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Author(s): Bernell K. Stone
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The Design of a Company's Banking System

BERNELL K. STONE*

IN THE PAST, companies provided virtually all compensation via demand deposit balances. Compensation was settled on a month-to-month basis. During the past decade, new compensation opportunities have emerged, namely: 1) the payment of fees, 2) the use of non-interest bearing time deposits,[1] and 3) long-period balance averaging, especially semi-annually and annually rather than monthly. While these compensation alternatives can significantly reduce a company's banking costs (while leaving the bank no worse off), they greatly complicate bank system design. They also expand the scope of the problem by creating interdependencies with cash budgeting.

I. Problem Definition

Banking system design refers to the selection of a set of banks and the allocation of required services to the banks. It is useful to distinguish two broad classes of services here—credit (which includes borrowing) and noncredit services. Noncredit services are often called *tangible services.* Most tangible services involve an explicit price for the service components with payment via either cash fees or balances. Balances earn service credits at an implicit interest rate generally called the *earnings credit rate.*

Even though there has been increased use of cash fees to pay for bank services over the last decade, surveys reveal that the great majority of companies still rely primarily on balances for their bank compensation. Since virtually all companies regard the opportunity cost of balances as much greater than the earnings credit rate, one might wonder why the persistence of balance compensation. One explanation is that many banks express a strong preference for balances and thus implicitly constrain companies to provide balance compensation. In this author's opinion, however, the real explanation is the emergence of new balance-based compensation opportunities, especially zero-interest time deposits and long-period averaging.

Cash budgeting is the determination of schedules of short-term borrowing, short-term investment, and cash balances given a company's operating, marketing, and capital investment plans. As discussed in Stone [6, 8], virtually all large

* Georgia Institute of Technology and National Corporate Cash Management Assoc.

[1] The reason for using zero-interest time deposits is the lower reserve requirement, at least 10% less than for demand deposits (transaction account deposits). Hence companies can provide their banks with the same loanable funds (deposits after reserve requirements) with at least 10% lower balances. The most common instrument is the zero-interest CD. Another is the zero-interest REPO (which has a reserve requirement of zero). A third is the deposit of international funds (which often involve cross-border transfer restrictions) in an international branch or affiliate of the bank.

companies and most middle-market companies develop cash budgets via computer-assisted projection of financial statements.

The compensation plan determines the level of balances and the amount available for investment. Moreover, much of the benefit of long-period averaging is reducing peak borrowing (by providing most balance compensation in non-peak periods), total borrowing (from the smoothing that allows a cash need in one period to be off-set with a cash surplus in another rather than investing in one month and borrowing in another), and reducing the total credit requirement[2] (which depends on peak borrowing and the required margin of safety). Thus, rather than first developing a cash budget and total credit requirement and then designing the company's banking system, these two problems must be solved jointly. Realizing the benefits of the new compensation alternatives (fees, zero-interest time deposits, long-period averaging) creates interdependencies between cash budgeting, credit requirement determination, and bank system design.

II. Problem Background

In *Linear Programming and Cash Management/CASH ALPHA*, Calman [1] presented the first formal, systematic, quantitative treatment of the banking system design problem. The CASH ALPHA model and a refinement by Pogue, Faucett,and Bussard [5] used linear programming to allocate both check and deposit services and to determine whether payment for these tangible services should be made via cash fees or demand deposit balances given both a tentative credit allocation and given a set of candidate banks. The assumed credit-borrowing allocation was then evaluated judgementally using the LP solution and post-optimality data. The primary reallocation criterion was to reassign planned credit and/or borrowing from banks where cash fees were paid to those banks where there were excess balances.

The primary source of benefits from the Calman-type model was 1) exploiting *double counting*, the at-that-time almost universal practice of letting the same balances that paid for credit also earn service credits to pay for tangible services, and 2) tending to minimize excess balances, i.e., balances that could not be used to pay for either credit or services.

The Calman-type models were implemented in the late 60s and early 70s by a number of companies. However, the formulation had two major limitations. First, credit-borrowing allocation was done judgementally via post-optimality analysis so that an optimum was not ensured, especially in a very complex system. Second, the model was only a one-period formulation while short-term borrowing on prearranged credit generally varies dramatically over a year for most companies. Therefore, the one-period model can at best find an on-average good solution of the credit-borrowing allocation for a "representative month."

Stone [7] formulates: 1) a global intertemporal model that extends Calman [1]

[2] Types of prearranged credit include credit lines, credit agreements, revolving credit arrangements, and international trade financing facilities. For simplicity of exposition, this article does not treat the mix of credit types and simply uses the terms *credit* and *credit arrangements* as generic terms for any of these types of prearranged credit.

by allocating credit as well as noncredit services over banks and across time, and 2) an intertemporal credit-borrowing allocation model with noncredit service allocation being given as input and then evaluated via post-optimality analysis. Stone argues for the simpler intertemporal credit allocation model as more pertinent to actual practice than either the one-period or the intertemporal global models because: 1) the simultaneous solution of both credit and noncredit allocation is a computationally immense task, especially in the intertemporal case and 2) the tangible services (especially lockbox collections and disbursements) are the ones that are logically allocated first since they depend on the geograpical distribution of a company's customers and suppliers while credit is logically allocated without geographical restriction.

III. The State of Current Practice

By the mid-70s, the Calman-type models had fallen into disuse. Besides the limitations noted above, three factors contributed to their abandonment.

1. *Unbundling and Double-Counting Phase-Out.* Major banks unbundled their service charges and phased out double counting. After the 1973–74 credit crunch, double counting was the exception rather than the rule for most major money-center banks. Hence, a major assumption and source of model benefits was eliminated.

2. *Bank Design Services.* For designing the lockbox and disbursement components of the banking system, most major banks began providing model-based consulting services supported by data bases of mail times, availability times, and clearing times. In effect, banks provided solutions for the two major components of the bank design problem addressed explicitly by the Calman-type models. Moreover, the bank models solved not only the allocation problem but also the location-selection problem.[3]

3. *New Compensation Possibilities.* The models of [1, 5, 7] did not include zero-interest time deposits or annual averaging. Moreover, they only allowed for fees as an alternative to balances for tangible services but not for either credit arrangements or borrowing, the latter being the trade-off between interest rates and balances.

By the late 1970s, almost universal practice in the design of a company's banking system had become: 1) using the consulting services of major banks for assistance with the design of the lockbox and disbursement components of the company's banking system, and 2) selecting credit banks and allocating credit judgementally with emphasis placed on greater flexibility in credit compensation (fees, non-interest bearing time deposits, and annual averaging).

Efficiently deciding on the form of compensation (fees, demand deposit balances, or various kinds of non-interest bearing time deposits) and planning balances to utilize the smoothing opportunities afforded by annual averaging is sufficiently complex that few companies realize the full potential of the new bank compensation opportunities. Moreover, because this problem is more complex

[3] For a review of these models and a discussion of their use, see [3, 4].

than lockbox and disbursement system design, it is the area where there is the greatest need for model-assisted decision making.

IV. Model Overview

There are two broad classes of constraints—bank-specific and system-wide. *Bank-specific* involve only variables characterizing activity at one bank. *System-wide* involve variables pertaining to several banks including the cash budgeting variables.

Figure 1 depicts the constraint structure. The model is block-diagonal in the bank-specific constraints. Since the number of system-wide constraints is small, decomposition and other special-purpose algorithms can provide computational efficiency.

Incorporating the new compensation opportunities requires: 1) an expansion of the bank compensation constraints, 2) including cash budgeting variables within the model, and 3) an expanded objective function.

For simplicity of exposition, the model will be formulated with only one type of credit and one type of zero-interest time deposit. It is straightforward to add more variables of each type whenever more than one is pertinent to the relationship with a given bank.

V. Objective Function

Assume that there are T time periods in the planning horizon. Time periods will typically be months although weeks are also possible. The index t will denote a

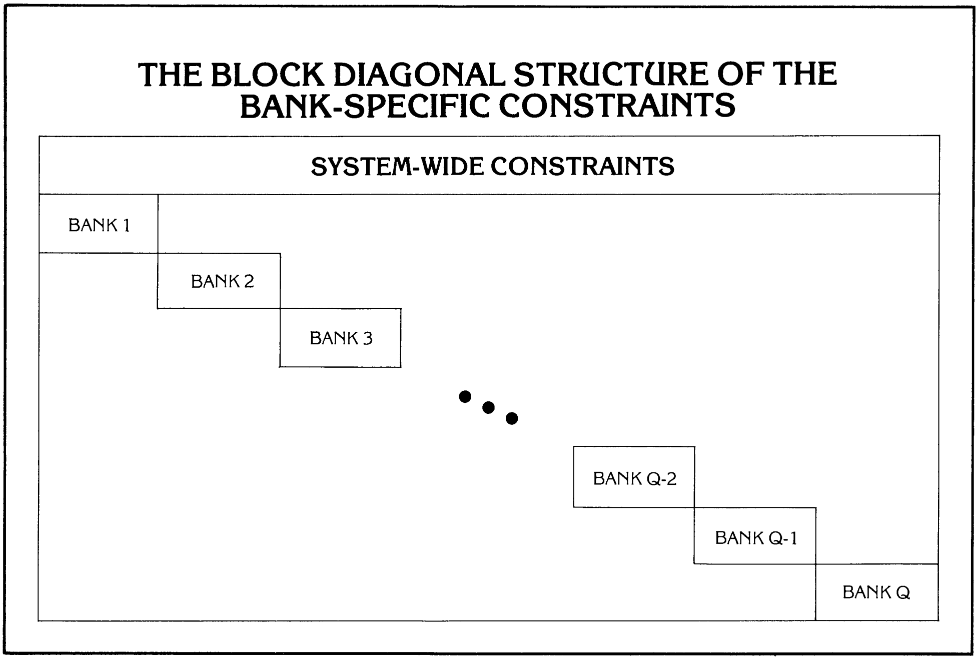

Figure 1. The Block Diagonal Structure of the Bank-Specific Constraints

time period. Assume that there are Q banks over which credit and borrowing are to be allocated. The index q will denote a typical bank. Summations with only q or t subscripts will be assumed to run over the entire range of each variable list. Let:

$I_t \equiv$ some measure of the level of interest in time period t such as prime or LIBOR or treasury bills
$\Delta_{qt} \equiv$ cost in excess of I_t to borrow at bank q in time period t so that total cost is $I_t + \Delta_{qt}$
$\Delta_{0t} \equiv$ return in excess of I_t on short-term security investments in time period t so that total return is $I_t + \Delta_{0t}$
$f_q \equiv$ commitment fee per dollar of credit for borrowing at bank q
$C_q \equiv$ rate of balances per dollar of credit
$D_q \equiv$ rate of balances per dollar of debt
$SFEE_{qt} \equiv$ cash fee paid for tangible services at bank q in time period t
$DDBAL_{qt} \equiv$ average demand deposit balance at bank q in time period t
$TDBAL_{qt} \equiv$ average non-interest bearing time deposit balance at bank q in time period t
$MABAL_{qt} \equiv$ minimum allowable demand deposit balance at bank q in time t
$DDRR_{qt} \equiv$ reserve requirement on demand deposits
$TDRR_{qt} \equiv$ reserve requirement on time deposits
$IVEST_t \equiv$ average level of short-term security investment in time period t
$DEBT_{qt} \equiv$ average level of short-term borrowing from bank q in time period t
$CREDIT_{qt} \equiv$ level of prearranged credit at bank q in time period t
$CRMAX_q \equiv$ maximum permissible level of credit at bank q

The objective is to minimize the sum of interest payments on short-term debt, credit commitment fees, cash fees, and the opportunity value of balances adjusted for interest income earned on short-term security investment, i.e., to minimize:

$$OBJ \equiv \sum_q \sum_t (I_t + \Delta_{qt})DEBT_{qt} + \sum_q \sum_t f_{qt}CREDIT_{qt} + \sum_q \sum_t SFEE_{qt}$$
$$+ k \sum_q \sum_t (DDBAL_{qt} + TDBAL_{qt}) - \sum_t (I_t + \Delta_{0t})IVEST_t.$$

Tangible Services and Float

The tangible services are taken as given in this model. However, the form of payment (cash fees versus some form of compensating balances) is not taken as given. The form of payment is a decision variable that can impact the overall cost of the banking relationship even when there is no double counting. Hence, this model incorporates the major interdependency between tangible services and credit, namely the form of tangible service compensation.

The objective function uses bank balances rather than company book balances to assess the opportunity cost of balances. The difference in company book balances and bank balances is the net float. Given an allocation of tangible activity, net float is fixed and can be dropped from the objective function without any loss of generality or completeness. However, if sensitivity analysis on the impact of tangible service allocation on float is desired, this can be handled as discussed in Stone [7].

VI. Bank Compensation and the Bank-Specific Constraints

The development progresses in a step-by-step fashion from the formulation of the Calman-type constraints to reflect: 1) no double counting, 2) fee-based credit compensation, 3) the use of non-interest bearing time deposits, and 4) long-period averaging.

Prototypical Bank-Specific Constraints with Double Counting

The following gives five standard bank-specific constraints typical of the extended Calman models such as Stone [7].

$$(1 - DDRR_{qt})DDBAL_{qt} \geq C_q CREDIT_{qt} + D_q DEBT_{qt} \tag{C1}$$

$$SFEE_{qt} + ECR_{qt}(1 - DDRR_{qt})DDBAL_{qt} \geq TSCHARGE_{qt} \tag{C2}$$

$$DDBAL_{qt} \geq MABAL_{qt} \tag{C3}$$

$$DEBT_{qt} \leq CREDIT_{qt} \tag{C4}$$

$$CREDIT_{qt} \leq CRMAX_q. \tag{C5}$$

Constraints (C1) and (C2) are the compensation constraints. Constraint (C1) says that *average* after-reserve demand deposit balances are at least as great as the compensating balance required for the level of credit and borrowing at bank q in month t.[4] Constraint (C2) says that the total of fees paid for tangible services plus service credits must be at least as great as the tangible service charges. Double counting is implicit in these constraints since the same balance that pays for credit in Constraint (C1) also earns service credits in Constraint (C2).

Constraint (C3) requires that the average demand deposit balance not be less than a minimum acceptable average balance. This company policy parameter must be at least zero after adjusting for float (no overdrafts) and generally reflects necessary transaction balances. Constraint (C4) limits borrowing at bank q to the amount of prearranged credit. Constraint (C5) limits credit at bank q to a maximum level. This could be the legal lending limit or a company policy limit. If multiple types of credit were being allocated, there would be constraints like (C4) and (C5) for each type of credit.

Elimination of Double Counting

Let $DDCCB_{qt}$ denote the demand deposit balance for credit compensation at bank q in time t. If there is no double counting, then the new versions of the

[4] It is noted that commercial paper borrowing backed by credit lines is a special case of constraint (C1) in which the rate of balances for borrowing is zero, i.e., $D_q = 0$ for commercial paper. Thus, in the rest of the paper, we shall speak of "bank borrowing" with the understanding commercial paper issuing is a special case treatable by appropriate choice of model parameters.

constraints are:

$$(1 - DDRR_{qt})DDCCB_{qt} \geq C_q CREDIT_{qt} + D_q DEBT_{qt} \tag{C1-a}$$

$$SFEE_{qt} + ECR_{qt}(1 - DDRR_{qt}) \cdot (DDBAL_{qt} - DDCCB_{qt}) \geq TSCHARGE_{qt}. \tag{C2-a}$$

In this formulation, it is assumed that demand deposit balances are first applied to compensate for credit and then the earnings on any remaining balances earn service credits to pay for tangible services. This order conforms to virtually universal bank practice in account analysis and the general corporate preference to pay fees first for tangible services and only then for credit. However, it is straightforward to reverse this ordering assumption if a company desires to do so at one or more banks.

To ensure model consistency, it is necessary to require that balances for credit compensation do not exceed the total balances, i.e.:

$$DDCCB_{qt} \leq DDBAL_{qt}. \tag{C6}$$

Non-Interest Bearing Time Deposits

Incorporating zero-interest time deposits requires adding the after-reserve amount to the bank compensation constraints. Let *TDBAL*, *TDCCB*, and *TDRR* denote total time deposit balances, time deposit balances used for credit compensation, and time deposit reserve requirements, respectively. With appropriate bank and time subscripts on these variables, the extended compensation constraints are:

$$(1 - DDRR_{qt})DDCCB_{qt} + (1 - TDRR_{qt})TDCCB_{qt} \geq C_q CREDIT + D_q DEBT_{qt} \tag{C1-b}$$

$$SFEE_{qt} + ECR_{qt}(1 - DDRR_{qt})(DDBAL_{qt} - DDCCB_{qt}) + ECR_{qt}(1 - TDRR_{qt})(TDBAL_{qt} - TDCCB_{qt}) \geq TSCHARGE_{qt}. \tag{C2-b}$$

As with demand deposits, the level for credit compensation cannot exceed the total, i.e.:

$$TDCCB_{qt} \leq TDBAL_{qt}. \tag{C7}$$

If there are several types of time deposit balances, then each type would be included in constraints (C1-b) and (C2-b) and a restriction like constraint (C7) would be used for each.

Since the objective function assigns the same cost to demand deposits and time deposits, the latter are more effective compensation and the LP model will use them to the maximum extent possible. Thus, the model will use time deposits once the demand deposits reach the level required by constraint (C3). Clearly, the policy parameter $MABAL_{qt}$ must reflect transaction requirements as well as the no-overdraft requirement. This treatment is consistent with most corporate statements of objectives, namely to have demand deposits as low as possible consistent with necessary transaction balances.

Fees versus Borrowing for Credit and Borrowing

Since the early 70s, it has been general banking practice to charge a commitment fee for a credit agreement in addition to the balances that would be charged for a credit line. It has also become common in more recent years to negotiate a reduction in required balances for a higher fee. While not as common, some companies also negotiate a change in the nominal interest rate in exchange for an off-setting change in the rate of required balances on the loan.

In designing a banking system, a company wants to know at what banks, if any, it pays to negotiate the substitution of fees (interest) for balance compensation. In practice, this problem is often approached as a "fees versus balances" issue. However, it is this author's experience that the best solution is rarely either all fees or all balances but rather a mixture of the two. Hence, companies that heuristically simplify the problem by trying to negotiate all fees or that stay with required balances generally incur significant costs.

To extend fee-balance mix from tangible services to credit and borrowing, a company should accept the quoted rates of balances for credit C_q and for debt D_q. Let $CFEE$ and $DFEE$ denote credit and debt fees respectively. Let CCR and DCR denote the analogues of the earnings credit rate that transform between fees and balances for credit and debt compensation, respectively. The extended constraints are:

$$\frac{CFEE_{qt}}{CCR_{qt}} + \frac{DFEE_{qt}}{DCR_{qt}} + (1 - DDRR_{qt})DDCCB_{qt} + (1 - TDRR_{qt})TDCCB_{qt} \geq C_qCREDIT_{qt} + D_qDEBT_{qt} \quad \text{(C1-c)}$$

$$SFEE_{qt} + ECR_{qt}(1 - DDRR_{qt})(DDBAL_{qt} - DDCCB_{qt}) + ECR_{qt}(1 - TDRR_{qt})(TDBAL_{qt} - TDCCB_{qt}) \geq TSCHARGE_{qt}. \quad \text{(C2-c)}$$

Note that constraint (C1-c) is expressed in balance terms while constraint (C2-c) is expressed in fee terms and is the same as (C2-b). The reason for expressing one in balances and the other in dollars is that credit compensation is usually quoted in balance terms and tangible services in fees. Thus, these versions conform to the conventional form in which the right-hand-side parameters usually appear. To put constraint (C2-c) into the balance form of (C1-c), simply divide each term by the earnings credit rate.

To force the LP model to reflect the trade-off between fees and balances for credit and borrowing also requires that these fees be added to the objective function. Thus, the previously stated objective function should be incremented by the terms $\sum \sum_{qt}(CFEE_{qt} + DFEE_{qt})$. The increase in fees will be offset by a decrease in balances.

Long-Period Averaging

The essence of long-period averaging is to relax the restriction that average balance requirements and possibly even fees be met on a month-to-month basis by allowing the averaging period on balances to increase. The averaging period may be a quarter, six months, or a year. However, to be of significant value in smoothing over a company's annual cash cycle, it must be at least six months. The most common practice today is annual averaging as the alternative to monthly.

There are a variety of ways that annual averaging can be specified. For instance, it may only be implemented for credit compensation and not for tangible services. Frequently, it only pertains to balance compensation.

To illustrate the types of constraints that would be used for long-period averaging, consider a 24-month solution horizon ($T = 24$) with annual averaging. The constraints for balance compensation are:

$$\sum_{t=1}^{12} \frac{CFEE_{qt}}{CCR_{qt}} + \sum_{t=1}^{12} \frac{DFEE_{qt}}{DCR_{qt}}$$

$$+ \sum_{t=1}^{12} (1 - DDRR_{qt})DDCCB_{qt} + \sum_{t=1}^{12} (1 - TDRR_{qt})TDCCB_{qt}$$

$$\geq \sum_{t=1}^{12} C_q CREDIT_{qt} + \sum_{t=1}^{12} D_q DEBT_{qt} \quad \text{(C1-d)}$$

$$\sum_{t=12}^{24} \frac{CFEE_{qt}}{CCR_{qt}} + \sum_{t=12}^{24} \frac{DFEE_{qt}}{DCR_{qt}} + \sum_{t=12}^{24} (1 - DDRR_{qt})TDCCB_{qt}$$

$$+ \sum_{t=12}^{24} (1 - DDRR_{qt})DDCCB \geq \sum_{t=12}^{24} C_q CREDIT_{qt} + \sum_{t=12}^{24} D_q DEBT_{qt}.$$

To handle tangible service compensation, similar summations over the appropriate one-period version of constraint (C2) would be used.

Total constraints have been reduced from twenty-four for month-by-month compensation to two for annual compensation with a two-year horizon. This illustrates how long-period averaging substantially decreases the size of the LP model. While the constraint itself is more complex, the block-diagonal structure is preserved.

The illustrative long-period constraints involved averaging periods that were integral subsets of the planning horizon. If this is not the case, carry-over amounts must be imposed in the constraints by adding constants to the right-hand side of some of the constraints to reflect compensation from time periods not in the model planning horizon.

VII. System-Wide Constraints

Both annual averaging and a choice between fees and various types of balances mean that neither the total credit requirement nor the schedule of short-term borrowing can be assumed as input to the bank system design problem as done in Stone [7]. Rather, these are determined by the decisions of the model on compensation form and timing. Moreover, as noted already, the firm's investment schedule is also dependent on the compensation plan.

There are two possible ways to reflect the interdependency. One is to incorporate the LP model within a financial statement generator to handle simultaneously cash budgeting and bank system design. The other is to incorporate the pertinent financial statement relationships within the LP model. Most companies using this type of model-based assistance to bank system design would want to use both approaches for reasons discussed subsequently.

The rest of this section gives the system-wide constraints that characterize credit policy and the cash budgeting decisions.

The Total Credit Need

For the case of only one type of credit, the total amount of prearranged credit should be the peak borrowing plus an uncertainty buffer. As discussed in Stone [6], most companies set their buffer policy to be a proportion of peak borrowing and/or an additive addition to peak borrowing. If B denotes the proportional increase and $BUFF$ any additive amount, the total credit need is:

$$\textstyle\sum_q CREDIT_{qt} = (1 + B)\max_t[\sum_q DEBT_{qt}] + BUFF.$$

The maximum function is nonlinear and would not fit in an LP model. However, a linear version of this policy equation is attainable by using the following inequality:

$$\textstyle\sum_q CREDIT_{qt} \geq (1 + B) \sum_q DEBT_{qt} + BUFF \qquad t = 1, \cdots, T. \qquad \text{(S1)}$$

When borrowing is less than the peak level, this expression will be an inequality. In the period when borrowing is at the peak level, it will hold as an equality since the credit costs in the objective function will force the LP model to set total credit at the smallest possible value consistent with this constraint.

When constraint (S1) holds for all t, there is an implicit assumption that the total line is fixed over the planning horizon. To allow for change, there would be such a constraint for all time periods belonging to each possible level. For instance, if the amount of prearranged credit were to change at t equal to 12, there would be one constraint for $t = 1, \ldots, 12$ and a second for $t = 13, \ldots, T$.

The credit level policy in constraint (S1) is fairly general. Most companies would have either B or $BUFF$ be zero, i.e., either a proportional buffer or an additive buffer but not both. Other policy constraints could replace (S1) and preserve the linear program as long as the total credit is a linear function of policy parameters and model variables (such as peak borrowing).

Cash Budgeting Constraints

Assume that the operating, marketing, long-term financing, and capital investment decisions have been made and translated into month-to-month pro forma financial projections as would be done in preparing for cash budgeting.[5] Let the output of the projection be summarized as an "operating cash flow." Quotations are used here to reflect the fact that this flow is much more inclusive than the usual "operating" cash flow since it includes long-term financing, capital budgeting, and the best possible estimate of tax payments. It is, in effect, all the

[5] It is stressed that all liquidity strategy has been set before a company starts its budgeting or using a linear program for banking system design. In particular, the debt-equity mix and the relative amount of long-term and short-term debt has been determined. Even the approximate magnitude of the credit need has been determined and its feasibility and associated risk ascertained. The cash budgeting and bank system design occur late in the financial planning process after most other work has taken place.

projected cash flow from all company activities except short-term borrowing and security investment.

Let $OPCASH_t$ denote an estimate of the net cash flow generated over time period t from all company activities except short-term borrowing and investment. The period-to-period change in the company's cash balance is the net operating cash flow plus the net increase in short-term debt adjusted for short-term debt interest payments less the net increase in short-term investment adjusted for any short-term investment interest less all fees, i.e.:

$$\begin{aligned}\textstyle\sum_q(TDBAL_{q,t+1} + DDBAL_{q,t+1}) &= OPCASH_t \\ &\quad + \textstyle\sum_q(DDBAL_{qt} + TDBAL_{qt}) + \sum_q(DEBT_{q,t+1} - DEBT_{qt}) \\ &\quad - \textstyle\sum_q(I_t + \Delta_q)DEBT_{qt} - (INVEST_{t+1} - INVEST_t) \\ &\quad + (I_t + \Delta_o)INVEST_t - \textstyle\sum_q(SFEE_{qt} + CFEE_{qt} + DFEE_{qt}). \quad \text{(S2)}\end{aligned}$$

Some companies may want a minimim level of short-term security investment that could vary over time. If $IVMIN_t$ is this policy minimum, then this constraint is:

$$INVEST_t \geq IVMIN_t. \quad \text{(S3)}$$

Use within Financial Generator Subsystem

System-wide constraints (S1) to (S3) incorporate the financial statement relations that determine the cash budget and total credit. If the model were to be a subsystem of a financial statement generator, relations such as (S1) and (S3) would be necessary (as in the cash planning model of Stone [6]) but (S2) would be eliminated since its content is handled by the accounting relationships of the financial statement generator.

The LP algorithm would replace the usual judgemental, trial-and-error revisions involved in finding consistent schedules of short-term investments and borrowing. Or it could replace a consistency algorithm such as the borrowing-investment adjustment algorithm set forth in Stone [6].

VIII. Bank Selection: Integer Variables

The development up to this point has been a model for simultaneously determining required credit and borrowing and allocating these requirements over the banking system. It has ignored any fixed costs associated with establishing a credit arrangement at a bank or including a bank as part of a company's credit system. There are significant fixed costs in establishing and maintaining a credit relationship, in fact, these are generally regarded as being much larger than the fixed costs associated with either a lockbox or disbursement service.

Let Z_q be a zero-one variable that is one only if bank q should be part of a company's credit system. Let $FCOST_q$ be the fixed cost of including bank q in the system. The term $\sum_q FCOST_q Z_q$ should be added to the objective function and bank-specific constraint (C5) should be replaced by

$$CREDIT_{qt} \leq CRMAX_q Z_q. \tag{C5$'$}$$

When Z_q is zero, this constraint forces the credit (and, therefore, the borrowing) to be zero at bank q for all t. When Z_q is 1, the fixed cost $FCOST_q$ is in the objective function and (C5′) limits the credit to the appropriate maximum level.

The maximum number of credit line banks can be constrained. Letting $MAXNO$ denote this policy variable, this constraint is

$$\textstyle\sum_q Z_q \leq MAXNO. \tag{S6}$$

IX. Model Perspective

The objective function and constraints presented here should not be viewed as a complete specification of a model but rather as the presentation of a modeling framework. The key to customizing this framework to a particular company across a variety of banks is a menu-driven conversational tableau generator in which the user selects the appropriate constraints and specifies the values of the pertinent parameters.

The uses of this model-based decision-support framework range from a cash budgeting subsystem through a stand-alone banking system design model to the on-going management of an already designed system. The bank design decisions include: 1) credit bank selection, 2) credit-borrowing allocation, 3) bank-by-bank pro forma borrowing schedules, 4) bank compensation determination for not only credit and borrowing but also tangible services, and 5) bank-by-bank, period-by-period balance targets by type of balance. These balance targets establish the framework for daily cash position management.

Use of the model should not be viewed as simply specifying model structure and providing the required parameters to obtain the best design of the credit side of the banking relationship. The compensation terms, prices, and other model parameters are generally determined by extensive negotiation. The primary use of the model is as an aid to negotiation. A company would typically start with their estimate of attainable terms and pertinent parameters and use the model runs to identify their target banks and the areas where negotiation of particular compensation term or prices has significant pay-off. As negotiations proceed, the model terms and parameters are refined and the model rerun and further negotiation effort targeted.

An appropriate adaptation of this model framework is also pertinent to actual management of borrowing, balance targets, and bank compensation. As interest rates, company cash flows and other estimates vary from the pro forma values used in the design phase, the actual use of bank debt can be allocated optimally within the given banking system and balance targets and bank compensation plan updated accordingly.

There are many variations and complexities involved in implementing this framework, especially for a large company with several types of credit and extensive international operations and financing. However, adapting the framework presented to a particular company should be straightforward for an operations researcher skilled in the implementation of conversational, mathematical-programming-based, decision-support models.

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DISCUSSION

J. G. KALLBERG*: The paper of Sartoris and Hill (S&H) builds upon their own and upon other academic research in trade credit policy. They view trade credit decisions within a more complete context of firm value maximization and while they present a net present value framework that is flexible enough to incorporate a variety of other working capital problems, they focus upon determination of credit period and discount. This question is particularly timely in view of the July 1981 passage of the Cash Discount Act which greatly extends the ability of vendors to (differentially) offer discounts for cash payment, and in view of the widespread usage of credit as a powerful marketing tool. The following analysis considers a number of ways to extend the S&H formulation, raises further pragmatic issues, and cites some additional relevant literature.

The basic qustion is: why should an optimal trade credit policy exist? In the Lewellen, McConnell, and Scott [4] study cited by S&H, in a perfectly competitive product and capital market with value-maximizing vendors and buyers, there is no optimal trade credit policy; all "feasible" credit terms are perfect substitutes. This type of irrelevance argument was previously presented in Schwartz and Whitcomb [6]. They develop three motives for a trade credit offer

> "The transactions motive reflects the fact that buyers' transactions costs are reduced if invoices are allowed to accumulate for periodic payment ... The financing motive exists if firms can profitably link financial intermediation to the sale of a product due to capital market imperfections. The pricing motive exists if product market imperfections make trade credit an effective means of disguised price reductions or discriminatory pricing." [6; p. 259]

* New York University.