DOI:10.26524/jms.2015.2

Journal of Management and Science ISSN: 2249-1260 | e-ISSN: 2250-1819

A goal programming model for working capital management

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ABSTRACT: This paper proposes a goal programming model for working capital management. Goal programming is necessary to model the working capital decision, as a balance has to be achieved between the conflicting objectives of liquidity and profitability. The model determines, for given working capital turnover and fixed assets turnover ratios, how funds should be maintained between working capital/current assets and fixed assets to achieve targeted levels of liquidity and profitability, whilst minimizing the opportunity cost/loss of excess liquidity.

Keywords: Goal programming, working capital, liquidity, profitability, trade-off.

INTRODUCTION

Proper planning is necessary for the efficient working of any organization. This can be in terms of marketing, production/operations, human resource, and financial plans. There should be proper flow of funds for running any business. This fund is called working capital. If at any point of time the organization does not have sufficient funds to meet its short-term debts such as creditors and salaries as well as day-to-day expenses it may become technically insolvent. On the other hand, if it is very conservative it will have a surplus of working capital, which will adversely affect profits. The trade-off between profitability and risk is the key to working capital management. Too little working capital increases profit but reduces liquidity, as current assets are more expensive than fixed assets. For instance if a management feels that worker training is a cost they will apportion less funds for it. If on the other hand a management sees it as an investment in manpower, the funds allocated would increase substantially. It is applicable in any case either for procurement, inventory, storage, processing, distribution and human capital and other investment decisions[1].

Businesses must continuously innovate and transform themselves to stay ahead of competition in this fast growing world. An efficient working capital management system has to be designed to run the business and make profits in the long run. As costs are ever-increasing, companies have to make efficient use of funds in managing the procurement, inventory, processing and distribution of finished product to the existing customers, and it is common in many business decision-making situations that certain goals or objectives of the firm can only be met at the expense of other goals. If it is not possible to quantify the exact cost-benefit trade-offs among these goals, it may be necessary for decision makers to rank order the various goals so that the less important goals are pursued only

[1] http://www.indianmba.com/Faculty_Column/FC285/fc285.html

after the more important goals are achieved or when no further progress toward goal achievement is possible.

This paper formulates the working capital decision as a goal programming model, balancing the conflicting objectives of liquidity and profitability. The model determines, for given working capital turnover and fixed assets turnover ratios, how funds should be maintained between working capital/current assets and fixed assets to achieve targeted levels of liquidity and profitability, whilst minimizing the opportunity cost/loss of excess liquidity.

1. REVIEW OF LITERATURE

Goal programming techniques have been widely used in many diverse fields, including operations, marketing, human resources, and finance. Aksoy (1990) presented a bibliography of multiple objective decision-making models applied in various disciplines. He proposed that there was a trend towards utilizing interactive techniques for solving the multiple objective decision making problem, allowing the involvement of the decision-maker throughout the decision process.

A variety of goal programming models have been applied in the operations contexts, usually interlinking operations, marketing, human resource, and financial decisions. Rifai (1996) discussed the limitations of linear programming in decision-making, and suggested the use of goal to handle problems with multiple objectives. He advocated caution in using the goal programming, since an improper structure of a goal programming model can induce misleading results.

Schniederjans and Hoffman (1999) proposed a goal programming model for downsizing in order to cut operation costs, based on a thorough analysis of the firm's prioritized opportunities and their limited economic resources to achieve them. They provided a new methodological approach that can be used to determine previously hidden goals in a manufacturing linear programming model of the downsizing problem. Their model illustrated how an optimal allocation of production resources can be achieved while providing useful information in which to ensure other prioritized goals and their economic tradeoffs.

Coskun et al (2008) studied integrative methods for improving business processes. Their approach involved determining and analyzing the weak points and reducing the weakness degrees. They suggested a four-phase business process improvement framework: start-up, self analysis, defining improvement strategy for making changes, feedback, and continuous improvement. They found that decision problems in process improvement could be structured to provide input data suitable for multi-criteria decision making techniques.

Lee and Kang (2008) developed a model for inventory management for multiple periods, considering not only the usual parameters, but also price/ quantity discounts, and storage and batch size constraints. The model is formulated as a mixed binary integer programming problem minimizing the total cost of materials in the system, and the optimal solution determines an appropriate inventory level for each period and the optimal purchase amount in each period.

Several studies have addressed the problem of working capital, and have developed a variety of models to assess the efficiency of working capital management. Rafuse (1996) argued that attempts

to improve working capital by delaying payment to creditors are counter-productive, and that altering debtor and creditor levels for individual tiers within a value system will rarely produce any net benefit. He proposed that stock reduction generates system-wide financial improvements and other important benefits, and suggested that, to achieve this, companies should focus on stock management strategies based on ‒lean supply-chain‖ techniques.

Cote and Latham (1999) explored the limitations of the traditional measures of working capital management and presented alternative measures based on earlier work in the finance literature. They also proposed a new ratio, the ‒merchandising ratio,‖ which measured the net effect of a firm's working capital management strategy.

Filbeck et al (2005) suggested that firms should be able to reduce financing costs and/or increase the funds available for expansion by minimizing the amount of funds tied up in current assets. They found significant differences in working capital measures between industries across time, and significant changes in these working capital measures within industries across time.

Garcia-Teruel and Martinez-Solano (2007) studied the effects of working capital management on the profitability of a sample of small and medium-sized Spanish firms. They found that managers can create value by reducing their inventories and the number of days for which their accounts are outstanding. Moreover, shortening the cash conversion cycle also improves the firm's profitability.

Chakraborty (2008) evaluated the relationship between working capital and profitability of Indian pharmaceutical companies. He pointed out that there were two distinct schools of thought on this issue: according to one school of thought, working capital is not a factor of improving profitability and there may be a negative relationship between them, while according to the other school of thought, investment in working capital plays a vital role to improve corporate profitability, and unless there is a minimum level of investment of working capital, output and sales cannot be maintained - in fact, the inadequacy of working capital would keep fixed asset inoperative.

Singh (2008) found that the size of inventory directly affects working capital and its management. He suggested that inventory was the major component of working capital, and needed to be carefully controlled.

Agarwal (1988) formulated the working capital decision as a goal programming problem, giving primary importance to liquidity, by targeting the current ratio and quick ratio. The model included three liquidity goals/constraints, two profitability goals/constraints, and, at a lower priority level, four current asset sub-goals and a current liability sub-goal (for each component of working capital). In particular, the profitability constraints were designed to capture the opportunity cost of excess liquidity (in terms of reduced profitability).

The literature of goal programming in operational/financial decisions is quite extensive, though only a few studies have directly focused on working capital decisions. Agarwal’s (1988) study was a step

forward, but no further refinements to his model have been proposed. This paper proposes certain modifications in Agarwal's (1988) model.

2. LIQUIDITY-PROFITABILITY TRADE-OFF MODEL:

The goal programming model proposed in this paper examines the trade-off between liquidity and profitability. Goal programming is appropriate because liquidity and profitability represent conflicting objectives of a firm.

The decision variables for the model are the usual components of working capital, viz. cash, marketable securities, accounts receivable, inventory, current liabilities, fixed assets, sales, and profit. Each of these variables is assumed to have well-defined target levels. Additionally, the current ratio, profit margin, working capital turnover ratio, and fixed assets turnover ratio are assumed to have stable target levels. These variables and targets are represented in Table 1.

Table 1: variables and target parameters

	Variable	Target
Cash	x_1	C
Marketable Securities	x_2	MS
Accounts Receivable	x_3	AR
Inventory	x_4	I
Current Liabilities	x_5	CL
Fixed Assets	x_f	FA
Sales	y	S
Profit	π	P
Current Ratio		θ
Profit Margin		m
Working Capital Turnover Ratio		ω
Fixed Assets Turnover Ratio		ϕ

Highest priority is given to maintaining liquidity, turnover, and profitability, built into the model via the current ratio, the working capital and fixed assets turnover ratios, and the profit margin, followed by the targeted levels of each of the variables. The different priority coefficients (P_i) assigned to each of the different goals are represented in Table 2.

Table 2: priority levels assigned to constraints

Constraints	Priority	Deviation Variables
Liquidity	P_1	d_1^- , d_1^+
Working Capital Turnover	P_2	d_2^- , d_2^+
Fixed Assets Turnover	P_3	d_3^- , d_3^+
Profit Margin	P_4	d_4^- , d_4^+
Opportunity Cost	P_5	d_5^- , d_5^+
Cash	P_6	d_6^- , d_6^+
Marketable Securities	P_7	d_7^- , d_7^+
Accounts Receivable	P_8	d_8^- , d_8^+
Inventory	P_9	d_9^- , d_9^+
Current Liabilities	P_{10}	d_{10}^- , d_{10}^+
Fixed Assets	P_{11}	d_{11}^- , d_{11}^+
Sales	P_{12}	d_{12}^- , d_{12}^+
Profit	P_{13}	d_{13}^- , d_{13}^+

The goal programming formulation for the problem is given below:

$$\min \quad w = \sum_{j=1}^{13} P_j (d^+_j + d^-_j) \quad ,$$

subject to the constraints:

(1) Total assets: $x_1 + x_2 + x_3 + x_4 + x_5 + x_f = C + MS + AR + I - CL + FA$

(2) Liquidity: $x_1 + x_2 + x_3 + x_4 + d_1^- - d_1^+ = \theta . CL$

(3) Working Capital Turnover: $y - w(x_1 + x_2 + x_3 + x_4 - x_5) + d_2^- - d_2^+ = 0$

(4) Fixed Assets Turnover: $y - \phi x_f + d_3^- - d_3^+ = 0$

(5) Profit margin: $\pi - my + d_4^- - d_4^+ = 0$

(6) Opportunity cost: $\pi - m\phi[x_1 + x_2 + x_3 + x_4 - x_5 \quad y/w] + d_5^- - d_5^+ = P$

***(7)* Cash:** $x_1 + d_6^- - d_6^+ = C_6$

(8) Marketable securities: $x_2 + d_7^- - d_7^+ = MS$

(9) Accounts receivable: $x_3 + d_8^- - d_8^+ = AR$

(10) Inventories: $x_4 + d_9^- - d_9^+ = I$

(11) Current liabilities: $x_5 + d_{10}^- - d_{10}^+ = CL$

(12) Fixed assets: $x_f + d_{11}^- - d_{11}^+ = FA$

(13) Sales: $y + d_{12}^- - d_{12}^+ = S$

(14) Profit: $\pi + d_{13}^- - d_{13}^+ = P$

(15) Non-negativity: $x_1, \ldots x_5, x_f, y_f, \pi, d_1^{\pm}, \ldots d_{13}^{\pm} \geq 0$

The model formulated above addresses a few limitations of Agarwal's (1988) model. Agarwal's model has an inbuilt over-emphasis on liquidity, through its liquidity goals and once again through its current assets and current liabilities sub-goals; in fact, the profitability goals also have an inbuilt liquidity target. Also, the profitability goals in Agarwal's model are somewhat ambiguous: profit as a variable seems to be unrelated to the other (working capital) variables, and the cost of capital term in the profitability goals is not very clear.

The proposed model tries to address some of the limitations of Agarwal's model. In order to relate the profit variable with working capital variables, the model introduces variables for fixed assets and sales, and interlinks the variables via the working capital turnover ratio, the fixed assets turnover ratio, and the profit margin goals. Liquidity remains as a major goal, and Agarwal's profitability goal is replaced by a profitability goal which functions to balance funds between working capital and fixed assets, in accordance with the targeted turnover ratios. The resulting opportunity cost is the profit forgone by excess/deficiency of liquidity (as determined by the turnover ratios).

3. APPLICATION OF THE MODEL

The goal programming model presented in preceding section was applied to the input data of the firm Vijaya Krishna Spice Farms Pvt. Ltd., a food-processing company mainly involved in the storage of different varieties of chilly and the processing of the same into chilly paste. The financial data required for analysis was obtained from the company, for the five year span from 2004-2009. The target values of the current ratio, working capital turnover ratio, fixed assets turnover ratio, and net profit margin were set approximately at their five-year averages, to eliminate chance fluctuations for a particular period. The optimal working capital position (assuming equal priorities of all goals and sub-goals) of the firm for the year 2008-09 is detailed in Table 3.

Table 3: results of the two models

	Targets	Data	Agarwal's Solution	Proposed Model Solution
Cash		3,721,056.00	3,721,056.00	3,721,056.00
Marketable Securities		33,098,161.00	33,098,161.00	33,098,161.00
Accounts Receivable		89,186,217.00	*89,186,217.00*	89,186,217.00
Inventory		51,884,584.00	51,884,584.00	48,911,465.21
Current Liabilities		33,433,346.00	33,433,346.00	33,433,346.00
Fixed Assets		20,265,723.00	-	23,238,841.79
Sales		322,370,524.00	-	348,582,626.88
Profit		31,782,509.00	34,809,474.76	34,858,262.69
(Opportunity Cost)			**3,026,965.76**	**3,075,753.69**
Current Ratio	2.00	5.32	5.32	5.23
Working Capital Turnover Ratio	2.50	2.23	-	2.46
Fixed Assets Turnover Ratio	15.00	15.91	-	15.00
Profit Margin	0.10	0.10	-	0.10

The results from Agarwal's model indicate a Rs. 3,026,965.76 opportunity loss due to excess liquidity, while the results the proposed model indicate a Rs. 3,075,753.69 opportunity loss. The results of the proposed model suggest that excess liquidity (in the form of Rs. 2,973,118.79 of inventory) be converted to fixed assets in order to improve profitability. It is observed that, in the solution, while the working capital turnover ratio, the fixed assets turnover ratio, and the profit margin are close to their targeted values, the current ratio is not.

The deviation variables in the optimal solution are presented in Table 4 (for simplicity, only non-zero values are displayed).

Table 4: deviational variables in the optimal solution

Constraints	Deviation Variables
Liquidity	$d_1^+ =$ 108,050,207.21
Working Capital Turnover	$d_2^- =$ 5,126,256.15
Fixed Assets Turnover	
Profit Margin	
Opportunity Cost	
Cash	
Marketable Securities	
Accounts Receivable	
Inventory	$d_9^- =$ 2,973,118.79
Current Liabilities	
Fixed Assets	$d_{11}^+ =$ 2,973,118.79
Sales	$d_{12}^+ =$ 26,212,102.88
Profit	$d_{13}^+ =$ 4,075,753.69

The deviation variables indicate over-achievement of liquidity far in excess of the targeted level, under-achievement of working capital turnover, and over-achievement of sales. Further, the deviation variables d_9^- and d_{11}^+ indicate excess liquidity (inventory) that is to be converted to fixed assets.

The sensitivity analysis of the model to different parameters is presented in Table 5.

Table 5: sensitivity analysis of the optimal solution

	Opportunity Cost	%Change	Elasticity
Cash			
+5%	3,110,638.59	1.13%	0.2268
+2.50%	3,093,196.14	0.57%	
0%	3,075,753.69	0.00%	
-2.50%	3,058,311.24	-0.57%	
-5%	3,040,868.79	-1.13%	
Marketable Securities			
+5%	3,386,048.95	10.09%	2.0177
+2.50%	3,230,901.32	5.04%	
0%	3,075,753.69	0.00%	
-2.50%	3,230,901.32	-5.04%	
-5%	2,765,458.43	-10.09%	
Accounts Receivable			
+5%	3,911,874.47	27.18%	5.4369
+2.50%	3,493,814.08	13.59%	
0%	3,075,753.69	0.00%	
-2.50%	2,657,693.30	-13.59%	
-5%	2,239,632.90	-27.18%	
Inventory			
+5%	3,562,171.66	15.81%	3.1629
+2.50%	3,319,045.81	7.91%	
0%	3,075,753.69	0.00%	
-2.50%	2,832,544.70	-7.91%	
-5%	2,589,335.71	-15.81%	
Current Liabilities			
+5%	2,762,334.39	-10.19%	
+2.50%	2,919,034.88	-5.10%	-2.0381
0%	3,075,753.69	0.00%	
-2.50%	3,232,472.50	5.10%	
-5%	3,389,191.31	10.19%	
Fixed Assets			
+5%	3,265,744.84	6.18%	1.2354
+2.50%	3,170,749.26	3.09%	
0%	3,075,753.69	0.00%	
-2.50%	2,980,758.11	-3.09%	
-5%	2,885,672.11	-6.18%	

It is observed that the results of the proposed model are highly sensitive to changes in accounts receivable (with elasticity +5.4369), followed by inventory (with elasticity +3.1629), current liabilities (with elasticity -2.0381), marketable securities (with elasticity +2.0177), fixed assets (with elasticity +1.2354), and, least of all, cash (with elasticity 0.2268).

4. DISCUSSION

Several studies have stressed the importance of effective working capital management. Agarwal (1988) had formulated a goal programming model for working capital decisions, but it had some serious limitations, especially its over-emphasis on liquidity. The model proposed in this paper extends the scope of Agarwal's model, whilst retaining the concept of a liquidity-profitability trade-off.

The results of the model suggest that working capital, and inventory in particular, should be streamlined to profitability. This approach is thus in conformance with several studies, including Rafuse (1996), Cote and Latham (1999), Garcia-Teruel and Martinez-Solano (2007), Filbeck et al (2005), and Singh (2008). In particular, the relationship between different components of working capital, fixed assets, sales, and profits needs to be examined in greater depth and modeled accordingly. Further, the role of inventory and of inventory turnover needs to be made explicit in the model.

The scope of the proposed model is also a question that has to be examined more carefully. In particular, the nature of the industry may determine the scope of applicability of the model. This would be the case, as the working capital problems of manufacturing companies are quite different from those of, for example, trading companies. Also, the model does not take into account such aspects as seasonality, which would play a role in some industries, especially agro-industries. These could perhaps be addressed by considering an industry-specific priority structure in the model. Another important determinant would be that of operations strategies. For example, it would be interesting to apply the model for companies that operate on ‒negative working capital,‖ with no investment at all in inventory and receivables, thereby reducing costs and enhancing profitability.

There is vast scope for extending the model proposed in this paper. The proposed model is a static, aggregate-level model; a dynamic/multi-stage micro-model, with appropriate inter-linkages between the different variables, incorporating the working capital cycle concept and time value of money, would give more detailed results. Also, the proposed model has some limitations: it considers a specific form of liquidity and profitability goals/constraints, which may not have taken some other relevant parameters into consideration; and it assumes stable turnover ratios, which may limit its applicability in practice. Further, the proposed model is a linear programming model, and thus deals only with the linear behavior of working capital; non-linearities are not taken into consideration.

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