

\[ \frac{E + X_1 + X_2}{C + X_2} \geq \vartheta \]  

(9)

3. The dividend payout of the company should be higher than a lower level \( \mu \), which leads to the following inequality:

\[ X_6 \geq \mu \times NP \]  

(10)

4. New capital injections should be limited by their dilution effect \( \Upsilon \) over the current capital, which gives the following inequality:

\[ X_2 \leq \Upsilon \times C \]  

(11)

5. The long-term amortization of the company’s assets must be within legal limits, which gives the following inequalities:

\[ X_3 \leq \sigma_1 \times NFA \]  

(12)

\[ X_3 \geq \sigma_2 \times NFA \]  

(13)
6. The reduction of working capital must be reasonable and operationally feasible. For this purpose, the factor $\pi$ associated with the reduction in days of the theoretical working capital has been considered as a measurement, leading to the following inequality:

$$X_7 \leq \frac{\pi \cdot REV}{365}$$  \hspace{1cm} (14)

7. The return on investment (ROI) and return on equity (ROE) must be higher than certain minimum levels $\rho_1$ and $\rho_2$, respectively, leading to the following inequalities:

$$\frac{EBIT \cdot (1 - T)}{NFA + WK} \geq \rho_1$$  \hspace{1cm} (15)

$$\frac{NP}{E} \geq \rho_2$$  \hspace{1cm} (16)

8. The degree of financial leverage measured as ROE-ROI must always be positive, giving the following inequality:

$$\frac{NP}{E} - \frac{EBIT \cdot (1 - T)}{NFA + WK} \geq 0$$  \hspace{1cm} (17)

9. The fixed asset investment (CAPEX) must be comprised between reasonable values for the renewal rate of the company and its sustainability, leading to the following inequality:

$$X_5 \geq \alpha_1 \cdot NFA$$  \hspace{1cm} (18)

$$X_5 \leq \alpha_2 \cdot NFA$$  \hspace{1cm} (19)

10. Due to the constraints in the multi-criteria optimization models, the decision variable values cannot be negative, which leads to the following set of inequalities:

$$X \geq 0$$

$$X \geq 0$$  \hspace{1cm} (20)

### 3.3. Accounting Rows

1. The standard relations of the income statement should match, leading to the following identities:

$$EBITDA = REV \cdot EM$$  \hspace{1cm} (21)

$$EBIT = EBITDA - X_2$$  \hspace{1cm} (22)

$$NP = EBIT - \left( (DN - X_4) \cdot K_f \right) \cdot (1 - T)$$  \hspace{1cm} (23)

2. The net profit is shared out, either to reserves or to dividends, which should lead to the following identity:

$$NP = X_6 + X_1$$  \hspace{1cm} (24)
3. Due to the structure of the balance sheet, net assets should be equal to net liabilities, leading to the following relation:

\[ E + X_1 + X_2 + DN - X_4 = NFA + X_5 - X_3 + WK - X_7 \]  

(25)

4. The cash flow statement implies that cash flow from operating activities (CFO), cash flow from investment activities (CFI) and cash flow from financing activities (CFF) are balanced as the model is defined with net debt that includes the cash variation:

\[ (NP + X_3 + X_7) + (-X_5) + (-X_6 - X_4 + X_2) = 0 \]  

(26)

### 3.4. FORMULATION OF THE PROBLEM

The previous objectives, constraints and accounting rows lead to the formulation of the following multi-objective problem:

\[ \text{EFF} \left[ f_1(X), f_2(X), f_3(X), f_4(X), f_5(X), f_6(X), f_7(X) \right] \]

Subject to:

- Restrictions (8)-(20)
- Accounting Rows (21)-(26)

(27)

Where EFF is an operator, which indicates the search for efficient or Pareto-Optimal solutions in a maximizing sense. The solution of this multi-objective (27) problem allows the calculation of a set of optimal solutions in the Pareto sense (Romero, 1993 and Ballestero, et al., 1998), and implies that there cannot be any other feasible solution causing an improvement in any objective without triggering a worsening effect in at least another objective.

Given that this multi-objective problem (27) is of moderate size, the number of efficient solutions will be also very large due to the considerable number of objectives. It is for that reason that only efficient financial strategies representing the best compromise solutions from a financial perspective should be selected. A computer efficient Extended Compromise Programming approach (Andre et al, 2008) will be used to calculate optimum solutions easing the computational requirements.

### 3.5. OPTIMIZATION MODEL WITH EXTENDED COMPROMISE PROGRAMMING

According with André et al., (2008) and Blasco et al., (1999), this continuous-economic problem (27) can be addressed with the following ECP model:

\[ \text{MIN } \phi = (1 - \lambda)D + \lambda \sum_{i=1}^{7} W_i \left( \frac{f_i^* - f_i(X)}{f_i^* - f_i} \right) \]
Subject to:

\[ W_i \frac{f_i^* - f_i(X)}{f_i^* - f_i^*} - D \leq 0 \quad i \in \{1, \ldots, 7\} \]

Restrictions (8)-(19)
Accounting Rows (20)-(25) (28)

where:
- \( D \) is the maximum discrepancy.
- \( \lambda \) a control parameter with values in the interval \([0.1]\).
- \( W_i \) the weight associated with the fulfillment of the \( i \)-th objective \((X)\).
- \( f_i^* \) the ideal value of the \( i \)-th objective, i.e., its maximum value over the set of constraints, without taking into account the achievement of the other objectives.
- \( f_i^* \) anti-ideal value of the \( i \)-th objective, i.e. its minimum value over the set of constraints without taking into account the achievement of other objectives.

The solutions of (28) for \( \lambda \in [0,1] \) will be Pareto-Efficient, given that the maximization of a linear combination of objectives over a feasible set will always produce efficient solutions for any positive set of weights (Martin et al., 2011).

If \( \lambda=1 \), the model maximizes the total achievement obtained by the seven financial objectives considered; whereas for \( \lambda=0 \), the model minimizes their individual discrepancy, maintaining a certain equilibrium in the achievement of the objectives. For other values of \( \lambda \), intermediate compromise solutions between the previous ones are obtained.

4. Application example

The methodology outlined in the previous sections was used to propose a Multi-Criteria Financial Planning model to the Gas Natural Fenosa company for the fiscal year of 2015. At present, despite the international financial crisis with a great reduction in the internal demand, the company has carried out a successful strategy and has become one of the European leaders in the gas and energy generation business field.

With regards to the model, the values selected for this company in both exercises were the following (million euros):

<table>
<thead>
<tr>
<th>INITIAL BALANCE SHEET</th>
<th>SHAREHOLDER FUNDS (E)</th>
<th>SHARE CAPITAL (C)</th>
<th>NET DEBT (ND)</th>
<th>WORKING CAPITAL (WK)</th>
<th>NET FIXED ASSETS (NFA)</th>
<th>REVENUE (REV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>23,651</td>
<td>1,001</td>
<td>17,508</td>
<td>1,652</td>
<td>39,507</td>
<td>26,015</td>
</tr>
</tbody>
</table>

EBITDA MARGIN (ME) ............................................. 0.185
TAX RATE (T) ................................................... 0.235
FINANCIAL COST (K) ......................................... 0.072
MIN. DIVIDEND PAYOUT RATIO (μ) ..................... 0.4

Source: Thompson Reuters (2017)

Similarly, the following parameters were considered for the company. Solvency, ROI, ROE and book value ratios had been limited in the low side as an 80% of the previous year looking for a soft evolution of the company in a restrictive environment, if needed. Other ratios had been defined as logic in a normal behavior of a company.

MODEL PARAMETERS
MINIMUM LEVEL OF SOLVENCY (ω) … 0.8 * E/DN (80% of previous exercise)
MINIMUM LEVEL OF BOOK VALUE (ϑ) …. 0.8 * E/C (80% of previous exercise)
MAXIMUM LEVEL OF NEW CAPITAL (γ) …… 0.5 * C (50% of previous exercise)
MINIMUM LEVEL OF AMORTIZATION (σ₁) … 0.025 * NFA (40 years)
MAXIMUM LEVEL OF AMORTIZATION (σ₂) … 0.1 * NFA (10 years)
MINIMUM LEVEL OF ASSET INVESTMENT (CAPEX) (α₁)……….. 0.01 * NFA
MAXIMUM LEVEL OF ASSET INVESTMENT (CAPEX) (α₂) ………. 0.08 * NFA
MAXIMUM LEVEL OF WORKING CAPITAL (WK) REDUCTION (π) …. 10 days of revenues
MINIMUM LEVEL OF RETURN OF INVESTMENT (ROI) (ρ₁)…. 0.8 * ROI (80% of previous level)
MINIMUM LEVEL OF RETURN OF EQUITY (ROE) (ρ₂)…….. 0.8 * ROE (80% of previous level)

The multi-objective pay-off matrix obtained for this case is shown in Table 1, where each of the seven objectives is optimized individually over the feasible set, i.e. MP \[ f_{ij} = f_j(X_i^*) \] with \[ i,j=1..7 \], subject to Restrictions (8)-(20) and Accounting Rows (21)-(26). In this matrix (Romero, 1993), the first element of the first row represents the maximum value of achievement for the first objective \( f_1(X) \) over the problem constraints; whereas the other six elements of the row represent the values of the remaining objectives considered, compatible with the individual maximization of this first objective \( f_1(X) \). The other rows have a similar significance; optimizing each objective individually and indicating the utilities reached by the rest of the objectives in their respective optimization processes.
Table 1. Pay-Off Matrix for the set of objectives considered.

<table>
<thead>
<tr>
<th></th>
<th>Optimization</th>
<th>Solvency</th>
<th>Value C.</th>
<th>Dividend</th>
<th>CFO</th>
<th>FCF</th>
<th>ROE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>1.786</td>
<td>1.676</td>
<td>18,902</td>
<td>469</td>
<td>3.749</td>
<td>3.770</td>
<td>0.0496</td>
</tr>
<tr>
<td>Solvency</td>
<td>1.786</td>
<td>1.676</td>
<td>18,902</td>
<td>469</td>
<td>3.749</td>
<td>3.770</td>
<td>0.0496</td>
</tr>
<tr>
<td>Value C.</td>
<td>554</td>
<td>1,583</td>
<td>24,862</td>
<td>824</td>
<td>3.405</td>
<td>3.480</td>
<td>0.0871</td>
</tr>
<tr>
<td>Dividend</td>
<td>554</td>
<td>1,433</td>
<td>18,902</td>
<td>2.007</td>
<td>3.351</td>
<td>3.480</td>
<td>0.0849</td>
</tr>
<tr>
<td>CFO</td>
<td>1.786</td>
<td>1.676</td>
<td>18,902</td>
<td>469</td>
<td>3.749</td>
<td>3.770</td>
<td>0.0496</td>
</tr>
<tr>
<td>FCF</td>
<td>1.786</td>
<td>1.676</td>
<td>18,902</td>
<td>469</td>
<td>3.749</td>
<td>3.770</td>
<td>0.0496</td>
</tr>
<tr>
<td>ROE</td>
<td>554</td>
<td>1,641</td>
<td>18,902</td>
<td>832</td>
<td>3.424</td>
<td>3.480</td>
<td>0.0879</td>
</tr>
</tbody>
</table>

Source: Self-Research

Table 2. Pay-Off Matrix for the set of objectives normalized according the maximum value (ideal solution)

<table>
<thead>
<tr>
<th></th>
<th>Optimization</th>
<th>Solvency</th>
<th>Value C.</th>
<th>Dividend</th>
<th>CFO</th>
<th>FCF</th>
<th>ROE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Solvency</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Value C.</td>
<td>0%</td>
<td>62%</td>
<td>100%</td>
<td>23%</td>
<td>13%</td>
<td>0%</td>
<td>98%</td>
</tr>
<tr>
<td>Dividend</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>92%</td>
</tr>
<tr>
<td>CFO</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>FCF</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>ROE</td>
<td>0%</td>
<td>86%</td>
<td>0%</td>
<td>24%</td>
<td>18%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Self-Research
After examining these results, it can be concluded that the corporate matrix is showing a logical behavior:

- There is a total correlation between the objectives asset optimization, solvency and cash flow (free and operations). This is logical since, in order to increase the solvency, it is necessary to generate a cash flow to pay off the debts.
- These objectives maintain a completely opposite behavior regarding the objective dividend, given that the maximum dividend is calculated when the rest of the objectives reached their minimum value. This behavior, already described in Martin et al., (2011), is caused since all the funds generated are used to repay the shareholders instead of self-financing the company.
- The objectives value creation and ROE maintain an intermediate relationship with the rest of the objectives.

Starting from these tables, the ECP model (28) was set up directly, replacing the parameters with their real values, and proceeding to the optimization process of the model for a given set of weights \( W_1, \ldots, W_7 \) and different values of control parameter \( \lambda \). In this work, it was opted to consider all the objectives being of the same importance, and seeking different efficient solutions for different values of \( \lambda \), but different strategies can be followed if different sets of preferential weights are chosen.

Pareto-Efficient solution sets can be obtained between the maximum overall utility (\( \lambda = 1 \)), and the maximum equilibrium (\( \lambda = 0 \)). The values obtained for the problem are shown in Table 2. As indicated in Figure 1, the solution corresponding to \( \lambda = 1 \) maximizes the sum of the individual utilities (average discrepancy is minimized down to 35%), but it is unbalanced for the attainment of the objectives dividend \( f_4 \) and ROE \( f_7 \), in clear conflict with the other objectives, with discrepancy degrees of 100%.

### Table 3. Compromise solutions calculated.

<table>
<thead>
<tr>
<th>( \lambda )</th>
<th>( z_1 )</th>
<th>( z_2 )</th>
<th>( z_3 )</th>
<th>( z_4 )</th>
<th>( z_5 )</th>
<th>( z_6 )</th>
<th>( z_7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1.109</td>
<td>1.539</td>
<td>21,495</td>
<td>1.138</td>
<td>3.532</td>
<td>3.611</td>
<td>0.0690</td>
</tr>
<tr>
<td>0.09</td>
<td>1.109</td>
<td>1.539</td>
<td>21,495</td>
<td>1.138</td>
<td>3.532</td>
<td>3.611</td>
<td>0.0690</td>
</tr>
<tr>
<td>0.10</td>
<td>1.060</td>
<td>1.529</td>
<td>24,217</td>
<td>1.075</td>
<td>3.516</td>
<td>3.599</td>
<td>0.0704</td>
</tr>
<tr>
<td>0.45</td>
<td>1.252</td>
<td>1.526</td>
<td>24,088</td>
<td>1.062</td>
<td>3.564</td>
<td>3.644</td>
<td>0.0644</td>
</tr>
<tr>
<td>1.00</td>
<td>1.763</td>
<td>1.619</td>
<td>24,331</td>
<td>469</td>
<td>3.726</td>
<td>3.764</td>
<td>0.0496</td>
</tr>
</tbody>
</table>

**Source:** Self-Research
Conversely, in a balanced solution ($\lambda=0$), the minimum discrepancy is minimized in the fulfillment of the objectives so that all of them reach a similar discrepancy degree (between 49% and 56%), but at the cost of not obtaining an average maximum utility between all objectives (only 55%).

Table 4. Average error obtained with real values for the solutions calculated.

<table>
<thead>
<tr>
<th>$\lambda$</th>
<th>z1</th>
<th>z2</th>
<th>z3</th>
<th>z4</th>
<th>z5</th>
<th>z6</th>
<th>z7</th>
<th>Avg. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00</td>
<td>-8,1%</td>
<td>5,0%</td>
<td>-10,1%</td>
<td>26,9%</td>
<td>19,7%</td>
<td>-0,9%</td>
<td>6,8%</td>
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Source: Self-Research
Finally, it is also of interest to observe the similarity between the solution of $\lambda = (0.10, 0.45]$ and the real strategy followed by the company. In this case, the average error over the real strategy planned is less than 7% and local objectives of value creation ($f_3$), free cash flow ($f_6$) and ROE ($f_7$) have local errors lower than 1%. It could be concluded that the company could be seeking a better compromise solution that equilibrates both the maximum overall utility and the minimum discrepancy between the objectives considered, avoiding extreme strategies.

5. Conclusions and future research lines

In this article it has been attempted to advance the previous research carried out with financial models in GP multi-criteria environments focused on searching “good-enough” satisfying solutions with other methodologies looking for optimal Pareto-Efficient solutions, in a financial planning context.

According to the document, optimum Pareto-Solutions can be calculated targeting all objectives at the same time, instead of using traditional one-by-one iterative optimization processes. Sustainable solutions are estimated since all objectives are involved in the calculation process, and optimized at the same time.

Each one of the solutions raised is Pareto-Efficient. The manager has to choose which criteria must be used, the additive maximization of objective goals, a minimum accomplishment for all objectives, or efficient solutions between those limits.

In addition, this work was aimed to update the strategic and long-term balance sheet model addressed in Martín et al., (2011), considering a complete set of financial statements, which include the financial balance sheet structure, the short-term financial management and the cash flow as problem objectives.

A possible extension of this work could be to compare the resulting financial planning strategies employing different parameters, and analyzing the deviation sources with real results. This issue could also be targeted with a similar strategy in the line proposed by Kvanli (1980), considering three consecutive exercises and checking the evolution with decision trees for different scenarios. Different decision strategies could be analyzed by considering different sets of values calculated with pair-wise comparison Saaty matrixes (Saaty, 1980).

6. Acknowledgements

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Bibliography


