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ABSTRACT

In 1973, Ronald G. Lykins presented a model for cash management and analysed its benefits for Ohio University. This paper attempts to expand on the previous method by providing answers to questions raised by the Lykins methods by a series of simple algebraic formulas. Both methods are based on two premises: (1) all cash over which the business officer has discretionary investment authority should be consolidated in one operating bank account; (2) balances shown on the books of the bank as credited to the institution's account should be kept at the minimum required or desired level, regardless of the amount of cash balances shown on the books of the institution. The model is designed to answer the following questions: (1) when should a short-term cash investment be initiated? (2) how much cash should be committed? (3) for what period of time should cash be committed? (JMF)

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A Cash Management Model

by William W. Boyles

A model for cash management is presented, which attempts to expand on a method suggested by Ronald G. Lykins.[1] Answers are provided to questions raised by the Lykins method by a series of simple algebraic formulas, which can easily be solved by hand calculation. However, the tedium of daily computation makes the use of a computer virtually mandatory for using the model.

Lykins postulated two basic premises:

1. All cash over which the business officer has discretionary investment authority should be consolidated in one operating bank account.

2. Balances shown on the books of the bank as credited to the institution's account should be kept at the minimum required or desired level, regardless of the amount of cash balances shown on the books of the institution.

From the second premise, it can be deduced that an institution's books may often show a negative cash balance. However, the books of the bank at all times reflect a positive balance in the institution's account. This results from the difference between the time checks are issued and the time they are presented for payment at the bank.

Although Lykins explained his method and analyzed the benefits for Ohio University, certain questions remain unanswered or the answer is determined by subjective judgment. Such questions are: When should a short-term cash investment be initiated? How much cash should be committed? For what period of time should cash be committed? The model presented here is designed to answer these questions.

[1] Ronald G. Lykins, *Studies in Management:* "Techniques for Improving Cash Management" (Washington, D.C.: National Association of College and University Business Officers, April 1973.)

Limitations of the Model

As with any methodology, this model is subject to limitations. In certain jurisdictions, the issuer of a check warrants that funds are on deposit to cover the amount of the check at the time it is issued; some persons question the legality of issuing checks that cause the ledger balance on an institution's books to be overdrawn. Or, the institution may have a negative cash book balance at the time of an audit; therefore, the model should not be used without the concurrence of all interested parties. Or, in smaller towns, it is possible that local banks may not be in a position to offer facilities for short-term investment of cash. Or, it may be politically inexpedient for an institution to consolidate bank accounts if a long-term relationship with several banks exists; bank balances must be maintained that are large enough to compensate the bank adequately for account activity.

The model is designed to give answers with a very small degree of error for the current day. The longer the future time span, the more the model results depend on estimates, and this factor should be considered in relying on the model recommendations. Since short-term cash investments are most rewarding in amounts of $100,000 and above, cash flows generated by some smaller institutions may not be sufficient to warrant using the model.

Methodology

The methodology adopted for solving the problem consists of a series of formulas that provide the user with the following information for the current day and as far into the future as the user is able to make meaningful estimates. The mnemonic symbol shown after each item is the abbreviation used in the formulas and is more fully explained in the section describing model development.

Beginning bank balance (BBB)
Beginning book balance (BKB)

Dollar amount of checks paid by the bank (CPD)
Change in short-term cash investments (INV).

In order to use the formulas, the user must estimate the following data for each day for which a solution is desired:

Amount of the regular deposit (DEP)
Amount of the extraordinary deposit (DEE)
Amount of regular (in the normal course of business) checks issued (CIS)
Amount of extraordinary checks issued (CIE)

The reasons for separating both deposits and checks issued into two items are: (1) to make more meaningful the analysis of prior results as an aid for future estimates and (2) to treat extraordinary checks issued (CIE) differently, as they are considered to have no float (that is, they may be expected to be presented for payment at the bank on the day of issue). Examples of extraordinary deposits would be receipt of a state support check, receipt of a grant, or receipt of an insurance recovery. Extraordinary checks issued would include payment to a contractor or a disbursement for a short-term cash investment.

An example of one day's activity only is described in the model development; in practice, a similar equation must be developed for each day of the year. The numerical value shown after the mnemonic symbol refers to the day of the year: for example, BBB001 is the beginning bank balance on January 1; BBB365 is the beginning bank balance on December 31, assuming that the year is not a leap year.

Development of the Model

The first formula is:

Formula 1: The Basic Formula

$$INV001 = BBB001 + DEP001 + DEE001 - CPD001 - CON$$

where:

INV001 is the additional short-term cash investment (or withdrawal from short-term cash investment) to be made on January 1.
BBB001 is the beginning bank balance on January 1.
DEP001 is the bank deposit (regular) made on January 1.
DEE001 is the bank deposit (extraordinary) made on January 1.
CPD001 is the dollar amount of checks charged to the institution's bank account on January 1.
CON is the minimum required or desired bank balance to be maintained.

Following the above formula, it appears that cash available for investment on January 1 (INV001) should be equal to the initial bank balance (BBB001), plus any additions for the day (DEP001 and DEE001), less any charges against the account (CPD001), less any balances that the business officer should wish to leave on deposit for the succeeding day's activity.

The elements in Formula 1 are determined as follows:

The amount of addition to (or subtraction from) short-term cash investment (INV001) is unknown and is determined by solving Formula 1. The beginning bank balance (BBB001) is determined by daily communication with the bank. The regular deposit (DEP001) and the extraordinary deposit (DEE001) are determined from deposit slips for January 1. In many institutions, posting to accounts follows by several days the actual deposit. This has no significance in utilizing the model, as the user is concerned solely with the total dollar amount of the deposit. A second unknown in the equation is the amount of checks paid by the bank (CPD001). While this amount cannot be determined precisely, it is approximated very closely by Formula 2. The minimum bank balance required or desired is determined by the bank and the institution, as mentioned above.

Formula 2: Estimating Checks Paid by Bank

$$\begin{aligned} CPD001 = {} & .10\,CIS363 + .50\,CIS364 + .40\,CIS365 + CIE001 \\ & - (CPD365 - .10\,CIS362 - .50\,CIS363 - .40\,CIS364 - CIE365) \\ & - (CPD364 - .10\,CIS361 - .50\,CIS362 - .40\,CIS363 - CIE364) \\ & - (CPD363 - .10\,CIS360 - .50\,CIS361 - .40\,CIS362 - CIE363) \end{aligned}$$

where:

CIS360 through CIS365 is the dollar amount of checks issued (regular) each day December 26 through December 31.

CIE363 through CIE001 is the dollar amount of checks issued (extraordinary) December 29 through January 1.

Formula 2 assumes that the user has analyzed the number of days the checks are in float and has found that an average of ten percent of the regular checks issued clear the bank three days after the issue date, fifty percent clear the bank two days after the issue date, and the remaining forty percent clear on the day after issue.

In the example, the only checks-paid figure (CPD) that is estimated is that for checks paid on January 1 (CPD001). All other checks-paid figures (CPD) are actual and are determined by Formula 3. Actual figures for checks paid (CPD) are modified by the estimated figures. For example, if actual checks paid on December 31 (CPD365) are less than estimated, it is logical to assume that those checks not presented for payment on December 31 will be presented on January 1. The checks paid on

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January 1 (CPD001) are adjusted accordingly by that part of the formula reading:

— (CPD365 — .10 CIS362 — .50 CIS363 — .40 CIS364 — CIE365)

Checks paid on January 1 (CPD001) have been corrected for the check-paying activity for the three prior days. With a computer, this period could be extended to any desired point in the past. Error in the estimate should be negligible for periods of up to thirty days. However, hand calculations probably would be limited to a short period, based on analysis of the number of days that checks typically are in float.

The next step is the computation of the actual figure for checks paid by the bank (CPD).

Formula 3: Determining Actual Checks Paid by Bank

CPD365 = BBB365 + DEP365 + DEE365 — BBB001

Formula 3 states that the amount of checks paid on December 31 is determined by the beginning bank balance on that date (BBB365), plus any deposits on that day (DEP365 and DEE365), less the beginning bank balance on the next succeeding day (BBB001). Since the beginning bank balance on January 1 cannot be determined on December 31, the actual checks-paid figure for the current day cannot be determined until the following day. At that time, it replaces the estimated figure.

Other items of information developed by the model are determined by the following formulas:

Formula 4: Determining Balances Created by the Float

BFL001 = BBB001 — BKB001

where:

BFL001 are balances created by the float on January 1
BKB001 is the beginning book balance on January 1

Balances created by the float (BFL) are simply the differences between the bank balance (BBB) and the book balance (BKB) at any particular time.

Formula 5: Determining Book Balances

BKB001 = DEP365 + DEE365 — CIS365 — CIE365

The January 1 beginning book balance (BKB001) is determined by the December 31 beginning book balance (BKB365), plus December 31 deposits (DEP365 and DEE365), less checks written on that date (CIS365 and CIE365).

Formula 6: Estimating Beginning Bank Balance

BBB001 = BBB365 + DEP365 + DEE365 — CPD365

The January 1 beginning bank balance is determined by the December 31 account activity. This estimated figure will be replaced by an actual figure obtained from the bank on the morning of January 1.

Items Requiring a Daily Entry

Estimated Data

Possibly once a month, at the user's option, an estimate of the following data for each day of the succeeding month will be made:

DEP — regular deposit
DEE — extraordinary deposit
CIS — regular checks issued
CIE — extraordinary checks issued

There is also another term, EEE, which is an explanation of extraordinary items.

A form similar to that depicted in Figure 1 should be of help in the process. Utilizing this form, the entry for January 15 would be:

75-015, DEP015 = .432, CIS015 = .386, CIE015 = 1.500, EEE015 = Contractor Payment

recognizing that:

The year is 1975
The day is the 15th day of the year
The regular deposit is $432,000
The amount of checks issued (regular) is $386,000
The amount of checks issued (extraordinary) is $1,500,000
The explanation for issuing extraordinary checks is: Contractor Payment

It will be noted that input and output are in millions of dollars. Since dollar entries are rounded off to the nearer thousand, rounding errors may develop over time. A periodic comparison of the actual ledger balance with the beginning book balance (BKB) will disclose such a difference. If a substantial difference exists, it may be cleared by entering a phantom extraordinary deposit (DEE) or extraordinary check issued (CIE) to reconcile the two balances.

If a computer program is utilized, it should be designed so that a later figure under a particular item will replace an earlier entry. For example, suppose that on January 10 it is discovered that, due to inclement weather, a contractor will be about ten days late in completing that phase of the work for which the January 15 payment was scheduled. The January 10 entry would be:

75-010, BBB010 = 4.333, DEP010 = .291, CIS010 = .307, CIE015 = 0, CIE025 = 1.500, EEE015 = Contractor Payment

The entry CIE015 = 0 would have the effect of eliminating any entry for EEE015. An entry of DEE015 = 0 would have the same effect.

Actual Data

The actual data items entered daily will be the same as the estimated data items, with one exception—the daily beginning bank balance (BBB), as determined by Formula 6.

To provide for accuracy for the daily checks-issued figures and at the same time to allow the user to benefit from the model during banking hours, it is necessary to discontinue issuing checks dated the current day at some arbitrary time in the morning. To equalize the workload, additional checks may be issued after that time, dated, and mailed the following day. Prior notice usually will be given for the issuance of checks crucial to the current day, so that payment may be scheduled in advance.

($ Million) January			Deposit (Regular)	Deposit (Extraordinary)	Checks Issued (Regular)	Checks Issued (Extraordinary)	Explanation of Extraordinary Items
Day of the Year	Month	Week	DEP	DEE	CIS	CIE	EEE
001	1	T	.458	—	.324	—	
002	2	W	.469	—	.201	—	
003	3	T	.328	—	.376	—	
004	4	F	.216	1.000	.489	—	Matured Investment
005	5	S	—	—	—	—	
006	6	S	—	—	—	—	
007	7	M	.367	2.820	.604	—	State Support
008	8	T	.482	—	.316	—	
009	9	W	.358	—	.406	—	
010	10	T	.291	—	.316	—	
011	11	F	.489	—	.281	—	
012	12	S	—	—			
013	13	S	—	—	—		
014	14	M	.376	—	.534	—	
015	15	T	.432	—	.386	1.500	Contractor Payment
016	16	W	.887	—	.506	—	
017	17	T	.703	—	.256	—	
018	18	F	.546	—	.489	—	
019	19	S	—	—			
020	20	S	—	—	—		
021	21	M	.608	—	.289	.835	Loan Payment
022	22	T	.532	—	.624	—	
023	23	W	.611	—	.473	—	
024	24	T	.455	—	.506	—	
025	25	F	.305	—	.289	—	
026	26	S	—	—	—	—	
027	27	S	—	—	—	—	
028	28	M	.448	.250	.516	—	Insurance Recovery
029	29	T	.302	—	.614	—	
030	30	W	.504	—	.441	—	
031	31	T	.813	—	.122	2.122	Monthly Payroll
032	1	F	.323	—	.211	—	
033	2	S	—	—	—	—	
034	3	S	—	—	—	—	

Figure 1

An example of the output that should be expected from the model is shown in Figure 2. Items normally calculated by the model are assigned arbitrarily for January 1, 2, and 3 because they are based on activity of December 29, 30, and 31, and data are not provided for these days. The figures for January 4 and subsequent days are calculated using the formulas in the model. Underlined entries indicate a negative balance, except for investments (INV), where underlining indicates a recommendation to sell.

Entries of a Semipermanent Nature

In the examples presented, the minimum required or desired bank balance (CON) is .500. The number of days prior to the current day used in estimation of float (FLD) is determined by analysis of the number of days that checks in any significant amount are in float. In the example, checks are estimated to be in float for a period of three days and this entry would be FLD = 03. In actual practice, the number of days probably would be between ten and fourteen.

Percentage (of the dollar amount) of checks estimated to be presented for payment on the current day that were issued X days prior to the current day is symbolized by FL%. In the example, the entry would read:

FL%01 = .40, FL%02 = .50, FL%03 = .10

CES is the number of days prior to the current day to be used in estimating checks paid by the bank. In the example, three days have been used, and the entry would be CES = 03. For thirty days, the entry would be CES = 30. The number of months to be displayed by the computer printout is DIS. For example, DIS = 1 instructs the computer to print only the current month; DIS = 2, to print the current month and the next following month.

In order to give the model greater utility, there is an option for the user who, for legal or other considerations, does not wish to invest the float, but wishes to keep book balances at a minimum. For this user, provision is made for "zero-balance banking" (BKM). If an entry is made for BKM, Formula 1 is replaced automatically by Formula 7.

Formula 7: Minimum Balance Banking

INV001 = BKB001 + DEP001 + DEE001 − CIS001 − CIE001 − BKM

The minimum book balance is represented by BKM. For zero-balance banking, the entry would be BKM = 0.

Application of the Model

From an examination of Figure 2, it would appear that the following short-term cash investment program is feasible:

1. .750 ($750,000) invested January 4 to 7
   (1.250 to January 15)
2. 3.250 ($3,250,000) invested January 7
   (1.500 to January 31)
   (.500 to January 21)
3. .300 ($300,000) invested January 22 to 31

($ Million)			Beginning Bank Balance	Beginning Book Balance	Balance Produced by Float	Checks Paid by Bank	Deposit (Regular)	Deposit (Extraordinary)	Checks Issued (Regular)	Checks Issued (Extraordinary)	Short-Term Investment	Explanation of Extraordinary Items
Day of the Year	Month	Week	BBB	BKB	BFL	CPD	DEP	DEE	CIS	CIE	INV	EEE
001	1	T	.756	.382	1.138	.360	.458	—	.324	—	.354	
002	2	W	.854	.248	1.102	.726	.469	—	.201	—	.097	
003	3	T	.597	.020	.577	.592	.328	—	.376	—	.267	
004	4	F	.333	.028	.361	.283	.216	1.000	.489	—	.766	Matured Investment
005	5	S	—	—	—	—	—	—	—	—	—	
006	6	S	—	—	—	—	—	—	—	—	—	
007	7	M	1.266	.699	.567	.735	.367	2.820	.604	—	3.218	State Support
008	8	T	3.718	3.282	.436	.242	.482	—	.316	—	3.458	
009	9	W	3.958	3.448	.510	.428	.358	—	.406	—	3.388	
010	10	T	3.888	3.400	.488	.381	.291	—	.316	—	3.298	
011	11	F	3.798	3.375	.423	.361	.489	—	.281	—	3.426	
012	12	S	—	—	—	—	—	—	—	—	—	
013	13	S	—	—	—	—	—	—	—	—	—	
014	14	M	3.926	3.583	.343	.511	.376	—	.534	—	3.291	
015	15	T	3.791	3.425	.366	1.714	.432	—	.386	1.500	2.009	Contractor Payment
016	16	W	2.509	1.971	.538	.421	.387	—	.506	—	1.975	
017	17	T	2.475	1.852	.623	.449	.703	—	.256	—	2.229	
018	18	F	2.729	2.299	.430	.394	.546	—	.489	—	.381	
019	19	S	—	—	—	—	—	—	—	—	—	
020	20	S	—	—	—	—	—	—	—	—	—	
021	21	M	2.881	2.356	.525	1.528	.608	—	.289	.835	1.461	Loan Payment
022	22	T	1.961	1.840	.121	.116	.532	—	.624	—	1.877	
023	23	W	2.377	1.748	.629	.394	.611	—	.473	—	2.094	
024	24	T	2.594	1.886	.708	.530	.455	—	.506	—	2.019	
025	25	F	2.519	1.835	.684	.501	.305	—	.289	—	1.823	
026	26	S	—	—	—	—	—	—	—	—	—	
027	27	S	—	—	—	—	—	—	—	—	—	
028	28	M	2.323	1.851	.472	.640	.448	.250	.516	—	1.881	Insurance Recovery
029	29	T	2.381	2.033	.348	.205	.302		.614	—	1.977	
030	30	W	2.477	1.721	.756	.504	.504	.441	—	—	1.977	
031	31	T	2.477	1.784	.693	2.657	.813	—	.122	2.122	.133	Monthly Payroll
032	1	F	.633	.353	.280	.331	.323	—	.211	—	.125	

Figure 2

In using the model as a planning tool, it is not necessary to wait until the day an investment is to be made to program the investment into the model. For example, if it is determined on January 1 to program the above investments into the model, the following entry is necessary:

75-001, CIE004 = .750, EEE004 = Short-Term Investment, DEE007 = 3.570,[2] EEE007 = State Support. Matured Investment. Short-term Investment, CIE007 = 3.250,[3] DEE015 = 1.250. EEE015 = Matured Investment, Contractor Payment. DEE021 = .500. EEE021 = Matured Investment. Loan Payment, DEE031 = 1.800,[4] EEE031 = Matured Investment, Monthly Payroll, CIE022 = .300, EEE022 = Short-Term Investment

[2] $.750 million matured investment: $2.820 million state support.

[3] $1.250 million invested to January 15; $.500 million invested to January 21; $1.500 million invested to January 31.

[4] $1.500 million from investment of January 7; $.300 million from investment of January 22.

The results produced by these entries are shown in Figure 3. Additional investment opportunities may be possible if facilities for overnight investments are available.

A comparison of actual and estimated balances produced by the float (BFL) will be useful. If the actual balance should consistently be less than the estimated balance, it could be an indication that the Federal Reserve System check-processing activity has been accelerated. At the least, it will indicate to the user that estimates of duration of the float need revision. By supplying an accurate estimate of the amount of cash available for investment, when, and for how long, the model should provide an institution with the means to use its cash more efficiently, resulting in increased revenues.

($ Million)			Beginning Bank Balance	Beginning Book Balance	Balance Produced by Float	Checks Paid by Bank	Deposit (Regular)	Deposit (Extraordinary)	Checks Issued (Regular)	Checks Issued (Extraordinary)	Short-Term Investment	Explanation of Extraordinary Items
Day of the Year	Month	Week	BBB	BKB	BFL	CPD	DEP	DEE	CIS	CIE	INV	EEE
001	1	T	.756	.382	1.138	.360	.458	—	.324	—	.354	
002	2	W	.854	.248	1.102	.726	.469	—	.201	—	.097	
003	3	T	.597	.020	.577	.592	.328	—	.376	—	.267	
004	4	F	.333	.028	.361	1.033	.216	1.000	.489	.750	.016	Short-Term Investment Matured Investment
005	5	S	—	—	—	—	—	—	—	—	—	
006	6	S	—	—	—	—	—	—	—	—	—	
007	7	M	.516	.051	.567	3.985	.367	3.570	.604	3.250	.032	Matured Investment Short-Term Investment State Support
008	8	T	.468	.032	.436	.242	.482	—	.316	—	.208	
009	9	W	.708	.198	.510	.428	.358	—	.406	—	.108	
010	10	T	.608	.150	.488	.381	.291	—	.316	—	.048	
011	11	F	.548	.125	.423	.361	.489	—	.281	—	.176	
012	12	S	—	—	—	—	—	—	—	—	—	
013	13	S	—	—	—	—	—	—	—	—	—	
014	14	M	.676	.333	.343	.511	.376	—	.534	—	.041	
015	15	T	.541	.175	.366	1.714	.432	1.250	.386	1.500	.009	Matured Investment Contractor Payment
016	16	W	.509	.029	.538	.421	.387	—	.506	—	.025	
017	17	T	.475	.148	.623	.449	.703	—	.256	—	.229	
018	18	F	.729	.299	.430	.394	.546	—	.489	—	.381	
019	19	S	—	—	—	—	—	—	—	—	—	
020	20	S	—	—	—	—	—	—	—	—	—	
021	21	M	.881	.356	.525	1.528	.608	.500	.289	.835	.039	Matured Investment Loan Payment
022	22	T	.461	.340	.121	.116	.532	—	.624	.300	.077	Short-Term Investment
023	23	W	.577	.052	.629	.394	.611	—	.473	—	.294	
024	24	T	.794	.086	.708	.530	.455	—	.506	—	.209	
025	25	F	.719	.035	.684	.801	.305	—	.289	—	.023	
026	26	S	—	—	—	—	—	—	—	—	—	
027	27	S	—	—	—	—	—	—	—	—	—	
028	28	M	.523	.051	.472	.640	.448	.250	.516	—	.081	Insurance Recovery
029	29	T	.581	.233	.348	.206	.302	—	.614	—	.177	
030	30	W	.677	.079	.756	.504	.504	—	.441	—	.177	
031	31	T	.677	.016	.693	2.657	.813	1.800	.122	2.122	.133	Matured Investment Monthly Payroll
032	1	F	.633	.353	.280	.331	.323	—	.211	—	.125	

Figure 3

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