STATE OF THE ART OF WORKING CAPITAL MANAGEMENT

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While major theoretical advances have been made in recent years with respect to the longer-range financial decisions of the firm, research devoted to shorter-range or working capital decision-making would appear to have been less productive. At the same time, we can probably attribute a large number of business failures in recent years to an inability of financial managers to plan and control properly the current assets and current liabilities of their respective firms. Current assets collectively represent the single largest investment for many firms, while current liabilities account for a major part of total financing in many instances. Toward the end of refocusing the attention of financial theorists and academic researchers on the "top half" of the balance sheet, this paper *summarizes* eight somewhat distinct approaches to working capital management. The first three, aggregate guidelines, constraint set, and cost balancing, are partial models; the next two approaches, probability models and portfolio theory, stress future uncertainty and interdependencies; while the last three approaches, mathematical programming, multiple goals, and financial simulation, have a broader, systematic focus. The eight approaches should be considered as representative of the existing literature rather than as an exhaustive survey. The paper also *synthesizes* the important features of these existing approaches.

It is useful to designate the balance sheet of a typical firm as follows:

Assets	Liabilities and equity
Current assets, a_j	Current liabilities, ℓ_j
Fixed assets, A_j	Long term liabilities, L_j
	Equities, E_j

The familiar balance sheet equation shows total assets, $\Sigma a_j + \Sigma A_j$, equaling total financial sources, $\Sigma \ell_j + \Sigma L_j + \Sigma E_j$. "Working capital" usually refers to the firm's current assets, Σa_j, while "net working capital" is given by $\Sigma a_j - \Sigma \ell_j$. A subscript j on each balance sheet category indicates that there may be several specific accounts within each category, while summation signs refer to totals within categories.

Aggregate Guidelines

One approach to analyzing working capital consists of *aggregate guidelines*, used in several leading textbooks to introduce working capital management. In the short run, the important relationship is that defining the level of short-term financing as given by

$$b = (\Sigma a_j^* + \Sigma A_j - \Sigma \ell_j^*) - (\Sigma E_j + \Sigma L_j), \quad (1)$$

where Σa_j^* here excludes short-term marketable securities, and $\Sigma \ell_j^*$ excludes short-term bank borrowing. If net asset requirements (first bracketed term) exceed long-term sources of financing (second bracketed term), then short-term bank borrowing is needed. For the converse, excess funds should be invested in short-term marketable securities. In other words, short-term borrowing or lending should be used to balance the available sources with contemplated needs.

For the longer run, Weston and Brigham [16] suggest that current asset holdings should be expanded to the point where marginal returns on increases in those assets would just equal the cost of capital required to finance such increases. Moreover, current liabilities should be used in place of long-term debt whenever their use would lower the average cost of capital to the firm. Additional propositions of this sort concerning working capital and risk also were suggested by Walker [13] in an earlier paper dealing with a theory of working capital. While correct in principle, such aggregate guidelines and propositions probably offer little practical help.

Constraint Set

In another approach, working capital is viewed as a *constraint set* for the larger problem of minimizing cost or maximizing the value of the firm. The constraint set may take the general form of $g\ [\Sigma a_j]$ or $g\ [\Sigma a_j - \Sigma \ell_j]$, depending on the exact specification of the model. Another way of viewing this second approach is that it removes the asterisks from the definition of short-term financing in equation (1). For example, Vernon Smith [10] proposed to minimize total production cost subject to money capital requirements, which include both fixed assets and net working capital. Net working capital was defined as

$$\Sigma a_j - \Sigma \ell_j = \alpha S - \sum_i \beta_i W_i X_i, \quad (2)$$

where S is firm sales, X_i is the number of units of resource i used in production, W_i is the unit price of that resource, and α and β_i are appropriate constants. In his classic synthesis of production, investment, and finance, Vickers [12] introduced a net working capital requirement defined as

$$\Sigma a_j - \Sigma \ell_j = g(Q), \quad (3)$$

where Q represents firm output. This requirement became part of the total money capital constraint which accompanied Vickers' objective function of maximizing the equity value of the firm. While these two excellent works are representative of how many writers have acknowledged the importance of working capital in financial decision-making, they are limited in that net working capital is treated as a single entity rather than as a series of interacting accounts on both sides of the balance sheet. The two works do consider working capital requirements as a component of a larger mathematical representation for financial management.

Cost Balancing

Cost balancing has perhaps received more attention than any of the other approaches to analyzing working capital. The cost balancing approach can be represented as the minimization problem

$$\underset{a_j}{\text{Minimize}}\ [C_1(a_j) + C_2(a_j) + \ldots + C_n(a_j)], \quad (4)$$

where the decision variable is a particular current asset, a_j, and where the $C_i(a_j)$ are distinct types of costs associated with the dollar level of that current asset. Typically, the several cost components move in opposite directions as the level of a_j is varied. In the case of inventory in the familiar "economic order quantity" model, for example, $C_1(a_j)$ would represent either the ordering or set-up cost associated with accumulating inventory, $C_2(a_j)$ would comprise inventory holding costs, $C_3(a_j)$ would denote shortage costs, and so forth. For accounts receivable, $C_1(a_j)$ might represent foregone profits as credit policy is relaxed and sales and receivables increase, while $C_2(a_j)$ could represent bad debt expenses and the opportunity costs of higher investments in receivables. For determining an appropriate cash balance, $C_1(a_j)$ would include order costs and brokerage fees for security investments, while $C_2(a_j)$ would reflect the opportunity costs of higher investment in cash balances.

One noteworthy limitation of cost balancing approaches is that they usually focus on only a *single* current asset, without giving due consideration to important interrelationships with other current assets and with current liabilities.

Probability Models

In contrast to the three approaches to analyzing working capital already presented, which are deterministic, the fourth considered here consists of *probability models*. These models reflect the same variables already encountered, except that certain of them are explicitly considered to be subject to random influences. For example, Beranek [1] extends certain of his deterministic models for analyzing credit policy to include random rates of sales and random collection patterns. The incorporation of risk and uncertainty in working capital models also necessitates a different type of objective function, such as expected cost, $\sum_i P_i C_i(a_j, \ell_j)$, where P_i represents probability or expected profit, $\sum_i P_i \pi_i(a_j, \ell_j)$, where π_i represents profitability. In either case, an expected value operation is used to summarize the uncertainty inherent in the cost and/or profit relationship.

Portfolio Theory

Portfolio theory, with its focus both on uncertainty and the interrelationships among items, may also be employed to analyze working capital. Friedland [2] suggested that the assets of a firm could be viewed in a portfolio context. In terms of current assets, his model would amount to

$$\underset{a_j}{\text{Maximize}}\ [\Sigma a_j e_j - \lambda \Sigma\Sigma a_i a_j \sigma_{ij}], \tag{5}$$

where e_j is expected profitability per dollar of current asset, σ_{ij} is the covariance between current assets a_i and a_j, and λ is an appropriate return-risk parameter. Friedland also suggested an indexing scheme based on sales to infer the mutual interrelationships between current asset accounts. While this is a useful framework for conceptualizing the management of firm assets, it would seem to offer little operational help in controlling specific asset levels over time.

Capital asset pricing theory also provides a powerful means of analyzing return-risk relationships for a number of important financial decisions. In a recent issue of this journal, Weston [17] showed that the capital asset pricing model can be used to provide guidelines for asset expansion decisions. In those decisions, which normally reflect long horizons, the focus is on fixed assets. Excepting an exploratory paper by Pringle and Cohn [8], adaptations of capital asset pricing theory to working capital management have not appeared in the literature of finance. This is somewhat surprising, since the capital asset pricing model is a single period model that is close to the horizon of working capital decisions. One implication of capital asset pricing theory is that diversification by investors may be more effective than diversification by firms themselves, thus diluting somewhat the potential value of a portfolio approach to working capital.

Mathematical Programming

Mathematical programming can be used to attack working capital directly and in a manner which deals simultaneously with a number of interrelationships. Several authors have discussed and illustrated programming approaches. Beranek [1] presented a series of models dealing with accounts receivable and cash balances; Mao [7] formulated cash management into a dynamic programming context, and Robichek, Teichroew, and Jones [9] constructed a linear programming model for short-term financing of the firm as

$$\underset{\ell_j}{\text{Minimize}}\ [\sum_k C_k(\ell_j)] \tag{6}$$

$$\text{Subject to } f_i(\ell_j) \leqslant \ell_i^*.$$

In this interesting model, the decision variables were different types of borrowing, ℓ_j; the objective function included a number of relevant costs, $C_k(\ell_j)$, associated therewith; and constraints, $f_i(\ell_j)$, were used to place limits, ℓ_i^*, on certain types of indebtedness. An important feature of this formulation is that it necessitated consideration of other working capital accounts such as cash, accounts receivable, and accounts payable.

Multiple Goals

The inclusion of *multiple goals* in the objective function of the firm is yet another method of analyzing working capital. While the usual programming approach includes a single goal (e.g., cost or profit), it is possible to formulate the decision-making problem as

$$\underset{b,\pi}{\text{Maximize}}\ u[b(a_j, \ell_j), \pi(a_j, \ell_j)], \tag{7}$$

where the preference function, u, summarizes management's feelings about the relative importance of the liquidity, $b(a_j, \ell_j)$, and profitability, $\pi(a_j, \ell_j)$, goals. The locus of feasible combinations of b and π will depend on the nature of the firm, its investment opportunities, and its possible sources of financing. If the shape of u is specified, it may be possible to deduce the shape of indifference contours and the nature of specific solutions in profitability-liquidity space.

One use of multiple goals suggested by Krouse [4] involves hierarchical optimization of a set of goals ranked in order of their relative importance to the firm. After the optimal level of the first goal is determined, a satisficing level for that goal is specified by management, and this level becomes a constraint for optimizing the second goal. The procedure is repeated with management able to see the tradeoffs between various goals at each step. Although such approaches to working capital involving multiple goals may be difficult to implement in an operational sense, they probably come closer than many alternatives to capturing the decision-making process actually employed by financial managers.

Financial Simulation

The final means of analyzing working capital management is *financial simulation*. Financial simulation allows one to incorporate both the uncertainty of the future and the many interrelationships between current assets, current liabilities, and other balance sheet accounts; and it permits consideration of multiple goals, although the goals are neither specified in an objective function nor incorporated in an optimizing algorithm. A good illustration of simulation relative to a single current asset or liability is found in Mao [7]. Based on 1,000 iterations of the financing requirements associated with normally distributed sales, a frequency distribution of total interest cost, $\Sigma C_k(\ell_j)$, is generated for each of three financing strategies. The final decision can then be made from summary measures, such as mean and standard deviation, from the three simulated distributions.

Two other papers proposing a simulation approach should be noted. Lerner [5] explained how cash budgeting can be extended to reflect the uncertainty inherent in future sales, the uncertainty in collecting accounts receivable, and the firm's flexibility in paying its accounts payable. By calculating both the expected value and the standard deviation of forecasted cash balances, the financial manager can trace the full impact of his decision-making. At about the same time, Van Horne [11] proposed a probabilistic forecast of the cash flows of the firm as a way of making return-risk tradeoffs. He also proposed that different assumptions about sales, receivables, payables and other related variables could be evaluated in terms of forecasted cash flows.

It is also possible to simulate future financial statements of a firm based on a set of simultaneous equations. For example, Warren and Shelton [14] present a model in which both current assets and current liabilities are directly related to firm sales. That is, $\Sigma a_j = f_1(S)$ and $\Sigma \ell_j = f_2(S)$ represent two out of a total system of twenty simultaneous equations that are used to forecast future balance sheets of the firm including current assets, $\widehat{\Sigma a_j}$, and current liabilities, $\widehat{\Sigma \ell_j}$. Although these forecasts are in the aggregate, it would be possible to treat the individual working capital accounts separately in a larger simulation system. By simulating future financial statements over a range of different assumptions, it would therefore be possible to reflect uncertainty in tracking future patterns of working capital.

Future Directions

From the foregoing review of different approaches to working capital, one might conclude that working capital management *has* received adequate attention as an area of inquiry within the broader field of finance.

On the other hand, a careful study of the financial literature concerned with working capital may lead many readers to the conclusion that richer extensions or novel approaches may be necessary in order to reach better solutions or to provide guidelines for assisting *practicing* financial managers in their decision-making. This viewpoint is easily confirmed in conversations with them.

Certain features of the foregoing summary should be reiterated as being essential to more useful approaches. The dual financial goals of profitability and liquidity must continually be weighed, and tradeoffs must be studied. Also, liquidity, not unlike profitability, more properly reflects the dynamic flow of dollars into and out of the firm over time, rather than merely reflecting a static picture. In addition, the several interrelationships among the management of current assets and current liabilities must be properly reflected. Recent attempts to capture some of these important interrelationships are found in papers by Welter [15] and Knight [3]. Finally, the uncertainty of the future must somehow be treated.

One of the most powerful means of reflecting such features, and thus better understanding the working capital situation of a particular firm, is through parallel forecasts (at least monthly) of net borrowing requirements, $\widehat{b}_t(a_{jt}, \ell_{jt})$, and resulting after-tax profitability, $\widehat{\pi}_t(a_{jt}, \ell_{jt})$, over some planning horizon t = 1, 2, . . . ,T. These dual forecasts are triggered by a forecasted sales schedule, $\widehat{S}_t$, and also by parameters that reflect the receivables, payables, inventory, and other policies of the firm. Because of a strong concern with working capital management, current assets, a_j, and current liabilities, ℓ_j, are included as arguments of both variables to be forecasted. Some suggestions along these lines have been made by Lewellen and Edmister [6] in their paper dealing with accounts receivable.

As previously mentioned, simulation is a powerful method of recognizing future uncertainty. One means of using simulation is accomplished by examining for each period t, the distribution of net borrowing, $\widehat{b}_t$, and after-tax profitability, $\widehat{\pi}_t$, that would result from simulated sales, $\widehat{S}_t$, or other random variables. Simulation may also be employed by altering the various receivables, inventory, and payables policies of the firm and by studying their individual or collective impacts on the profitability and liquidity goals of the firm.

Such approaches do not lead to optimal solutions *per se;* instead they portray a series of tradeoffs between liquidity and profitability. The relevant objects of choice in attempting to determine optimal tradeoffs are, thus, not the levels of current assets, a_j, and current liabilities, ℓ_j; rather they are the management policies whereby such levels are determined. It is thus suggested that future efforts to examine individual working capital accounts, such as inventory or accounts receivable, should be made with an eye toward how their treatment will ultimately affect both net borrowing and profitability.

Dual projections of $\widehat{b}_j$ and $\widehat{\pi}_j$ can be viewed as a systems approach to the two central goals of interest to the financial manager and, of course, to the firm. This approach is consistent with financial simulation, wherein the entirety of financial planning of the firm is considered, particularly if the system of equations includes working capital as a series of accounts rather than an aggregate variable. Financial simulation in this manner also allows for better understanding of how working capital decisions are related to longer-term investment and longer-term financial decision-making by firm management.

Fortunately, one may predict that improved methods are likely to be forthcoming. In the usual way competition will intensify the need for better allocation of resources. In a very pragmatic sense, increased costs of money have placed additional pressure on management to limit investment in working capital. Better data bases and improved computer capability will add to the potential for better methods and guidelines. Above all, one may predict that closer ties between the academic world and practice will provide the motivation for parallel and simultaneous assaults on both the short-range and long-range financial problems of the organization.

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