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Alan W. Heston

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Corporate Cash and Security Holdings: An Empirical Study of Cash,
Securities and Other Current Accounts of Large Corporations.

Alan Heston

October 9, 1961

ERRATA

- I. a. Page 11, 1st line, should read "in each year,"
- b. Page 55, 1st line, second paragraph, should read, "referred to as short"
- c. Page 58, 4th line, should read "actual cash balances are"
- d. Page 65, 5th line should read "that it is partial"
- e. Page 80, should read
- 1) " (A-1) $\Delta C_{it} = \alpha_{1i} +$ "
 - 2) " (A-2) $\alpha_{1i} =$ "
 - 3) "Substituting (A-2) for α_{1i} in "
- f. Page 81,
- 1) 3rd line should read, " be a stock or flow."
 - 2) 14th line, 2nd paragraph, " (A-3), and the "

II. Notes

- a. Pages 32, and 70 to 76, omitted.
- b. A reference read after writing is,

Meltzer, Alan, "Mercantile Credit Monetary Policy and the Size of Firms," Review of Economics and Statistics, November, 1960.

Meltzer, for aggregated data on firms, found similar relations to those described on pages 28 to 37, and 68-69, of this paper.

CORPORATE CASH AND SECURITY HOLDINGS

An Empirical Study of Cash, Securities and Other
Current Accounts of Large Corporations

Alan W. Heston

1962

A Dissertation

Presented to the Faculty

of the Graduate School of Yale University

in Candidacy for the Degree

of Doctor of Philosophy

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CHAPTER 1

SCOPE AND METHOD OF THE STUDY

Non-financial corporations hold about one-fourth of the currency and demand deposits in the United States and about one-sixth of the total federal government marketable securities. In 1955 this sector created for itself roughly \$ 50 billion in credit as accounts payable. In addition net receivables-----receivables minus payables---of this sector provided another \$ 30 billion in credit to non-corporate businesses, governments and consumers. An understanding of the short-run fluctuations of these and the other current accounts of corporations is important to an understanding of fluctuations in the economy as a whole.

This study concentrates on explaining short-period movements in cash and security holdings of an important segment of the corporate sector, large non-financial corporations. We will also be concerned with variations in the other current accounts of firms, and in particular with short-term bank loans and net receivables. Though some of our results relate to long-run behavior of large corporations, the study is oriented toward explaining short-run fluctuations in these accounts.

Any explanation of cash and security holdings will probably involve the level of transactions and the interest rate. In Chapter 2 a selected group of theoretical and empirical studies concerning the relation of cash balances, transactions, and the interest rate are reviewed, Chapter 2 also presents a theoretical discussion of the variables entering into the models of cash and securities. Chapter 3 presents empirical

tests of propositions about the relationship of cash and securities and the other current accounts. Empirical tests of more detailed models of cash and securities are presented in Chapter 4. In Chapter 5, the empirical results are analysed and their implications for monetary policy are discussed.

This study is empirically oriented. Because the models are a liberal dose of experimentation with data combined with, we hope, an equal dose of deductive reasoning, it seems appropriate to discuss the data and methodology of the study in this chapter. For a study of corporate cash and security holdings, quarterly or monthly time series observations for a number of different firms would be desirable. Unfortunately, annual observations were all that could be obtained. Nevertheless, the particular sample of firms used has a number of advantages including eleven observations per each firm. The sample was collected and the accounts standardized by the Board of Governors of the Federal Reserve System.¹ The sample consists of balance sheet and income statement information for 11 years, 1946 to 1956, for each of 209 firms.²

For the purpose of this study the sample was split into a group of 44 firms chosen randomly, which will be called the

¹A discussion of the data is given in the Federal Reserve Bulletin, (June, 1956), p. 580.

²The industries represented by the firms are food, tobacco, rubber, petroleum, chemicals, iron and steel, non-ferrous metals, automobiles, other transportation equipment, machinery including electrical, and retail trade. Also available but not used in this study are data for some 50 firms in electric power and railroads.

sub-sample, and the remaining group of 165 firms, which will be referred to as the main sample. Summary data for the subsample and main sample are presented in Table 1 which shows the mean dollar value for 1947-1955 of cash, securities, sales and total assets for the firms. The firms in the main sample are split into four size groups by total assets. Ratios of the variables are also presented by size class and for all firms. The 209 firms studied accounted for about 1/6 of the cash, 1/5 of the marketable securities and 1/6 of the sales of all United States non-financial corporations.

The purpose of using a subsample was to choose from several alternative relationships a form that could in turn be tested on the main sample.¹ Questions arise in empirical work as to the functional form in which to use variables and often neither theory nor conclusions from previous investigations is a helpful guide. Variables may be "deflated" by some size measure such as total assets or used in dollar terms. Theory does not tell which procedure is appropriate. Nor does it generally specify the way in which variables should be dated in relation to one another. A balance sheet item as of December 31, 1960, may in principle be related to a flow variable of 1960 or 1961 or some combination of these flows. Another question is the type of regression analysis to be used when a rectangular array of data such as the present sample is available.

¹The use of subsample when the original sample is large may also economize on computing facilities. In the present case, where the subsample is 1/5 of the total, one could, with equal computing time, examine at least 10 relations on the subsample and test the seemingly best relation on the remainder of the sample or estimate three different relationships on all the observations.

TABLE 1

1947-1955 AVERAGES OF CASH, SECURITIES,
SALES AND TOTAL ASSETS AND RATIOS FOR THE
FOR THE SAMPLE OF 209 FIRMS
(Dollar Figures in Millions)

	Main Sample Asset Size Groups				Total	Subsample	Total
	<u>10-70</u>	<u>70-180</u>	<u>180-500</u>	<u>500 and up</u>			
Number of Firms	41	42	39	43	165	44	209
(1) Average Cash Holdings	4.19	9.66	23.40	57.30	23.96	26.68	24.54
(2) Average Securities Holdings	2.19	6.44	17.60	69.10	24.36	23.44	24.15
(3) Average Sales	74.7	134.2	372.2	862.2	365.3	530.5	400.1
(4) Average Total Assets	33.8	92.2	219.0	746.5	275.3	296.4	282.0
(5) Cash to Sales Ratio (1)/(3)	.056	.072	.063	.066	.066	.050	.061
(6) Cash to Assets Ratio (1)/(4)	.124	.105	.107	.077	.087	.090	.087
(7) Securities to Sales Ratio (2)/(3)	.029	.048	.047	.080	.067	.044	.060
(8) Securities to Assets Ratio (2)/(4)	.065	.070	.081	.093	.089	.079	.081
(9) Sales to Assets Ratio (3)/(4)	2.21	1.46	1.70	1.15	1.33	1.79	1.42

Is it necessary to run a separate regression for each firm or can firms be expected to share common values of some or all parameters?

Another advantage of working with a pilot group of observations is that by reducing the number of relations examined for the main sample, it gives more meaning to relations tested on the main sample. Because a large number of regression equations were estimated using the data of the subsample, some of the relations could appear good by chance rather than because a good formulation of the behavior of firms had been found. The test of whether a good fit on the pilot sample is due to a good description of behavior or to chance must employ an independent group of observations such as those provided by the main sample. The process of hypothesis testing does not end here. As will be indicated, some of the formulations suggested by the subsample did not prove significant on the main sample and in turn the main sample also suggested further hypotheses. The principal conclusions from the subsample are incorporated in the theoretical discussion of Chapter 2 and the models of Chapters 3 and 4.

CHAPTER 2

SOME VARIABLES INFLUENCING CORPORATE CASH AND SECURITY HOLDINGS

The variables discussed in this chapter are by no means all those that will affect the cash and security holdings of firms. The discussion is mainly concerned with short-run influences on cash and securities of an individual firm. Variables that may cause cash and security holdings to differ among firms are largely neglected in the treatment. Nor will the treatment of short-run influences on a firm's cash and security holdings attempt to be exhaustive. The first part of this chapter discusses the level of transactions and the bill rate, while the second part treats the interrelationships among cash and securities and the other current accounts.

A. The Level of Transactions and the Interest Rate

Interest rates and the volume of transactions have frequently been used to explain cash holdings and, to some extent, security holdings, and there seems no reason to break with tradition. In particular there have been a number of analytical and empirical studies of the relation of cash holdings to the volume of transactions, though the exact form of the relation has not generally been established.¹

¹An extensive bibliography of empirical studies on the velocity of money is contained in a recent study by Richard T. Seldon, "Monetary Velocity in the United States," (Chicago, University of Chicago Press, 1955), in Studies in the Quantity Theory of Money, Milton Friedman, editor, pp. 179-195. A discussion of the relation of velocity to interest rates is contained on pp. 195-199.

William Baumol and James Tobin have argued analytically that cash held for transactions purposes will rise less than proportionately to the volume of transactions. Tobin emphasizes (cont'd. on next page)

The relation between money and interest rates has also received extensive theoretical investigation; however, this literature will not be discussed here. The general view taken in this study is that corporations hold cash because the transactions costs into and out of short-term assets exceed the return on these assets for the period they will be held.² The cost of purchasing government securities is quite small, varying from about 5 cents per \$1,000 to 30 cents per \$1,000 depending on the thickness of the security market and the size of the purchase.³ Suppose a firm receives \$1 million today and

1 (cont'd from previous page)
that other short-term assets are suitable for transactions balances, and both Baumol and Tobin emphasize the inverse relation that may be expected between the proportion of cash in transactions balances and the interest rate. See Baumol, "The Transactions Demand for Cash: An Inventory Theoretic Approach," Quarterly Journal of Economics, (November, 1952), and Tobin, "The Interest Elasticity of the Transactions Demand for Cash," Review of Economics and Statistics, (August, 1956).

If the relation between cash holdings and transactions is non-proportional, then estimation of a relation that is additive in the logarithms of the variables will often provide a better fit than estimation of a relation that is additive in the variables. Avram Kisselgoff, for aggregated data on a sample of corporations from 1921 to 1939, has used a relation between corporate cash and transactions that was additive in the variables. See "Liquidity Preference of Large Manufacturing Corporation (1921-1939)," Econometrica, (October, 1945).

More recently, Friedman has estimated an aggregate relation between cash and income using an equation that was additive in the logarithms of the variables. See "The Demand for Money: Some Theoretical and Empirical Results," Journal of Political Economy, (August, 1959). For the economy as a whole cash held for all purposes appears to have risen more than proportionally to income.

²It is recognised that firms may hold demand deposits as compensating balances with banks from which they customarily borrow. Although no attempt is made to incorporate compensating balances into the analysis, the possible effect of these balances on our results is discussed in Chapter 5.

³Broker's charges begin at \$2.50 per \$1,000 for government securities and decrease fairly quickly with the size of the (cont'd on next page)

must make a \$1 million payment in a week. Even if the costs of buying and selling a government security earning 4% were as high as 60¢ (30¢ in the 30¢ out) per \$1,000, there would be an excess of return over costs for holding \$1 million of that security for a week.

The most important short-term asset that firms buy is Treasury bills. The tax anticipation certificate is a security especially suited to absorbing one type of excess funds of firms. In addition repurchase agreements with government bond dealers and commercial paper of sales finance companies are especially tailored to the maturity needs of corporate lenders. Large firms are able to earn interest on temporary excess funds for periods as short as a few days by use of either of these arrangements.¹

3 (cont'd. from pervious page)
purchase. When the size of purchase is \$1 million of bills (or somewhat less for bonds) it is possible to deal directly with government bond dealers. The implicit transactions costs are the difference between bid and ask yield (for bills) or price (for bonds) of the government security dealers. This may vary according to the state of the money market and the length to maturity of the security. In terms of the purchase price of a bill the difference will frequently run 5¢ to 10¢ per \$1,000. For other securities the difference may be as high as 1/32 of one percent of the price, or roughly 30¢ per \$1,000. Contrary to the example above, the implicit transactions cost includes both purchase and sale of securities. For a more detailed discussion of the buying and selling of securities by dealers see Carl H. Madden, The Money Side of "the Street", (New York, Federal Reserve Bank of New York, 1959), pp. 47-72.

¹Repurchase agreements are described by Hyman Minsky, "The Central Bank and Money Market Changes," Quarterly Journal of Economics, (May, 1957), pp. 176-78, and by Madden, op. cit., pp. 61-62. Madden also describes the selling of their own commercial paper by sales finance companies. He says, "While most sales finance companies still market their notes through dealers, nine of the largest now sell them directly to investors, and in doing so have fashioned a new market for themselves. The dealer function--locating buyers and arranging purchase terms--is performed within the finance company organization. In effect the companies make a general offer to sell their IOU's at the various rates of discount, in any desired denomination, for any number of days from 5 to 270, and sometime more. The notes are thus completely tailor-made for the customer." (p. 69).

Empirical studies employing aggregative time series data have found an inverse relation between cash holdings and the interest rate.¹ Critics of these studies have underlined some of the statistical problems of isolating the effects of interest rates on cash holdings but for aggregative data an inverse relationship appears well established. A statistical difficulty with time series analysis of the effects of interest rates is the typical positive correlation between income and interest rates or the existence of similar trends in income,

¹Kisselgoff, op. cit., related the interest rate to aggregate cash holdings of a sample of corporations for the period 1921 to 1939. He also found a strong inverse relation between "free" cash and the interest rate. Free cash is defined as current cash holdings minus the product of current cash holdings and the ratio of cash to transactions in 1929, a year when the cash-transactions ratio was at a minimum for the period. This procedure in effect assumes that free cash in 1929 was zero. Kisselgoff used some of the data of a study of businesses by the National Bureau of Economic Research. One of the monographs from this study, Corporate Cash Balances, 1914-1941, (New York, National Bureau of Economic Research, 1945), Chapters 4 and 5, by Friedrich Lutz also employs the concept of free cash and his results support an inverse relation between free cash and interest rates. James Tobin examined the relation between the prime rate and free cash (calculated in a similar manner) for the economy as a whole during the pre-World War II period and found an inverse relationship. See his "Liquidity Preference and Monetary Policy," Review of Economics and Statistics, (May, 1947), pp. 130-131. Andrew Stedry ["A Note on Interest Rates and the Demand for Money," Review of Economics and Statistics, (August, 1959), pp. 303-307], has extended Tobin's computations through 1958 and has demonstrated the need for considering wealth in any long-run analysis of the demand for money. L. S. Ritter, ["Income Velocity and Monetary Policy," American Economic Review, (March, 1959), pp. 120-129], has examined quarterly cash and free cash holdings for the economy as a whole (third quarter of 1957 represents the low point of the ratio of money to real income for the period) for the period 1948-1957, finding an inverse relation of cash holdings to the bill rate. Similar results were found by Henry A. Latané, "Cash Balances and the Interest Rate--A Pragmatic Approach," Review of Economics and Statistics, (November, 1954), pp. 456-60. Phillip Cagan presents related results, ["The Demand for Currency Relative to the Total Money Supply," Journal of Political Economy, (August, 1958), pp.303-329], finding that the interest rate on demand and time deposits has been an important determinant of the ratio of currency to total demand and time deposits that the public wishes to hold.

cash and interest rates.¹ While it is likely that there will be some positive relationship between interest rates and the level of transactions of individual firms, it is doubtful that the relations will be as strong as for aggregative data. In addition, interest rates and the level of transactions are probably interdependent in the aggregate, and this need not be the case for the individual firm.² While there are likely to be estimating difficulties for micro-data not present in macro-data, an objective of this study is to estimate the effect of interest rates on money holdings in a way that avoids many aggregate time series problems.

The models of cash and security holdings developed below are theoretically concerned with the interest rate on Treasury bills, tax certificates, commercial paper, repurchase agreements, other short-term securities, and short-term bank loans. Unfortunately, the short-term rates earned and paid are not available for the individual firms of the sample. For any particular asset or liability, it is therefore necessary to use the same

¹The study of Kisselgoff, op. cit., was criticized by Acheson J. Duncan, "'Free Money' of Large Manufacturing Corporations and the Rate of Interest," Econometrica, (July, 1946), p. 251, because of a similar trend of both free cash and interest rates in the data that Kisselgoff used. Clark Warburton, "Monetary Velocity and the Rate of Interest," Review of Economics and Statistics, (August, 1950), pp. 256-257, has similarly argued that the results of Tobin's study (see previous footnote) could be interpreted in terms of the correlation of unrelated trends rather than a functional relationship between money and interest rates.

²Latané, op. cit., explicitly treats this problem in his study. He regresses the reciprocal of the rate of interest ($1/r$) on the ratio of money to income (M/Y), and also regresses (M/Y) on ($1/r$). He uses an average of these regression lines as an approximation of the true relationship among these variables.

rate for all firms in all years, and because the rates on short-term assets and liabilities will be highly correlated, a choice must be made as to which rate to use. The bill rate has been chosen because a major concern of this study is the substitution of cash for short-term securities, and a major portion of these securities are Treasury bills. As the bill rate is correlated with other short-term rates, there will not be much harm in using the bill rate as "the interest rate" in applications where it may be that other rates would be more relevant.

B. The Relationship of Cash and Securities to Other Current Accounts.

The current accounts of firms consist of three principal liabilities, accounts payable, taxes due, and short-term bank loans, and four principal current assets, cash, securities, accounts receivable, and inventories. There are other current assets and liabilities that for any particular firm or group of firms may be more important than some of the above, but we will limit the present discussion to the above accounts.

Three of the accounts mentioned are unlikely to be influenced by the levels of cash and security holdings. These are taxes due, accounts receivable, and accounts payable. Taxes due are in effect a short-term interest free loan of the government to firms making profits. Although firms may always pay their tax liability before it is due, there is no reason for them to do so. The firms should always let the taxes due liability be as large as legally possible, since these funds

can always earn the interest rate on tax certificates, and at worst earn zero as cash.¹ Accounts receivable should also be unaffected by the levels of cash and securities. The terms on accounts receivable are set by the firm and are stable in the short-run. If, for example, the interest rate changes, it is not business custom to alter the terms on their accounts receivable.² This means that in the short-run a firm's receivables are largely determined by the customers of the firm. A firm's customers may be expected to increase their use of receivables as they increase their purchases from firms and as the rate of interest rises.

The relation between receivables and the interest rate occurs because of the stability of the terms on receivables over the cycle.³ Firms in effect offer a given number of days credit

¹Firms may hold these funds as cash in the form of compensating balances.

²Part of the firms in the present sample are engaged in retail trade and it will be true that some retailers alter the terms on their accounts receivable in relation to business conditions. In particular, installment credit terms are subject to cyclical change, though firms frequently do not finance this credit themselves. While the statement in the text needs to be qualified to take account of installment credit, the fact that a few firms in our sample do alter their terms on receivables over the cycle will not be very important to the subsequent analysis.

³Though terms vary widely among firms, probably the most frequent terms on accounts receivable are a 2% discount for cash payment by the tenth day of the month after purchase. Other terms on accounts receivable are presented by Charles W. Gerstenberg, Financial Organization and Management of Business, revised edition, (New York, Prentice-Hall, 1934), p. 458. Industries where the delivery date is somewhat uncertain often give longer terms on receivables. The striking example is capital goods producers whose turnover of receivables before World War II was almost twice as long as most other industries. The rate of turnover of receivables is given for various industries by Walter Chudson, Pattern of Corporate Financial Structure, (New York, National Bureau of Economic Research, 1945), pp. 11-43, and Albert Koch, in Financing of Large Corporations, 1920-1939, (New York, National Bureau of Economic Research, 1943), pp. 53-56.

at a zero interest rate no matter what the cost of borrowing funds. When the costs of borrowing rise, this should induce customers who have not charged their purchases to do so. Those customers who have for convenience paid invoices early upon their arrival are led, by the higher costs of cash, to consider delaying payment until the tenth of the month. Some customers might not take the cash discount if paying for purchases by the tenth of the month requires securing a new bank loan.¹ These actions by customers in response to interest rate changes may cause quite a large increase in accounts receivable.²

It is possible to test whether the customers of large firms, and large firms as customers, increase their use of trade credit in relation to the interest rate. Given the level of

¹Charles Silberman, in "The Strange Money Shortage," Fortune, (March, 1957), p. 123, says, "Big companies have had to let their receivables rise for several reasons. Many small firms, for example, have stopped discounting their bills. Why pay in ten days to claim a flat 2 per cent discount, many treasurers reason, if they have to borrow from the banks in order to do so? Similarly, larger companies that still discount their bills now delay payments until the tenth day (or whenever the discount runs out), rather than pay as soon as the invoice is received."

²If the terms of receivables are such that a purchase on the first of a month can be delayed to the 10th of the next month, then the maximum length of turnover of receivables is roughly 40 days, assuming the cash discount is taken. Thus the turnover of receivables can range from zero days (no one charges) to 40 days, or from zero to roughly 1/9 of annual sales. Denoting receivables by R, annual sales by S, and the average turnover of receivables by T, then $R/S = T/365$. If T moves from 28 to 30 days for a firm with \$500 million in sales, then receivables will increase by 3.7 million. Silberman reports that, in 1956 and 1957, firms found their receivables lengthening considerably. Continental Can, for example, found its T moving from 26 to 28 days in a year, requiring nearly a \$10 million increase in receivables, while other firms reported 10% or larger increases in T in a year. See Silberman, "The Strange Money Shortage," Fortune, (March, 1957), p. 258.

sales it is expected that the large firms of this sample will find their receivables rising with the interest rate. And given the level of purchases of the firms of this sample it is expected that their accounts payable---the credit they take as customers---will rise with the interest rate. The results of these tests are reported in Chapter 3.

Why should firms leave the terms on accounts receivable stable during a cycle? The reason is that the return on increased sales is so high relative to costs of borrowing for large firms that they are quite willing to allow their customers to take what credit they wish. If the return from increased sales is high then the return on inventory investment, if the alternative is lost sales, will also be very high when sales are rising. Since non-financial corporations are selling goods, and the return from increased sales is likely to be high for large firms, relative to borrowing costs and also to the bill rate, firms are likely to give priority in short-run adjustments to inventories. That is, when there is a sales increase firms will first attempt to adjust their inventories to a higher level and only then worry about adjusting cash and securities to the new level of sales. If this is a reasonable description of firm behavior, then inventories may be assumed to be unaffected in the short-run by the levels of cash and security holdings and the effect of inventories on cash and security holdings may be examined without simultaneously considering the influence of cash and securities on inventories.¹

¹This statement may be amended slightly. Once firms have at least partially adjusted their inventories to a higher level of sales, and firms are beginning to adjust their cash and securities, there may well be some feedback from the cash and security position to the inventory position. Such feedback means (Cont'd on next page)

The interest here in assuming that net receivables and inventories are not influenced in the short-run by the levels of cash and security holdings is that it allows us to use net receivables and inventories as independent variables in regression equations explaining cash and security holdings. An indirect test of this assumption is incorporated in the models used to explain cash and security holdings. These models test whether firms adjust their cash and security holdings to their desired levels immediately or with a lag. If cash and securities are only adjusted to desired levels with a lag, it is evidence consistent with the assumption that short-run inventory adjustments of the firm are given priority in time to adjustments of cash and securities.

Having put the cart before the horse we can turn now to the more interesting question of why inventories and net receivables might enter into an explanation of cash and security holdings. When a firm's sales increase, receivables rise, and the return on inventories, inventory investment and accounts payable also rise. Since we are here considering large firms, the impact of a sales increase on net receivables is decidedly positive.¹ Thus during a business expansion a source of finance

1 (cont'd from previous page)
that inventories are affected by the levels of cash and securities. However, so long as the influence on inventories of cash and securities comes at a different time from the influence of inventories on cash and securities, it is not necessary to consider these accounts simultaneously.

¹In the present sample, on the average, receivables were 13.9% of total assets, payables, 6.7% and hence net receivables, 7.2% of total assets. The average annual amount of net receivables for all 209 firms is about \$4.3 billion.

is needed for the increase in net receivables and inventories. One obvious and traditional source of such finance is short-term bank loans. As an alternative to short-term bank loans, firms could borrow long-term and hold funds as securities when sales were low and as inventories and net receivables when sales were high.

It is an hypothesis of this study that firms will find it economical to substitute between the use of securities and short-term bank loans in the finance of these periodic increases in net receivables and inventories. The reason it may be economical for firms to use securities is that the rate on short-term bank loans during the peak of a cycle may be high relative to the long-term rate at the time when firms borrow long-term. In Appendix 1 it is shown that substitution between securities and short-term bank loans will depend on the rate on long-term debt, short-term bank loans and bills, and on the character of the periodic fluctuations in inventories and net receivables. In particular it is shown that the more quickly inventories and net receivables are accumulated during a cycle the more likely are firms to use securities. The model developed in Appendix 1 is consistent with the empirical observation that firms predominantly use long-term sources of finance for their stock of net receivables and inventories.¹

¹The average of the ratio of receivables plus inventories to total assets for the 165 firms is .3886, while the average of short-term bank loans to total assets is .0237. As short-term bank loans are only 6.1% of the stock of net receivables and inventories, it is clear that large firms prefer or find more readily available other sources of finance than short-term loans.

It is expected, then, that inventories and net receivables will be inversely related to security holdings, and that the causation is one way running from inventories and net receivables to securities. It is also expected that cash holdings will bear the same relation to these variables and that both cash and security holdings will be substitutes for short-term bank loans. Since security holdings of firms do earn a return and can be liquidated without capital loss at fairly short notice, it is expected that the above relations will be much stronger for securities than cash.

These are the relationships between cash and securities and the other current accounts that are expected over a firm's inventory cycle. As the receipts of firms are not particularly stable, it is important that they be held constant if the above relationships are to be observed. Thus if a firm has an unexpectedly large inflow of receipts during an inventory expansion it may be in a position to expand inventories and, in addition, augment its cash and security holdings. If a measure of unexpected receipts is not included as a variable in the model, we would observe in the above example a positive relation between inventories and cash and security holdings rather than the negative relation that is expected. The variable measuring unanticipated receipts should be positively related to cash and security holdings and negatively related to short-term bank loans.

The reasons that firms may temporarily put receipts into cash and securities are: a). there are no liabilities that may be immediately retired whose borrowing costs are as great as

the return on bills (e.g., there is no point in using unexpected receipts to reduce accounts payable since, assuming the cash discount is taken, this liability costs less than the return on bills), and b). the firm has not had time to put money into other more lucrative assets. In short, the firm may get "caught" with an unexpected influx of funds which it must hold in a form yielding a relatively low return. As usual it is argued that the rational firm would hold as much as possible of such receipts in the form of securities rather than cash.

The discussion of this section may be summarized as four propositions about the current accounts of firms. If a proposition is an assumption that is to be tested, then propositions (1) and (3) are more assumptions than propositions of this study.

1). Short-run fluctuations in accounts payable, accounts receivable and taxes of firms will not be influenced by the level of cash and security holdings.

2). When interest rates rise, accounts receivable may be expected to rise with the level of interest rates for the same reasons that firms will increase their use of accounts payable, namely, the terms on accounts receivable are stable in the short-run.

3). The inventory position gets first priority in short-run adjustments of firms and any influence of securities and cash on the desired inventory holdings will come at a different point in time from the influence of inventories on cash and securities. Thus, these accounts do not have to be considered as simultaneously determined in the short-run.

4). Securities and, to a lesser extent, cash will be used as a substitute for short-term bank loans in the financing of short-period increases in inventories and net receivables.

This leaves us with an explanation of cash and security holdings involving some of the other current assets and liabilities, the level of transactions, and the interest rate. There are other variables that might be considered, but we have introduced only one, a measure of unexpected receipts. It is felt that such a variable is important because in the short-run unexpected receipts are apt to appear as cash or securities whether or not the firm wishes additional cash and securities. In Chapter 3 tests are made of proposition (2) and (4). In Chapter 4 lagged adjustment models of cash and security holdings are estimated. These estimates should provide some evidence about the inventory assumption, and test the relation of cash and securities and the explanatory variables.

CHAPTER 3

A. Notation and General Description of Tests

This chapter is divided into three parts. The notation and definitions of variables that are used in all of the empirical work are presented in this section. In the second part we report the results of estimating a canonical correlation, which attempts to test in a very general way the validity of the short-run adjustment model presented in the previous chapter. The third part reports the results of testing the hypothesis that customers of firms increase their use of accounts receivable as a function of the interest rate.

Definitions of Variables: All Variables are a Ratio to Average Total Assets of the Firm, except the Bill Rate.

Notation	Definition of Variable
T	Expected level of transactions of a firm in year t is measured by current sales.
B	The rate of interest. It is the 90 day treasury bill rate, average of October, November, and December rates in year t.
C	Cash holdings of firms includes demand deposits, time deposits (negligible) and currency.
S	All fixed claim marketable securities. Does not include equities.
D	Accounts payable of firm.
L	Short-term bank loans of maturity under a year.
R	Accounts receivable.
I	Inventories.
P	Retained earning, i.e., profits after taxes minus cash dividends.
N	Taxes due--a balance sheet item.

- "i" The subscript "i" on a variable is an index running over the number of firms, and for this sample $i = 1, 2, \dots, 165$
- "t" The subscript "t" on a variable is an index of time. $t = 48, 49, \dots, 56$, i.e., there are 9 observations on each variable for each firm. A variable subscripted "t-1" will be observations on the variable from 1947 through 1955.
- " The symbol " indicates an estimate.
- Δ Denotes a one year change in a variable. E.g., for a stock, $\Delta C_{it} = (C_{it} - C_{it-1})$, so ΔC_{455} is the change in the stock of cash between Dec. 31, 1954 and Dec. 31, 1955 for the 4th firm in the sample. Similarly for flow variables, ΔP_{13249} , is retained earnings for the year ended Dec. 31, 1949, minus retained earnings for the year ended Dec. 31, 1948 for the 132nd firm in the sample.

A few comments should be made about the measures of variables used. Sales is used as a measure of transactions because there appears little difference between the two variables in annual data. It is possible to derive a measure of transactions from balance sheet and income data that includes all but interannual purchases and sales of assets. When such a measure of transactions is computed from annual data it is very nearly the same as sales.¹ In the remainder of this study

¹For the subsample of firms a concept of transactions was used that measured outpayments associated with current production. The correlation (R^2) between the level of sales and the level of transactions was .982 and for changes in sales and changes in transactions, R^2 was .905. When sales and the measure of transactions were used in regressions the coefficients were virtually the same. A more inclusive concept of transactions was used by Lutz and Kisselgoff and is described in Lutz, op. cit., Appendix B. Kisselgoff, op. cit., p. 335, who uses a part of the data used by Lutz, comments that there was little difference between this concept and sales.

the terms "transactions" and "sales" will be used interchangeably.

The balance sheet information on securities does not provide a breakdown by maturity or type of security. Included in the measure of securities are corporate and government bonds, tax certificates, bills, notes and commercial paper. A survey by Fortune magazine of 276 large corporations indicates that typically the securities held were short-term Treasury obligations.¹

Finally, all variables for each firm have been divided by a size measure that is constant for each firm over all years but differs among firms. The size measure used was average total assets for each firm for the period 1947-1955. This procedure seems advisable because, in cross section data for firms, the variance of the dependent variable among firms is frequently related to the size of the independent variable. The residual term in a linear relationship among variables such as we will be using, is likely to be larger for larger values of the independent variable; this violates the assumption of homoscedasticity underlying estimates of the standard errors of regression coefficients.² For firm data stated in dollar magnitudes,

¹Charles E. Silberman, "The Big Corporate Lenders," Fortune (August, 1956), pp. 111-114.

²The observations on an individual firm over a short period of years may be considered as a sample of observations from the population of all observations that could have been observed for the firm during the period. The true error term in a regression equation estimated for a firm from this population is assumed to be unrelated to the independent variable. If the assumption of homoscedasticity was not met for each individual firm it would be appropriate to divide all variables by a size variable that differed between observations for each firm as well as differing among firms.

the size of most independent variables is related to the size of the firm. Dividing all variables by a size measure is intended to reduce the size of the true error component of the estimated residuals.

In the following sections and Chapter 4 the least squares estimates of several regression equations will be presented. For each regression equation the estimates of the coefficients and their standard errors, R^2 , and the F ratio for the equation will be presented. The standard errors of the regression coefficients allow us to test whether a coefficient is different from any particular value. For all coefficients it is reported whether the estimated value is different from zero at the 5 and 1% levels of significance.¹

R^2 is the percent of variance of the dependent variable of a regression equation that is explained by the independent variables. Contrary to usual usage we will always use correlation and correlation coefficient to refer to the value of R^2 . This should not lead to any ambiguity since R, which in conventional usage is the correlation coefficient, is not used in any of the discussion. To test whether R^2 is significantly different from zero we compare the "F" value of a regression equation with the critical value of F at the 5 and 1% levels.²

¹Because N is large for the present tests, the critical value of "t" (the ratio of a coefficient to its standard error) is virtually the same for all coefficients in all regression equations, namely 1.96 and 2.58 at the 5% and 1% levels respectively.

²The "F" value of a regression equation is the ratio of the explained variance of the dependent variable divided by the degrees of freedom (minus 1) used in estimating the regression equation to the unexplained variance divided by the remaining degrees of freedom.

In the use of canonical correlation it is not possible to make the usual tests of significance, and our hypothesis has to be accepted or rejected on the basis of a sign test and to some extent intuitive judgement. Where tests of significance are used, we reject the null hypothesis that a coefficient is equal to zero only if the critical value of F or t we have obtained is greater than the critical value of F or t at the 1% level. Although we report results at the 5% level it is felt the 1% level is appropriate in this study because of the large number of observations.¹

B. Canonical Correlation Analysis.²

Proposition 4 of Chapter 2 considered the interrelationships of cash, securities, and short-term bank loans, and net receivables, inventories and unanticipated receipts. One set of equations that could be used to analyze these relationships is,

$$(3-1) \quad \Delta C_t = \alpha_{11} + \alpha_{12} \Delta I_t + \alpha_{13} \Delta(R-D)_t + \alpha_{14} \Delta(P - N)_t + u_{1t}$$

$$(3-2) \quad \Delta S_t = \alpha_{21} + \alpha_{22} \Delta I_t + \alpha_{23} \Delta(R-D)_t + \alpha_{24} \Delta(P-N)_t + u_{2t}$$

¹The computations were carried out at the Yale University Computing Center, and the availability of a computer greatly eased the task. The calculations were further facilitated by the availability of computer programs. I am particularly grateful to Harold W. Watts and Donald D. Hester of the Cowles Foundation for Research in Economics at Yale University. Watts is to be thanked for his extremely useful set of programs for estimating regression equations, and Hester for his program for canonical correlation.

²Canonical correlation theory has been described by Prof. Harold Hotelling, "Relations Between Two Sets of Variates," Biometrika, Vol. 28, (1936), pp. 321-377.

$$(3-3) \quad \Delta L_t = \alpha_{31} + \alpha_{32} \Delta I_t + \alpha_{33} \Delta(R-D)_t + \alpha_{34} \Delta(P-N)_t + u_{3t}$$

where u_1 , u_2 , and u_3 are residual or error terms, and the α 's are parameters. The change in retained earnings plus the change in taxes owed is used in this set of equations as a measure of unanticipated receipts in any year. As we will discuss in Chapter 4 there is no particular reason to suppose that $\Delta(P+N)$ is either a good or bad approximation of unanticipated receipts.

These three equations do not allow us to explore the relationships among securities, cash, and bank loans. We could, if it is true, specify a system of equations that would let us take account of the interrelationships among securities, cash, and short-term bank loans. A simpler approach which answers our questions about C, S, and L, is to use the method of canonical correlation.

We define the variable "q", where $q_t = \beta_1 \Delta C_t + \beta_2 \Delta S_t + \beta_3 \Delta L_t$, and where the β 's are weights. And the variable "r", where $r_t = b_1 \Delta I_t + b_2 \Delta(R-D)_t + b_3 \Delta(P-N)_t$, and the b 's are weights. The canonical weights are those values of the β 's and b 's which maximize (or give the canonical) correlation between q and r.¹ The expected signs of the canonical weights are that inventories, net receivables and short-term bank loans will have the same sign, and that cash, securities, and unexpected receipts will all have the opposite sign. This pattern of signs is consistent with the substitution of short-term bank loans for cash and securities in the financing of inventories and net receivables, and one test with the canonical correlation is a sign test.

¹The canonical weights are invariant up to a linear transformation and the computing method used makes use of this property.

Also some subjective judgement about the hypothesis can be made from examining the correlation coefficients. Let us denote the squared canonical correlation coefficient as \underline{R}^2 and denote the largest R^2 occurring in the three regression equations, (3-1), (3-2), and (3-3) as R_m^2 . \underline{R}^2 must always be greater than or equal to R_m^2 . If \underline{R}^2 is not much larger than R_m^2 then the hypothesis may be rejected. While if the sign test is passed, and \underline{R}^2 is considerably larger than R_m^2 , then the hypothesis is accepted. Because the distribution of the differences between \underline{R}^2 and R_m^2 is not known, it is not possible to test for a significant difference in these coefficients, and only rough judgements can be formed.

The results of estimating the regression equations and the canonical correlation are presented in Table 2. The "F" values are all significant at the 1% level which means that the three regression equations each explain a significant amount of the variance of the dependent variables. The regression coefficients are all significantly different from zero at the 1% level except net receivables for cash and all of the expected sign.

Examination of the signs of the b's and β 's from the canonical correlation show that net receivables, inventories, and short-term bank loans have negative signs, and cash, securities, and unexpected receipts positive signs. Thus when inventories and net receivables rise, short-term bank loans go up, and cash and securities go down. As this is the expected pattern of signs the sign test is consistent with the conclusion that cash and securities are substitutes for short-term bank

TABLE 2

ESTIMATED REGRESSION EQUATIONS AND CANONICAL CORRELATION

Variables	Regression Equation (3-1)	Regression Equation (3-2)	Regression Equation (3-3)	Canonical Correlation and Canonical Weights***
Intercept	.0025 (.0009)*	.0060 (.0012)*	-.0050 (.0011)*	
Change in Cash (ΔC)	1.0			1.000
Change in Securities (ΔS)		1.0		1.132
Change in Short-term Bank loans (ΔL)			1.0	-1.460
Change in Inventories	-.0518 (.0134)*	-.1783 (.0182)*	.3084 (.0159)*	-.705
Change in Net Receivables [$\Delta(R-D)$]	-.0511 (.0208)**	-.1728 (.0282)*	.3159 (.0247)*	-.709
Change in Retained Earnings and Taxes [$\Delta(P+N)$]	.1978 (.0162)*	.3830 (.0221)*	-.1303 (.0193)*	.824
R ²	.093*	.198*	.290*	
F	50.64	121.67	201.19	
degrees of freedom	1481	1481	1481	
Squared Canonical Correlation Coefficient				.440

*Significantly different from zero at 1% level.

**Significantly different from zero at 5% level.

***These weights are based on a weight of 1.000 for cash. Because of the computational method used, these weights will differ by an uninteresting factor of proportionately from the canonical weights.

loans in the finance of inventories and net receivables. The squared canonical correlation coefficient of .440 exceeds by 15% the value of R_m^2 , which was .290 in equation (3-3). The difference between these coefficients appears substantial and is interpreted as evidence that firms prefer to use combinations of securities, cash, and short-term bank loans, for short-term finance, rather than any one of these accounts alone.

What of the importance of cash, securities, and bank loans relative to each other in the finance of inventories and net receivables? The canonical weights, the β 's tell us that short-term bank loans are still used more relative to securities and cash, as short-term bank loans have the largest weight. This conclusion is important because it means that large firms do have short-term credit requirements for which they are apparently dependent on bank loans.

Part C. Relation of Accounts Payable and Net Receivables to the Bill Rate

In the course of the discussion of the behavior of accounts receivable it was suggested that large firms as customers will tend to increase their use of trade credit as the interest rate rises. The test of this proposition performed here is fairly simple, and should not be considered an attempt to specify a complete explanation of accounts payable. It is expected that given the level of purchases from other firms, a firm would increase its accounts payable as the interest rate rises. This hypothesis may be expressed,

$$(3-4) \quad D_t^* = \alpha_{41} + \alpha_{42}(T + \Delta I)_t + \alpha_{43}B_t + u_{4t}$$

where D_t^* is desired accounts payable, and u_{4t} is the error or residual term. We do not have data on purchases by the firm, but the level of sales plus the change in inventories should be a good approximation. The assumption is made that $D_t = D_t^*$, since we see no reason why, given the terms on which firms can obtain accounts payable, the observed volume of accounts payable of a firm should be different than the amount it desires.

With the substitution of D_t for D_t^* into (3-4) we have the equation we wish to estimate except for one further modification. The equation to be estimated is,

$$(3-5) \quad D_{it} = \alpha_{41i} + \alpha_{42}(T + \Delta I)_{it} + \alpha_{43} B_t + u_{4it},$$

where u_{4it} is the error or residual term. The subscript "i" on α_{41} indicates that separate intercepts are specified for each firm. The lack of subscript "i" on the interest rate indicates it is a constant for all firms in a particular year. The theoretical argument for specifying separate intercepts for each firm is the same as will be made in the next chapter with respect to equations for cash and securities. Discussion of this point will be deferred until then.

The estimates of (3-5) are,

$$(3-5)" \quad D_{it} = \alpha_{41i}^{''} + .0450 (T + \Delta I)_{it} + .4961 B_t + u_{4it}^{''}$$

(.0016) (.0980)

where " indicates an estimate. R^2 for the regression equation was .832. The critical value of F at the 1% level is 1.33, while the F value for the equation was 39.31.¹ Both of the

¹The number of observations was 1485, the number of parameters estimated was 167 (165 intercepts plus 2 slope coefficients), so the number of degrees of freedom in the numerator of the F ratio is 166, and in the denominator 1318.

regression coefficients are significantly different from zero at the 1% level.¹ Our hypothesis that given the level of purchases firms increase their use of accounts payable when the interest rate rises, is consistent with these results. We turn now to the behavior of the customers of large firms.

Rather than work directly with accounts receivable, net receivables will be examined as a dependent variable in order to find out if large firms on net supply credit to small firms when the interest rate rises. Specifying for the individual firm,

$$(3-6) \quad (R-D)_t^* = \alpha_{51} + \alpha_{52}T_t + \alpha_{53}B_t + u_{5t},$$

and assuming $(R-D)_t = (R-D)_t^*$, and specifying separate intercepts we have,

$$(3-7) \quad (R-D)_{it} = \alpha_{51i} + \alpha_{52}T_{it} + \alpha_{53}B_t + u_{5it}.$$

While we have specified accounts payables to be related to purchases, there seems no reason to expect net account receivables to be related to purchases. Rather, since accounts receivable will be related very closely to sales, it seemed appropriate to use sales in (3-6). The estimate of (3-7) is,

$$(3-7)'' \quad (R-D)_{it} = \alpha_{51i}'' + \frac{.0289T_{it}}{(.0040)} + \frac{2.1124B_t}{(.2415)} + u_{5it}''$$

R^2 was .771 and F was 26.72, the equations and the two slope coefficients being significant at the 1% level.

¹It is not necessary to estimate the α_{41i} 's in order to estimate the other coefficients and since there was no particular interest in the α_{41i} 's we did not estimate them. In computing the other coefficients we make use of the fact that the least squares estimate of $\alpha_{41i} = \bar{D}_i - \alpha_{42} \frac{(S + \Delta I)_i}{42} - \alpha_{43} \bar{B}$. Substituting this expression for α_{41i} in (2-4) gives us an alternative form of our original regression equation. This alternative form is much simpler to compute when the number of separate intercepts is quite large.

The estimated coefficients for net receivables are quite large, and there is some reason to expect this may be due to a significant trend in net receivables. While accounts payable and accounts receivable may individually have some trend, cyclical movements, especially in a nine year time series, are apt to be equally important. However, even if receivables and payables display strong cyclical movements, their difference may still have a large trend over a nine year period.

To test this conjecture the sum of the estimated residuals ($\sum u_{5it}''$) was calculated for each year for all firms. Examination of the series of these sums of residuals suggested that time might be included in our regression equation for net receivables. The resulting estimates are,

$$(3-8)'' \quad (R-D)_{it} = \alpha_{6li}'' + .0182T_{it} + .9795B_t + .0049t + u_{6it}''$$

$(.0043)_{it} \quad (.3040)_t \quad (.0008)$

where "t" is now also a variable, u_{6it}'' is our estimated residual term in this equation, and α_{6li}'' the separate intercepts. The F ratio was 27.48, and R^2 was .777 and significant. Although the sales and interest coefficients are still significant at the 1% level, they are considerably reduced by the inclusion of time. The introduction of time adds virtually nothing to the explained variance of the regression equations, and the significance of the time coefficient results directly from the reduced magnitude of the sales and interest coefficients.

In Table 3 the sums of residuals in each year for the accounts payable regression equation and for the two net receivables equations are presented. Also in Table 3 are the

sums of the original variables by year. A casual glance at Column (2) suggests that the residuals for the accounts payable equation display a fairly random pattern. However, time was added to the accounts payable equation, anyway, and the results were as expected. The coefficient on time was not significantly different from zero and the coefficients on sales and the bill rate were identical in the 4th decimal place in the two equations.

The sums of residuals ($\sum u_{5it}''$) for each year for equation (3-7)" for receivables are presented in Column (4), while the sums of residuals ($\sum u_{6it}''$) after time has been introduced are shown in Column (5). It appears that pattern of the residuals in column (5) is more random than those in Column (4) and it is concluded that the introduction of time has improved the explanation of net receivables.

It should be pointed out that a good part of the explained variance of the regression equations for accounts payable and net receivables is due to the estimation of separate intercepts. If the variance of D_t and $(R-D)$ is measured around the means of these variables for each firm, the values of R^2 (partial coefficients of determination) that measure only the explained variance due to the independent variables may be calculated. This measure of R^2 for accounts payable, when B_t and $(S + \Delta I)_t$ are the independent variables is .509. For net receivables, when B_t , S_t , and time are the independent

Table 3

ANALYSIS OF RESIDUALS FOR
ACCOUNTS PAYABLE AND NET RECEIVABLES BY YEAR

Year	Sum of Accounts Payable*	Sum of Residuals for Accounts Payable	Sum of Net Recei- vables*	Sum of Net Recei- vable Resi- duals**	Sum of Net Receivable Residuals
	(1)	(2)	(3)	(4)	(5)
1948	-2.9858	- .3918	-4.9840	-1.7713	- .0250
1949	-3.8164	- .2676	-5.4166	-1.5483	- .9039
1950	-1.2662	.8206	-2.2610	.0592	.6316
1951	.0376	-.0979	- .4234	- .2719	.4744
1952	1.0250	.2330	.7893	- .3647	.1902
1953	.4974	-.5081	.9161	.7470	- .1033
1954	.0906	.2870	.9236	2.7704	.1043
1955	2.2445	-.0233	3.9461	.4257	- .2694
1956	4.1733	-.0579	6.5100	- .0961	- .0989

*These figures are the sums of the variable as deviations from the mean of the variable for all the observations.

** The residuals in Column (4) are estimated without the inclusion of time as a variable, while those in Column (5) are estimated when time is included in the regression equation.

variable, R^2 due to these variables is .184.¹ For the sake of completeness, two other regression equations for accounts payable and net receivables have been estimated.

These two equations do not assume that $D_t = D_t^*$, and $(R-D)_t = (R-D)_t^*$, but rather the following relationships are specified for each individual firm,

$$(3-9) \quad \Delta D_t = B_1(D_t^* - D_{t-1}) + u_{7t}$$

$$(3-10) \quad \Delta(R-D)_t = B_2[(R-D)_t^* - (R-D)_{t-1}] + u_{8t}$$

Substituting the expressions for D_t^* from (3-4) into (3-9) and (3-6) for $(R-D)_t^*$ in (3-10), and adding separate intercepts we obtain,

$$(3-11) \quad \Delta D_{it} = B_1\alpha_{41i} + B_1\alpha_{42}(T + \Delta I) + B_2\alpha_{43}B_t + B_2(-D_{it-1}) + v_{1it}$$

$$(3-12) \quad \Delta(R-D)_{it} = B_2\alpha_{51i} + B_2\alpha_{52}T_{it} + B_2\alpha_{53}B_t + B_2[-(R-D)_{it-1}] + v_{2it}$$

where $v_{1it} = (B_1u_{4it} + u_{7it})$ and $v_{2it} = (B_2u_{5it} + u_{8it})$, and where

¹It may be useful to define these measures of correlation more precisely. For the regression equation for accounts payable,

$$R^2 = \left[1 - \frac{\sum \sum u_{4it}^2}{\sum \sum (D_{it} - \bar{D})^2}\right],$$

when the variance of D is calculated about the mean of all observations. The second measure of correlation discussed above is,

$$R^2 = \left[1 - \frac{\sum \sum u_{4it}^2}{\sum \sum (D_{it} - \bar{D}_i)^2}\right],$$

where the variance of D is calculated about the mean for each firm. In Appendix 3 [p. 80 and equation (A-3)], it is shown why the second R^2 might be considered appropriate for measuring the explained variance due to the estimated slope coefficients on the independent variables. The choice of the term "partial coefficient of determination" may not have been felicitous.

again, common slopes are assumed for all firms, but separate intercepts are specified. As the α 's from estimating (3-11) and (3-12) may differ from (3-5) and (3-7), they are under-scored in (3-11) and (3-12).

The estimated regression equation for accounts payable is

$$(3-11)'' \quad \Delta D_{it} = \underline{\alpha}_{4li}'' + .0324 (T + \Delta I)_{it} + .7991B_t + .7003(-D_{it-1}) + v_{lit}''$$

(.0016) (.0943) (.0247)

and for net receivables ,

$$(3-12)'' \quad \Delta(R-D)_{it} = \underline{\alpha}_{5li}'' + .0106T_{it} + 1.1011B_t + .3078 [-(R-D)_{it-1}] + v_{2it}''$$

(.0031) (.1871) (.0227)

The regression coefficients in both equations are significant at the 1% level and the F ratios indicate that a significant amount of the variance of the dependent variable is explained in both equations.¹ R^2 for accounts payable is .442 and R^2 not counting the explained variance due to the separate intercepts is .411. For net receivables the corresponding correlations are .266 and .134.

The coefficients in (3-11)'' and (3-12)'' are fairly comparable in magnitude with (3-5)'' and (3-8)'', and the conclusions we wish drawn from these estimates will not depend on which equations are considered. Since it is felt that observed and planned, or expected, accounts payable and net receivables should be equal, equations (3-5)'' and (3-8)'' will be used as the basis for our conclusions.

The results suggest that even though large firms are induced to increase the credit they take from other firms in

¹When time was introduced into the equation for net receivables the "t" value of the time coefficient was 1.02, so time has not been included above.

response to changes in the interest rate, their customers are even more responsive. We would expect the interest coefficient for net receivables to be zero if the customers of large firms showed the same response as do large firms as customers. Quite evidently this is not the case.

The magnitude of the interest coefficient on net receivables indicates that large firms supply a sizeable credit stream to other firms, governments, and consumers when interest rates rise. The coefficient of .9795 tells us that a rise in the interest rate of 1% (say from 2% to 3%) increases net receivables as a ratio to total assets by nearly 1%. For the sample, this means roughly a \$450 million increase in net receivables for a rise of 1% in the bill rate.¹ These results are discussed further in Chapter 5.

¹Average total assets of the firms of this sample are \$275.3 million, so $[165 \times 275.3 \times .009795] = \445 million.

Chapter 4

ESTIMATES OF REGRESSION EQUATIONS FOR CASH AND SECURITIES

In Part A of this chapter the models of cash and security holdings developed in Chapter 2 are expressed as regression equations. The estimates of these regression equations are given in Part B. One set of regression equations developed in Part A specifies separate intercepts for each firm, and these intercepts have been analysed by industry and asset-size of the firm in Appendix 2. Part C of this chapter reports the results of analysing the error terms from certain equations for cash and securities. A complete description of the tests used on the residuals is given in Appendix 3.

A. The Regression Models of Cash and Securities

The discussion of Chapters 1 and 2 suggest the following relations,

$$(4-1) \quad C_t^* = \alpha_{60} + \alpha_{61}T_t + \alpha_{62}B_t + \alpha_{63}I_t + \alpha_{64}(R - D)_t + v_{3t},$$

$$(4-2) \quad S_t^* = \alpha_{70} + \alpha_{71}T_t + \alpha_{72}B_t + \alpha_{73}I_t + \alpha_{74}(R - D)_t + v_{4t},$$

where C_t^* and S_t^* are respectively the desired levels of cash and securities of an individual firm, the α 's are parameters and the v 's are residual terms. In addition to the traditional variables, the level of transactions and the bill rate, net receivables and inventories are included in accord with the discussion of Chapter 2.

Will $C_t = C_t^*$ and $S_t = S_t^*$? In the discussion of Chapter 2 it was suggested that short-run adjustments in inventories and net receivables will take precedence over adjustments

of cash and securities. Another proposition of Chapter 2 was that firms may have to hold unexpected receipts in the form of cash and securities whether or not they wish to increase these holdings. If this argument is correct then the observed levels of C_t and S_t are unlikely to be their desired levels, and another approach is necessary.

The following identities are used,

$$(4-3) \quad \Delta C_t = \Delta C_t^p + \Delta C_t^u, \text{ and}$$

$$(4-4) \quad \Delta S_t = \Delta S_t^p + \Delta S_t^u,$$

where the superscript "p" denotes a planned change, and the superscript "u" an unplanned change. Planned changes in cash and securities are written as some proportion of desired changes,

$$(4-5) \quad \Delta C_t^p = \beta_3 (C_t^* - C_{t-1}),$$

$$(4-6) \quad \Delta S_t^p = \beta_4 (S_t^* - S_{t-1}).$$

The coefficient β_3 tells us what portion of a desired change in cash made in a year, and similarly for β_4 for securities. It is expected that the β 's lie between 0 and 1.0. If $\beta_3 = .5$, it is interpreted to mean that because of the many balance-sheet adjustments that must be made, a firm only gets to adjust its cash holdings one-half of the way to their desired level in any year.

Finally unexpected receipts are introduced into the model,

$$(4-7) \quad \Delta C_t^u = \alpha_{65} \Delta N_t + v_{5t},$$

$$(4-8) \quad \Delta S_t^u = \alpha_{75} \Delta N_t + v_{6t},$$

where the v 's are residual terms. The change in taxes owed is used as the measure of unexpected receipts in the above formulation. It may be recalled that in Chapter 3, $\Delta(P + N)$ was used. Since the decision as to which of these variables to use as a measure of unanticipated receipts is non-theoretical, discussion of this point is postponed until the next part of this chapter.

Substituting equations (4-1) into (4-5), and equations (4-5) and (4-7) into (4-3), equation (4-9) is obtained.

$$(4-9) \quad \Delta C_t = (\beta_3 \alpha_{60}) + (\beta_3 \alpha_{61})T_t + (\beta_3 \alpha_{62})B_t + (\beta_3 \alpha_{63})I_t + (\beta_3 \alpha_{64})(R-D)_t + \beta_3(-C_{t-1}) + \alpha_{65}\Delta N_t + w_{1t},$$

where $w_{1t} = (\beta_3 v_{3t} + v_{5t})$. Substituting equation (4-2) into (4-6), and equations (4-6) and (4-8) into (4-4), equation (4-10) is obtained.

$$(4-10) \quad \Delta S_t = (\beta_4 \alpha_{70}) + (\beta_4 \alpha_{71})T_t + (\beta_4 \alpha_{72})B_t + (\beta_4 \alpha_{73})I_t + (\beta_4 \alpha_{74})(R-D)_t + \beta_4(-S_{t-1}) + \alpha_{75}\Delta N_t + w_{2t},$$

where $w_{2t} = (\beta_4 v_{4t} + v_{6t})$. Parentheses are put around pairs of coefficients, as $(\beta_4 \alpha_{71})$, in these equations to indicate that only the product of the two coefficients can be estimated directly.

Can these two relations be estimated pooling the data for all firms? It is assumed here that the coefficients on the independent variables will tend to share common values. However, work with the subsample of firms suggested that firms frequently may not have common intercepts. That is, $(\beta_3 \alpha_{60})$ and $(\beta_4 \alpha_{70})$ are likely to differ among firms. Examination of the cash equation may illustrate the problem. Consider the

coefficient β_3 on lagged cash ($-C_{t-1}$). If C_{t-1} is more cash than the firm desires this year it is expected that the change in cash will be negative. Suppose for a particular firm $C_{t-1} = .10$ this year which was more cash than the firm desired so it decreased its cash holdings. Suppose for some other firm with the same values of T , I , $(R-D)$, B , and ΔN , it is observed that $C_{t-1} = .10$. Would it be expected that the second firm would also decrease its cash holdings by the same amount this year, assuming the value of β_3 was the same for both firms. This would be expected to occur only if factors affecting differences in average cash holdings among the two firms were effectively explained by T , I , $(R-D)$, B , and ΔN . It is not believed that these other variables do adequately explain differences in average cash holdings among firms. In addition, work with the subsample of firms was not very suggestive as to other variables that might be related to inter-firm differences in mean cash holdings. While it would be desirable to specify a model that explained differences in the average values of variables among firms, if this is not easily done, why not abstract from these differences by the use of separate intercepts for each firm?

This discussion may also be illustrated graphically. In Figure 1 the marginal relation, given the effects of the specified independent variables, between ΔC_t and C_{t-1} is plotted for two firms A and B. The slope, β_3 , is assumed the same for both firms, and the mean values of changes in cash may or may not be equal, though they have been assumed to be

zero for both firms in Figure 1. The only difference between the two firms is the mean of $(-C_{t-1})$. If common slopes and intercepts were estimated pooling the data for the two firms, the slope would be some relation like the dotted line in Figure 1, which could differ markedly from the "true" value of β_3 . If separate intercepts of OA for firm A and OB for firm B were estimated, the common slope estimate would be β_3 , which illustrates why it is desirable to estimate separate intercepts if the mean values of the variables differ in a manner not easily explained.

If separate intercepts are estimated by the method of least squares the slope β_3 is estimated from deviations of ΔC and $(-C_{t-1})$ from the respective means of these variables for each firm. This is illustrated in Figure 2 where the mean of ΔC and $(-C_{t-1})$ for firm A have been removed from A's observations, and similarly for firm B. The same type of reasoning used here is the basis for the estimation of separate intercepts for accounts payable and net receivables in Chapter 3. Also it may be recalled that in Chapter 3, common intercepts were employed in the regression equations estimated in Part B of that chapter. As all the variables entering these regression equations were changes in stocks and flows, rather than stocks or flows, there is no reason to expect that differences in the means of the variables are not explained by the other variables in the equations.

The addition of separate intercepts to (4-9) and (4-10) gives,

Figure 2

Illustration of the Use of Separate Intercepts

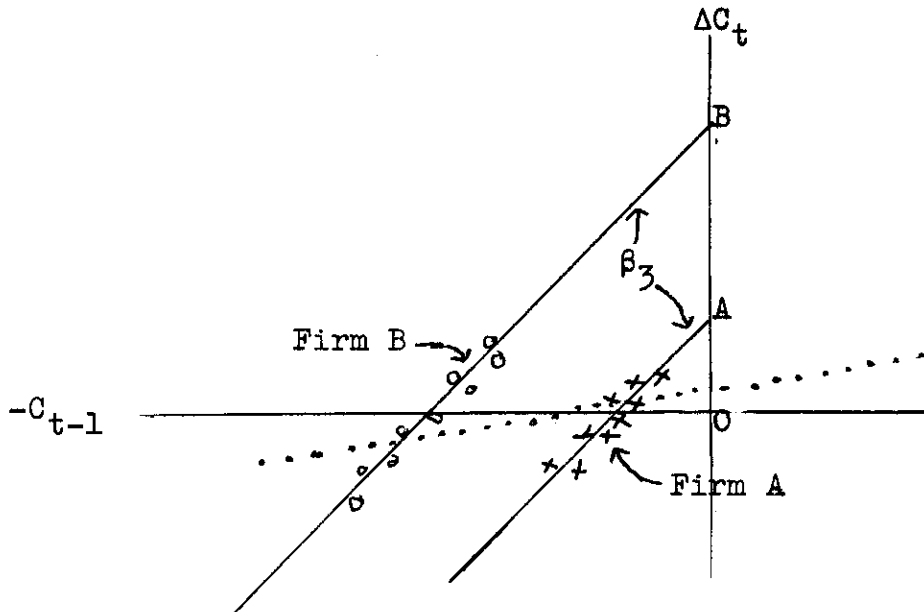
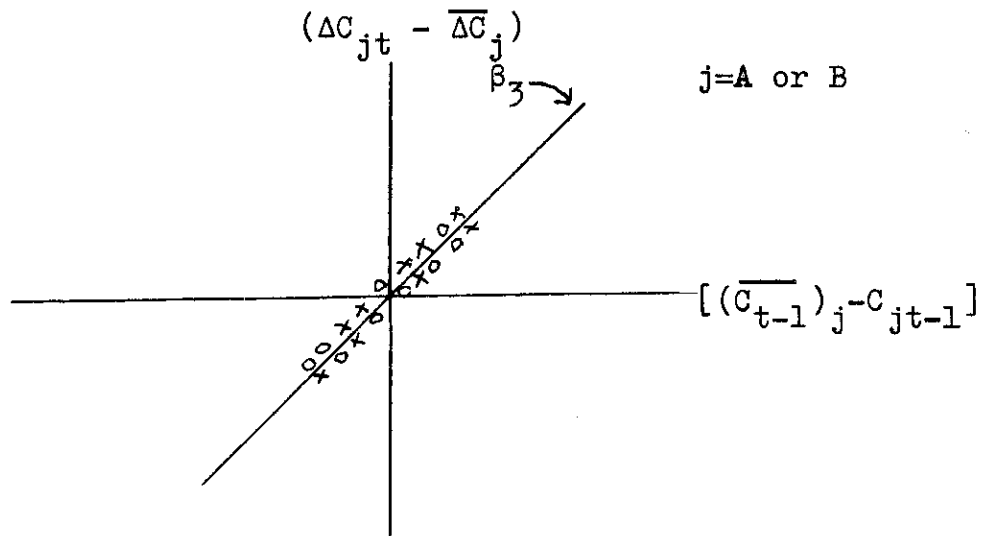


Figure 3

Transformation of Variables When Separate Intercepts Are Used



$$(4-11) \Delta C_{it} = (\beta_3 \alpha_{60})_i + (\beta_3 \alpha_{61})T_{it} + (\beta_3 \alpha_{62})B_t + (\beta_3 \alpha_{63})I_{it} + (\beta_3 \alpha_{64})(R-D)_{it} + \beta_3(-C_{it-1}) + \alpha_{65}\Delta N_{it} + w_{1it}, \text{ and}$$

$$(4-12) \Delta S_{it} = (\beta_4 \alpha_{70})_i + (\beta_4 \alpha_{71})T_{it} + (\beta_4 \alpha_{72})B_t + (\beta_4 \alpha_{73})I_{it} + (\beta_4 \alpha_{74})(R-D)_{it} + \beta_4(-S_{it-1}) + \alpha_{75}\Delta N_{it} + w_{2it}.$$

Both (4-9) and (4-11) for cash and (4-10) and (4-12) for securities will be estimated to see whether the specification of separate intercepts does help in the explanation of changes in cash and securities.

B. The Estimates of Regression Equations for Cash and Securities

The estimates of the two cash equations and the two securities equations are presented in Table 4. In Table 4 equation A for cash is (4-9) of the previous section, and equation B is (4-11). Similarly for securities, equation A in Table 4 is (4-10) of the previous section, equation B is (4-12). An F test is used to determine whether an equation specifying separate intercepts provides a better explanation of changes in cash than does an equation with a common intercept. The addition to explained variance due to the separate intercepts divided by the number of additional intercepts is the numerator. The denominator is the residual variance of the equation with the additional intercepts divided by the remaining degrees of freedom. The F ratio for cash is thus,

$$F = \frac{1.555416 - 1.043537}{164} \div \frac{1.043537}{1314} = 3.94.$$

With 164 and 1314 degrees of freedom the critical value of F at the 1% level is 1.33, so the hypothesis that separate

Estimates of Regression Equations for Cash and Securities***
(Standard Errors of Regression Coefficients in Parentheses)

Independent Variables	Cash Equation		Securities Equation	
	A. (4-9)	B. (4-11)	A. (4-10)	B. (4-12)
Lagged Cash ($-C_{it-1}$)	.1672 (.0150)*	.6312 (.0239)*		
Lagged Securities ($-S_{t-1}$)			.1235 (.0140)*	.4782 (.0231)*
Sales (T)	.0043 (.0008)*	.0333 (.0029)*	.0017 (.0011)	.0263 (.0042)*
Bill Rate (B)	-.0235 (.1405)	-.3848 (.1384)*	-.2834 (.1996)	.0008 (.2000)
Inventories (I)	-.0228 (.0079)*	-.0391 (.0120)*	-.0367 (.0076)*	-.1321 (.0179)*
Net Receivables (R-D)	-.0029 (.0053)	-.0098 (.0153)	-.0307 (.0101)*	-.0260 (.0228)
Change in Taxes (ΔN)	.2199 (.0229)*	.1207 (.0206)*	.4721 (.0322)*	.3237 (.0310)*
R ^{2**}	.140	.423	.191	.390
F	40.15	5.67	58.19	4.95
degrees of freedom	1478	1314	1478	1314
Sum of squared residuals	1.555416	1.043537	3.066702	2.311055

*Different from zero at the 1% level of significance.

**If the variance of ΔC is computed about ΔC_i , the mean of ΔC for each firm R² for regression equation B above is .392 and significant. For securities the corresponding R² for equation B is .366.

***The intercept term for equation A for cash is .0144, and for equation A for securities is .0318, both coefficients being significant at the 1% level.

intercepts add significantly to the explanation of changes in cash is accepted. The test is identical for securities where $F = \frac{3.066702 - 2.311055}{164} \div \frac{2.311055}{1314} = 2.62$. The hypothesis for securities that specification of separate intercepts adds significantly to the explanation of changes in securities is also accepted at the 1% level.¹

This is not quite the final word on the subject of separate intercepts. It is shown in Appendix 3 that the same slope coefficients on the independent variables for cash and securities would result if the independent variables were expressed as deviations from their mean for each firm, and the change in cash and the change in securities were expressed as deviations from the mean of all observations.² This formulation

¹An assumption of the above test is that the slope coefficients on the independent variables are the same for each firm. The assumption of common slopes has not been tested here. To test for common slopes equations (4-9) for cash and (4-10) for securities would be estimated for each firm separately and the residual variance for the individual regression equations summed over all firms would be compared with the residual variance from a pooled regression. The reason for not making the test of common slopes is that it is a substantial investment in computation that would yield regression equations for individual firms that one would probably not otherwise wish to estimate. That is, the regressions for each firm would only have two degrees of freedom each which is apt to produce from sampling error some wide but uninteresting variations in coefficients. Since the common slope assumption has not been tested the above F tests could have the interpretation that has been placed on them. Or the F tests could also have the interpretation that enough of the differences in slope coefficients among firms has shown up as differences in intercepts to allow separate intercepts to add significantly to the explained variance of cash and securities.

²The reasons for specifying such a set of equations is implicit in the discussion of separate intercepts in Part A of this chapter. The reason it is not necessary to actually use separate intercepts for the cash and security equations is that the dependent variables are changes in stocks, and the variations in the means of changes in stocks among firms over a short period is not expected to be, or is not in fact, large.

uses only one intercept and yields values of R^2 of .371 for cash and .352 for securities, and patterns of significance identical with equations B of Table 4 for cash and securities.¹ It does not really make any difference to the conclusions of the text whether the set of equations just described, or equations B of Table 4 are used, and so we have chosen to work with the latter set because it is slightly less cumbersome to describe. However, in the analysis of residual variance it is not convenient to use the equations with separate intercepts. A complete description of the above set of equations and the analysis of residual variance is contained in Appendix 3.

For cash all of the coefficients in equation B in Table 4 are of the expected sign, and all but the coefficient on net receivables are significant at the 1% level. For securities the coefficients in equation B of Table 4 are of the expected sign, and all but the coefficients on net receivables and the bill rate are significant at the 1% level. One problem in estimating the effect of the bill rate on cash and securities is that we only have the quantities of net receivables and inventories, and not the returns on these assets. Since substitution of inventories for cash and securities is due to the increased return on inventories the estimates of the effects of the bill rate on cash and securities will be affected by the use of the quantity of inventories. The problem is further complicated by the fact that the bill rate, and the return on inventories and the quantity of inventories are correlated.

¹This statement means that the same variables have significant "t" values in the two sets of equations. The standard errors of the coefficients differ in the two sets of equations, and in particular they are larger for equations B of Table 4.

We can not really say how the estimates of the bill rate coefficients are affected because we do not know how accurately the quantity of inventories mirrors the return on inventories. In any event it must be concluded that the present estimates yield no significant relation between the bill rate and securities.

The fact that net receivables is not a significant variable in equations B for cash and securities is not too surprising. It is expected that inventories and net receivables with respect to all variables but the bill rate would have the same general relationship. While it was expected that net receivables would be positively related to the bill rate, it turns out that inventories in the sample are also related positively to the bill rate evidently because it has not been possible to hold the rate of return on inventories constant. If there is not much difference in the behavior of two independent variables entering into a regression equation, it may be difficult to distinguish their effects on the dependent variable. The reason for treating the variables separately was to see if cash and securities are used more to finance one or the other of the assets. The answer is either that cash and securities are used predominantly for inventories, or that the model is not sensitive enough to the differences between receivables and inventories to allow an answer to the question. Equations B for cash and securities are not much changed if net receivables is dropped as a variable, or if net receivables is added to inventories as a composite variable, so in analyzing the results in Chapter 5, the original equations (4-11)

and (4-12) will be used.

In Chapters 2 and 3, three different regression equations involving the relation of cash and securities to net receivables have been reported. In none of these regression equations for cash was net receivables a significant variable at the 1% level. This suggests that, though persistently a negative relation is found between these variables, the relation is not strong enough to take into account. Again, this conclusion is subject to the reservation above---namely that the models do not allow us to distinguish very sharply between the effects of inventories and net receivables. For securities only regression equation B of Table 4, of the three equations examined, yields a relation between net receivables and securities that is not significant at the 1% level. It is concluded that the negative relation found between securities and net receivables is strong enough to take into account, but that equation (4-12) for securities does not allow a good estimate of this relation.

Changes in taxes due was used as the measure of unanticipated receipts in the regression equations in this chapter. Four variables had been considered. These were the change in sales, change in profits, change in taxes, and the change in taxes plus profits. In the work with the subsample it appeared that an average of lagged sales was a better measure than current sales of expected transactions, the conceptual variable to which firms would adjust their cash and security

holdings.¹ When this lagged measure of sales was used for transactions, the change of sales was used to measure unexpected receipts. For the main sample it turned out that current sales worked better than a lagged average of sales, and because the change of sales is highly correlated with current sales, the change of sales was no longer considered as a measure of unexpected receipts.²

The other three measures of unexpected receipts are not much different in the results they produce. In general it was better to use either the change in taxes or the change in profits plus taxes. Taxes are important because the change in the tax law in 1954 made it necessary for firms to pay one half of their tax liabilities in the year they accrued and one

¹Two other variables that appeared to have explanatory value for the subsample, but did not for the main sample, should be mentioned. The first was investment. It was reasoned that if firms were planning large capital expenditures they might build up funds as securities, and perhaps also as cash. A fairly strong negative relation between investment and changes in securities was found for the subsample. While the relation of securities and investment was consistently negative for the main sample, the relation was not generally significant at the 1% level. The second variable was a lagged measure of the liquidity position of the firm. The liquidity position was measured as total fixed claim liabilities minus current assets. It was expected that large values of this liquidity measure would be associated with a subsequent build up of cash and securities. However, no persistent relationship was found either for cash or securities in the main sample. One reason why these variables might not be important in the model used is that the lagged measure of cash and securities may bury the effects of such variables. Thus a large value of lagged securities means securities decrease next year, whether or not the large value of lagged securities is due to a build up for investment. Similarly a low value of lagged cash will result in a buildup in cash next year, whether or not the low value of lagged cash was a reflection of a low liquidity position of the firm.

²By worked better it is meant that for identical regression equations for cash and securities, the coefficients and their "t" values for current sales were larger than for the lagged average of sales. Two measures of lagged sales were used. The first was $.5(T_{t-1} + T_{t-2})$, and the second was $.25(T_t + T_{t-2} + 2T_{t-1})$.

half in the following year, instead of all in following year. This reduced the size of the permissible taxes owed account for any given level of profits, and Silberman reports that this had an appreciable effect on the working capital of firms in 1955 and 1956.¹ Since profits would not reflect this "unanticipated" drop in receipts for firms, it seemed desirable to use taxes and profits, or taxes alone. In general ($\Delta P + \Delta N$) did about as much better for cash as (ΔN) did better for securities, where the difference in R^2 's are in the third decimal place. There did not seem any justification for taking the best of both worlds, so the change in taxes was used in both regression equations (4-11) and (4-12), as indicated above.²

C. Discussion of the Residuals for Cash and Securities

The regression equations estimated in this study pool observations over industries, asset-size groups, and years. The advantage of pooling the data is that it allows us to make more general statements. Since the models used here are of a very simple form and involve some misspecifications of relationships among the independent variables, the results will

¹Charles E. Silberman, "The Strange Money Shortage," Fortune, (March, 1957), p. 123.

²In the regression equations in section B of Chapter 3, ($\Delta P + \Delta N$) was used as the measure of unexpected receipts. This was considered consistent procedure in the sense that the measure chosen was better for securities which was the criterion above. (ΔN was better in these regressions for cash and short-term bank loans.) It would also have been consistent to use the change in taxes in all regressions. Differences in R^2 's between ΔL , ΔS , and ΔC , and ΔN and ($\Delta P + \Delta N$), are in the third decimal place so that our consistency, or lack of it, will have had little effect on the results.

be of an inexact character no matter what level of aggregation is used. While the inexact nature of the results may justify our procedure, pooling of data is unlikely to be without costs. These costs may be assessed to some extent by examining the error terms from the regression equations.

Residuals have been estimated for cash and securities from equations with the same slope coefficients as those in equations B of Table 4. The residuals have been classified by year, industry, asset size, and by the size of certain independent variables. There was no significant difference in the means of residuals for cash by year using the homogeneity of means test at either the 5% or 1% level of significance. For securities there was a significant difference in the means by year at either the 5% or 1% level of significance. With only nine annual observations it is difficult to discern cyclical or other patterns in any time series including the present residuals. From examination of the means of the residuals and the independent variables we observe no obvious systematic factors that would explain the apparent differences in the means of residuals of securities by year, and believe the differences are due to circumstances in particular years. There is no trend in the residuals of cash and securities at the 1% level, though there is a trend in the residuals for securities at the 5% level. It is suggested that any importance of time in the explanation of securities is due to the observations for 1948, but other judgements are certainly possible, and the interested reader may wish to consult Appendix 3, and especially Table (A-4).

Classification of the residual variance by the size of sales, inventories, and the lagged values of cash and securities, revealed that there is heteroscedasticity for both cash and securities with respect to some of the independent variables. It appears that dividing variables by total assets may have reduced one cause of heteroscedasticity only to introduce another. This analysis also suggested that non-linear forms might have been more appropriate for describing certain relationships than the linear forms used here.

The "explained variance" for subgroups of observations, due to the regression equations estimated over all observations, has been examined. The subgroups consist of observations classed by year, industry, and asset-size. For each of these subgroups except 1948 for securities and 1956 for cash the hypothesis that the "explained variance" is equal to zero is rejected at the 1% level. The quotation marks about "explained variance" indicates that the present usage differs from the usual usage. All of these terms, tests, and conclusions are discussed in more detail in Appendix 3.

Chapter 5

THE RESULTS: ANALYSIS, SUMMARY, AND IMPLICATIONS FOR MONETARY POLICY

A. Analysis of the Estimated Equations for Cash and Securities

In this part of the chapter, the coefficients for cash and securities estimated in Chapter 4 will be discussed in more detail. The estimated regression equation for cash was,

$$(4-11)'' \quad \Delta C_{it}'' = (\beta_3 \alpha_{60})_i'' + .0330T_{it} - .3838B_t - .0391I_{it} - .0098(R-D)_{it} \\ + .6312(-C_{it-1}) + .1207\Delta N_{it} + w_{lit}'' .$$

This is a short-run relationship. Setting ΔC_{it} and ΔN_{it} equal to zero and substituting C_{it}^* for C_{it-1} , an estimate of "equilibrium cash holdings" is obtained, which is,

$$(4-1)'' \quad C_{it}^*'' = \alpha_{60i}'' + .0528T_{it} - .6096 B_t - .0619 I_{it} - .0155(R-D)_{it} \\ + \frac{w_{lit}''}{\beta_3''} .$$

By identical procedure an estimate of the equation (4-2) of equilibrium security holdings may be obtained.

The derivation of these equilibrium coefficients whether done as above, or directly from the equations of Chapter 4, is simple enough. And their interpretation for sales and the bill rate is straightforward. Because the firm is not able to adjust its cash balances to their desired levels immediately, the observed adjustment will be less than the long-run adjustment. To estimate the long-run adjustment we must divide the short-run coefficient by the speed of adjustment coefficient. However, because it is not possible to compartmentalize cash and security holdings, we must assume, for example, that the full

adjustment of security holdings to sales takes the same time as the adjustment of security holdings to inventories. Actually the latter adjustments are apt to be very nearly immediate and the equilibrium coefficients for inventories and net receivables, are for this reason, probably too high, and no conclusions are drawn from the values of these coefficients.

The original coefficients will be referred to a short-run coefficients, and the derived coefficients as long-run or equilibrium coefficients. Both sets of coefficients are presented in Table 5 with their standard errors. The standard errors of the derived coefficients are only approximate.¹ There has been no change in the pattern of significance between the short-run and long-run coefficients. The coefficients in Table 1 tell the change in cash and securities as a ratio to total assets for a

¹Using the notation of equation (4-12) of the previous chapter, p. 44, the approximation used is,

$$s_{\alpha_{6j}}^2 = \frac{s^2(\beta_3 \alpha_{6j})}{\beta_3^2} + \frac{(\beta_3 \alpha_{6j})^2}{\beta_3^4} s_{\beta_3}^2 - \frac{2(\beta_3 \alpha_{6j})}{\beta_3^3} \text{cov}[(\beta_3 \alpha_{6j}), \beta_3],$$

where $j = 1, 2, 3,$ and $4,$ for the four long-run slope coefficients, and where s^2 denotes sample variances, and where the variance and covariance terms on the right side are obtained from the covariance matrix of residuals. This approximation of the variance of a ratio from the parameters of the components of the ratio is given by G. Udry Yule, and M.G.Kendall. An Introduction to the Theory of Statistics, 13th edition, revised, (London, Charles Griffin and Company, 1947), formulas, 16.8 and 16.9, pp. 299-300. The approximation is suitable for the present case because the speed of adjustment coefficients are expected to be between zero and one, and importantly, are not expected to take on values very close to zero.

TABLE 5

Short and Long-Run Coefficients and Elasticities for Cash and Securities
(Standard Errors of Coefficients in Parantheses)

Variable	Short-Run Coefficient	Long-Run Coefficient	Short-Run Elasticity	Long-Run Elasticity	Means of Variables
Part A. Cash					
Lagged Cash (-C _{t-1})	.6312 (.0239)*	1.0000	.6312		.1042
Sales (T)	.0333 (.0029)*	.0528 (.0059)*	.558	.885	1.7465
Bill Rate (B)	-.3848 (.1384)*	-.6096 (.2191)*	-.062	-.098	.0167
Inventories (I)	-.0391 (.0120)*	-.0619 (.0190)*	-.115	-.183	.3075
Net Receiv- ables (R-D)	-.0098 (.0153)	-.0155 (.0242)	-.008	-.012	.0811
Change in Taxes (ΔN)	.1207 (.0206)*		.093		.0800**
Part B. Securities					
Lagged Securi- ties (-S _{t-1})	.4782 (.0231)*	1.0000	.4782		.0734
Sales (T)	.0263 (.0042)*	.0550 (.0097)*	.626	1.309	1.7465
Bill Rate (B)	.0008 (.2000)	.0017 (.4338)			.0167
Inventories (I)	-.1321 (.0179)*	-.2762 (.0389)*	-.553	-1.156	.3075
Net Receiv- ables (R-D)	-.0260 (.0228)	-.0544 (.0585)	-.029	-.061	.0811
Change in Taxes (ΔN)	.3237 (.0310)*		.353		.0800**

*Different from zero at the 1% level of significance.

**This is the mean of N as a ratio to total assets, not the mean of ΔN. In computing elasticities the means of C, S, and N, are used rather than the means of changes in these variables.

unit change in the independent variable. The coefficients may be easier to interpret if they are expressed as elasticities as in columns (3) and (4) of Table 5. These elasticities are computed at the mean values of the variables, except that for the variables which are changes, as ΔC , the mean value of C is used, rather than the mean of the change in the variable.¹ The mean values of the variables are presented in column (5).

Elasticities of linear relations are frequently not useful because they depend on the initial position chosen. However, the initial values used here, the mean values of the variables for the sample, may provide a reasonable position from which to consider small departures. The estimated elasticities in Table 5 tell us the short-run and long-run percentage change in the dependent variable for a 1% change in the independent variable, given that the other independent variables are at their mean values.²

¹The computation of the short-run elasticity of cash with respect to sales may be illustrated. The elasticity formula is $\Delta C/C \div \Delta T/T$, where in this instance, ΔC is the coefficient on sales; and C is the mean of cash, so the numerator is $.0333/.1042 = .3196$. The coefficient on T for cash is for a unit change in T , so $\Delta T = 1.0$, and T is the mean of T , so the denominator is $1/1.7465$, and the resulting elasticity is $.558$. The reason for not using the mean of changes in cash is that for most purposes one is interested in the elasticity of cash with respect to sales, not the elasticity of changes in cash with respect to sales.

²The effects on the elasticities of other variables entering into the regression equations may be illustrated. The interest elasticity of cash will be less if sales are greater than the mean value. If the value of sales was greater than its mean value then, because of the positive coefficient on sales, the ratio of cash to total assets would be greater than its mean value. In this case any change in cash for a given change in the bill rate would be a smaller percentage change in cash than if sales was equal to its mean value. Thus the interest elasticity of cash would be inversely related to the value assumed to sales. And the elasticity of cash to sales will be positively related to the value assumed for the bill rate.

Kisselgoff's findings, based on aggregated data for a sample of firms during the period 1921-1939 imply an elasticity of cash with respect to transactions of 1.14.¹ Since Kisselgoff's estimates assume that actual cash balance are desired balances it is probably appropriate to use the long-run elasticity of .885 of this study for comparison. If it is assumed the variance of the sample means of cash and sales for each of the two studies is zero, an estimate of the standard errors of these elasticities may be calculated.² They are .485 for Kisselgoff's elasticity and .051 for the equilibrium elasticity of this study. Since differences between the elasticities could be the result of sampling error, there does not seem much point in pursuing the comparison.³

It would appear that the estimated long-run sales elasticity here is less than one. This suggests that cash holdings may grow less than proportionately to sales. However, the cross-section statistics in Table 1 indicate that as the

¹Kisselgoff, op. cit., pp. 336-38, presents the data underlying his estimates. The above elasticity was computed using his data and the estimated coefficient on transactions. This elasticity assumes that the interest rate is at its mean value for the period.

²The elasticity of cash to sales (long-run) in these studies is $\bar{T}\alpha_{61} + \bar{C}$. If \bar{C} and \bar{T} are assumed to have zero variance then the variance of the elasticity is $[(\bar{T}/\bar{C})^2 s_{c61}^2]$

and the standard error of the elasticity estimates may be easily calculated.

³If the elasticity estimates are normally distributed then with 95% probability Kisselgoff's elasticity of cash to sales would lie between .07 and 2.11. The 95% confidence limits for the elasticity estimate of this study are .78 to .99. As the limits of the present estimate are contained within the limits of Kisselgoff's elasticity it is concluded that there is no significant difference in the estimates. The usual test of equality of means is not appropriate here because the variances differ markedly.

sales of firms get larger there is no clear variation in the ratio of cash to sales, which may mean that the sales coefficient for cash is a little low.¹

The elasticity of securities with respect to sales is greater than 1.0, suggesting the ratio of securities to sales rises with sales. This is in agreement with the pattern found in Table 1 where the ratio of securities to sales in the smallest asset size groups is .029 while for the largest it is .080.

Kisselgoff has also estimated the elasticity of cash with respect to the interest rate, but it is not very meaningful to compare his estimate with that of the present study.² A

¹As the interest coefficient on cash show corporations during the period of this study have been willing to hold less cash as interest rates rose. However, it is unlikely that the interest coefficient has picked up all of the long-run effects of generally rising interest rates during the period, e.g., the development of repurchase agreements between corporations and government bond dealers, and methods of speeding up payments and receipts. If the interest coefficient does not pick up these effects, then the coefficient on sales may be unduly low. This could be called a bias in the present study if the methods of economizing cash developed because of higher interest rates are not retained when, and if, interest rates decline to their early postwar levels. A description of some methods corporations have developed for economizing cash is given by Charles Silberman, "The Big Corporate Lenders", Fortune, (August, 1956).

²The reason is that Kisselgoff used the interest rate on two to five year government bonds while the bill rate is used here. Longer term interest rates have a higher mean (Kisselgoff's mean rate was 2.95% as compared with 1.67% for this study) and exhibit smaller fluctuations, in general, than short-term rates. This means that long-term interest rates, everything else the same, will produce higher interest elasticities. Kisselgoff's elasticity of cash with respect to the interest rate on two to five year bonds was -.332. Kisselgoff also estimated the elasticity of free cash with respect to the interest rate. Free cash was defined as observed cash in any year minus current sales times the ratio of cash to sales in 1929, a year when the cash sales ratio was at a minimum. The estimated elasticity was -1.26. op. cit., p. 254. Acheson J. Duncan, op. cit., p. 251, has pointed out that there is a high probability that the close relation between free cash and the interest rate is spurious because the correlation of deviations from the trend of free cash and the interest rate was only -.03.

comparison of the coefficients shows that a 1% increase in the interest rate, say from 2% to 3%, results in an 11.3% decrease in cash ($\Delta C/C$), using Kisselgoff's estimates. For this study the short-run percentage decrease in cash is 3.7% and the long-run decrease is 5.9%. Assuming the mean of cash has a variance of zero the standard deviation of Kisselgoff's estimate is .030, and for the long-run coefficient of this study the standard error is .021.¹ As the present equilibrium estimate is over 2 standard deviations from Kisselgoff's estimate, it is likely that there is a significant difference in the coefficients.² While it has been suggested that Kisselgoff's estimate may have an upward bias, there is also some reason to suppose the present estimate may also have a bias, though not necessarily downward.³

The interest coefficients of Table 5 may be used to examine the proposition of Baumol and Tobin that the proportion of

¹The long-run percentage decrease in cash due to a 1% rise in the bill rate is $.01 \alpha_{62} \div \bar{C}$, and the variance of this estimate if the variance of \bar{C} is zero, is $.0001 s_{\alpha_{62}}^2 \div \bar{C}^2$, from which the standard error is computed.

²The equality of the two estimates of the percentage decrease in cash could be estimated if the variances of these estimates were homogeneous. When the variances of the two estimates were compared using Bartlett's test, the Chi Squared value was over 100 indicating that the variances were not homogeneous. It may be noted that the present long-run estimate is within two standard deviation of Kisselgoff's estimate of the percentage decrease in cash due to a 1% rise in the interest rate. However, because the number of observations is much larger in this study the standard error of the present estimate would get most of the weight in tests of equality of the two estimates.

³See footnote 2, p. 59 above for a discussion of Kisselgoff's interest estimates. A source of bias for the present estimates, the use of quantities rather than returns on inventories and net receivables, is discussed above, p. 47.

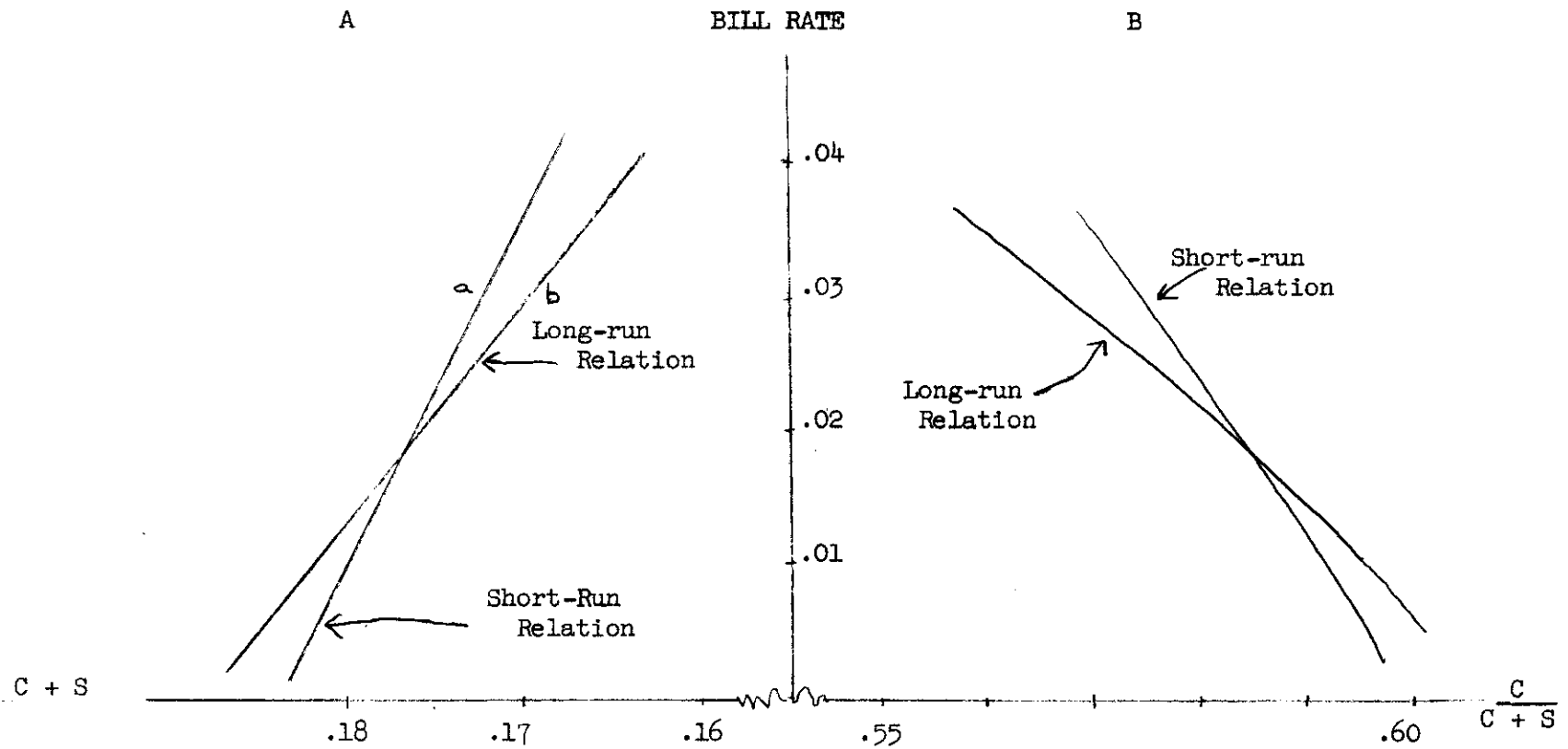
cash in transactions balances is inversely related to the interest rate.¹ The relation between transactions balances, cash and the bill rate will be illustrated in Figure 3. It is assumed that the sum of cash and securities are transactions balances, though as some amount of securities (and cash) is set aside as a buffer for changes in inventories and net receivables, this figure will be high. It is also assumed that the other variables in the model are held constant. The percent of cash plus securities to total assets is plotted on the horizontal axis of Figure 3A, and the bill rate on the vertical axis.

As it is assumed in Figure 3 that all variables are initially at their mean values, one point on Figure 3A is the mean of cash plus securities to total assets and the mean of the bill rate. This point is .178 on the horizontal axis of Figure 3A and .0167 on the vertical axis. In Figure 3B the percent of cash in transactions balances is on the horizontal axis, and the initial point is the mean of the bill rate and the mean of $(C/C+S)$, which is .585. In both figures 3A and 3B the short-run and long-run relations are plotted, the two relations intersecting at the initial points discussed above.

If the interest rate rises from its mean value of 1.67% to say 3%, then in Figure 3A the firm moves up the short-run relation curve to point a. If the interest rate stays at 3% for some time then the firm does not stay at point a, but rather moves over to point b on the long-run curves, since

¹See above, footnote 1, pp. 6-7.

FIGURE 3
 ESTIMATED RELATION OF TRANSACTIONS BALANCES
 AND THE PROPORTION OF CASH IN TRANSACTIONS
 BALANCES TO THE BILL RATE



point b represents the full adjustment of the firm to a 3% interest rate. If after the bill rate had remained at 3% for some time, there was another change in the bill rate, the firm would not be on the short-run curve of Figure 3A. Rather the firm would have another short-run curve intersecting the long-run curve at a 3% bill rate, and it would be this curve that would tell the short-run movement of the firm from a 3% bill rate. There will thus be a different short-run curve for every point on the long-run relation. The long-run relation is a locus of equilibrium levels of transactions balances in relation to the bill rate. There will also be different long-run relations for values of the other variables that are different from their mean values. If sales were to be above its mean value for example, the long-run and short-run curves of Figure 3A would shift to the left in an analagous manner to the effects of changes in income in a liquidity preference diagram (in the northwest quadrant).

In figure 3B the interpretation of the long-run and short-run relations is the same as to that of Figure 3A. The long-run relation is a locus of equilibrium percentages of cash to transactions balances in relation to the bill rate, and this relation will be a function of the values assumed for the other variables. The long-run and short-run relations are negatively sloped which is consistent with the proposition of Baumol and Tobin.

The coefficients and elasticities for securities on inventories, net receivables and the change in taxes due are

much larger than those for cash. It would be expected that securities are in all ways a superior asset to hold as a buffer asset for changes in inventories and receivables, and a more profitable way to hold unanticipated receipts, which is what was found. As the variance of changes in securities is over twice as large as the variance of the change in cash, there is additional evidence that securities, rather than cash, absorbs most of the shocks from short-run adjustments in the current accounts. Another indication of this is the relative magnitudes of the speed of adjustment coefficients for cash and securities. For cash the estimated proportion of a desired change in cash made in a year is .6312, while for securities the figure is .4782. A glance at the standard errors of these coefficients indicates that this is a significant difference. The interpretation given to this finding is that securities must absorb much more of the adjustments of the current accounts of firms than cash and it is therefore likely the firm will not be able to adjust securities to their equilibrium level as fast as cash.

B. Summary and Implications of the Findings

The empirical findings of this study are based on a sample of large non-financial corporations, and for this reason the results are unlikely to have applicability to firms in general. In addition several of the hypotheses of the study are framed with large corporations in mind. While it might be expected that the lagged adjustment part of the models of cash

and securities would describe a large class of firms, it is doubtful whether the relationship between securities and inventories suggested for large corporations would have much applicability to smaller firms.

A serious limitation on the analysis is that it is partial. Because the models are not simultaneous, and because there are relationships among the independent variables, it is not possible to describe the total short-run impact on cash and securities of the explanatory variables. With at least these reservations in mind the results of this study may be summarized.

The firms in this sample maintain about 10% of their total assets as cash, while the ratio to sales is about 6%. The long-run elasticity of cash with respect to sales was estimated at .885. The other component of transactions balances, securities, are about 7.3% of total assets and 4.2% of sales. The long-run elasticity of securities with respect to sales was estimated to be 1.31, which is consistent with the finding that the ratio of securities to sales increases with the absolute level of sales. Securities may rise more than proportionately with sales because large firms are more likely to find it economical to use securities as a substitute for bank loans in the finance of inventory and net receivable fluctuations.

The expected negative relation between the bill rate and cash holdings was found. Measuring transactions balances as cash plus securities, it was also found that the proportion of cash in transactions balances is inversely related to the bill rate. The estimates of the relation between the bill rate and

cash holdings may have some bias (plus or minus) because the quantities of inventories and net receivables and not their returns were used as variables. The model of security holdings did not produce a significant relation between the bill rate and securities.

Lagged adjustment models of cash and securities appear to give a reasonable description of the behavior of large firms. One reason that firms may adjust cash and securities with a lag is that they give priority in the short-run to the adjustment of inventories. It was found that securities tend to be adjusted to their equilibrium position more slowly than cash. One reason suggested for this is that securities relative to cash tend to bear the brunt of short-run adjustments of the firm. In this study it has not been possible to distinguish cash holdings held as compensating balances in banks where firms customarily borrow. If large firms do hold compensating balances this might account for the relative stability of cash holdings that has been found.

Canonical correlation analysis suggested that firms substitute between the use of short-term bank loans, and securities and cash in financing temporary increases in inventories and net receivables. Using a more complete model to describe cash and securities it was again found that securities and cash are negatively related to inventories. Cash does not appear to be significantly related to net receivables, but some negative relation between securities and net receivables appears to exist.

Allowing for the effects of purchases by firms, it was found that increases in the interest rate induce large corporations to expand the credit they take in the form of accounts payable. However the relation between the interest rate and net trade credit taken by the customers of these firms, given the effects of time and sales, is even more striking. The estimates suggest that net receivables as a percent of total assets increase by about 1% in response to a rise in the bill rate of 1%, say from 2 to 3%. In addition the net receivables of large corporations do increase with the sales of firms which means that during an expansion of business activity there will be a sizeable amount of credit offered by large firms to their customers. During a business expansion interest rates and inventories will also be rising. In response to the higher interest rates large firms reduce their cash needs significantly. And some part of the increase in net receivables and inventories is financed by running down security and cash holdings.

These results suggest that during an inflationary period large corporations are in a position to finance some of their credit needs internally, and to extend credit to smaller businesses and consumers. As these large corporations do use short-term bank loans to finance a substantial part of their increase in net receivables and inventories during an expansion, there is clearly scope for restraining their activity. However, if, because of earnings, low risk or other reasons, large firms are more likely to be accommodated by the banking system in periods of tight money than smaller borrowers, the scope for restraining their activity is substantially reduced. Assuming

it is true that large corporations are somewhat removed from the impact of monetary policy because they maintain internal sources of finance and are accommodated readily by the banking system, and if it is desired to influence their behavior, what can be done about it? In attempting to answer this question the results of this study are interpreted more liberally than is probably justified.

The problem could be attacked from the standpoint of the availability of short-term credit to large firms, but this approach appears to involve discriminatory controls on bank lending. In addition, to the extent firms, in the face of tight money, are able to expand their activity by the sales of securities it is because they have adequate long-term credit. During a business expansion it would probably require a very high bill rate to induce firms to retain their security holdings instead of increasing net receivables and inventories. Another approach to the problem is to view large corporations for present purposes as a type of financial intermediary. As it may be difficult to control the source of funds of large corporations, attention is focused on the control of their lending.

An alternative method of restraining large corporations, then, is to curtail the trade credit they offer their customers. If the terms on accounts receivable were subject to control, such as the minimum terms that could be offered, the monetary impact of large corporations might be significantly reduced. If monetary restraint on some portion of the customers of large firms is effective, then the effect of tightening terms on receivables will be to reduce the sales of all firms including

large corporations. This will in turn reduce the demand for inventories of large corporations, and result in a lower level of activity. And symmetrically, if the monetary authorities reduced the terms in recessions, it might prove a stimulant to sales and inventory investment. These comments are intended to be provocative of further thought and research. Much more study is needed to determine whether large corporations are fairly insulated from the effects of monetary policy, and whether the trade credit offered by large firms allows their customers to make purchases they would not otherwise have been able to finance. And some judgement must be made as to the desirability of the use of selective controls of the type suggested.

APPENDIX 2

Analysis of Firm Intercepts

The firm intercepts for equations (4-11) and (4-12) for cash and securities have been estimated. Examination of these equations reveals that the estimated intercepts are a product of two coefficients, $\beta_3 \alpha_{60}$ for cash and $\beta_4 \alpha_{70}$ for securities. To obtain an estimate of α_{60} and α_{70} which are the intercepts in the equations for desired cash (4-1) and desired securities (4-2), the calculated intercepts for each firm are divided by the estimate of β_3 for cash and β_4 for securities. The purpose of estimating these coefficients was to see if they exhibited any pattern by industry or asset size.

In Table A-2 the following statistics are presented. In Column (1) the mean of average cash holdings by industry is presented, in Column (2) the mean of α_{60}'' by industry, in Column (3) the mean of average cash holdings by industry divided by the standard deviation, and in Column (4) the mean of α_{60}'' by industry divided by its standard deviation. In Column's four to eight the same statistics for securities are presented. These same statistics are presented for the firms classified by asset size. The mean intercepts for cash, and even more so for securities, do tend to exhibit a pattern similar to that of the means of average cash and security holdings both by asset size and industry. The coefficients of variation of the intercepts for cash and security are of similar size for the various groups of firms, while the coefficients of variation for the means of cash are generally much larger than the coefficients of variation for the intercepts for cash.

TABLE A-2

Means and Coefficients of Variation (V) of Cash and Security Holding and Firm Intercepts by Asset Size and Industry

	Mean of Cash	Mean of α''_{60}	V for Cash	V for α''_{60}	Mean of Securi- ties	Mean of Secur- α''_{70}	V for Secur- ities	V for α''_{70}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Asset Size Classes								
1. \$10 to 40 million	.1222	.0432	2.23	.97	.0548	.0324	.79	.33
2. \$40 to 65 million	.1080	.0089	2.65	.10	.0671	.0234	1.17	.18
3. \$65 to 100 million	.1414	.0921	2.03	1.51	.0528	.0658	.71	.75
4. \$100-150 million	.1071	.0560	2.65	.86	.0581	.0819	1.08	1.06
5. \$150-200 million	.0849	.0388	3.64	1.37	.1101	.1315	.89	.90
6. \$200-400 million	.1027	.0424	2.59	.88	.0654	.0546	1.08	.55
7. \$400-700 million	.1040	.0518	1.75	.65	.0769	.0916	1.32	.87
8. Over \$700 million	.0742	.0339	2.13	1.25	.0979	.0962	1.37	1.13
Industry								
1. Food and Tobacco	.1114	.0077	1.68	.06	.0473	.0102	.68	.07
2. Petroleum and Rubber	.0729	.0366	2.40	1.20	.0591	.0483	1.37	.88
3. Steel and Non-Ferrous	.0821	.0445	2.68	1.21	.0940	.1066	1.24	1.20
4. Chemicals	.1048	.0717	3.25	1.80	.0993	.1160	1.55	1.64
5. Machinery	.1020	.0680	2.46	1.89	.0843	.1262	1.00	1.25
6. Transportation	.1131	.0637	3.48	2.40	.0920	.1155	.95	1.39
7. Retail Trade	.1326	.0275	2.04	.41	.0522	.0045	.82	.05
Total	.1042	.0446	2.32	.71	.0734	.0710	.98	.66

If for any of the groups of firms examined the intercepts clustered about some mean value it would suggest that only an intercept for the whole group of firms need be estimated, rather than an intercept for each firm. The results in Table A-2 are not very suggestive on this count. The possible exceptions are industry groups 3, 4, and 5, whose intercepts for both cash and securities display much less variation than other groups of firms.

APPENDIX 3

Analysis of Residuals by Year, Asset-Size and Industry of the Firms and Size of the Independent Variables

In Chapter 4 it was mentioned that the analysis of the residuals is based on a slightly different form of the regression equations than was presented in that chapter. The appendix will begin with a discussion of this point. With no loss of generality, and some saving of space, we will consider for illustrative purposes that the change in cash is related to one independent variable, X , and that separate intercepts are specified for each firm so we have,

$$(A-1) \Delta C_{it} = \alpha_{1it} + \alpha_2 X_{it} + u_{it},$$

where, as in the text, t runs over 9 years and i over 165 firms. When least squares estimating procedure is used,

$$(A-2) \alpha_{1it} = \overline{\Delta C}_i - \alpha_2 \bar{X}_i.$$

Substituting (A-2) for α_{1it} in (A-1) we have,

$$(A-3) (\Delta C_{it} - \overline{\Delta C}_i) = \alpha_2 (X_{it} - \bar{X}_i) + u_{it}.$$

Thus (A-3) is an alternative way of formulating an equation specifying separate intercepts.

The reason given in Chapter 4 for specifying separate intercepts is that it is frequently difficult to explain the differences in the average value of stock variables among firms. However, means of changes in stocks (or flows), as $\overline{\Delta C}$, over a short period, anyway, are not apt to exhibit many inexplicable differences among firms. Thus instead of (A-3) one might write,

$$(A-4) \Delta C_{it} = \alpha_2 (X_{it} - \bar{X}_i) + \alpha_3 + v_{it},$$

where the v 's are a new error term, and a common intercept, α_3 , is specified. If we consider X to be a stock of flow variable whose average value among firms is not easily explained, then it will be useful to use this variable as a deviation from the mean of each firm, especially since it costs no degrees of freedom to do this.

Interestingly the least square estimates of α_2 are the same in (A-4) as in (A-3), and therefore as in (A-1). In (A-3) and (A-4) the variance of $(X_{it} - \bar{X}_i)$ will be identical. And since $\Sigma \Sigma (\Delta C_{it} - \bar{\Delta C}_i) (X_{it} - \bar{X}_i) = \Sigma \Sigma \Delta C_{it} (X_{it} - \bar{X}_i)$, the covariance is the same in (A-3) and (A-4), and so the two estimates of α_2 will be the same. And for any number of X 's the matrix of raw moments for form (A-4) will be identical with the form (A-3) except for the row of sums.¹ Instead of the number of observations and zero's in the row of sums as in (A-3), the row of sums for form (A-4) will consist of the number of observations, zero's for all the independent variables, and the last element will be the sum of ΔC_{it} . So the slope estimates on the independent variables will be the same in (A-4) as in (A-3), the inverse of the matrix of raw moments will be the same. And the estimate of the common intercepts, α_3 , will be precisely, $\bar{\Delta C}$. Finally the difference in residual variance between form (A-3) and (A-4) will be $t \Sigma (\bar{\Delta C}_i - \bar{\Delta C})^2$. Since for changes in stocks or flows this magnitude is not apt to be large it points to the advantage of form (A-4) over (A-3). However, when a firm stock or flow is the dependent variable,

¹And except for the measure of the variance of the change in cash in the last row.

the situation may be different.¹

Another advantage of form (A-4) over (A-3) is savings of degrees of freedom. In the present study, going from form (A-4) to (A-3) uses 164 additional degrees of freedom in estimating the mean of ΔC for each firm. The estimates of the cash and security equations of Chapter 4 when written in the form of (A-4) are,

$$(A-5)' \Delta C_{it} = \frac{.0020}{(.0000)} + \frac{.0330}{(.0029)} (T_{it} - \bar{T}_i) - \frac{.3848}{(.0118)} (B_t - \bar{B}) - \frac{.0391}{(.0118)} (I_{it} - \bar{I}_i) \\ - \frac{.0098}{(.0151)} (R_{it} - \bar{R}_i - D_{it} + \bar{D}_i) + \frac{.6312}{(.0235)} [(\bar{C}_{t-1})_i - C_{it-1}] + .1207 (\Delta N_{it} - \bar{\Delta N}_i) + w_{3it},$$

$$(A-6)' \Delta S_{it} = \frac{.0029}{(.0000)} + \frac{.0263}{(.0041)} (T_{it} - \bar{T}_i) + \frac{.0008}{(.1942)} (B_t - \bar{B}) - \frac{.1321}{(.0174)} (I_{it} - \bar{I}_i) \\ - \frac{.0260}{(.0222)} (R_{it} - \bar{R}_i - D_{it} + \bar{D}_i) + \frac{.4782}{(.0225)} [(\bar{S}_{t-1})_i - S_{it-1}] + \frac{.3237}{(.0301)} (\Delta N_{it} - \bar{\Delta N}_i) + w_{4it}.$$

As mentioned the coefficients on the independent variables are identical with those of equations B of Table 4, but now there are common intercepts of $\bar{\Delta C}$ and $\bar{\Delta S}$ respectively. The coefficients above have lower standard errors because the sum of residuals squared when corrected for degrees of freedom is less in (A-5) and (A-6), than in equations B of Table 4. $R^2 = .371$ and $F = 145.82$ for cash in (A-5) and $R^2 = .352$ and $F = 126.58$ for securities in (A-6). As the same degrees of freedom are used in estimating (A-5) and (A-6) as are used in estimating equations A of Table 4, it is clear that (A-5) and (A-6) explain significantly more of the variance of the change in cash and the change in securities. The addition of 164 intercepts for each firm to (A-5) and (A-6) does not add significantly to the explained variance

¹See p. 36, Chapter 3, above, where two stocks, payables and net receivables were used as dependent variables.

of changes in cash and securities.

Having established why w_{3it} and w_{4it} of (A-5) and (A-6) are the residuals that are to be examined, some general comments about the character of these error terms are in order. From the form of (A-4) it should be clear that the sum of residuals for each firm for cash is $t(\overline{\Delta C}_i - \overline{\Delta C})$, and for securities, $t(\overline{\Delta S}_i - \overline{\Delta S})$. As the sum of residuals for each firm are unrelated to the independent variables, which sum to zero for each firm, they are not of much interest. And if the sums of residuals for each firm are of little interest, then the same is true for groups of firms by asset-size and industry. However, the sum of residuals by year will be of interest and this is discussed below.

For this reason the analysis deals principally with the residual variance of subgroups of observations. Suppose for cash the 1st ten firms of the sample are a subgroup of interest. The initial variance of ΔC for this group is, $\sum_{i=1}^{10} \sum_{t=1}^{56} (\Delta C_{it} - \overline{\Delta C})^2$, and subtracting from this, $\sum_{i=1}^{10} \sum_{t=1}^{56} w_{3it}^2$, we get a quantity which we shall call the "explained variance" for a subgroup. We then make the usual F test. The explained variance is divided by 6, for the 6 independent parameters estimated, to make the numerator of the F ratio. And the denominator is the sum of residuals squared for the subgroup divided by the number of observations less 7, the number of parameters estimated. Thus for the first ten firms of the sample,

$$F = \frac{\left[\sum_{i=1}^{10} \sum_{t=1}^{56} (\Delta C_{it} - \overline{\Delta C})^2 - \sum_{i=1}^{10} \sum_{t=1}^{56} w_{3it}^2 \right] \div 6}{\left[\sum_{i=1}^{10} \sum_{t=1}^{56} w_{3it}^2 \right] \div (90-7)}$$

The principal peculiarity of our concept of explained variance for a subgroup is that it could be negative. In this case, of course, no test is needed, and the hypothesis that the explained variance for the subgroup is zero (or less) is accepted. If we summed the numerator of the F ratios for an exhaustive set of subgroups, it would equal the numerator of the F ratio for the regression equation for all observations. However, the sum of the denominator over all subgroups must necessarily be larger than the denominator for the F ratio of the regression equation for all observations.¹ This means that the null hypothesis, that the explained variance of a subgroup is zero is more likely to be accepted for a subgroup, regardless of the difference in observations, than the same hypothesis for all observations. Since we want to be able to reject the null hypothesis this characteristic of the test is (rightly?) not in our favor.

In Table A-3 firms are classified into 8 asset-size groups, and 7 industry groups. The explained variance as defined above, and the residual variance for these groups is presented in Columns (1) and (2) for cash and (4) and (5) for securities. The above F statistics are given in Column (3) for cash and (6) for securities. For all subgroups the explained variance is

¹This characteristic of the test makes it very difficult to reject the null hypothesis for small subgroups. Several of the industrial groupings of the present sample were four firms or less, and these have been put with other industrial groups for this reason. Thus, autos are included with transportation equipment, tobacco with food, rubber with petroleum, and non-ferrous metals with steel.

TABLE A-3

Analysis of Residual Variance by Asset Size and Industry

Group	Sum of Squared Residuals (1)	Cash		Sum of Squared Residuals (4)	Securities		Number of Firms (7)
		Explained Variance (2)	F* (3)		Explained Variance (5)	F* (6)	
A. Asset size Groups							
1. \$10 to 40 million	.20615	.07627	10.77	.18288	.19009	30.45	20
2. \$40 to 65 million	.16822	.14530	23.73	.28366	.15121	14.73	19
3. \$65 to 100 million	.21210	.17961	20.78	.19245	.06469	8.35	17
4. \$100 to 150 million	.10641	.08139	19.94	.24623	.07598	8.06	18
5. \$150 to 200 million	.10245	.07798	18.52	.38345	.21051	13.54	17
6. \$200 to 400 million	.11928	.03307	10.20	.36922	.19304	19.14	25
7. \$400 to 700 million	.16023	.04254	9.91	.32298	.13472	14.67	24
8. Over \$700 million	.06148	.03612	21.49	.48688	.31354	29.18	25
B. Industry							
1. Food and Tobacco	.10721	.05081	17.27	.17590	.05093	10.74	25
2. Petroleum and Rubber	.05867	.01677	8.73	.12151	.07547	19.34	21
3. Chemicals	.16168	.12747	24.13	.49781	.24401	15.00	21
4. Steel and Non-Ferrous	.12180	.04922	11.71	.27349	.22391	23.91	20
5. Machinery	.34118	.25299	36.97	.75302	.35925	23.75	34
6. Transportation Equipment	.11570	.08158	14.15	.40303	.29538	14.69	14
7. Retail Trade	.23008	.09380	17.96	.23632	.08716	16.31	30

*Critical values of F range from 2.90 (2.14) for industry group 5 with 34 firms (306 observations) to 2.99 (2.19) for industry group 6 with 14 firms (126 observations), at the 1% (5%) level.

significantly different from zero at the 1% level. It should be made explicit that these tests do not tell us whether it would have been "better" to run a separate regression for each subgroup.

We turn now to analysis of residuals by year. In Table A-4 the sums of residuals for cash and securities, and the sums of the dependent variables, ΔC and ΔS , are presented by year in Columns (1) and (2). In Columns (3) and (4) the residual variance and the explained variance are presented, and in Column (5) the F ratios are given. It may be noted that the sums of the estimated residuals by year will be the same for either equation form (A-3) or (A-4).

Do the means of residual differ by year? This question may be answered if it is assumed that the variances of residuals are the same in each year. As there exists no test of the homogeneity of means independent of the variances, there is little choice but to accept this assumption. The critical value of F for this test for 8 degrees of freedom in the numerator (8 independent estimates of means) and (1485-7-9) degrees of freedom in the denominator is 2.53 (1.95) at the 1% (5%) level of significance. The F ratio for cash is 1.57, and the null hypothesis that the means of the residuals for cash are equal, and equal to zero, is accepted. The F ratio for securities is 3.58 and the null hypothesis is rejected for securities. The null hypothesis that the explained variance for each year is zero is rejected in all years except 1948 for securities and 1956 for cash.

TABLE A-4

Analysis of Residual Variance by Year*

YEAR	Sum of Dependent Variable	Sum of Residuals	Sum of Residuals Squared	Explained Variance	F Ratio**
	(1)	(2)	(3)	(4)	(5)
1948					
Cash	-.217669	-.644198	.12688	.10213	22.30
Securi- ties	.973297	-1.700487	.27179	.02192	2.14***
1949					
Cash	.532040	.585148	.10799	.03699	9.06
Securi- ties	2.073883	.691080	.22374	.08990	10.62
1950					
Cash	.564818	-.055149	.11589	.03851	8.78
Securi- ties	1.587197	-.617922	.18500	.07036	10.11
1951					
Cash	.785820	-.237122	.16306	.13436	21.73
Securi- ties	.584626	-.706728	.35175	.21132	15.93
1952					
Cash	.108225	.321343	.11727	.08989	20.23
Securi- ties	-.813031	.884847	.29845	.38934	34.50
1953					
Cash	.913694	-.122216	.16000	.07639	12.60
Securi- ties	.715271	.214770	.26881	.11043	10.89
1954					
Cash	.197350	-.356185	.11160	.09072	21.59
Securi- ties	-.323810	.898786	.22307	.09014	10.73
1955					
Cash	-.579722	-.608756	.10181	.09117	26.50
Securi- ties	1.689740	1.118945	.31649	.12693	10.63
1956					
Cash	.676442	.404765	.13186	.00741	1.48***
Securi- ties	-2.233863	-.783291	.31605	.22596	18.92

*Figures in Columns (2) through (4) need to be divided by 165 to obtain average values for any year.

**Critical values of F for each year are 2.92(2.16) at the 1%(5%) level.

***Null Hypothesis is accepted at 5% or 1% level of significance.

The results for securities that the means are different from zero has something to do with time. The correlation of time with the residuals of each firm is not significant at the 1% level, and the correlation with the sums of residuals is not significant at either the 5% or 1% levels. However, the correlation is enough to substantially change the patterns of the sums of residuals. If we estimate,

$$w_{4it} = a(t - \bar{t}) + w_{4it}^i,$$

the estimate of "a" is .0009, $R^2 = .003$, and the F ratio is 4.83. The critical value of F is 3.84 at the 5% level and 6.66 at the 1% level. If time is used to explain the residuals the sum in 1948 is -1.1, and in 1955, is .67, which is an improvement, but the sum in 1956 becomes -1.38, and in 1949, 1.14. For the test of the homogeneity of means the F value for securities with time as a variable is 2.97, and the hypothesis that the means are equal in each year would be rejected at the 5% or 1% level. However, where as the null hypothesis that the explained variance for securities was zero at the 5% or 1% level in 1948 was accepted when time was not a variable, with time as a variable the F ratio would be 2.97, which is greater than the critical value at the 1% level, i.e., 2.72, with 7 and 158 degrees of freedom. These results, suggest, we believe, that the explanatory value of time for securities has something to do with 1948.

In 1948 the equation predicted an increase in securities for 152 of the 165 firms. This preponderance of predicted increases may be partly due to the trend in the values of variables. However, inventory holdings for the firms in 1948 were

not high relative to sales, so this factor led to more predicted increases in 1948 relative to other years of business expansion. And the fact that the sum of changes in securities is positive in 1948 also suggests that an equation describing security holdings might well have a large number of predicted increases in that year. However, actual increases in security holdings were made by only 70 firms. The problem with 1948, we suggest, is that a substantial number of the firms were still getting rid of their accumulation of securities from the war. This adjustment, though related to the lagged value of securities, would not necessarily be related to the values of the other variables in the model, and may be the reason for the relative poor performance of the securities equation in 1948.

The performance of the cash equation in 1956 is somewhat mystifying. An examination of signs revealed that the predicted change in cash holdings in 1956 was of the same sign as the actual change for 105 of the firms. Neither the sums of the changes in cash or the sums of residuals are suggestive of any particular bias in that year. The values of the independent variables for that year are also not suggestive of why the explanatory value of the regression equation is low for 1956. One reason for the poor performance of the cash equation for 1956, which is not helpful in indicating the manner in which the estimates err, is that the initial variance of changes in cash is lowest in that year.

The error terms for cash and securities have also been related to the size of some of the independent variables, and

in particular, sales, inventories, lagged cash, and lagged securities. As the size of these independent variables for each firm will tend to rise through time because they are divided by average total assets for the period, the average values of these variables for each firm have been used to rank firms. That is, firms have been ranked by the average size of the independent variables, and not observations. The firms have been divided into ten groups by the size of the variables, and the average residual variance has been converted into an index number for each group. These index numbers are presented in Table A-5.

It is quite obvious that there is substantial heteroscedacity for cash with respect to lagged values of cash, and for securities with respect to lagged securities. For sales, it is not easy to tell whether the pattern of residual variance suggests a non-linear relationship between cash and sales, or that there is simply heteroscedacity. For inventories the pattern of residual variance is quite mixed for cash. For securities the residual variance for both sales and inventories suggests that there may be some type of non-linear relationship which would describe the data better than the simple linear forms used here.

TABLE A-5

Analysis of Residual Variance of Firms Classified by Size of Sales, Inventories, Cash, and Securities

(Range of variable for each classification given with class numbers)*

Variable of Classification	Index of Residual Variance		Variable of Classification	Index of Residual Variance	
	Cash (1)	Securities (2)		Cash (1)	Securities (2)
A. Sales			C. Lagged Cash		
1) .54-.77	89.8	70.5	1) .008-.050	16.1	
2) .77-.91	72.1	115.5	2) .050-.065	38.6	
3) .91-1.10	65.4	186.9	3) .065-.073	36.1	
4) 1.02-1.21	79.3	127.2	4) .073-.079	40.8	
5) 1.21-1.36	95.0	79.5	5) .079-.089	56.1	
6) 1.36-1.43	82.8	124.7	6) .089-.102	120.8	
7) 1.43-1.69	114.7	123.7	7) .102-.124	114.8	
8) 1.69-2.16	164.5	63.6	8) .124-.138	167.1	
9) 2.16-2.77	133.9	83.1	9) .138-.175	200.3	
10) 2.77-6.11	100.0	30.2	10) .175-.317	194.2	
B. Inventories			D. Lagged Securities		
1) .046-.124	56.8	82.9	1) .000-.001		13.0
2) .124-.160	82.5	97.9	2) .001-.007		26.7
3) .160-.194	127.8	119.9	3) .007-.022		30.2
4) .194-.246	72.8	128.0	4) .022-.030		54.8
5) .246-.276	103.2	143.8	5) .030-.045		87.4
6) .276-.305	98.8	97.9	6) .045-.079		110.0
7) .305-.341	84.1	92.3	7) .079-.099		118.1
8) .341-.380	146.5	69.8	8) .099-.126		174.4
9) .380-.456	157.8	57.4	9) .126-.158		182.5
10) .456-.864	68.5	57.9	10) .158-.482		186.8

*Sixteen firms are included in each of the first five classes for each variable, and 17 firms in the last five classes. The average of the sum of squared residuals over all observations was used to form the index numbers. Thus the index numbers for cash for all variables have the same base and similarly for securities.

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