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Supporting Working Capital Decisions Through Fuzzy Analysis

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Abstract

Working Capital Management is concerned with the short term decisions regarding current assets and current liabilities. Although being related with the short term, the decisions must take into account the overall strategy of the firm and how effectively they are implemented at the operational level. The satisfaction of the goals and the measurement of the risks associated with these decisions are subjective and changeable depending on the situation. In this paper we propose the use of the Fuzzy Scenario Analysis to support the decisions at the operational level of a firm modeling the subjectivity of the process.

The module we chose to illustrate the approach is related to purchase decisions. The method consists of modeling the satisfaction of an strategic goal (inventory conversion period) and the risk associated (of estimating sales) using fuzzy sets. We present an example where once these fuzzy sets are defined, the system suggests purchase decisions meeting the firm's constraints regarding the amount of purchase and the associated benefits.

Keywords: *Working Capital Management, Inventory Conversion Period, Liquidity, Fuzzy Systems.*

Introduction

There are two main reasons that make the Working Capital (WC) management an essential topic for a firm. First, it represents a large amount of capital tied up to the firm's operations, since the proportion of current to the total assets often varies from 50% to 80% (typically, the higher percentages occur in retail stores). Second, the short term decisions have direct implications in the overall performance of the business, since their consequences have impact over the continuity of the firm's profitability.

Any financial decision must consider three basic aspects: efficiency, market share, and profitability. The WC management decisions are not an exception. Any operational goal related to the WC has to be tuned to the strategies built over those basic aspects.

The schematic flow in Figure 1 shows the relation between operational and strategic goals of a firm. In that context, the several decisions at operational levels are inherently imprecise, subjective, and are taken under time constraint. These features of the decision making process come from the nature of the reasoning and communication involved. Fuzzy Set Theory [13] has been an efficient tool to deal with this kind of problem. Here we develop a system using this theory at an operational level of decisions, particularly, the purchase module. The system built not only integrates the subjectivity of that decision but also links it with the overall management of the firm.

The Decision Process of Purchase

The module we are considering here, as shown in Figure 1, involves the Purchase decisions. The amount of raw material purchased (or, if it is a retail store, the amount of product to be resold) during certain period will affect some important variables directly connected to the strategic goals of the firm.

While deciding how much to purchase, the decision maker (DM) faces the following constraints: the firm's goal about the inventory conversion for that period (*Is*), how much the firm is willing to spend and the estimated sales.

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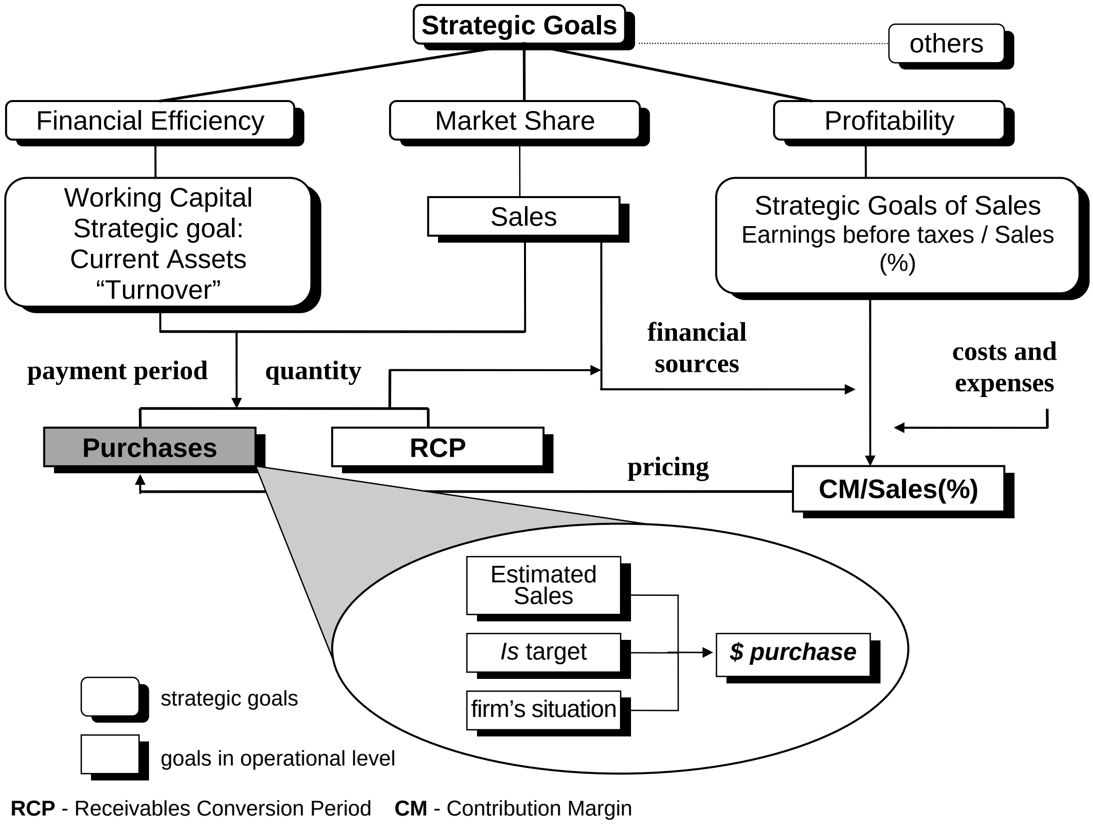


Figure 1: From the Strategic to the operational goals of a firm. Any strategic goal implies in operational goals. The figure illustrates the translation between the upper (general) to the lower (operational) goals of a firm. The operational goal analyzed in this paper (purchase) is exploded in the figure showing the three criteria considered in a purchase decision.

The **inventory conversion period** represents the average time which an inventory takes to be sold[1]. The *Is* target value comes from the financial analysis of liquidity indicators (in Figure 1 represented by Financial Efficiency). The lower is the *Is*, the greater is the firm's liquidity, since less money is tied up for an equal level of sales. Thus, in terms of strategic goals, the DM will seek to diminish *Is* as long as there is no conflict with stockout. In small companies and retail stores, for instance, *Is* can play a central role, since they are more flexibe to negotiate terms and reevaluate inventory policies. Furthermore, they often face more difficulties in accessing funds [10].

The second constraint the DM has to respect while deciding how much to purchase is related to the **amount to be spent**. The amount purchased has to be within an interval of feasible values. The lower bound is limited by the stockout risk. The upper bound is the smaller value between the *Is* target and the maximum amount the firm is capable of spending (which comes from investment decisions). In the proposed approach, the DM enters this interval that is not violated by any alternative.

Finally, the third concern of the DM when deciding about purchase is the **estimated sales**. Despite many techniques available, sales forecasting is still a process which involves subjectivity, a considerable amount of qualitative data and can be significantly influenced by human biases [7]. Nevertheless, the DM still has to decide how much to buy and need to foresee the sales. Besides helping the decision maker to choose among different techniques ([9]), the researchers have emphasized some guidelines to sales forecasting. For instance, according to Herbig, *et al.* [7] and Barnett [1] the DM should:

- remember that the further out the forecasts, the less accurate they tend to be;
- conduct sensitivity analyses to understand the most critical assumptions and to gauge risks (use scenarios);

[1] Here we measure *Is* in *days of sales* through the following relation: Is = average inventory ÷ average daily sales

- consider an interval of forecast (e.g., “the sales will be between $25,000 and $35,000”);
- do not become overly dependent on computer analysis and algorithms (be subjective!).

Looking at these guidelines, the following two issues arise:

- which technique can incorporate these guidelines?
- how one can make a scenario analysis about the consequences of the decisions when subjectivity is involved?

Both the questions are still unanswered. Many researchers believe that the traditional techniques cannot incorporate subjectivity. Furthermore, they agree that the techniques are not able to deal with the essential feature of financial management, which is the nonlinearity of its behavior. In the past three years, the financial analysts have been looking at the theory of complexity to model the nonlinearity of the financial patterns. This can be seen in the increasing application of Chaos Theory, Fractals and Fuzzy Engineering in financial problems [3]. The coming years will show if these techniques can help the DM in answering the first question.

In this paper, we are concerned with the second issue. The aim is to present a mechanism by which the DM can pursue a scenario analysis investigating how each possible purchase decision affects the firm. Each feasible decision has an associated risk-benefit tradeoff. More specifically, the DM decides how much to buy taking into account both the estimated sales for the period and the current situation of the firm. When deciding how much to purchase, the DM is taking risk (associated with the estimated sales) and expects certain benefit (measured by how close the firm will be to the desired *Is*). We apply Fuzzy Logic [ZAD65] to model the subjectivity on both counts, the risk and benefit.

Chorafas [3] justifies the use of Fuzzy Theory in financial problems reminding that we are producing cleaner data as well as knowledge that is part of the basic intellectual capital of traders, investors, and other professionals. Furthermore, several terms used in Finance are intrinsically subjective and imprecise, such as “probable”, “remote”, etc [8]. Fuzzy Set Theory provides mechanisms to represent the actual meaning of these expressions and use them in a computational system. As we will show through an example, the motivation for using Fuzzy Theory comes from the attempt to clarify data and show the consequence of a decision in terms closer to the DM’s feelings.

Example

Figure 2 describes two fuzzy sets modeling the risks associated to the estimated sales of a certain firm. These fuzzy sets are described by the DM based on the risk of being optimist or pessimist while forecasting sales. An optimist role means estimated sales (ES) greater than the actual ones (S) and a pessimist role happens otherwise. If the relation between estimated and actual sales is different for the next period (e.g., the firm is in a seasonal period) , the fuzzy sets associated with the risks need to be adjusted. Figure 3 shows the fuzzy set describing how good is the *Is* for that firm. It can also be changed by the DM if the firm’s parameters change (e.g., by new inventory policies).

The fuzzy scenario analysis consists of presenting to the DM a set of alternatives about how much to purchase. The purchase has to be of such amount that meets the firm’s constraints and goals. Generally more than one alternative will fulfill these requirements. The DM has to select an alternative based on how good each one is in relation to the goals and risks involved. Here we provide a tool to help the DM in this process, linking strategic and operational goals.

The process begins when the DM presents his/her interval of expected values. There are two intervals: one for the estimated sales and the other for the amount that the DM is willing to spend. For instance, for the fuzzy sets in figures 2 and 3, the DM can enter the following intervals:

- sales between 60,000 and 80,000 for the next 15 days.
  (based on what he/she expects about the sales behavior during this period).
- purchase amount must be between $40,000 and $60,000.

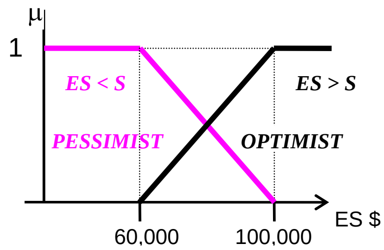


Figure 2 - Fuzzy sets describing the risks in forecasting sales. Here, the firm has always sold more than \$60,000 and less than \$100,000 in that period. Hence, the risk of being optimist (ES > S) will be maximum for ES ≥ \$100,000 and minimum for ES ≤ \$60,000. The risk of being pessimist (ES < S) will be maximum for ES ≤ \$60,000 and minimum for ES ≥ \$100,000. Intermediate risks, in both sets, were modeled by a linear function but a different approach could be used.

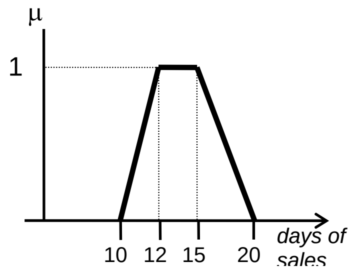


Figure 3 - Fuzzy set describing the firm's goal (satisfaction of achieving it) to its inventory conversion period. When *Is* is between 12 and 15, the firm's goal is entirely achieved ($\mu = 1$). On the other hand, the firm is not willing to admit values above 20 days (for financial efficiency reasons) and lower than 10 (because of stockout risk, $\mu = 0$). For simplicity, we assume linear functions for values in these intervals.

The relation between sales, inventory conversion period and purchase for the period is stated by the following:

$$Is = I_0/ES_d + 1/2(P/ES_d) - Cg/2ES_d \qquad \textbf{(1)}^2$$

where:

Is is the inventory conversion period in days of sales;
I_0 is the initial inventory of the period in dollars;
P is the purchase for the period in dollars; ES_d is the estimated average daily sales in dollars; and
Cg is the cost of the goods sold.

From Eq. 1 we can derive the purchase for the period as:

$$P = 2\, ES_d.Is + Cg - 2I_0 \qquad \textbf{(2)}$$

First, the system uses Eq. 2 and the interval of estimated sales given by the DM, building different decision scenarios (generated by selecting discrete points in the sales interval). Each one is compared to the firm's constraint associated to purchase and those with values not in the feasible interval are rejected. Then, the system presents a table with the estimated sales, the resulting *Is* and the purchase amount associated with each alternative. The system then shows the risks and satisfaction with the selected alternative.

In the example, the relation Cg/ ES_d is equal to 0.7 and the initial inventory is \$70,000. The feasible alternatives will be those shown in figure 4. The purchase amounts fall within the interval given by the DM and the risk (the estimated sales) and satisfaction (the *Is* value) are explained in each case.

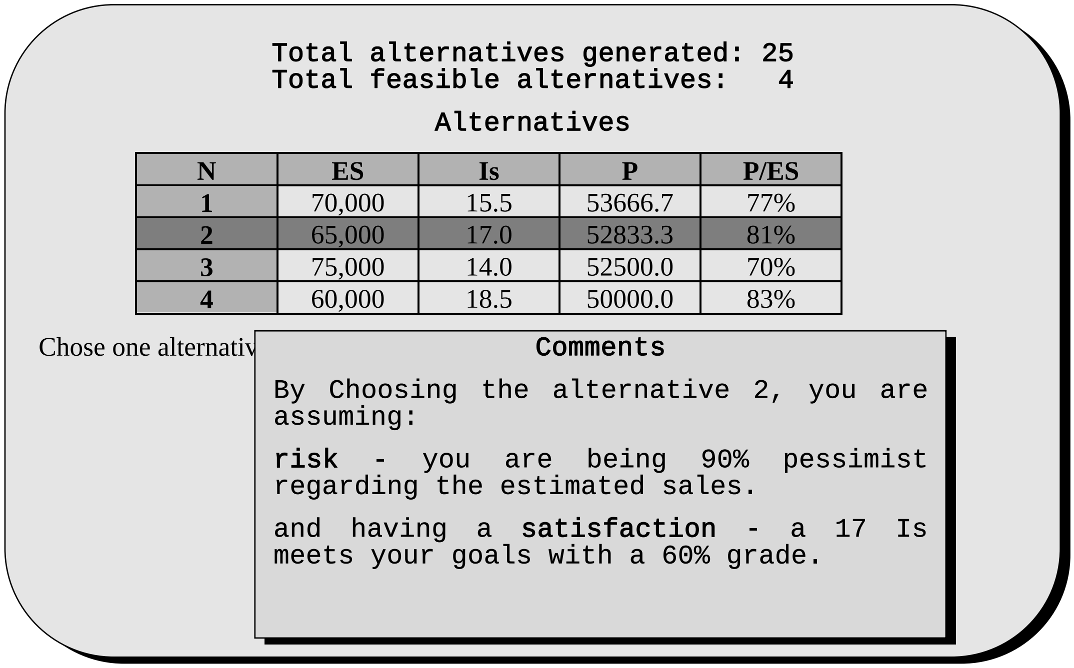
The decision process is not static in the sense that further periods will be affected by present decisions. The ending inventory of the final period becomes the initial inventory for the second period. Thus, when deciding the purchase for a period, the DM should foresee the consequences by analyzing scenarios for the next period(s) as well. The fuzzy scenario analysis implements this process simply by presenting further scenarios taking into account the decisions and expectations (estimated sales) for previous periods.

Conclusions

Our main purpose in this work was to present a tool capable of including the DM's expectations and goals when he/she is taking decisions about WC, or more specifically, when deciding how much to purchase. The fuzzy scenario analysis has met this purpose by allowing a subjective definition of risk and benefit of a purchase decision and by using these descriptions to determine the feasible alternatives of decisions available to the DM.

The technique is flexible enough to be adaptable to changing business environments. For instance, different beliefs about the estimated sales can be integrated by simply changing the fuzzy sets associated

[2] This relation is used for retail firms. For an industrial case a similar approach can be used with minor modifications, including raw material and work-in-process.



N	ES	Is	P	P/ES
1	70,000	15.5	53666.7	77%
2	65,000	17.0	52833.3	81%
3	75,000	14.0	52500.0	70%
4	60,000	18.5	50000.0	83%

Figure 4 - The fuzzy scenario analysis of each feasible alternative. The system determines the alternatives that meet the constraints of the firm and shows them to the DM. By choosing one, the DM can see the impact of that alternative on the operational goal of the firm (Is) and the associated risk.

with the estimation of the risk. On the other hand, if the strategic goals of the firm have changed implying a different operational goal related to *Is*, the DM has to change only the fuzzy set describing the satisfaction of a decision. The fuzzy scenario analysis will then consider the new information.

As future developments, we can mention the integration of this module to the entire WC management system (e.g., [12] and [11]); the integration of a natural language translation to the fuzzy sets describing risks and goals of the firm (rather than the percentage descriptions currently used); and the use of this approach for other decision processes in the WC management.

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