THE DEVELOPMENT OF A SIMPLE GOAL PROGRAMMING MODEL TO ASSIST IN ATTAINING THE TRIPLE BOTTOM LINE FOR A BUSINESS

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ABSTRACT

The recent global financial crisis together with the problem of global warming and other environmental challenges, has intensified the necessity for businesses to seriously adopt the triple bottom line (TBL) approach to their operations in order to be sustainable and meet stakeholder objectives and expectations. In this paper a model of a business which wishes to attain its triple bottom line is developed and a solution methodology established. Many models aimed at solving this type of problem utilise multi criteria decision making (MCDM) as the chosen approach. This paper uses the relatively simple MCDM approach of Goal Programming (GP) to achieve a best practice solution.

Keywords: MCDM, goal programming, triple bottom line, mathematical modelling

INTRODUCTION

The triple bottom line (TBL), originally coined by [1] [2] and expanded on by [3], is essentially an accounting concept which measures and evaluates performance from the perspectives of "people; planet, and profit. In order for an organisation (business) to be considered as undertaking sustainable entrepreneurial activity, the three aspects of People, Planet and Profit need to be satisfied (see [4]). In this paper the simple (but realistic) problem posed addresses each of these aspects. People in general, i.e., the stakeholders, may include employees of the business, shareholders, customers, possibly suppliers and certainly the community. However, in this paper, the People bottom line focuses on production labour. From these employees' perspective, there is an *indirect* interest in the profit(ability) of the business as this is the foundation for sustainability and thus the business' continuation (i.e., ongoing employment and the potential for increased wages). *Directly*, this group of employees primarily wants (in this simple instance) an undertaking from the business to continue to employ (during the current planning period) *at least* a specified number of people (i.e., hours of labour). Other more realistic options have been developed but are not included in this paper.

The Planet bottom line is dealt with in this model through the reduction of CO_2 emissions generated in the manufacturing process. Here a simple target tonnes of CO_2 is agreed to by the stakeholders (using a process outlined later in the paper). Alternatively, some reverse 'engineering' could be used whereby the stakeholders specify the target CO_2 as a percentage (with respect to what is currently the emission level) and the tonnes target derived from that. The Profit bottom line is one shared by all stakeholders, as only a business with a healthy profit will be sustainable, thereby providing jobs, income and valuable products to the stakeholders and the community. The Profit bottom line is addressed in this paper by seeking the maximum profit possible (taking into account all the other bottom lines). It is possible to determine the maximum possible profit *per se* by solving the model formulated (using say LP) to arrive

at the maximum profit with the Plant and People bottom lines relaxed. The arrival at the agreed stakeholder targets discussed above under People, Planet and Profit is achievable using a 'Consensus Panel', i.e., representatives of all groups of stakeholders. It should be noted that there will almost certainly be multiple runs of the solution heuristic in order to present the stakeholders with the full impact of the targets at selected values, i.e., the use of scenario evaluation.

The solution approach aimed at 'best practice' for the business during the next planning period, is arrived at using MCDM. However, the specific MCDM approach adopted needs to be one that can be simply applied and easily understood by the stakeholders. As Stewart [5] indicates, "*Multicriteria decision making is a human, managerial task. It can and never will be automated by tools, techniques or algorithms.*"[5, p. 571]. The plethora of techniques available under MCDM can be confusing. For example, there are as Stewart [5] points out, value or utility based approaches, the analytic hierarchy process, the goals and reference points approach, the outranking concept, fuzzy set theory and descriptive methods (principal components). Within the goals and reference points approach resides the simple goal programming GP methodology (see Romero, 1986). This approach is relatively straightforward, objective and without the complexity associated with many of the other MCDM approaches. All that is required to be specified by the stakeholders are the priorities associated with the TBLs, the TBL target values and an agreement as to the types of penalties (if appropriate) for not achieving them. When GP is coupled with the *mixed-mode modelling* approach as adopted in this paper the power of the GP method is evident with people playing the important role of providing the information, assessing possible solutions, revising priorities and finally making the decision, with the results of the GP being but only *one* input into the solution.

Mixed-mode modelling "*...describe(s) the process of the bringing together of 'soft' and 'hard' sub-models which then, through an heuristic solution process (which is itself 'soft'), arrives at a 'best practice' solution to the problem at hand"* [6, p 3]. As previously pointed out, Stewart [5] notes that MCDM can never be automated as it relies on participation by people as epitomised by the mixed-mode modelling. The soft models referred to above involve the panel consensus and judgement processes undertaken by the stakeholders, who ultimately determine best practice. There is no "optimal solution" to this type of problem, merely a range of solutions from which to choose best practice. While Goal Programming has been employed extensively in the solution of business (e.g., [7]), there appears to be very few applications of GP in achieving a "best practice" solution for problems involving the TBL for a business.

THE MODEL

The following general assumptions are made with respect to the business, its stakeholders and the environment:

(i) The company manufactures products at its single plant and sells them directly to wholesale outlets.

(ii) The company has stakeholders, namely; shareholders, employees and the government and community at large.

(iii) The company operates on a triple bottom line of "people, planet and profit" in the specific form of targeting to use a negotiated *minimum number* of labour hours, *reducing CO_2 output* to a target figure and striving to achieve the *maximum possible profit*.

(iv) The company utilizes a Consensus Panel with representatives of all the stakeholders participating in setting the priorities, targets and selecting the best practice solution.

(v) The Consensus Panel assigns points to each bottom line reflecting their importance (i.e., the more points the more important is the bottom line). There are a total of 100 priority points available for assignment to the bottom lines.
(vi) 'Bettering' or exceeding a bottom line target is acceptable.
(vii) A target for a bottom line is either achieved or not, there are no alterations to priority weights as a result of 'nearly' achieving the target.
(viii) There is no differentiation in weighting (priority) associated with achieving or under-achieving a TBL target.
(ix) All relationships are linear.
(x) While there is an interdependence associated with the TBL targets, this is be addressed by the the priorities assigned to them by the machinations of the Consensus Panel.

The model for the simple base case is as follows:

$$\text{Min } Z = \sum_{i=1}^{I} z_i \, w_i$$

s.t.,

$$\sum_{p=1}^{P} a_{i,p} \, x_p - y_i = 0 \qquad (i = 1, \ldots, I) \qquad (1.1)$$

$$y_i \, q_i + z_i = 1 \qquad \forall \; i \in I_1 \qquad (1.2)$$

$$y_i \, q_i - z_i = 1 \qquad \forall \; i \in I_2 \qquad (1.3)$$

$$\sum_{p=1}^{P} b_{j,p} \, x_p \leq h_j \qquad (j = 1, \ldots, J) \qquad (1.4)$$

$$\sum_{p=1}^{P} c_{k,p} \, x_p \leq r_k \qquad (k = 1, \ldots, K) \qquad (1.5)$$

$$y_i, \, x_p \geq 0 \; \forall \; i,p; \; I \in (I_1, I_2) \qquad (1)$$

In (1) the variables are defined as follows:

x_p = the level of production of each of the company's products of which there are P
z_i = the proportional distance from each the set triple bottom line targets (of which there are I) given the current production levels (i.e., x_p). Note that z_i can be negative or positive depending on the bottom line being considered. Since the targets for the TBLs are all expressed in the same units of measurement (i.e., normalised as proportions and multiplied by a standard weight) they may be added.
w_i = the weights assigned to each of the bottom lines (i.e., the priority) by the Consensus Panel.
y_i = the amount of labour used (hours), carbon produced (tonnes) and profit made ($) (the triple bottom line base measures in this paper) given x_p**.**

$\mathbf{b_{j,p}}$ and $\mathbf{c_{k,p}}$ are coefficients relating to the consumption of other resources and 'technical' production requirements respectively.
$\mathbf{q_i}$ is defined in (5) below and note that:

$$0 \le w_i \le 100 \qquad (i = 1, \ldots, I)$$

$$\sum_{i=1}^{I} w_i = 100 \qquad (2)$$

In this application of MCDM, we require the stakeholders to decide as a group on the priorities associated with the TBL. It is possible that AHP could be used to rank the TBL targets, however, quantifying these into priorities might end up a little more complicated as the opinions of the stakeholders would really need to be translated into a quantified priority, i.e., different data (opinions/preferences) which would need to be brought together to arrive at the priorities to be used (see [8] for a methodology that would facilitate achievement of this). As Yang *et al* [8] illustrate, this is not an easy process and its adoption would unduly complicate (possibly prevent) the assignment of priorities. Effectively, the priorities arrived at in this paper are subjective average weights, reflecting the stakeholder group as a whole.
In (1), the objective function (Z), in the context of this paper, is the sum of the weighted proportions that each of the bottom lines of people, planet and profit are from their individual targets (which are initially expressed in hours, tonnes and $s respectively). The objective function therefore normalised allowing the aggregation of each of the bottom line targets. The objective is to minimize this distance so that all targets are either met or (where possible) exceeded. Constraints in (1.1) are balance equations, measuring the quantity (in this example) of labour used, carbon produced and profit earned – i.e., people, plant and profit bottom lines respectively (I=3). Constraint (1.2) establishes the proportion that the solution is from each of the bottom lines that aim for the solution to be *above or equal to* the target, as in the case of using at least a minimum amount of labour hours and making the maximum profit ($i \in I_1$). If the solution renders these targets not met, then the appropriate z_i will be positive or zero. This is consistent with the objective function's minimization. As an example of this constraint, consider the bottom line of profit (y_i where i=3). Let the maximum profit (target) be designated Π^* (which is known by solving (1) with no targets). Then the proportion of the target not met with respect to profit is:

$$z_3 = (\Pi^* - y_3)/\Pi^* \qquad (3)$$

Rearranging:

$$y_3\, q_3 + z_3 = 1 \qquad (4)$$

where;

$$q_3 = 1/\Pi^* \qquad (5)$$

Here also, $i \in I_1$ (which includes i=1 as well) and $z_3 \ge 0$ by definition and is consistent with the objective function. In the case of Labour (i=1), the z_i (i=1) could be negative also and again consistent with the objective, i.e., we are exceeding the target set (i.e., 'bettering' the target). In the case of Labour (i=1) and $\in I_1$, $q_1 = 1/L^*$ where L^* is the agreed target amount of labour (hours) to strive to maintain for the current period negotiated with the stakeholders.
Constraint (1.3) is similar to (1.2) except that it deals with bottom lines where the proportion that the solution is from each of the bottom line targets aims be *above or equal to* the targets as in the case of carbon emissions (i=2) ($i \in I_2$). Here, using the equivalent of (3) results in a *negative* z_i which would result in (1) attempting to move further away from meeting the target, i.e., z_i would be inconsistent with

the objective function. In order for the z_i ($(i \in I_2)$ and contains only i=2 in this case) to be consistent with the objective function, the formulation of the constraint is (as in the case of Carbon):

$$z_2 = (y_3 - C^*)/C^* \quad (6)$$

Rearranging:

$$y_2 q_2 - z_2 = 1 \quad (7)$$

where;

$$q_2 = 1/C^* \quad (8)$$

Constraints (1.4) and (1.5) are other resource constraints (excluding labour in this instance) and other constraints (e.g., minimum output requirements for some products etc) respectively.

SOLUTION OF THE TRIPLE BOTTOM LINE MODEL

The solution process for this problem (1) is ideal for a mixed-mode modelling approach (see [6] [9]). The heuristic solution process starts with the creation of the Consensus Panel (CP) ensuring appropriate representation of each of the stakeholder groups. Broadly, such a process acknowledges what many writers on change management observe, that any change process where people are likely to be affected is better managed when the people are involved to some extent in shaping and directing that process (see [10] [11] [12]). Involvement of the affected people does not assure full acceptance nor does it guarantee a conflict-free process, but it does make a final acceptance and level of consensus possible where it might otherwise seem very improbable. Additionally, the processes for gathering members of such a consensus panel are important. Each of the key stakeholder constituencies needs to be represented, and yet the overall number of panel members needs to be contained to a manageable number so as not to lead to division and fracture of the panel due to the differences of view. Group facilitation experts suggest that consensus with any more than, say, seven participants, is almost unachievable (see [13]).
Consensus in such industry situations is rarely a 100% pure and full agreement with all aspects of all issues. More realistically, consensus might be taken to mean in this situation a substantial agreement on the key elements and goals. It would be unrealistic to expect a complete uniformity of view given the differing agendas and interests of say, union and management, especially around employment levels and cost containment, although enterprise bargaining in many instances comes close to achieving this when the overarching goal of organisation survival is placed at the centre of the consideration. This has implications for the way in which a CP is facilitated once comprised. In this paper, CPs are envisaged as part of an advisory function to management, assisting managers to make key decisions about the TBL. They are not primary decision-makers, taking the responsibility from managers. Nonetheless, as advisors to management, and as parties to a decision which will have direct impact upon some of the stakeholders themselves, they have an important role to play, and in some instances, the advice might actually form the basis of labour and employment undertakings which are actually incorporated into an enterprise agreement.
The difficulty of arriving at any shared understanding of the stakeholders' various perspectives and objectives is not to be underestimated. It is unlikely to be achieved where the various groups mistrust each other, and where there is any attempt to overpower the discussion to lead it in a particular direction. Accordingly, an independent facilitator, acceptable to all stakeholder groups as an 'honest broker' is most helpful and most likely to achieve a greater trust climate for CP interaction. Facilitators generally need to encourage listening and non-judgemental understanding of the differing viewpoints, rather than rushing to a consensus view on goals or targets. They need considerable skill in managing and intervening in complex group dynamics. They also need to regularly lift the CP attention to the

overarching goals to which all stakeholders might be able to subscribe. Conflict about detail is always more manageable when viewed against the perspective of the larger organisational interest. In most instances, a shared desire for the survival of the organisation can in some form become the overarching goal. This is consistent with the sustainability expectations that are widespread in current circumstances and which will likely be part of any TBL considerations ([13]). Achieving consensus is also more likely if there is a level of transparency about financial data, production and labour costs, strategies being pursued and shareholders' and directors' benefits, in that an overall view of the organisation's health is possible. This paper does not address here the significant aspects of organisational power implied in transparency of data, other than to note that a CP process will require some level of openness about the state of the organisation in order to make the possibility of sound goal setting and compromise become possible.

Thus having established the Consensus Panel, a logical next step is for the CP to agree to an initial starting point for the TBL targets with all necessary data on the table. In the case of this paper, this will amount to agreeing to the minimum usage level of labour hours (L^*), the percentage carbon reduction (or the tonnes (C^*)) over the current amount generated. Equally important, is the agreement to the priorities associated with each of the targets (w_i). The TBL target achievement, profit level and production mix to date is provided to the CP to consider and evaluate. The CP can then decide on the TBLs to be aimed for thus establishing the problem to be solved. This solution can be achieved using an imbedded solver in a simple proprietary spreadsheet with a user friendly interface. This evaluation by the CP of the solution arrived at is a complex task due to the interconnectivity of the TBL targets. The CP needs to evaluate the level of achievement of the labour and CO_2 targets as well as the profit obtained and how these all lie with the priorities specified. With an assessment of the obtained solution the CP can either decide that they have a solution that constitutes 'best practice' or that they need a number of new scenarios to be evaluated. The CP would normally (at least once) need to work out some scenarios that will allow them to see the impact of small changes to the priorities and/or targets thereby allowing them to gain a sense of perspective. The best way of achieving the solution evaluation would be working with a 'facilitator' as described above since this is the point at which the CP process can most easily disintegrate into conflict. The problem generation, solution and evaluation parts of the solution heuristic will iterate until the CP has arrived at what they are prepared to accept as 'best practice'. However, this does not preclude the CP from deciding to review the 'year to date' results of the best practice solution at any time and put into effect further iterations of the solution heuristic.

REFERENCES

A full list of references is available from: miles.nicholls@rmit.edu.au