UNIVERSITY OF ALBERTA

PORTFOLIO SUBSTITUTION AND THE DEMAND FOR GOVERNMENT OF CANADA MARKETABLE BONDS

by

Joe Amoako-Tuffour

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled **PORTFOLIO SUBSTITUTION AND THE DEMAND FOR GOVERNMENT OF CANADA MARKETABLE BONDS** submitted by Joe Amoako-Tuffour in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Paul Boothe
....
Paul Boothe (Supervisor)

NK Dastoor
....
Naorayex K. Dastoor

Bradford G Reid
....
Bradford Reid

Rolf Mirus
....
Rolf Mirus

John F Chant
....
John Chant (External Examiner)

Date March 16, 1990

DEDICATION

To you my Parents

Kwame Amoako and Akua Nyantakyiwaa

You who taught me a great deal more in silence than in language.

You who prayed and wished me well in search of destiny.

You who filled my dreams with silent, beautiful images.

You who endured the pain of my long absence from home.

ABSTRACT

Knowledge of the role of government bonds in the intermediation activities of banks and the substitution relationships between government bonds of different maturities and for other debt instruments is important for policy decisions bearing on debt management and credit control. Debate about bond market stability and the implications of debt management strategies resolves into issues of the nature of maturity preferences and asset substitution/complementarity in investors' portfolio. This study examines the nature of bond market transactions and the factors determining the demand for Government of Canada marketable bonds by the banks and the public.

The essential features of the model are the derivation of a static portfolio model in which financial and nonfinancial variables serve as determinants of aggregate bond demand; the generalization to allow for flexible portfolio dynamics; the attention paid to institutional features; and the attempt to account for term structure effects. Observations from a new bond-by-bond data set are used to analyze the demand patterns for three maturity classes of bonds: short maturities (1-3 years), medium maturities (3-10 years) and long maturities (over 10 years).

Determinants of bond demand and the nature of substitution relationships between government bonds and other debt claims are suggested. These determininants vary between investor groups. Asset and deposit composition effects are important in explaining the banks' transacting behaviour. The important determinants of the public's aggregate demand for bonds include income, and relative money and capital market yields. Term structure effects appear minimal. Evidence that the various factors affect maturity choices differently shows up in the estimated lag patterns in a way that could not be captured by dynamic models that impose uniform a priori lag constraints. The substitution and complementary relationships between government bonds and equity, corporate, municipal, and provincial securities vary among the maturity classes. The results also suggest that open market operations in short- and long-term bonds may not be felt as strongly in financial markets as they would be if changes occurred in medium maturities. Financial crowding out of debt issuers will most likely

be confined to medium-term maturities. The pricing and redemption features of non-federal government debt instruments ought to be important considerations in the pricing of new issues of medium-term federal bonds.

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Chapter 1

INTRODUCTION

Developments in the market for government securities have always attracted widespread attention because of the central role of this market in the functioning of financial markets in particular and in macroeconomic activities in general. The government securities' market facilitates the government's active and direct participation in financial markets. It provides a potential medium through which the government can influence movements in interest rates, credit flows and consumption-savings decisions through timely sales and purchases of securities. Historically, much of the interest in the market for government securities has centered on the size and composition of outstanding securities and the cyclical behaviour of the yield structure. Size and maturity composition prompt debate about the optimal management and economic consequences of the public debt. The yield structure, in large part, reflects the (un)willingness of lenders to absorb these securities, and it has direct bearing on the management of the debt and the general level of interest rates.

Empirical analysis of the demand for government securities has a relatively short history. The motivation for such work was the general trend, beginning in the mid-1960's, towards understanding aggregate financial behaviour. Knowledge of the extent to which government securities of different maturities can substitute for each other or for other debt claims was seen as essential for any serious analysis of the impact of bond market activities on broader economic outcomes. Early analyses of bond market behaviour began as part of the general modelling of the financial side of the economy in large-scale macroeconometric models. Most of these studies focused on analyzing aggregate bond holdings. Over time, attention switched to sectoral analyses, recognizing, as data permitted, separate demand equations for different maturities by different ownership groups. The basis of this line of research is that when investors choose term-differentiated securities, their different decision-making characteristics, the predictability and duration of their liabilities, and institutional factors all serve as important conditioning factors. Indeed, basic to all theories of the term structure is the notion of how investors might choose to hold term-differentiated securities in order to cope with interest rate uncertainty (Meiselman, 1962). In particular, the basis of the market segmentation theory is that investors' maturity preferences can be deduced from knowledge of the maturity of their liabilities. Such is the basis of most empirical analyses of the market for government securities. Sectoral analyses should help discover a number of useful relationships which cannot be inferred from aggregate analysis. Such analyses should serve usefully in understanding bond market activities, in interpreting the behaviour of the yield curve over time, and in analyzing strategies of debt management. For example, the results should provide an informed empirical basis for debt management policies aimed at changing the maturity mix of the debt. An important by-product of the analysis is an understanding of the similarities and differences in the portfolio preferences of the different ownership groups.

1.1 Purpose and Scope of the Study

This study contributes to an understanding of the Government of Canada bond market by focusing on a structural analysis of the underlying demand. The study emphasizes explanations for the observed movements in the chartered banks' and the nonbank public's holdings of marketable bonds for the period 1967-1984. Three issues are of interest: the extent to which different maturities can substitute for each other in investors' portfolios, the substitute-complement relationships between government bonds and other debt instruments and equities, and the contrast in the portfolio behaviour of the different ownership groups.

The first two issues relate directly to the problem of whether or not there is an optimum maturity mix of government debt instruments, and whether or not there is an optimum government-private debt ratio for an economy. The nature of maturity substitution is at the centre of the term structure debate (see, for example, Meiselman, 1962, Kessel, 1965, Malkiel, 1966, and Van Horne, 1978). One of the essential points of this debate has to do with the relationship between investors' maturity choices and the equilibrium structure of bond yields. Any of several maturity substitution relationships has been shown to imply different term structure relationships. Briefly, infinite elasticities of maturity substitution are predicted to enforce equality of holding period returns in equilibrium. The policy implication is that optimal debt management policies should be independent of the maturity composition of the outstanding securities, and presumably, independent of the distribution of bond holdings. On the other hand, less than infinite elasticities of substitution are predicted to create segmentation or preferred habitat effects, in which case the debt composition matters as does the distribution of bond holdings.

Concerning the relationship between government debt and other private debt claims, the central question is whether bond-financed spending displaces private sector financial claims held by the public. What is being sought are the conditions for debt management to have a stimulative, a restrictive, and or a neutral impact on the economy (Roley, 1980). The basic premise, as shown by Tobin (1963), is that portfolio substitution is one channel through which crowding out of private expenditures by government expenditures could occur. Continuous public sector borrowing implies increasing imbalance between the mix of public and private debt instruments. To the extent that bond-financed spending has perverse effects on private sector financing, it is because the relative attractiveness of government bonds induces portfolio substitution away from private sector claims.

The implication of imperfect substitutability is that the net effects of expansionary bond-financed spending become less obvious. A low degree of substitutability between government and private debt instruments implies less arbitrage at the margin, diminishing the influence of bond market activities on private securities and vice versa. The contested issues are largely empirical and rest on the relevant interest rate coefficients in the aggregate demand for public and private financial instruments. If government and private debt claims are perfectly substitutable in investors' portfolio, complete crowding out is possible. Otherwise, the economic consequences of bond-financed spending span a number of possibilities (Friedman, 1978).

The third issue has to do largely with the role of financial intermediaries (hereafter, simply 'banks') in the market for government securities. This role, which has been recognized by many researchers (e.g., Tobin, 1963; de Leeuw, 1965; Silber, 1969; and Roley, 1980), arises from the fact that the banks' participation in the bond market has been very much a function of cyclical fluctuations of the economy. Specifically, banks tend to buy bonds during periods of monetary ease and sell bonds during periods of monetary restraint. From the standpoint of monetary control, cyclical sales and purchases of bonds by the banks have the potential to weaken the impact of countercyclical credit policy and consequently, increase the policy transmission lag. During the sixties, the concern that banks can initiate or exacerbate cyclical bond price movements as they carry their portfolio adjustments to the bond market motivated debate to insulate the government bond market. Discussions about the role of the banks in the government bond market abated somewhat after the 1970's, due in part to the fact that banks reduced their reliance on government bonds as the primary store of excess liquidity. Although interest in these issues appear to have lessened, financial market trends in general and the growth of the bond market in particular have given cause to examine the behaviour of the banking institutions and other major institutional bond holders. In the U.S., the motivation seems to have come from the need to further understand how the aggregate financial behaviour of these institutions, generally with distinct maturity preferences, impact on the behaviour of the yield curve (Friedman 1980, 1982, and Roley, 1980 and 1981).

The present study attempts to shed light on the foregoing issues in the context of the Canadian economy by examining the determinants of the demand for government bonds and interpreting the implied portfolio substitution-complement relationships. For the banks, the goal is to examine the nature of the variations in bond holdings and to relate them to changes in yield and non-yield influences, paying attention to the relative influences and testing for maturity-specific effects of such determining factors. For the nonbank public, we examine issues of portfolio substitutability of government bonds: across maturities and with respect to the range of substitution with other debt instruments. From a market viewpoint, federal government bonds rival all kinds of money market obligations and corporate, provincial, and municipal debt claims. We explore the nature of the public's preferences for government bonds with respect to the high-coupon and relatively riskier corporate bonds, with respect to the relatively secured provincial and less secured municipal bonds, with respect to the relatively riskier equity claims. A whole range of assets could be considered in this respect but only that of selected assets are considered.

Questions regarding the implications of nvestors' portfolio behaviour on the equilibrium structure of bond yields are not addressed in this paper. For a small open economy, such analysis will be incomplete without extending the model to recognize the open economy influences on the Canadian term structure. Boothe et al. (1985) observed that U.S. and Canadian bonds are highly but not perfectly substitutable. The implication is that the influence of variations in the U.S. term structure, adjusted for exchange rate risk, on the Canadian term structure, cannot be ignored a priori. Lacking detailed maturity data on domestic holdings of foreign bonds and on foreign holdings of Canadian bonds prevents us from proceeding to this important next step.

The rest of the study is organized as follows. Chapter 2 provides a brief overview of the marketplace within which the study is situated. We focus on the major trends in the bond market as they relate to the willingness of the market to absorb bonds, the distribution of bond holdings, and the shifting maturity composition of the public's bond portfolio. The major institutional bond holders are identified and their motives for holding government bonds are briefly explored. The evidence assembled here serves as a background for the empirical work. The survey of the issues underlying the demand for government bonds and the related empirical evidence form the content of chapter 3. We develop the framework for the ensuing empirical analysis in Chapter 4. This framework is Parkin's (1970) adaptation of the Tobin-Markowitz portfolio selection model. Essential characteristics of the analysis are the generalization of Parkin's model in which financial as well as nonfinancial variables serve as the determinants of the demand for term-differentiated securities; the generalization of the static model to account for short- and long-run portfolio dynamics without imposing a priori uniform lag constraints; and the attention paid to the institutional features of the Canadian market in identifying sectoral demand equations. The econometric specification, estimation and testing procedures used to study the generalized dynamic portfolio model are presented in chpater 5. The empirical evidence follows next in chapter 6, with summary observations of the study appearing in Chapter 7. The data sources and definitions are given in the appendices.

Chapter 2

TRENDS IN THE GOVERNMENT OF CANADA BOND MARKET AND PATTERNS OF MATURITY PREFERENCES

Prior to the late 1960s, the Government of Canada bond market was relatively stable. For the most part, bond market activity was confined to refunding maturing issues while net new borrowing was met largely through the sale of Canada Savings Bonds and Treasury Bills.[1,2] The maturity distribution of bonds was concentrated largely in the short-term and intermediate-term maturity classes; less active secondary market trading made long-term bonds (with final maturity greater than 10 years) less marketable and perhaps less attractive to hold.

Developments since the early 1970s contrast sharply with the predominant pattern of the 1960s, both in the dollar magnitudes of outstanding bonds and in the maturity mix. Four aspects of recent changes have been (1) the gradual decline in reliance of the market on traditional clients—the Chartered banks and Government of Canada Agencies, (2) a moderate increase in participation of the near banks, (3) the increased participation of non-depository financial institutions, and (4) the lengthening of the average term to maturity of new bond issues. These trends reflect either the results of deliberate debt management policy or the results of changes in demand. Both, in turn, reflect the changing financial environment. For our purpose the supply side changes are not of immediate concern. Even if growing cash requirements underlie the increase in the supply of bonds, it is also true that the volume of

[1] A source of information about debt management operations, the issue and purchase of bonds, the frequency of new issues, and the maturity composition of bond issues is the Bank of Canada Annual Report to the Minister of Finance.
[2] The Canadian Government Securities market is tapped through the issue of treasury bills with a maturity of 91 days to 365 days, through marketable bonds with maturity range of over one year, and through non-marketable Canada Savings Bonds, designed for personal investors. With few exceptions, Government of Canada marketable bonds are non-callable, subject to neither sinking funds nor purchase funds, while some issues are extendible at the option of the holder (Hatch and White, 1985). Fullerton (1962) and Neufeld (1972) provide an historical overview of the development of the Canadian Government bond market prior to 1970. Also available from these sources are the institutional arrangements of the market. Recent discussions about the Canadian bond market can be found in various issues of the Bank of Canada Annual Report. Other salient features of the market can be found in OECD Committee on Financial Markets Group of Experts, Vol II (1983).

new bond issue and the maturity mix cannot deviate from what the market is willing to hold.[3] In this chapter, we review briefly the major trends in the bond market as reflected by the shifting distribution of bond holdings and the changing maturity composition of bonds in investors' portfolios. These trends are examined in turn for the chartered banks in section 1 and for the non-bank public in section 2. Summary observations conclude the chapter.

To give some context to the interpretation of the data and a framework for subsequent discussion, we digress briefly to consider existing 'explanations' of the demand for term-varying securities. Theories of the demand for money show how money demand can be analyzed from knowledge of the underlying motivations for holding money (Laidler, 1985). In the same vein, traditional term structure theories convey different views on how investors might choose to hold different maturities of securities and why we should expect systematic differences in the maturity composition of investors' portfolios over time.

The expectations hypothesis associated with Lutz (1940) and Meiselman (1962) assumes that bond demand is predominantly determined by the desire to maximize end-of-period wealth. Speculative motives for bond holdings are expected to be important. Investors are assumed to be unaffected by the risk of return variations and will engage in maturity arbitrage if there are perceived benefits in doing so. According to this view, if the market behaves as predicted, we will not observe any rigid patterns of maturity composition in investors' portfolios. Continually shifting maturity preferences are determined largely by the market's expectations of the future course of interest rate movements and the prospects of higher holding-period returns.[4]

Culberston (1957) dismissed the expectations view of bond market behaviour, the arbitrage support which underlines it, and the implications for debt management. The thrust of the market segmentation hypothesis is in terms of hedging, not speculative behaviour.

[3] Indeed, the market determines the amounts of different maturity tranches making up a maturity package while the government determines the overall issue amount, bearing in mind the ability of the market to absorb them to avoid indigestion (OECD, 1983, II p 62).

[4] Modern interpretations of the expectations view of market behaviour discount the risk neutrality assumption, adopting the view of risk aversion as the rule (Cox, Ingersoll and Ross 1981).

Investors' hedging motives induce specific maturity preferences in order to match the maturity of the underlying liabilities. In much the same way that the conventional precautionary demand for money stems from the uncertainty about the timing of cash flows, here, liquidity or precautionary motives are expected to be important. As a result, shifting maturity preferences reflect largely the shifting maturities of the underlying liabilities. To the extent that non-yield considerations determine maturity preferences, market demand for these securities may shift causing short-run movements in bond prices.

The Hicksian liquidity premium hypothesis stresses the role of risk aversion. As in the expectations hypothesis, investors' preference for maturity arbitrage remains a key underlying assumption and so is the desire to minimize the risk of capital value uncertainty. No assertions are made about the maturity composition of investors' portfolio. However, as Buse (1975) observed, "If the liquidity premiums are interpreted as threshold levels, varying monotonically only as a function of the maturity span ---, then this model implies plunging behaviour."(p. 83). In other words the portfolio composition of such investors will reduce to a special case of the market segmentation hypothesis, with short-term maturities being the preferred maturity holdings. If the market behaves as predicted, we can expect the preferred maturities to vary depending on the current state of market's expectations about future interest rates, the degree of confidence in these expectations, and the willingness of the market to bear the risk associated with different maturities.

2.1 Chartered banks

Table 2.1 shows the pattern of distribution of total Government of Canada marketable securities for selected years.[1] Despite the increase in the volume of outstanding securities, the data point to the declining reliance of the market on the traditional clients: Government of Canada Accounts,[2] the Bank of Canada, and the chartered banks. Excluding

[1] This includes Treasury bills.
[2] This category of security holders includes the Securities Investment Account and other Government Agencies. These Agencies hand over their cash surpluses to the Treasury and receive in return interest-bearing government securities. Securities held in this category are generally of no economic significance.

Table 2.1

PERCENT DISTRIBUTION OF GOVERNMENT OF CANADA DIRECT AND GUARANTEED MARKETABLE SECURITIES AS OF YEAR-END

Securities Held By:	1965	1970	1975	1980	1984
1. GOV'T OF CANADA ACCOUNTS	4.10	5.70	3.64	1.75	1.67
2. BANK OF CANADA	25.30	24.47	38.73	29.05	16.83
3. CHARTERED BANKS	27.10	37.43	38.19	17.96	14.71
4. GENERAL PUBLIC					
Near-banks					
Trust Co.	2.80	3.05	1.78	2.77	2.62
Mortgage & Loan Co.	0.08	0.68	0.48	0.62	1.70
Quebec Savings	0.15	0.19	0.13	0.08	0.26
Local & Central Credit Unions	0.31	0.45	0.88	1.52	1.51
Non-Depository Financial Institutions					
Investment Dealers	0.46	1.79	1.78	1.91	2.73
Sales Finance & Consumer Co.	0.12	0.04	0.07	-	0.36
Mutual & Close-End Funds	0.57	0.18	0.12	0.55	0.95
Life Insurance Co.	3.80	2.85	2.72	5.57	7.53
Other Insurance Co.	4.10	3.55	2.94	4.87	4.20
Trusteed Pension Plans	2.30	1.81	1.60	9.07	11.80
Others					
Non-Financial Corp.	3.30	1.27	1.29	0.75	5.49
Provincial & Munc. Govt.	4.20	3.34	2.16	7.50	6.58
All Other Canadian Residents	20.5	13.9	7.07	15.94	22.60

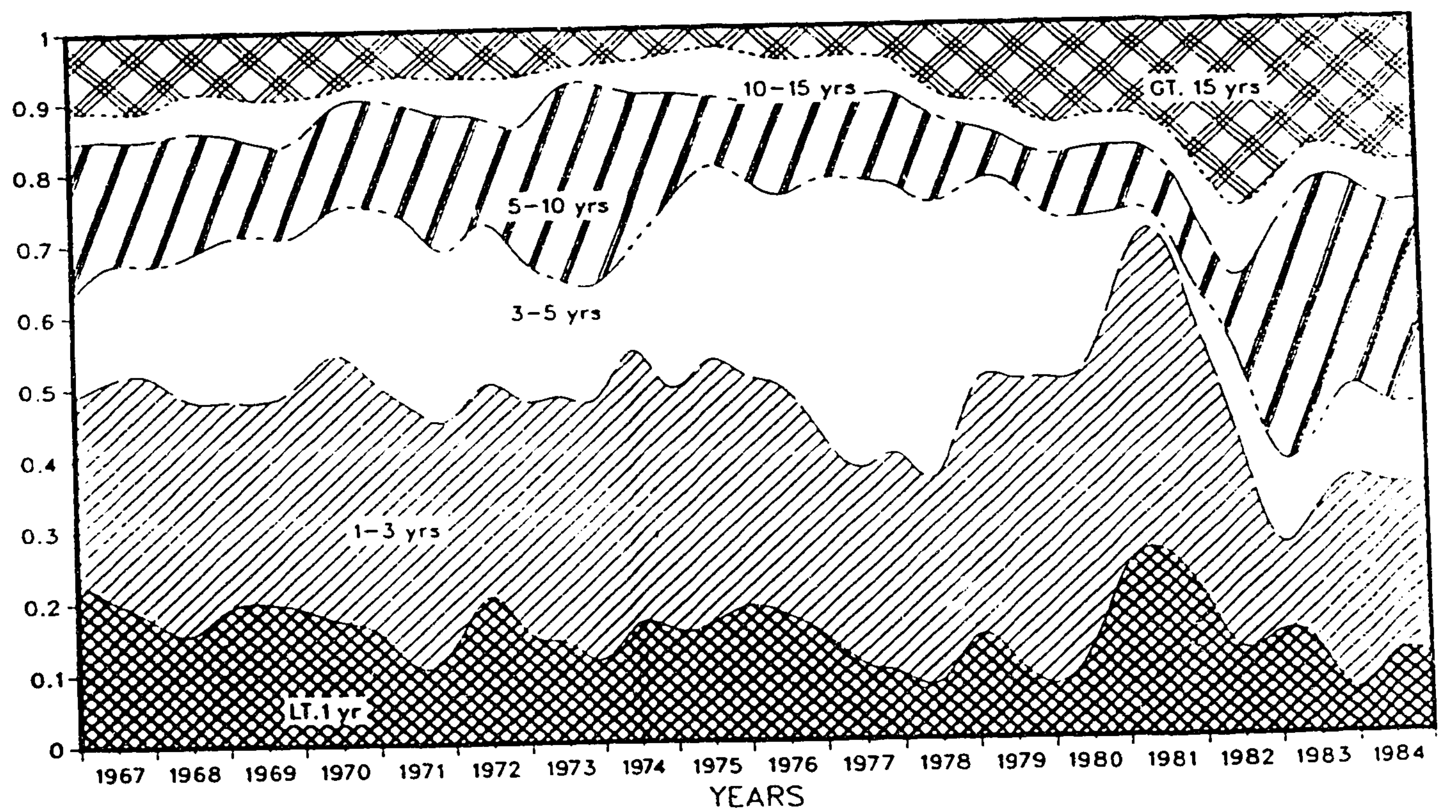
Data compiled by author from Bank of Canada Review, various issues. Notes:(1) Total securities are defined to exclude Canada Savings Bonds but includes Treasury bills.
(2) Details may not add to 100 percent because of rounding.
(3)All other holdings of market issues by Canadian residents are derived as residual.

Government of Canada Accounts and Bank of Canada, the rest of the discussion focuses on securities held by private investors.

Over the period of 1965 to 1984, one of the noticeable changes seemed to have occurred in the chartered banks' holdings of government securities; their share fell from 27.1 percent in 1965 to 14.7 percent in 1984. More important, the banks' share of total outstanding bonds were 26, 34, 28, 11, and 5 percent in 1967, 1971, 1975, 1979, and 1984, respectively. The decline was more rapid beginning in the late 1970s. Within their bond portfolio, the decline is most marked in the share of bonds in the 1 to 5 years category while there is an increase in the share of bonds with maturities greater than 5 years.

Figure 2.1 illustrates the trends in the maturity composition of the banks' bond holdings. These trends can be interpreted as reflecting a combination o the stylized portfolio behaviour patterns implied by term structure theories. Prior to 1978/79, the data reveal a definite and unchanging maturity mix with bonds under 5 years to maturity making up almost 60 percent of the total bond portfolio holdings. Indeed prior to 1980, the banks showed no tendency to lenghten the maturity of their bond portfolio. The liquidity accommodating and hedging motives in bond holdings appeared to have dominated the desire to hold bonds as primary earning assets. Needless to say, the motives for bond holding are subject to change, reflecting the continuous change in the banks' investment behaviour. By 1984, bonds under 5 years had fallen to just under 40 percent. Offsetting this reduction are noticeable increases in the share of 5 to 10 years bonds and in the share of bonds with original maturity greater than 15 years. The share of bonds in the 10 to 15 years maturity range has remained fairly constant. In line with the institutionalist view of bond market behaviour, the marked increase in the average term to maturity of the banks' bond holdings from 68 months in 1970 to almost 104 months in 1982 can be interpreted as reflecting changes in the average maturity of their deposit liabilities. Citing some evidence, the total notice and term deposits as a fraction of total private domestic deposits (excluding goverment [illegible]) grew steadily from about 70 percent in 1971 to almost 85 percent in 1982. Of the total notice deposits, the proportion of fixed to non-fixed term deposits increased beginning in mid-1971 from 15.7 percent to almost

MATURITY DISTRIBUTION OF CHARTERED BANKS' GOVERNMENT BOND PORTFOLIO



50.1 percent in 1984. As a fraction of total deposits (including government and foreign currency deposits), the share of term and notice deposits has risen from an average level of 67 percent in 1976/80 to about 77 percent in 1981/84.[3]

Apart from innovations in liability management, the overall decline in the banks' bond holdings reflect, in part, the broadening of the range of assets that banks can hold. Contributing to the latter was the Bank Act revision in 1967, which removed "both direct and cost-related barriers"[4] to the banks' participation in several sectors of financial markets. The removal of interest rate ceilings on bank loans and the removal of the ban on banks' participation in conventional mortgage lending must have led to a re-allocation of investable funds away from bond holdings into mortgage lending and other loan activities.

2.2 Non-bank public

The remainder of table 2.1 provides a disaggregation of the distribution of holdings by the general public. The finer breakdown reflects homogenous ownership groups- the near banks, non-depository financial institutions, non-financial corporations, provincial and municipal governments, and a residual category. Consider first the near-banks. These are savings-type institutions. Their combined holdings increased up to 1970, declined during the 1970-1975 period, and showed an upward trend after 1975, although their total holdings remain modest. The attractiveness of government bonds to the near-banks lies in the benefits arising from the protection against the risk of default. Because of their marketability, government bonds also provide the flexibility for cyclical adjustment in their liquidity position. For the near-banks short-term loans extended to households and mortgage loans are the major alternative investment outlets to holding government bonds.

Non-depository financial institutions include security dealers, insurance companies, financial corporations, investment companies, and pension plans. These institutions are much more diverse among themselves than the near-banks and are likely to differ widely in their

[3] Information is based on "Chartered Bank Assets and Liabilities: Wednesday and Average of Wednesday," CANSIM data matrix 913.
[4] Dean and Schwindt (1976, p.20).

investment decisions. However, with the possible exception of investment dealers, they can all be characterized as non-savings type institutions having low or moderate demands for liquidity, long-term investment horizons, and bond portfolio likely to emphasize flexibility and adequate yield. Excluding dealers, the combined holdings of government securities by the non-depository financial institutions fell from 10.9 percent in 1965 to about 7.5 percent in 1975, rose sharply to 20.1 percent in 1980, and rose moderately to about 24.8 percent in 1984. Of the individual sub-groups, government securities have not become a major investment outlet for Sales and Finance companies and Mutual and Close-End Funds. Security holdings by Property and Casualty Insurance companies declined initially and in 1984 remained slightly above the 1965 level of 4.1 percent. The most significant changes in trend occurred in the portfolio of Life Insurance companies and Trusteed Pension Funds, following a pattern similar to that of the near-banks. Together, their share of securities outstanding declined from 10.2 percent in 1965 to 7.3 percent in 1975, rose sharply to 13.6 percent in 1980 and to about 21 percent in 1984. A particular feature of this trend is the continuous liquidation of bonds by pension funds, totalling $151 million from 1971 to 1975. This was followed by an upward trend in acquisitions of $243 million in 1976, $648 million in 1978, $1697 million in 1980, and $1192 million in 1982. The net acquisitions by the insurance companies were $116 million in 1975, $405 million in 1976, $1081 million in 1978, $1046 million in 1980 and $1147 million in 1982[5].

To non-depository financial institutions, the major alternative investment outlets are provincial, municipal and corporate bonds, and equities in physical capital. Hence we would expect that the major determinants of the rate of acquisition and liquidation of government bonds by these institutions will depend on the relative attractiveness of these other debt instruments. Moreover, the differences in yields should be enough to compensate for the relative lack of marketability of these securities in order to induce significant portfolio shifts away from government bonds. Some recent shifts in the portfolio of pension funds and insurance companies have been noted by Davis (1985). The evidence suggests that the share

[5] System of National Accounts: Financial Flow Accounts, Statistics Canada Catalogue 13-002.

of corporate bonds as a percent of the total assets of Pension Funds fell from about 14.6 percent in 1975 to 7.4 percent in 1985. During the same period, the share of total provincial and municipal bonds also fell from 30 percent to 23 percent, while the share of federal government bonds rose from about 3.8 percent to 15.9 percent.[6] For the life insurance companies, the share of corporate, provincial and municipal bonds fell slightly from about 20 percent in 1975 to 16 percent in 1985 whereas the share of government bonds rose from 12 to 20 percent over the same period.[7]

Concurrent with these changes were developments in the corporate bond market which may have affected the demand for government bonds. For example, net new domestic issues of corporate bonds declined from $5105 million in 1977 to $1859 million in 1981, and fell drastically to $91 million in 1982, increasing slowly to $1789 million in 1985. There was also a noticeable decline in the average term to maturity of new domestic corporate bond issues, especially in the 1980s. The share of new issues with original term to maturity greater than 10 years dropped from 67.7 percent between 1975-1980 to 45.1 percent during 1981-1985. The difference was reflected largely in the issue of 5 to 10 years bonds (See Appendix A, Table A.1). The contraction in domestic economic activity in the late 1970s and early 1980s may have created significant market uncertainty, sufficient to induce investors to shift preferences away from corporate securities into the more certain government securities. Furthermore, the unusual incidence of downward revisions in corporate bond ratings— 9 downgrades in 1981, 40 in 1982 and 28 in 1983[8]— may have led investors to demand higher default premiums on corporate bonds. For example, the default spread (measured by the excess of corporate weighted long-term yields over Government of Canada bonds with greater than 10 years to maturity) increased from 66 basis point in 1978 to 127 basis point in 1981 and stood at 80 basis point in 1985.[9] With rising interest rates and higher default premiums, firms became

[6] Trusteed Pension Funds Financial Statistics, 1986, Statistics Canada Catalogue 74-201.

[7] These figures are approximations from graphs presented in Davis (1985, pp. 37 - 53).

[8] Bank of Canada Review (December 1986, p. 12).

[9] Figures are computed from Bank of Canada Review using series B 14013 and B 14048.

more reluctant to lock in their domestic obligations at higher interest rates, preferring instead to wait for a fall in long-term bond yields.

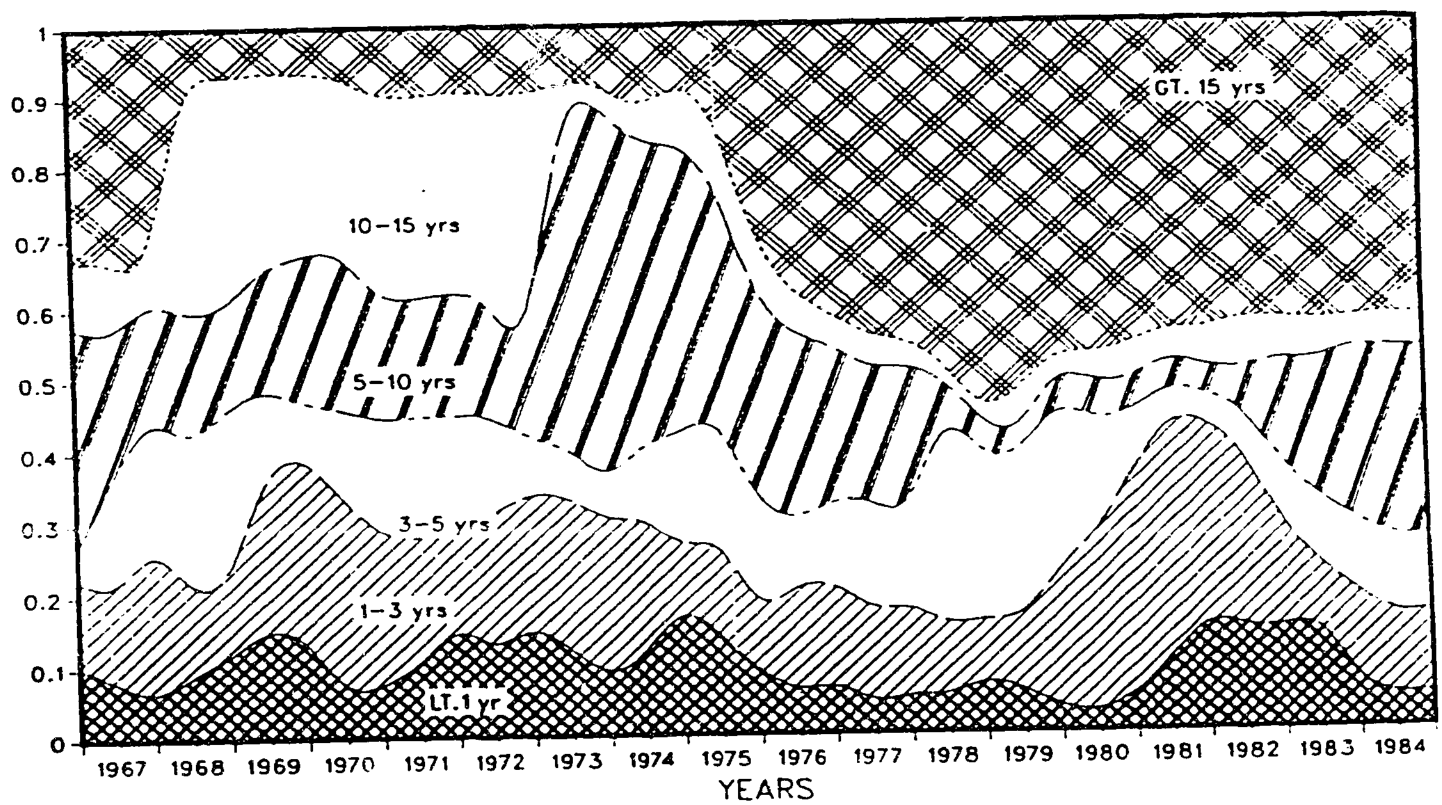
Direct holdings of government securities by non-financial corporations represented a fairly small portion of their portfolio until recently, increasing from 0.75 percent in 1980 to 5.4 percent in 1984. Provincial and municipal governments' holdings of federal government securities posted significant increases between 1975 to 1980 and have since declined slightly from 7.5 percent to 6.58 percent. For individual households, government marketable bonds have not directly become a significant part of their investment portfolio except perhaps as indirect investments via other investment outlets. In the U.S., for example, Kaufman (1973) observed that the direct participation of individual investors has historically been very thin and volatile, depending largely on the extent to which open market interest rates have exceeded deposit rates. Individual participation is also be deterred by the tendency to keep higher minimum denomination of bond issues. The class of holders identified as Canadian Residents is a residual category and as such offers no particular insights.

An examination of Figure 2.2 suggests that the changing maturity mix of the non-bank public is distinctively different from that of the banks. It is relevant to note that the definition of the non-bank public (table 2.1), may mask maturity shifts between different types of security holders. The fraction of bonds maturing within 10 years remained fairly stable until 1973. The abrupt increase in the share of 10 to 15 years maturities and subsequently the 5 to 10 year category merely reflects passive crossovers of outstanding issues.[10] The most significant feature of the public's holdings of bonds is the relative decline in the short- and long- intermediate maturity holdings (3 to 15 years), and the rise in the share of bonds with original maturity greater than 15 years.

Two concluding observations can be made. First, the decline in the banks' holdings of government bonds and the moderate rise in the share of bonds held by the near-banks

[10] Available data suggests that with the exception of a single 18.5 year bond issued in 1971 and a 20.5 year bonds issued in 1974, there were no new issues of bonds with final maturity greater than 10 years between 1970 and 1974. To the extent that there was any trading in this maturity range it must have involved only secondary market trading in outstanding and maturing issues.

MATURITY DISTRIBUTION OF NON-BANK PUBLIC'S GOVERNMENT BOND PORTFOLIO



contrast with the increased holdings of bonds by the non-depository financial institutions. The implications of these trends on the structure of the yield curve remain speculative. For the U.S., Friedman (1980, 1982) examined the effects of wealth redistribution on the yield curve. Using simulation experiments, he observed that shifting wealth away from households and depository institutions to long-term oriented institutions will tend to narrow the yield spread, reducing the slope of the yield curve. The reason, according to Friedman, is that shifting wealth to long-term institutional investors will reduce aggregate liquidity preference and liquidity-motivated bond transactions. In the Canadian context whether the slope of the yield curve will become less pronounced over time depends on the relative attractiveness of competing domestic debt instruments and the open economy influences on the bond market.

Another observation is that the contrasting patterns of maturity-mix between the banks and the non-bank public justify a disaggregation of their bond holdings in the present study. The maturity-mix of the public's bond holdings tends to show greater variation than that of the banks. The relative constancy of the maturity composition of the banks' bond holdings, however, obscures the fact that the banks tend to turn over their portfolio more quickly than the non-bank public.[11] That the banks are likely to exhibit seasonal and irregular patterns of bond transactions should be expected because of the nature of their balance sheet. They hold a wide range of assets and liabilities variations in which reflect changes in several aspects of the nature of economic activity. Revisions in bond holdings remain an important part of the banks' adjustments to these changes. No discernible seasonal patterns emerged from similar analysis of the non-bank public bond holdings. Without doubt, various ownership groups of the non-bank public may exhibit marked differences in the pattern of bond sales and purchases to reflect differences in their liability structure. Lack of disaggregated data places major limitations on our ability to analyze in detail their separate bond market behaviour. For this reason, the econometric modelling proceeds with strong assumptions about aggregation.

[11] See Appendix A, tables A.2 and A.3.

Chapter 3

THE DEMAND FOR INTEREST-BEARING BONDS: A REVIEW OF THE THEORY AND EMPIRICAL EVIDENCE

Chapter two provided an overview of recent trends in the Government bond market. The issues underlying the demand for government bonds are explored in sections 1 and 2 of this chapter. The empirical evidence is reviewed next, to be followed by summary observations.

3.1 Banks' Bond Portfolio Operations

For some time now economists have been concerned with the maturity composition and the portfolio behaviour of the banks in the market for government securities. The series of studies commissioned by the Cowles Foundation for the Commission on Money and Credit (CMC) and undertaken by, among others, Cootner (1963), Schlesinger (1963), Tobin (1963), and de Leeuw (1965) focused on the bond market activities of the banking system. Much of the motivation for these studies can be found in Tobin (1963). Banks have long held large amounts of government securities either as part of regulatory requirements and as part of their discretionary portfolio management. The bond portfolio may serve as a source of cyclical liquidity, as investment outlet of excess lending capacity, or as primary investments in of themselves. These roles exist side by side, often fuse and may shift in relative importance over time.[1]

Two related issues are of interest. These concern the implications of the banks' portfolio behaviour for the stability of the bond market and for effective credit control. Underlying these concerns is the potential role of government bonds in the overall management of the banks' portfolio. The banks participate directly and widely in various segments of the economy and hold more different categories of assets and liabilities than any other institutional bond holder. The lack of marketability of a greater portion of their assets and the unpredictability of their deposit turnover make the portfolio of government bonds a

[1] See, for example, Robinson (1962) and Haslem (1984) for practioners' views on the role of government bonds in the banks' portfolio.

potential instrument for managing cyclical liquidity. The ability to alter their bond holdings during changes in credit conditions suggests the banks can weaken the impact of countercyclical credit policy, even if only in the short-run. For example, during periods of restraint, banks may maintain or expand their loan activities through the sale of government bonds without an exogenous increase in total bank deposits. If bonds are bought by the non-bank public, inactive deposit balances are transferred from buyers to borrowers who use them more actively for spending purposes. The resulting increase in money velocity would thus mitigate the intended restraining effect (Levy, 1965). The banks substitute investment in government securities for direct private debt claims, without corresponding changes in the monetary base. If bonds are bought by the central bank, the central bank accommodates passively the liquidity needs of the banking system. The immediate effect of the transaction is an increase in the cash reserves of the banking system. The ability of the banks to ease their liquidity constraints by selling government bonds can increase the lag between shifts in monetary policy and the impact on the economy. The existence of a store of unlocked liquidity enables the banks to respond to tightening credit slowly, initially by selling bonds and only later cutting down on loans as the liquidity constraint becomes binding.

Subsequent research on the role of the banks in the securities market has focused on the nature of variations in their bond holdings caused by exogenous changes in deposit flows and the demand for bank credit. These changes tend to reflect fundamental changes in the behaviour of surplus and deficit spending units in the economy, and are less predictable in their occurrence. If significant, the resulting changes in bond holdings may cause the market demand for government bonds to shift, causing short-run movements in bond prices (Roley, 1980). The concern that banks can initiate or exacerbate short-run bond price movements on their own accord underlay earlier debate on whether or not to insulate the government bond market from cyclical fluctuations of the economy (Schelsinger, 1963). It was held that if banks behave as speculators, the availability of highly marketable and default-free securities serves much the same role for banks as do futures and hedges in the commodity market (Cootner, 1963).

Hypotheses concerning the bond portfolio behaviour of financial intermediaries have centered on whether changes in deposit flows and the demand for credit have significant maturity-specific effects. If so, the banks can transmit cyclical shocks set off by changes in other sectors of the economy into the bond market. For example, Silber (1970), Hendershott (1977), and Roley (1980) observed that bond demand may show greater responsiveness to shifts in term and notice deposits than to shifts in demand deposits. The reason is that these liabilities are different in their degree of liquidity and turnover, with term and notice deposits being less frequently withdrawable. If the deposit composition matters, then divergent trends in the growth of demand and term deposits will have implications for the banks' aggregate demand for government bonds. Roley (1980) observed further that bond holdings may change asymmetrically with negative and positive flows of investible funds. On the asset aside, interest centers on the nature of the substitution between government bonds and different categories of loans, and whether these relationships differ along the maturity spectrum (Goldfeld, 1965 and Roley, 1980). Aside from these hypotheses, there are reasons to think that the relative influence of yield and nonyield variables may also vary along the maturity spectrum, differences which could be reflected in the dynamic portfolio adjustments. A maturity class of bonds held primarily for liquidity motives may respond much more quickly to changes in the relevant non-yield factors than to yield-related factors, and vice versa for bonds held largely as primary income earning assets. These hypotheses about the banks' bond portfolio behaviour are explored in this study.

In the Canadian context, evidence from the Bank of Canada Annual Reports suggests that the potential influence of the banks on the bond market has not gone unnoticed and unchecked. The Bank of Canada has, on occasions, taken measures to cushion the market from what it perceives to be aggressive purchases or sales of bonds by the banks. Reductions in the banks' bond holdings are typically accompanied promptly by large purchases of securities by the Bank, an indication of the willingness of the latter to underwrite the stability of the bond market.[2] Also, evidence suggests that periods of substantial declines in the banks'

[2] A source of information about debt management operations, the issue and purchase of bonds, the frequency of new bond issues, and the maturity composition

bond holdings have often coincided with periods of credit restraint. Thus despite the decline in the banks' share of outstanding bonds, the potential impact of the turnover of their bond holdings perhaps remains no less severe. Even if the banks' influence on the market cannot persist in the long-run, it may be a fundamental source of short-term price movements. Unless otherwise countered, such price movements may be greater if the rest of the bond market perceives the banks' transactions as signalling information about future credit conditions.

Although these concerns received limited attention in the 70s, the growth in the market for government securities has led researchers to examine the transacting behaviour of financial institutions. In the U.S., the motivation seems to have come from the need to further understand how the behaviour of the yield curve is affected by the changing distribution of bond holdings. To the extent that the bond market is dominated by institutional investors, who display distinct maturity preferences, shifts in the allocation of deposits and patterns of wealth ownership all have implications for the behaviour of the yield curve and the stability of the market.

3.2 The Public's Portfolio Substitution

Interest in the public's demand for government bonds has focused not so much on the implications for the stability of the market, as on the nature of the substitution and complementary relationships between government bonds and other debt instruments. Comparative static results (e.g., Blinder and Solow, 1973, and Friedman, 1978) assessing the economic consequences of bond-financed deficits ultimately depend on assumptions made about the nature of substitutability and complementarity between money and government bonds, between short- and long-term bonds, and between government bonds and other private debt instruments. For example, Blinder and Solow's (1973) conclusion that government bond issue can impact negatively on private instruments rests on the assumption that both are perfect substitutes. By implication, if government bonds and equity holdings are complements,

[2](cont'd) of bond issues is the Bank of Canada Annual Report to the Minister of of Finance.

the net effect of bond-financed spending must be nonnegative. The role of portfolio substitution in fiscal and monetary policies and debt management is examined by Okun (1967), Blanchard and Plantes (1977), Friedman (1978), Roley (1979, 1983), and most notably by Tobin (1963). What is being sought are the conditions for a deficit financed, not by money, but by issuing interest-bearing government debt, to have non-neutral impacts on the economy.

One of the well-known results from the term structure literature[3] is that debt management effects are transmitted to the rest of the economy through the influence on the structure of yields across maturities. The latter depends largely on the degree of substitutability of different maturities of government bonds. With arbitrage support, the willingness of investors to substitute between maturity segments enforces term structure relationships that are neither rising nor falling in equilibrium. In this case changing the composition of the debt will have minimal influence on the shape of the yield curve, and by implication on broader economic outcomes. On the other hand, less-than-infinite elasticities of maturity substitution create 'preferred habitats' that make maturity-specific disturbances possible. Such disturbances may be caused by changing the mix of securities or by changes in investors' maturity preferences. Rolph (1957) observed that if there exists an optimal maturity composition of debt in the public's portfolio, expansionary debt managament may have a restrictive impact on the economy. The reason is that increases in yields would be required to induce the public to make the required shift in their portfolio. Uncertainty about the nature of substitutability implies less predictable effects of debt management or, for that matter, any public policy that bears directly on the market for government securities.

As far as substitution between government bonds and private debt instruments is concerned, the central issue is whether bond-financed spending displaces private sector financial claims held by the public. Continuous public sector borrowing implies increasing imbalance between the mix of public and private debt instruments in an economy. This causes upward pressure on the structure of rates of return in a way that induces portfolio

[3] Van Horne (1978) provides comprehensive survey of this literature.

substitution. Portfolio substitution and arbitrage will ensure that relative yields adjust to reflect the non-diversifiable risk associated with each security. Approximating the 'rate of interest' by the yield on securities (Tobin, 1963), the upward pressure on interest rates will reduce interest-sensitive private expenditures, the market value of private debt, and the return on equity. At the empirical level, the contested issues rest on the relevant interest rate coefficients in the aggregate demand for the various debt instruments. Analogous to consumer demand analysis, the signs of the coefficients may be interpreted to reflect the nature of demand relationships between any two securities. As Tobin (1963) observed, the extent of short-run crowding out depends on the substitutability among assets. If the elasticity of demand for government bonds with respect to the yields on private debt instruments is infinite, complete crowding out is possible through the interest rate channel. The role of the public's asset-holding preferences and portfolio substitutability in assessing the effect of bond-financed spending is reiterated by Friedman (1978). In a three asset economy— money, bonds and equity in physical capital— he observed that complete crowding out could occur if bonds are more substitutable for equity holdings and less substitutable for money or money substitutes. However, if bonds are more substitutable for money and less substitutable for equity, portfolio crowding out need not occur. To the extent that short-term securities are likely to be more substitutable for money market instruments and less so for equity and vice versa for long-term bonds, Friedman's observation suggests that the maturity mix is also important in determining the nature of substitution between government and private debt.

An important consideration in the analysis of the demand for government bonds is that institutional structures play an important role in financial market behaviour (Friedman, 1980). What this implies is that the range of portfolio substitution possibilities and the cyclical nature of asset demand may vary from one economy to the other. Studies of other economies may differ in their answers to these issues unless their institutional and financial structures are identical. In the Canadian context, for example, corporate bonds have a wider range of features than government bonds, and until the mid 1970s were available over a wider maturity range. Provincial and municipal bonds are generally less marketable and are available in fewer different maturity ranges. In addition, because of the purposes for which they are issued, provincial and municipal bonds tend to be concentrated at the long-end of the market.[4] The market for municipal bonds may be quite 'thin' because of the imperfect information about the revenue generating capacity of municipal governments. The generally small volume of municipal bonds extant may also diminish their marketability.[5] If these securities form different compartments with different substitution properties in investor's portfolio, we should expect different elasticities of substitution with different maturity segments of government bonds.

3.3 Empirical Evidence

With the need to understand aggregate financial behaviour, a number of studies, notably in the U.S., have sought to examine various aspects of the demand for federal government securities. The studies by de Leeuw (1965), Goldfeld (1965), Silber (1970), Friedman (1980), Roley (1980, 1981), Masson (1978), and Christofides (1980) focused on sectoral disaggregation and, with the exception of de Leeuw, employed some kind of maturity disaggregation.[6] Underlying these studies is the notion that there exists some form of market segmentation or preferred maturity habitats. Differences in investors' behaviour are the result of the differences in the liability structure of investors' balance sheet or of institutional constraints that govern their investment choices. If this is so, it should be possible to verify the nature of market segmentation on the basis of (1) the explanatory power of variables which are assumed to reflect specific decision-making characteristics of different investors,

[4] Hatch and White (1985, pp. 22-27).

[5] Unlike the U.S., Canadian municipal bonds are not tax-exempt securities.

[6] In these studies, separate demand equations are estimated for ownership groups. These equations are combined with an exogenous bond supply condition to represent market-clearing equilibrium. The implied market-clearing yields are derived by inversion of the aggregate demand curves, which can be used in large-scale macroeconometric models for forecasting and simulation. There are also a number of studies which examine the demand for government bonds either as a single homogenous asset or aggregate them with other non-money assets. In this category are studies by Hamburger (1968), Hendershott (1970), Backus et al.(1980), Parkin (1970), Courakis (1980), Sharpe (1974), Clinton and Masson (1975), and Bewley (1986). Also, see the survey by Owen (1986, ch.5).

and (2) differences in elasticities of demand with respect to common market influences, such as interest rates.[7]

In earlier U.S. studies, Friend (1964) examined, as part of a system of equations describing the U.S. financial sector, the demand for U.S. government securities by banks, savings institutions, insurance companies, pension funds and the public. Using GNP as the index of business activity, he observed that, for the banks, the income coefficients were positive but insignificant, suggesting a less pronounced cyclical effect on the banks' bond portfolio behaviour. The interest sensitivity of the demand for bonds differed among ownership groups. In the case of the banks and insurance companies, the interest rate coefficients were negative, yet significant. Yield effects were positive but insignificant for savings institutions and significantly positive for the public. A plausible interpretation of the results is that although all bond holders do respond to changes in the yield curve, they may differ in terms of what aspects of the yield curve they perceive as relevant. Banks and insurance companies are likely to reduce their bond holdings when interest rates are rising or when they are high. They are motivated by the desire to minimize the capital losses associated with rising rates if they are forced to liquidate. On the other hand, the public was observed to respond positively to the promise of higher coupons when rates are high. Such portfolio responses should be expected if the public perceives that when bond yields are high, the chances that the interest rate effect will be cancelled by capital losses appear smaller, making bonds attractive to hold. The interest rate information used in the demand equations varied among different ownership groups. For banks, insurance companies, and savings and loan associations, interest rates were measured as the yield differentials over the relevant opportunity cost of the use of funds. The interest rate in the public's demand equations was measured in levels. What is implied here is that the interest rate information required in the decision to buy, hold, or sell bonds may vary among investors, recognizing in each case the

[7] Analysis of the nature of sectoral and maturity segmentation of the bond market is not without precedent. The notion that different investors have preferred maturities dates back to Culberston's (1957) market segmentation theory and the related preferred habitat theory of Modigliani and Sutch (1967). The extensive literature is well surveyed by Van Horne (1978).

relevant opportunity cost of holding government bonds.

The 2-volume work by Levy (1965) examined postwar cycles in the U.S. Government securities market. The first volume examined the cyclical expansions and contractions of the securities market and how they relate to fluctuations in economic activity. The second volume examined the cyclical changes in the distribution of security holdings and the behaviour of the commercial banks, non-financial corporations, savings institutions and insurance companies. Relying on ordinary least squares estimates, Levy observed that the yield differential between mortgages and U.S. government bonds were important in determining the buying and selling of bonds by savings institutions and mutual savings banks. For insurance companies, the relevant interest rate information was the yield differential between newly issued corporate bonds and government bonds. The effect was negative, meaning that increases in the yield differential in favour of corporate bonds will induce substitution away from government bonds.

De Leeuw (1965) examined the demand for U.S. securities by banks, non-bank financial houses, business firms, and the non-bank public. He found that, for the non-bank public and business firms, current income constraints did not seem to have any significant influence on the choice of treasury bonds. Rather, including the lagged stock of time and notice deposits seemed to improve the fit of the demand equations. As in Friend (1964), the role of interest rate variables was less clear. Using the treasury bill rate as proxy for bond yields, de Leeuw reported that interest rates had an "unexpected negative sign" (p. 512) in the banks' demand equation. For the households and non-financial business firms, the interest rate coefficient was significantly positive. The changes in the deposit and loan variables and the lagged stock of excess reserves were significant in the bank's demand equation.[8]

In other studies, Goldfeld (1965) found that the variations in commercial banks bond holdings were better explained by the variations in deposits and the demands for bank credit than by the variations in yields. Silber(1970) estimated bond demand equations for six financial intermediaries: savings and loan associations, mutual savings banks, life insurance

[8] Friend (1964) and de Leeuw (1965) made no distinction between maturity groups.

companies, pension funds, commercial banks, and other life insurance companies. Although yield differentials appeared to influence the banks' choice between short-term and long-term bonds, the overall bond portfolio variation seemed less responsive to changes in interest rates. Silber reported that interest rate effects were improperly signed, that is, negative. Attempts to include the weighted averages of past values of treasury bill rates and bond yields proved unsuccessful.

The work of Benjamin Friedman and Vance Roley represents a major extension of previous U.S. studies. In a series of papers appearing between 1977 and 1983, they undertook an extensive study of the demand for U.S. government securities. They examined the behaviour of ten ownership groups.[9] In contrast with the previous studies, asset demands of different investors were derived from the mean-variance framework. Asset demands were assumed to be linearly homogenous in expected yields on government bonds, corporate and municipal bonds. Among the non-yield variables were the variance of bond yields, changes in wealth and changes in the deposit and loan variables.[10] Roley examined the nature of maturity preferences of financial and non-financial institutions and the implications of their bond market behaviour for the structure of bond yields. A number of his results are noteworthy. In his 1980 study, Roley observed that net contemporaneous flows of demand, time, and government deposits and the variations in the demand for bank credit all appeared to have significantly different impacts on the banks' bond porfolio operations. To the extent that these differences exist, shifting savings patterns between different deposits will likely lead to shifting maturity preferences by financial intermediaries. For example, Roley undertook

[9] Roley (1981, 1983) provides a bibliography of their work and other related U.S. studies.

[10] The specification of the demand equations estimated by de Leeuw (1965), Goldfeld (1965), Silber (1970), Masson (1978), Christofides (1980), and Hoggart and Ormerod (1985), among others, loosely acknowledges that security holders follow an optimization procedure, asset choice is influenced by some budget constraint and there are opportunity costs of holding assets. A consensus specification is

$$y = f(r_1, r_2, \ldots r_n, w, z)$$

where y, the aggregate asset holdings, is assumed to depend on a set of interest rates, $r_1, r_2, \ldots r_n$, a measure of income or wealth, w, and other exogenous variables, z, which characterise the behaviour of economic agents. Exclusion restrictions are common and vary from one study to the other.

simulation experiments to assess the impact of changes in demand and time deposits on the yield curve. The experiment involving a shift of $2 billion from time to demand deposits resulted in net purchases of $12 million of long-term bonds and a drop in yield by 19 basis point in the first quarter. By contrast, net purchases of short-intermediate-term securites (3-5 years) increased by $471 million and a drop in yield by 68 basis point. Roley observed further that the banks' maturity-choice combination behaved asymmetrically with negative and positive deposit flows of investible funds. Finally, the variations in loans and mortgages were found to affect the 2 to 4 years maturity range but had no effect on long-term maturities.

For the non-bank institutional bond holders, evidence from Roley (1981) suggests that increases in yields on commercial paper, treasury bills, corporate bonds, municipal bonds and equity, all led to a decrease in the demand for 3-5 years and over 10-years bonds. To the extent that these substitution possibilities exist, the yields on these segments of government bonds are likely to move in the same direction with the yields on these other instruments. Even then differences in yields will persist to reflect the specific liquidity or capital risk associated with specific instruments.

In addition to the detailed sectoral disaggregation, one novelty of the Friedman-Roley's structural framework is the use of the marginal adjustment mechanism to capture portfolio dynamics. The approach developed by Friedman (1977) separates the portfolio adjustment to reflect reallocation of existing holdings and the marginal allocation of new financial flows. Roley (1980, 1981) extended the model to allow for asymmetric effects of positive and negative financial flows on the revision of bond holdings. The major drawback of this approach is that it induces considerable non-linearities in both parameters and variables. The result is that the signs and magnitudes of the estimated coefficients are difficult to interpret in terms of portfolio behaviour. While admitting that interest rate expectation variables cannot be the only determinants of bond demand, Modigliani (1980) observed that the lack of ease of interpretation of the structural parameters detracts from the contributions of the optimal adjustment model. Pesando (1980) noted whether or not one can determine the relative explanatory role of the expectational and non-expectational variables in the structural model estimated by Roley (1980). In a summary, what we learn from the structural optimal adjustment model is that both financial and non-financial variables matter. What is not apparent is whether the relative influence of these variables differ. If they do, the differences should be reflected in the estimated lag patterns in the portfolio dynamics, too. This evidence, however, cannot be captured in dynamic models that impose a priori uniform lag constaints. The general distributed lag model specification used in this study enables a distinction to be made between short-run effects, the time distribution of influence of the various explanatory variables, and the long-run effects.

Studies of the demand for Government of Canada bonds are relatively rare. Previous work includes Dobson (1973), Christofides (1975), Clinton and Masson (1975), White (1975), Masson (1978), and Christofides (1980), and Owens (1980). With the exception of White (1975), the primary interest of most of these studies was to explore the empirical relevance of the structural bond demand models in the analysis of the term structure. The papers by Sparks (1974) and Poloz (1986) focused narrowly on the aggregate bond demand by the public and treated all maturities as homogeneous. Because of our present focus, we will concentrate on three studies: White (1975) and the related pair of studies by Masson (1978) and Christofides (1980).

The study by White (1975) looked at the chartered banks' management of their domestic portfolio of which government bonds are a major component. He separated the balance sheet components into predetermined and choice-set variables. Predetermined variables included those categories of asset and liabilities whose size is either institutionally determined (e.g., required primary and secondary reserves), or is determined largely by the behaviour of the non-bank public at interest rates set by the bank (e.g., deposits and loans). The choice set variables included tertiary liquid assets (TLA), excess secondary reserves (ESR), and net foreign assets (NFA). In White's notation, TLA consists of call loans (CL), short-term bonds (BSC), and long-term bonds (BLC).[11] Static demand equations were specified for CL, BSC, and BLC. These were linear in interest rates, a constraint variable, and

[11] The cut-off between short and long-term bonds is 3 years.

shift dummies to reflect the timing of bond portfolio revisions. The dynamics of the equations were specified as multivariate partial adjustment model and polynomial distributed lag on interest rates. His results are summarized as follows. With the exception of the rate on short-term bonds, interest rate effects were generally mixed. The short-term rate was positive and significant in the short-term bond demand equation. However, White constrained the interest rate effect in the long-term bond demand equation to zero, reportedly after unsuccessful experimentation with several specifications. On the allocation of investible funds, White found that a dollar increase in TLA, in the short run, led to an increase in CL, BSC, and BLC by 40.3, 4.45, and 55.2 cents respectively. In contrast, the derived equilibrium multipliers suggested that the corresponding allocations in the long-run are 6.1, 57.0, and 36.9 cents respectively. While the implied portfolio re-allocation away from long-term bonds into short-term bonds might seem puzzling, White observed that this switching strategy seems to occur in practice. The implication is that if the banks actively engage in maturity switching, we would expect this to occur during periods of falling interest rates and rising security prices. Banks would sell long-term bonds at a profit and re-invest the proceeds in short-term maturities. This means banks will shorten the average maturity of bond holdings during periods of low interest rates, and vice versa during periods of high interest rates. This strategy should lead us to expect that short-term bond holdings will vary inversely with the level of interest rates; increasing when rates are low or falling and decreasing when rates are high or rising.

Compared to White (1975), Masson's (1978) framework for the analysis of bond market behaviour was simpler and pragmatic. He examined the demand for government bonds by the banks and the public separately but in a totally different model. He set up two-maturity static demand equations which were linear in relative yields on government and corporate bonds. Missing from the banks' demand equations were the effects of variations in deposits and the demand for bank credit, conveying the impression that the balance sheet composition effects were irrelevant. He implicitly assumed that bond holdings are predominantly driven by investment or speculative motives so that liquidity motives are expected to be less important. On the assumption that non-yield variables are unlikely to influence bond demand, the public's demand was expressed as a function of bond yields, the rate on deposits and provincial bond yields. The dynamics of the model were assumed to reside in the disturbance terms, setting it apart from other studies which employed the partial adjustment model. Masson used maximum likelihood estimation methods (with correction for first order autocorrelation) to estimate the model with monthly data over the period 1968-1974.

Masson observed that the elasticity of the banks' responsiveness of bond demand to changes in short-term bond yield was about 2.3 times that of the public. On the other hand, the public's responsiveness to changes in long-term bond yields was about 1.56 times greater than the banks' responsiveness to similar changes. His results not only justify the need for disaggregation, but also suggest that we should expect the bond market behaviour of the bank and non-bank public to differ along the maturity spectrum. Government bonds with less than 3 years to maturity and provincial bonds were found to be substitutes for each other in the portfolio of the public. In addition, corporate securities and long-term bonds (with maturity greater than 3 years) were found to be substitutes in the portfolio of the banks (Masson, 1978, tables 2 and 6). Masson did not allow substitution over a variety of assets, restricting it to corporate bonds for the banks, and to provincial bonds for the public. In view of the fact that Masson omitted all non-yield variables from his specification, it is difficult to give much weight to his results. Evidence from White (1975) and form U.S studies cited earlier suggest that, at least for the banks, non-yield variables tend to dominate yield effects. Marginal changes in yields tend to have relatively little independent effect.

Christofides (1980) considered only the demand for bonds by the non-bank public using the two-maturity aggregation of under 10 years and over 10 years. His static demand equations were linear in income, GNP, and bond yields. Unlike Masson, no other relative returns were considered. Two dynamic formulations were investigated: the partial adjustment model of Brainard and Tobin (1968) and a restricted version of it. In the latter, all off-diagonal elements of the adjustment matrix were constrained to be equal, and adjustment to own-discrepancies were assumed to proceed faster. The model is estimated using quarterly data for 1955(2) to 1974(4). Although the estimates of interest rate coefficients were all of the 'predicted sign' and significantly different from zero at the 5 percent level, the results are not comparable to those of White or Masson because of the differences in maturity and sectoral aggregation. It is important to note that Christofides did not address issues of substitution or complementary relationships that may exist between government bonds and other debt instruments.

3.4 Summary

The studies reviewed in the preceding section provide a number of contrasts and similarities both in results and in approaches. Two aspects of the results are noteworthy: first, the specification and interpretation of interest rate information, and second, the problem of maturity aggregation.

Despite their central importance in the demand for financial assets, accounting for interest rate influences remains excruciating. In the works cited, interest rate effects are regularly reported to be negative and often not significantly different from zero. Non-yield variables tend to dominate all kinds of interest rate specification, in part supporting Culberston's (1957) assertion of zero, or near-zero interest elasticity of bond demand by institutional investors. Ambiguous interest rate effects were reported in de Leeuw (1965), Silber (1970), Bosworth and Duesenberry (1973), White (1975), Bewley (1980), and Sharpe (1974). For the U.S., the institutional requirement that government deposits be 'secured' by holding government securities has been cited as partly responsible for the weak interest rate effects. [12] In his study of London Clearing banks, Bewley (1980) explained his results as perhaps an indication of the banks' concern with the capital value of their securities. This will cause the banks to sell securities when rates are expected to rise and prices are expected to fall and vice versa. In a study of the public's demand for U.K. government securities (gilts), Hoggarth and Ormerod (1985) observed that the yield gap (measured by the differential

[12] See Goldfeld (1965), Silber (1970), and Roley (1981).

between consols and 3-month securities) had a negative sign. They interpreted this result as an indication of the strength of expected capital gains effect on the demand for gilts. Namely, the higher the yield gap, the higher it is expected to rise, leading to a fall in demand in anticipation of falling gilt prices. The implicit assumption is that the yield gap varies positively with the level of interest rates. If this is so and if the public base their decisions on extrapolative expectations, then the chance of speculative gains becomes low and the opposite chance of speculative losses becomes high when interest rates are high or are expected to rise. Sharpe (1974) provided a different interpretation of the 'perverse' interest rate effects. In his Australian study, he noted that although long-run own interest rate effects may be expected to be positive, cross-adjustments of asset holdings in a multivariate stock adjustment context may cause short-run own-yield effects to be positive, negative, or insignificantly different from zero. Poloz (1986) made similar observation in his analysis of the household demand for financial assets in Canada, commenting that "the complexity of dynamic structures can at times result in signs contrary to expectations" (p. 16).

In addition to the institutional and behavioural considerations are the usual statistical and conceptual problems. These include the high collinearity among interest rate variables and the difficulties in specifying the lag relation between interest rates and variations in asset demand. There is also the general problem of specifying expectations, and possibly improper identification of what the relevant information is in the asset selection process. There has been considerable diversity in the way in which interest rates are specified. This ranges from the use of current levels of interest rates, to autoregressive expectations schemes, and to the use of interest rate differentials. Silber (1970) observed that the interest information required in asset selection process may differ among different security holders to reflect the relevant opportunity costs. In their analysis of the demand for U.S government securities, Bosworth and Duesenberry (1973, pp. 71-72) reported that the interest rate information that seems to influence the saving banks in choosing between short and long-term securities is the spread between bond yields and a moving average of short-term yields. A similar specification was unsuccessful in explaining the demand for bonds by Life Insurance companies. For households, the relevant information variables were (a) difference between bond yields and a moving average of short-term yields and (b) the rate of change of the short-term rates.

In most studies the choice of interest rate specification is made on the grounds to minimize collinearity effects, especially when the yields on a whole range of assets are to be considered. For this reason, yield differentials are to be preferred over levels information. The use of yield differentials as the only interest rate information determining the demand for financial assets, implicitly assumes that portfolio choices will remain unchanged if the means of the alternative rates increase by the same factor. This, however, can be misleading considering that a general rise in interest rates can alter the risk-return profile of financial assets, making some less attrative to hold at higher interest rates than others (Scott, 1957). In other words, using yield differentials as the only interest rate variable may provide inadequate information in the portfolio selection process. One important innovation in this study will be to separate the interest rate information into three components: the average level of interest rates, the maturity spread or yield differentials along the yield curve, and the variability of the maturity spread. The levels information are assumed to be captured by the treasury bill rate. The latter two pieces of information are derived from auxiliary regressions. Since the yields of different maturities are anchored to the treasury bill rate, the latter two variables are intended to reflect information about the occasional humps and inversions of the yield curve and its variability. To the extent that these pieces of information affect bond demand differently, they should be reflected in the econometric results.

On maturity disaggregation, there is wide variation in the classification of maturity classes. For example, the following aggregations have been employed: less than 3 years and over 3 years (Clinton and Masson 1975, White 1975, and Masson 1978); less than 5 years and over 5 years (Goldfeld 1965, Bosworth and Duesenberry 1973, Christofides, 1980); 1-3 years, 3-5 years, 5-10 years, and greater than 10 years (McCallum 1976); and under 3 years, 3-12 years and over 13 years (Boothe 1986). As far as the terms "short", "intermediate", and "long" are concerned, no clear cut and generally acceptable boundaries exist. The decision to disaggregate bonds rather than to aggregate them is made on the grounds that the motives of bond demand and the portfolio substitute-complement relationships may differ considerably across maturities. If we assume that there exists some degree of market segmentation, then a greater degree of disaggregation is essential to reflect better the underlying market behaviour. Broader maturity classes are recommended if the market is less segmented, or if we have information that the market is historically 'thin' in certain maturity segments and active in others. Because no such a priori information is available and because there are no rules on what constitutes the appropriate maturity classes, the optimum disaggregation depends on the purpose of the study and the econometric considerations. In this study, we will employ the Bank of Canada aggregation: 1-3 years, 3-10 years, and greater than 10 years. The first class is short-term and bonds in this category are generally classified as money market instruments; the second is classified as medium-term; and the third is long-term. The derivation of the general mean-variance portfolio model follows next in chapter 4.

Chapter 4

A PORTFOLIO MODEL OF FINANCIAL ASSET DEMAND

Our goal in this chapter is to derive an asset demand equation in the spirit of Parkin's (1970) portfolio model. The starting point is the tradtional Tobin (1958) and Markowitz (1959) mean-variance (MV) model with its classic static formulation. The essential features of the model are the generalization of Parkin's model in which financial and non-financial variables serve as determinants of the demand for term-differentiated securities; the further generalization of the static model to account for short- and long-run portfolio dynamics; the attention paid to institutional features; and the attempt to account for term structure effects. Section 1 introduces the basic elements of the MV model. The generalized static asset demand equation is derived in section 2. The static model is generalized further by specifying flexible lag schemes for each of the explanatory variables in section 3. Sectoral demand equations are developed in section 4.

4.1 Elements of the Mean-Variance Portfolio Model

It is assumed that there are n different securites with random one-period returns. Economic agents choose at the beginning of the period that feasible combination of securities (y) which maximize a von Neuman-Morgenstern utility function for end-of-period wealth subject to their budget constraint, W_0, (i.e., $l'y = W_0$). l' is a unit vector. Economic agents maximize a utility function of the form $U(W) = U(\mu_W, \sigma^2_W)$. μ_W is the expected end-of-period wealth, W, and σ^2_W is the variance of end-of-period wealth. It is further assumed that U is an increasing strictly concave function on the range of feasible values for W and that U is twice-continously differentiable (Merton, 1982).[1] Investors are assumed to concentrate on the mean and variance, and to behave as if they have a one-period decision-making horizon.[2]

[1] The strict concavity assumption implies that investors are everywhere risk averse. In a mean-variance sense this implies that $U_1>0$; $U_2<0$; $U_{11}<0$; $U_{22}<0$, and $U_{11}U_{22}-U_{12}^2>0$, where subscripts denote partial derivatives with respect to the mean and variance, respectively.

[2] Although a one-period static analysis may not be rich enough to describe

It is assumed that the optimal demand functions for all risky securities and the resulting distribution of the optimal portfolio will depend on the risk preference of the investor, his initial wealth and the joint distribution of securities' returns. If the underlying utility function, $U(W)$, satisfies the Arrow-Pratt constant absolute risk aversion criterion, that is, $U''(W)/U'(W) \; = \; \flat$, it can be shown (Merton, 1982) that by integrating this function twice, the general class of utility functions can be written as

$$U(W) \; = \; -e^{-\flat W},$$

which is a negative exponential. In addition, if we regard the uncertain outcomes of end-of-period returns as all normally distributed, then end-of-period wealth is also normally distributed; that is, $W \sim N(\mu_W, \sigma^2_W)$, and so is $\flat W$ with mean $\flat\mu_W$ and variance $\flat^2\sigma^2_W$. Consequently,

$$e^{-\flat W} \sim \Lambda\,(-\flat\mu_W, \;\; \flat^2\sigma^2_W)$$

which is lognormal. By the definition of moment generating function (DeGroot, 1975) the expected utility of wealth is

$$E[U(W)] \; = \; -E(e^{-\flat W}) \; = \; -e^{\,\flat\mu_W + 0.5\flat^2\sigma^2_W}.$$

The expected utility maximization problem can be formally stated as[3]

[2](cont'd) investment behaviour, Fama (1970) observed that in a multi-period consumption-investment model, consumers' observable behaviour in the market will be indistinguishable from that of a risk averse expected utility maximizer who has a one-period horizon if consumers are risk averse and if markets for consumption goods and portfolio assets are perfect. Merton (1973, p. 878) added that in a multi-period context, an assumption that the investor faces a constant investment opportunity set is a sufficient condition for investors to behave as if they are single period maximizers. A consequence of using a one period trading horizon is that all bonds with term to maturity beyond the interval (t,t+1) are risky. Portfolio risk is thus directly associated with end of period cash flows which in turn depend directly on the variability of end-of-period prices.

[3] See Freund (1956) and Hendershott (1977) for an alternative derivation of the objective function. Bhattacharyya (1978) and Bewley (1986) provide alternative derivations of the MV model based on the quadratic utility function. Hicks (1962) criticised the use of the quadratic utility function (QUF) because it implies that all risky assets are inferior.

$$\text{Max } E[U(W)] = \text{Max}[\mu_W - \frac{b}{2}\sigma^2_W]. \tag{4.1}$$

Criticisms of the MV model are provided by Borch (1969), Feldstein (1969) and Stiglitz (1970). In defense, Tsiang (1962, p. 360-361) remarked that the application of the MV model is justified provided the aggregate risk taken by the individual remains a fairly small fraction of his wealth. Samuelson (1970) observed that the MV model can be expected to produce asymptotically valid approximations to other utility functions when risks are small, as implied by his "compact probabilities".

NOTATION

Let y^* and r^e be n-dimensional column vectors of the representative investor's desired balance sheet items and the expected rates of return respectively. Denote the subsets y_1^* and y_2^* as the n_1 and n_2 ($n_1 + n_2 = n$) column vectors of y^*. Similarly the subsets r_1^e and r_2^e are the n_1 and n_2 column vectors of asset returns. Let y and r be the actual realizations of y^* and r^e, and η and ϵ are the respective forecast errors. These conditions imply the following:

$$y^{*\prime} = (y_1^{*\prime} \quad y_2^{*\prime}),$$

$$r^{e\prime} = (r_1^{e\prime} \quad r_2^{e\prime}),$$

$$y^* = y + \eta,$$

and

$$r^e = r + \epsilon.$$

It is also assumed that

$$E(\eta) = E(\epsilon) = 0, \qquad E(\eta\eta') = \Omega,$$

$$E(\epsilon\epsilon') = \Psi \quad \text{and} \qquad E(\eta\epsilon') = \Lambda.$$

The symmetric variance-covariance matrices Ω and Ψ are assumed to be positive definite. But Λ need not be symmetric since $E(\eta_{it}\epsilon_{jt})$ need not equal $E(\epsilon_{it}\eta_{jt})$ for $i \neq j$. If the investor holds n assets and liabilities, the desired end-of-period wealth is

$$W^* = y^{*\prime}r^e = (y + \eta)'(r + \epsilon) \tag{4.2}$$

so that expected end-of-period wealth is

$$E(W^*) = y'r + E(\eta'\epsilon)$$

$$\text{or} \quad \mu_W = y'r + tr\Lambda. \tag{4.3}$$

The trace of Λ, $tr\Lambda$, is the sum of the diagonal elements of the covariance matrix Λ. The variance of end-of-period wealth is

$$V(W) = E[W - E(W)]^2 = E(y'\epsilon + \eta'r + \eta'\epsilon - tr\Lambda)^2. \quad (4.4)$$

Let

$$E(\eta'\epsilon\epsilon'\eta) = \zeta,$$

$$E(\epsilon\epsilon'\eta) = \theta = (\theta_1' \; \theta_2'), \text{ and}$$

$$E(\epsilon'\eta\eta') = \Phi' = (\phi_1' \; \phi_2').^4$$

Using these definitions, the variance of end-of-period wealth (Bewley, 1986) simplifies to

$$V(W) = y'\Psi y + y'\Lambda r + y'\theta + r'\Lambda y + r'\Omega r + r'\Phi + \theta'y + \Phi'r + \zeta + (tr\Lambda)^2,$$

or

$$\sigma^2_W = y'\Psi y + 2y'\Lambda r + 2y'\theta + r'\Omega r + 2r'\Phi + \zeta + (tr\Lambda)^2. \quad (4.5)$$

4.2 A General Static Mean-Variance Portfolio Model

Let the subset y_1 be the n_1 choice-set items (in this case the portfolio of government bonds indexed by maturity) and y_2 the n_2 predetermined items. The balance sheet constraint facing the investor at the beginning of the decision period is given by

$$l'y = l_1'y_1 + l_2'y_2 = 0, \quad (4.6)$$

where l, l_1, and l_2 are n, n_1, and n_2 unit vectors, respectively. Using (4.1), (4.3), (4.5) and (4.6) we can solve for the set of bond demand equations as follows.[5]

The Lagrangian expression for the expected utility maximization problem (4.1) subject to the budget constraint (4.6) is

$$L(y_1,\lambda) = \mu_W - \frac{b}{2}\sigma^2_W - \lambda(l'y), \quad (4.7)$$

[4] θ_1 and ϕ_1 are of dimension (n_1 x 1) and θ_2 and ϕ_2 are of dimension (n_2 x 1).
[5] The derivation of the generalized mean-variance portfolio model draws on the work of Parkin (1970), Merton (1972), and Bewley (1986).

where λ is the Lagrange multiplier. Substituting for (4.3) and (4.5) into (4.7) gives

$$L(y_1,\lambda) = y'r + tr\Lambda - \frac{b}{2}[\,y'\Psi y + 2y'\Lambda r + 2y'\theta + r'\Omega r + 2r'\Phi + \zeta + (tr\Lambda)^2\,] - \lambda(l'y), \tag{4.8}$$

where y, r and l' should be viewed as conformably partitioned vectors. It follows that the $n_1 + 1$ necessary conditions for maximization are

$$\frac{\partial L}{\partial y_1} = r_1 - b\,(\Psi_{11}y_1 + \Psi_{12}y_2 + \Lambda_{11}r_1 + \Lambda_{12}r_2 + \theta_1) - \lambda l_1 = 0, \tag{4.9}$$

and

$$\frac{\partial L}{\partial \lambda} = l_1'y_1 + l_2'y_2 = 0, \tag{4.10}$$

where Ψ_{11}, Ψ_{12}, Λ_{11}, and Λ_{12} are the partitioned matrices of Ψ and Λ. Since Ψ is positive definite by assumption, the principal submatrix Ψ_{11} is also positive definite and nonsingular (Goldberger, 1964, pp. 35-36). We can combine (4.9) and (4.10) into demand equations which depend directly on λ; that is,

$$y_1 = \Psi_{11}^{-1}(\,b^{-1}r_1 - \Psi_{12}y_2 - \Lambda_{11}r_1 - \Lambda_{12}r_2 - \theta_1 - b^{-1}\lambda l_1). \tag{4.11}$$

If we premultiply (4.11) by l_1' and use the budget constraint (4.6) we obtain the expression

$$l_1'y_1 = b^{-1}l_1'\Psi_{11}^{-1}r_1 - l_1'\Psi_{11}^{-1}\Psi_{12}y_2 - l_1'\Psi_{11}^{-1}\Lambda_{11}r_1 - l_1'\Psi_{11}^{-1}\Lambda_{12}r_2 - l_1'\Psi_{11}^{-1}\theta_1 - b^{-1}l_1'\Psi_{11}^{-1}l_1\lambda = -l_2'y_2. \tag{4.12}$$

Letting $l_1'\Psi_{11}^{-1}l_1 = \nabla$, the solution for the Lagrange multiplier from (4.12) is

$$\lambda = b\nabla^{-1}(b^{-1}l_1'\Psi_{11}^{-1}r_1 - l_1'\Psi_{11}^{-1}\Psi_{12}y_2 - l_1'\Psi_{11}^{-1}\Lambda_{11}r_1 - l_1'\Psi_{11}^{-1}\Lambda_{12}r_2$$

$$- l_1'\Psi_{11}^{-1}\theta_1 + l_2'y_2). \qquad (4.13)$$

Substituting for λ in (4.11) gives the equation for the choice-set items:

$$y_1 = b^{-1}\Psi_{11}^{-1}r_1 - \Psi_{11}^{-1}\Lambda_{11}r_1 - b^{-1}\Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}r_1$$

$$+ \Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}\Lambda_{11}r_1 - \Psi_{11}^{-1}\Psi_{12}y_2 + \Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}\Psi_{12}y_2$$

$$- \Psi_{11}^{-1}l_1\nabla^{-1}l_2'y_2 - \Psi_{11}^{-1}\Lambda_{12}r_2 + \Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}\Lambda_{12}r_2$$

$$- \Psi_{11}^{-1}\theta_1 + \Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}\theta_1. \qquad (4.14)$$

Re-arranging terms, (4.14) simplifies to

$$y_1 = b^{-1}HH_1r_1 - (H\Psi_{12} + h_2l_2')y_2 - H\Lambda_{12}r_2 - H\theta_1 \qquad (4.15)$$

where

$$H = \Psi_{11}^{-1} - \Psi_{11}^{-1}l_1\nabla^{-1}l_1'\Psi_{11}^{-1}$$

$$H_1 = I - b\Lambda_{11}$$

$$h_2 = \Psi_{11}^{-1}l_1\nabla^{-1}$$

$$\nabla = l_1'\Psi_{11}^{-1}l_1$$

Equation (4.15) is a general statement about the determinants of the choice set items. Optimal asset demand and the resulting distribution of the optimal portfolio depend on own-yields r_1, competing yields r_2, and predetermined non-yield variables y_2. The term $H\theta_1$ may be interpreted as a constant to capture scale effects. For the remainder of this chapter, equation (4.15) is modified to include risk terms and to account for short- and long-run portfolio behaviour. Next, the components of y_2 and r_2 are defined to incorporate institutional information relevant to the class of bondholders examined in this study. [6]

The derivation of (4.15) implies certain restrictions on the coefficients attached to r_1, r_2, and y_2. In particular, $l_1'h_2 = 1$ and $l_1'H = 0$, where 0 is used interchangeably as a scalar zero, a null vector, and a null matrix. Hence $l_1'y_1 = -l_2'y_2$, since all terms involving H go to zero. That the sum of the 'constant' term is also zero suggests that portfolio shifts in one direction may have to be compensated by shifts in the opposite direction for a given portfolio size. The symmetry of H follows immediately from the symmetry of Ψ_{11} which also implies the symmetry of Ψ_{11}^{-1}. Hunt and Upcher (1979) have shown that H is a positive definite matrix. It must be noted that since Λ is not necessarily symmetric, so is Λ_{11} and hence H_1. As a result, the symmetry of the yield coefficient matrix $\flat HH_1$ depends on the assumption that the errors η_1 and ϵ_1 are independent.[7] Finally, the interest rate effects in each equation sum to zero, that is, $Hl_1 = 0$. This condition suggests that the asset demand equation is homogenous of degree zero in the vector of interest rates. Equal percentage changes in the interest rates on the relevant competing assets should leave the portfolio composition unchanged.

Portfolio Model with Risk and Term Structure Effects

The specification in (4.15) gives us a basis for introducing the way in which changes in the yield curve can affect bond market transactions. We can distinguish between bond market transactions due to expectations of a permanent change in the overall level of interest rates, a change in the shape of the yield curve, and a change in the variability of yields along the yield curve. A change in the overall level of short-term rates may cause the entire yield

[6] Exclusion restrictions can be accommodated directly into (4.15) by imposing restrictions on ϵ and η. For example, Parkin's (1970) version of (4.15) is given by the expression $y_1 = \flat^{-1}Hr_1 + \Psi_{11}^{-1}l_1\nabla^{-1}W_0$ after imposing the following restrictions on (4.15):
(i) $E(\eta\epsilon') = \Lambda = 0$,
(ii) $E(\epsilon'\epsilon') = \theta = 0$,
(iii) $-l_2'y_2 = l_1'y_1 = W_0$, and
(iv) $E(\epsilon_1\epsilon_2') = \Psi_{12} = 0$. Courakis (1974) referred to this formulation as the myopic version of the mean-variance model. It is myopic in the sense that the composition effects of W_0 are ignored.
[7] Further remarks on the symmetry conditions are made later in chapter 5.

curve to shift up or down, with or without any effect on the shape or variability of the curve. Such change is captured by the behaviour of the three-month Treasury bill rate (RTB). It is assumed that the entire yield curve is anchored to the Treasury bill rate in the form of 'mark-up' relationships. Changes in these 'mark-ups' or yield differentials ($er_i = r_{1i}$-RTB) end up twisting the shape of the yield curve, resulting in the occasional humps and inversions. Indeed, for speculators, maturity substitution may be percieved as depending in part on the divergence of the yield differentials from some target levels. The strategy then is to replace the all encompassing yield variable r_i by its components RTB and er_i (for the i-th maturity class) to reflect these pieces of information.

The third piece of information about the yield curve has to do with its variability, as a measure of the risk associated with different maturities. The very facts of uncertainty and speculation on interest rate changes underlay the term structure theories (Meiselman, 1962). Choosing different maturity combinations is one way to cope with the variability of the yield curve. Relevant as this consideration may be, developing a measure of the variability of the yield curve is less straightforward. A conventional measure is provided by the variance and covariance of asset returns. The framework leading to the derivation of (4.15) implicitly recognizes this through the variance-covariance matrices Ψ and Λ. However, a quick glance at (4.15) reveals that these matrices are absorbed in a complicated fashion into the unknown parameters, with the result that there is no explicit measure of risk. Davis (1988, p. 93) observed that if the variances do not change over time, their effects can be reflected in the constant term. Earlier, Parkin (1970) suggested that one way of modifying the model is to obtain proxies for the covariance terms and compute the relevant parameters directly, using the expressions in (4.15). Parkin's attempt in this direction proved unsuccessful, citing the approximation of the covariance matrix as the potential source of error. Friedman (1980) and Roley (1981) introduced a moving average of the standard errors of returns as proxies for the risk terms. Roley justified his approach as providing a linear approximation to the non-linearities implicit in (4.15). In Friedman, the variance term was intended to separate the expected returns effect from the variability or risk effect. In other words, the fundamental parameters attached to r_1 and r_2 are composite parameters depicting two seperate influences: the portfolio choice due to expected returns and the portfolio choice due to the variabilility of asset returns. It seems reasonable to explicitly introduce a proxy measure of the latter rather than merely subsume its influence in the fundamental parameters. The expression (4.15) can be approximated linearly as

$$y_1 = \kappa + Br_1 + Cr_2 + Dy_2 + F\nu^* + u \qquad (4.16)$$

where

$$\kappa = H\theta_2$$

$$= \flat HH_2$$

$$C = H\Lambda_{12}$$

$$D = H\Psi_{12} + h_2 l_2'.$$

κ is the n_1 vector of constants, B is an n_1 x n_1 matrix of coefficients, and both C and D are n_1 x n_2 matrices of coefficients. ν is an n_1 vector of unobservable 'risk measures' on bonds and F is an n_1 x n_1 matrix of 'risk response' coefficients. u is a vector of disturbances taken to be normally, identically distributed with zero mean and finite elements of the covariance matrix. u reflects the fact that this specification is an approximation in functional form. A shortcoming of this simplification is that the fundamental parameters in (4.15) cannot be recovered from the estimated parameters in (4.16).

4.3 A General Dynamic Portfolio Model

Dynamic specification stands as one of the most important empirical issues in asset demand analyses. Short-run adjustments are typically rationalized by invoking information and adjustment costs, institutional restraints and uncertainty.[8] In previous studies, lagged responses to changes in the relevant environment are accounted for by introducing one-period lagged dependent variables, as in the familiar partial adjustment model, or, in addition, the

[8] See Hendry et al., (1984, pp. 1037-1040) for a survey of quasi-theoretic bases for dynamic models.

lagged values of some explanatory variables (see, for example, De Leeuw, 1965, Goldfeld, 1965, Silber, 1970, White, 1975, and Hendershott, 1977). Other specifications such as in Modigliani (1972) and Friedman (1977) all draw on the appeal of the familiar partial adjustment model.

Traditional concern in demand analyses is with serial independence in the model disturbances, which, if not accounted for, results in inefficient estimation of the model (Beggs, 1988). Thus, most demand studies have needed to transform the demand equations frequently to account for autocorrelation (e.g. Aigner, 1973 and Masson, 1978) or adopted the partial adjustment transformation. Indeed, in early applications of Parkin's model, failure to account for autocorrelation was cited as reason for the rejection of homogeneity and symmetry restrictions (see Berndt, McCurdy and Rose (BMR), 1980). BMR re-examined Parkin et al.'s (1970) data and observed that the hypothesis of no autocorrelation must be rejected. After correcting for autocorrelation, they were unable to reject these restrictions. They observed, however, that "(t)he presence of autocorrelation in the residuals may simply reflect fundamental deficiencies in the specification of the static model" (p. 871). Earlier, Aigner (1973) noted that the justification for using first-order autocorrelated residuals in a portfolio model "is only that 'it works' " (p. 226). He remarked further that improvements in modelling asset demand lie in recognizing the dynamics of the explanatory variables. Friedman (1977) reiterated this remark. Support for a new formulation of portfolio dynamics can be found in the money demand literature. Courakis (1978) emphasized the familiar conjecture[9] that while autoregressive error specification may be a convenient simplification, it may only approximate a dynamic structure which can be represented by a general dynamic formulation. Indeed, while a first order autocorrelation approximation always seems reasonable (e.g., Masson, 1978), practitioners are aware that it will lead to inconsistent estimates if the true model involves higher order dynamics. Moreover, there may be instances where the dynamics cannot be well approximated by a transformation of the error terms. This will arise, for example, if the duration of influences on the dependent variable differ among

[9] See, for example, the surveys by Griliches (1967) and Nerlove (1972).

regressors in a given equation, or differ across equations in a system.

Recent literature recognizes the need for flexible lags and cautions that it is not sufficient to concentrate on models that impose uniform a priori lag constraints.[10] A specification that allows for a more general adjustment path is the autoregressive distributed lag representation of the form

$$A(L)y_{it} = Q(L)Z_t + u_t \qquad t=1,2...T \tag{4.17}$$

where A(L) is a 3 x 3[11] matrix of polynomials. Q(L) is a 3 x K matrix of polynomials of unknown parameters — B, C, D and F in (4.16). y_{it} is a 3 x 1 vector of choice variables. Z_t is the K-component vector of the theoretically identified explanatory variables, and u_t is the 3 x 1 vector of disturbances. The matrices can be partitioned and (4.17) written as

$$\begin{bmatrix} A_{ss}(L) & A_{sm}(L) & A_{sl}(L) \\ A_{ms}(L) & A_{mm}(L) & A_{ml}(L) \\ A_{ls}(L) & A_{lm}(L) & A_{ll}(L) \end{bmatrix} \begin{bmatrix} y_{st} \\ y_{mt} \\ y_{lt} \end{bmatrix} \tag{4.18}$$

$$= \begin{bmatrix} B_s(L) & C_s(L) & D_s(L) & F_s(L) \\ B_m(L) & C_m(L) & D_m(L) & F_m(L) \\ B_l(L) & C_l(L) & D_l(L) & F_l(L) \end{bmatrix} \begin{bmatrix} r_{1t} \\ r_{2t} \\ y_{2t} \\ v_t \end{bmatrix} + \begin{bmatrix} u_{st} \\ u_{mt} \\ u_{lt} \end{bmatrix}.$$

where[12]

$$A_{ij}(L) = \delta - \sum_{h=1}^{p} a_{ij,h}L^h; \quad \delta=1 \text{ for } i=j \text{ and } 0 \text{ otherwise.}$$

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[10] See Pagan (1985) and Hendry and Richard (1983). A comprehensive survey of dynamic specification is Hendry et al. (1984).
[11] For typographical convenience the dimension of the choice variables, n_i, is replaced by '3' the number of maturity classes of bonds examined in this study. For the rest of the study, the subscript i is used as an index for the three maturity classes s, m, and l for short (1-3 years), medium (3-10 years), and long (over 10 years) maturities, respectively.
[12] p is the maintained lag. The constant term is suppressed for simplicity.

$$B_i(L) = \sum_{h=0}^{p} b_{i,h} L^h, \qquad C_i(L) = \sum_{h=0}^{p} c_{i,h} L^h,$$

$$D_i(L) = \sum_{h=0}^{p} d_i L^h, \quad \text{and} \quad F_i(L) = \sum_{h=0}^{p} f_{i,h} L^h.$$

The leading terms of all the diagonal elements in the polynomials A_{ii}'s equal unity, and the leading terms in all the off-diagonal elements of $A_{ij}(L)$ equal zero. In equation (4.18), it is assumed that the portfolio decision regarding each maturity segment depends on the own-dynamics, the cross-over effects as longer maturities move passively to become shorter maturities, the systematic dynamics of the yield and non-yield explanatory variables, and the stochastic innovations in the disturbance terms. Insignificant cross-over effects would suggest an active discretionary buying and selling induced by changes in the yield and non-yield variables. The optimal holdings of each maturity segment would stabilize should the elements of Z stabilize to some constant value over time.

Equation (4.18) has its advantages. It can be related to several simplifying dynamic specifications. For example, when there are zero restrictions on all lags greater than unity, Hendry and Richard (1983) develop a taxonomy of nine different versions of dynamic specifications that can be derived by imposing various restrictions on the remaining parameters, of which the partial adjustment model is only one. The static long-run equilibrium model results if (i) A_{ii} is set to unity, (ii) A_{ij} is zero, and (iii) all elements of B, C, D, and F except for the leading term in each polynomial, are set to zero. Each of these restricted structures may be tested against (4.18). Any indication that the general model rejects a more restricted nested specification constitutes evidence against the latter.

The nature of the expected response of y to changes in Z depends on the pattern of the lag coefficients implied by the polynomial $A(L)^{-1}Q(L)$. The impact response which describes the immediate effect on y of a unit change in Z is obtained by setting L=0 in the polynomial. This is simply the parameter Q_0— β_0, C_0, D_0, and F_0. The equilibrium or total multipliers represent the long-run effect of a unit increase in Z on y. This is obtained by setting L=1 in the lag polynomial, giving $A^{-1}(1)Q(1)$.[13] The stability of the general distributed lag is given by the well-established condition that the sum of the coefficients of own-lagged regressors in each equation must sum to less than unity. The next section examines the modifications to (4.18) to reflect the behaviour of the banks and the nonbank public.

4.4 Sectoral Demand Specification

4.4.1 Chartered Banks

Our task is to identify those aspects of the banks' operations which, in addition to yield related influences, are closely related to the buying and selling of government bonds. Hypotheses discussed earlier in chapter 3 focused on the key sources of variations in the banks' bond holdings. There we assumed that the buying and selling of government bonds are closely related to cyclical changes in the overall level of economic activity which also induce changes in the demand for bank credit and fluctuations in deposits. De Leeuw (1965) and Goldfeld (1965) studied the effects of aggregate deposit and loan variables. Silber (1970) and Roley (1982) examined the effects of deposit composition on bond holdings. Different categories of deposits are predicted to have different consequences for the desired maturity mix for reasons noted earlier. In the Canadian institutional setting, deposits at the chartered banks can be grouped into "public" and "private" deposits. The former refer to Government of Canada deposits and the latter refer to all kinds of non-federal government deposits. Because variations in government deposits are intended to control the availability of cash reserves to the chartered banks, their turnover seems less predictable (Martin, 1989). Private deposits sub-divide into Canadian dollar denominated deposits and foreign currency deposits.[14] The former further sub-divide into demand, notice, and term deposits. [15] If the

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[13] If all the lag coefficients are non-negative, the mean lag and the variability can be calculated following procedures outlined in Griliches (1967) and Drhymes (1981).

[14] See Shearer et al. (1984, pp. 208-209).

[15] Total deposits also sub-divide along the same lines on the basis of their statutory

banks' asset holdings match the maturity and uncertainty of cash flows of the underlying liabilities, we would expect the use of funds to differ according to their sources in order to minimize the banks' solvency risk.

In the same manner, lending activities may be grouped into risk classes— high-risk and low-risk loans. Low-risk loans include loans to customers or securities issued by customers of high credit standing who have ready access to the capital markets. In this category are the banks' holdings of provincial, corporate and municipal bonds. These are generally classified as loans and grouped together as less liquid assets- LLA-(White, 1975). As far as yields are concerned, these may be considered as close substitutes to federal government bonds. High-risk loans include business loans, mortgage lending, and personal loans. If we assume that the banks' exposure to credit risk depends upon the risk associated with any loan or investment and the average default rate, then liquidation of government securities to grant high-risk loans will generally increase the risk of the bank's asset portfolio and threaten its solvency. Substitution between loans and investment in government securities will require yield differentials sufficient to compensate for the associated risks.

A consideration of these features leads us to identify the sectoral demand equations for the banks. To this end, we make the following simplifying assumptions. First, it is assumed that banks act as rate-setting (rather than as quantity-setting) firms who choose the rates payable on their deposit liabilities and on loan and mortgage holdings over short-term decision intervals. Even when the rates are not fixed by the banks, or are chosen for the banks, it is assumed that banks have rate-setting discretion by varying service charges, by giving preferential loan rates for depositors, and by other types of non-price competition.[16] Discretionary changes in these variables alter the effective rate of return on the banks' deposit-taking and loan-granting activities. Second, we assume that the non-choice balance sheet items, though endogenous to the bank in a complete model, are predetermined for the

[15](cont'd) reserve requirements; being highest for government and private demand deposits, and lowest for notice and term deposits.

[16] For an analysis of bank portfolio behaviour under rate-setting, or monopoly price assumption see Klein (1971), and Pyle (1972). Alternative behavioural assumptions made in modelling bank behaviour are surveyed in Baltensperger (1982).

bond portfolio decisions (White 1975) and are without measurement errors.[17] These assumptions imply restrictions on the errors as follows:

$$\epsilon_2 = 0, \quad \eta_2 = 0,$$

which in turn lead to the following simplifications:

$$E(\epsilon_1\epsilon_1') = \Psi_{11}, \quad E(\epsilon_1\epsilon_2') = 0, \quad E(\epsilon_2\epsilon_2') = 0,$$

$$E(\eta_1\epsilon_1') = \Lambda_{11}, \quad E(\eta_2\epsilon_1') = 0, \quad E(\eta_1\epsilon_2') = 0,$$

$$E(\epsilon_1\epsilon_1'\eta_1) = \theta_{11}, \text{ and } E(\epsilon_1\epsilon_2'\eta_2) = 0, \quad E(\epsilon_2\epsilon_2'\eta_2) = 0.$$

Putting these together, (4.15) simplifies to

$$y_1 = \flat HH_1r_1 + (\Psi_{11}{}^{-1}l_1\nabla^{-1}l_2')y_2 - H\theta_{11} + u \tag{4.19}$$

and with risk terms, we obtain

$$y_1 = \kappa + Br_1 + Dy_2 + F\nu + u. \tag{4.20}$$

The dynamic specification analogue of (4.20) follows readily by imposing zero exclusion restrictions on the polynomial coefficients $C_s(L)$, $C_m(L)$, and $C_l(L)$ in (4.18).

The Institutional Setting

The next step is to identify the exact components of the predetermined variables, y_2. Following White (1975), a simplified balance sheet identity is defined as follows:

$$CBD+TC+TB+DLN+CLN+GB+BLN+PLN+MTG+LLA+NFA$$
$$=GVD+SDD+SND+FCD+E. \tag{4.21}$$

The variables are defined as follows: [18]

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[17] Alternatively, we may envisage the bank as holding anticipations regarding the level of all deposits and the volume of loan demand that will prevail over the 'decision period'. But these anticipations are subject to error. In terms of the assumptions leading to (4.20), this implies that the elements of y_2 are subject to measurement error; that is, $\eta_2 \neq 0$ but only that $E(\eta_2) = 0$. The net result in terms of the demand equation will be identical to (4.20), except for the econometric implication that the y_2 variables must be replaced by their instruments in the estimation.

[18] The list of definitions of all variables used in this study are presented in

BLN	Business Loans
CBD	Banks' deposits at Bank of Canada
CLN	Call and Short Loans.
CSB	Canada Savings Bond.
CSR	Cash Reserves.
DLN	Day-to-Day Loans
EPR	Excess Primary Reserves
ESR	Excess Secondary Reserves
FCD	Foreign Currency Deposits
GB	Government bonds
GVD	Government Deposits
LLA	Less Liquid Assets
MTG	Mortgage Loans
NFA	Net Foreign Assets
PLN	Personal Loans
RPR	Required Primary Reserves
RSR	Required Secondary Reserves
SDD	Statutory Demand Deposits
SND	Statutory Notice and Time Deposits
TB	Treasury Bills
TC	Vault or Till Cash.

The balancing item E includes the capital account— equity and debentures. The latter are assumed to be exogenous (Klein, 1971) and can be dropped without any consequences for the bond maturity-choice decisions. The following simplifications are made. Let (White 1975, pp. 12-13)

$$CBD+TC \cong RPR + EPR \tag{4.22}$$

$$EPR+TB+DLN \cong RSR + ESR.\text{[19]} \tag{4.23}$$

Combining (22) and (22) gives

$$CBD+TC+TB+DLN \cong RPR+RSR+ESR. \tag{4.24}$$

We can rewrite (4.21) as

$$GB \cong GVD+SDD+SND+FCD-RPR-RSR-ESR-CLN$$
$$-BLN-PLN-MTG-LLA-NFA + E. \tag{4.25}$$

[18](cont'd) Appendix B.

[19] Secondary reserves requirement are met by holding cash, treasury bills, or day-to-day loans (Shearer et al. 1984, p. 221).

Furthermore, imposing the institutional reserve constraints, we can define RPR and RSR as

$$\text{RPR} = \rho_1(\text{GVD}+\text{SDD}) + \rho_2\text{SND} + \rho_3\,\text{FCD} \qquad (4.26)$$

and

$$\text{RSR} = \rho_4(\text{GVD} + \text{SDD} + \text{SND} + \text{FCD}).^{20} \qquad (4.27)$$

Substituting (4.26) and (4.27) in (4.25) and re-arranging terms, the balance sheet identity may be written as

$$\text{GB} \cong \bar{\text{GVD}} + \bar{\text{SDD}} + \bar{\text{SND}} + \bar{\text{FCD}} - \text{ESR} - \text{CLN} - \text{BLN} - \text{PLN} - \text{MTG} - \text{LLA} - \text{NFA} - \text{E}. \qquad (4.28)$$

where all deposits are defined net of the reserve constraints as

$$\begin{aligned} \bar{\text{GVD}} &= \text{GVD}(1 - \rho_1 - \rho_4), \\ \bar{\text{SDD}} &= \text{SDD}(1 - \rho_1 - \rho_4), \\ \bar{\text{SND}} &= \text{SND}(1 - \rho_2 - \rho_4), \quad \text{and} \\ \bar{\text{FCD}} &= \text{FCD}(1 - \rho_3 - \rho_4). \end{aligned} \qquad (4.29)$$

Following Clinton and Masson (1975) we treat NFA as a residual component of the balance sheet. CLN represent a small fraction of total assets and may be added to the residual category without loss of information regarding the bond allocation decision. BLN and PLN also may be grouped into a single general loans category, BPL. Hence the set of predetermined variables is defined as

$$y_2' = (\bar{\text{GVD}}, \bar{\text{SDD}}, \bar{\text{SND}}, \bar{\text{FCD}}, \text{ESR}, \text{LLA}, \text{BPL}, \text{MTG}). \qquad (4.30)$$

The balance sheet composition represented by (4.30) reflects the institutional constraints and

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[20] It is assumed that the deposit variables are defined as the statutory deposit base on which legal reserve requirements are calculated. Statutory deposit base for the computation of reserves are measured as the average of four consecutive Wednesdays ending with the second Wednesday in the month prior to the averaging period (Shearer et al 1984, p. 219). The legal reserve ratios are defined as
Prior to March 1981, $\rho_1 = .12$, $\rho_2 = .04$, and $\rho_3 = 0$.
After March 1981, $\rho_1 = .10$, $\rho_2 = .02$ for SND less than \$500 million, and .03 for SND in excess of \$500 million, and $\rho_3 = .03$. ρ_4 has been changed periodically. See Binhammer (1988, table 18.2) for the history of changes in the secondary reserves ratio.

the effects of voluntary and market considerations on the bank's behaviour. Together, the first four items represent maximum free deposits. The net deposit terms are grouped into "public" ($GV\bar{D}$), and "private" deposits ($SD\bar{D}$,$SN\bar{D}$,$FC\bar{D}$). The last four items represent alternative uses of free deposits. ESR are voluntarily held as a second store of liquidity and are generally held at levels considered prudent by the banks. Variations in ESR may reflect the banks' current or anticipated liquidity needs as well as their perception of general credit conditions (Dingle et al., 1972). LLA, BPL, and MTG are intended to represent the effects of loan activities on the acquisition and sales of government bonds.

4.4.2 Non-Bank Public

It is reasonable to assume that the public's aggregate demand for bonds, as for goods and money, depends on own-yields, r_1, a vector of other interest rates, r_2, and some non-yield variable(s), y_2. Unlike the banks, there is no formal way in determining which variables to include in y_2 and r_2. The empirical work cited earlier suggests that specifying the public's bond demand equation is not without some degree of arbitrariness. A sample of these studies are tabulated in table 4.1, emphasizing the choice of explanatory variables. For example, the two related Canadian studies by Masson (1978) and Christofides (1980) provide a strong contrast. Masson specified bond demand as a function of bond yields, the 90-day term deposit rate, and provincial bond yields. There are no considerations of non-yield variables, implicitly setting zero restrictions on the parameters D attached to y_2. On the other hand, Christofides included income (GNP) and a wealth constraint[21] as proxy elements of y_2, while setting all elements of C attached to r_2 to zero. In Roley's (1981) analysis of the demand for U.S. government securities, the choice of competing yields, r_2, and non-yield variables, y_2, varied, depending on the class of investor groups. For example, r_2 included the three-month treasury and municipal bond yields for households, commercial paper rate and municipal bond yields for life insurance companies, corporate bond yields and the stock dividend price ratio for pension funds. In all cases, Roley included a moving average of the

[21] This is the sum of money stock and marketable bonds, excluding treasury bills.

Table 4.1
Specification of Representative Empirical Studies of the Non-Bank Public's Demand for Government Bonds

STUDY	REGRESSAND	DATA	EXPLANATORY VARIABLES: YIELD	EXPLANATORY VARIABLES: NON-YIELD
Christefides(1980)	1-10 years, 10+ years bond holdings	Canada	Bond yields.	GNP, Measure of Wealth.
Hoggarth and Omerod (1985)	Aggregate Bond Holdings	U.K	Bond Yields(measured as differential over Treasury yields), Expected Capital Gain on Equities.	Net Wealth
Masson (1978)	1-3 years, 3+ years bond holdings	Canada	Bond Yields, R90TD, RPROV	-
Poloz (1986)	Aggregate Bond Holdings	Canada	Weighted bond yields, R90F	Lagged Stocks of Bonds, Currency and Deposits, Equity holdings, Life Insurance and Pension Holdings.
Roley (1981)	2-4 years, 6-8 years bonds	U.S.A.	Bond Yields, RTB, RMUN, RCP, RCORP, D/P	Variance of yields, CPI, Rates multiplied by changes in Wealth and lagged stocks.
Sparks (1974)	Aggregate Bond Holdings	Canada	Weighted Bond Yields, RMORT, RNPT, RPD	GNP, Quarterly seasonal Dummies.
Spencer (1981)	Changes in Purchses of Gilts	U.K.	Excess yields of long term bonds adjusted for capital gains	Growth rate of Net Worth, Stock of Gilts divided by Net Wealth, Growth rate of real expenditures.

Notes:
R90F=90-day Finance Company paper rate.
RPROV= Provincial bond yield.
RCORP=Corporate bond yield.
RCB=rate on Commercial paper.
RPD=Rate on personal deposits.
R90TD=Rate on 90-day term deposits.
RMUN=Municipal Bond yield.
RTB= Treasury bill yield.
D/P= Equity yield.
RNPT=Rate on non-personal term and notice deposits.

variance of long-term security yields and changes in the consumer price index as additional regressors. In their U.K. study, Hoggarth and Ormerod (1985), specified the demand for gilts as depending on the expected rate of return on gilts relative to treasury bill yields, the expected capital gain on equities, and a measure of net wealth. Clinton and Masson (1975) adopted the view that the public's demand for Government of Canada bonds is a residual demand function. That is, bond yields will adjust to clear the excess of bonds not absorbed by the chartered banks. If this conjecture is valid, then the appropriate approach to analyzing the bond market is to specify an inverse demand function with yields as the regressand and the quantity or supply related variables as the explanatory variables. It is the limitations of such term structure specifications in studying bond market behaviour which motivated Masson's 1978 study.

These studies suggest that a reasonable way to identify the components of r_2 is to determine which other assets or debt instruments might bond holders prefer to hold. The relevant interest rates, or the rate differentials relative to some capital certain assets can be defined as the appropriate opportunity costs variables. The choice here is between the introduction of a single rate to capture the opportunity costs of holding federal government bonds, or the introduction of a whole range of money and capital market rates in order to reflect the full range of substitution possibilities. Neither extreme is desirable; the former limits the range of portfolio substitution, while the later is empirically not feasible because of collinearity in interest rates. The alternative adopted here is to allow for some substitution possibilities between federal government bonds and selected non-federal government debt instruments.

The Institutional Setting

We follow Sparks (1974) and sub-divide the non-bank public into two groups: households (including unincorporated businesses), and non-deposit-taking institutional investors. We assume that short- and medium-term bonds compete with all kinds of deposits and Canada Savings Bonds (CSBs) in the portfolio of households with limited access to the capital markets. Deposits include the liabilities of the chartered banks, Trust Companies and Credit Unions. For simplicity, we assume that the effect of deposits is captured by the rate on non-chequable savings deposit accounts in the chartered banks (RSDB). The alternative to this will be to compute the weighted average of RSDB and the rate on non-chequable demand and savings deposits in Trust and Mortgage Loan Companies (TML). Sparks (1974) used this weighted-average measure in his analysis of aggregate demand for Government of Canada bonds. We did not follow this approach because of the lack of data on the latter rates, and because the rates set by the TMLs are generally anchored to the chartered bank rates.[22] The variable CSBs is intended to capture the substitution between such bonds and short-term government bonds. The CSBs are a unique type of securities; they are designed for individuals (although trust and estates maya hold them)[23], they are issued by the federal government once a year at a fixed rate of return, and they are non-marketable. Since CSBs are always redeemable at par without penalty, they can be used as an option to hedge against future changes in the overall level of interest rates. With the rapidly rising interest rates experienced in recent years, this provides a definite advantage over marketable bonds, the value of which depends on interest rates. Because there is no specific data on the relative return on CSBs, we choose the stock counterpart to reflect the influences, if any, on the public's demand for marketable bonds. At the medium- and long-term segments of the bond market the range of possible substitution effects may be captured by a simple arithmetic average of the rate on TMLs 5-year Guaranteed Investment Certificate (RGIC) or the rate on the chartered banks 5-year personal fixed term deposits (RP5B).

In contrast with households, the large non-deposit taking institutional investors typically hold a relatively large portfolio of government bonds[24] and have relatively greater access to the capital markets. The range of possible substitution effects by these investors at the short end of the market is represented by the rates on their liquid asset holdings. Financial corporations (such as insurance companies and pension funds) and non-financial business

[22] A discussion of this can be found in Bank of Canada (1980, p. 201).
[23] Hunter (1988) p. 54.
[24] See table 2.1.

corporations may enter the near-term bond market primarily for liquidity reasons. They may hold short-term bonds as temporary means of earning interest on funds waiting either for future investment opportunities or for other outpayments. It is reasonable then to assume that the range of substitution effects will be confined to money market instruments with comparable risk of capital losses. In this category are Treasury bills, Finance company paper, Provincial and Municipal short-term bonds, TML securities and chartered bank deposits.[25] A representative rate on any of these assets or a weighted combination can be chosen to reflect the relative influence of the corporate demand for liquidity at the short-end of the government bond market. We will denote this rate as RCST.

The portfolio substitution possibilities by these investors regarding their demand for medium- and long-term bonds can be captured by the yields on alternative debt instruments and the return on equity. These include yields on corporate, provincial and municipal bonds. Including a measure of the rate of return on equity (REQ) in r_2 allows for the possibility that real capital, in the form of share holdings, compete with government debt in the portfolio of the investing public (Tobin, 1963). In the context of money demand analysis, Hamburger (1977) included the dividend-price ratio (D/P), as a proxy for the return on equities. Friedman (1977, p. 273) observed that D/P also may be interpreted as an indicator of the yield on all physical capital. In his 1978 paper, Friedman noted further that D/P may also serve as a proxy for wealth since most of the changes in the ratio come from the price term which is correlated with wealth. In this study we will follow Poloz (1986) and define REQ as the sum of the stock-dividend yield of the TSE300 and the expected rate of change of the TSE300 price index. Finally, real GNP may also be included on the grounds that the demand for bonds may vary cyclically with the level of economic activity. Its role is analogous to the role of income in money demand analysis (see, for example, Laidler, 1985, and Judd and Scadding, 1982).

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[25] In the Bank of Canada's RDXF (1980, p. 206), commercial paper, non-personal term and notice deposits at the chartered banks and time deposits at the TML's are identified as making up the liquid assets of the corporate sector and are substitutes for each other.

Taking all these into account the non-yield variables are

$$y_2 \quad = \quad [CSB, GNP] \qquad (4.31)$$

and

$$r_2 \quad = \quad [RPROV, RMUN, RCORP, RGIC, RP5B, RDEP, RCST, REQ] \qquad (4.32)$$

where RPROV, RMUN, RCORP are provincial, municipal and corporate bond yields, respectively. All other variables are as previously defined in the text.[26]

AGGREGATION

The long-run demand equations (4.15) developed in the previous sections relate to the individual bank and the individual bond holder in the respective sectors. As we noted earlier in chapter two, different sectors of the non-bank public are likely to exhibit marked differences in the pattern of bond portfolio turnover to reflect differences in their liability structure. If the demand equations are to be generally applicable, strong aggregation assumptions must be made. It is assumed that investor's expectations about the relevant decision variables are nearly the same. Furthermore, even if their demand functions are not identical, it is assumed that the demand curves display systematic patterns of correlations with the relevant decision variables, differing only by their respective balance sheet and institutional constraints. Similarly for the banks, it is assumed that bond portfolio managers maximize portfolio outcomes based on an identical institutional utility function. Since the banks constitute a homogenous sector, problems of aggregation are likely to be of relatively less importance for banks than for the non-bank public. The estimation and model selection procedures follow next in chapter 5.

[26] A glossary of abbreviations is also provided in appendix B.

Chapter 5

MODEL SPECIFICATION, ESTIMATION, AND TESTING TECHNIQUES

The theoretical basis of the generalized distributed lag portfolio model was developed in chapter 4. The econometric specification, estimation, and testing procedures form the content of this chapter. In section 1 we focus on the choice of the appropriate lag lengths and the treatment of expectational and risk terms. The estimation and testing procedures follow in section 2. The chapter concludes with a discussion of our handling of some aspects of the estimation of financial asset demand.

5.1 Specification of the General Dynamic Portfolio Model

From equation (4.18), the t-th observation of the i-th demand equation can be written as

$$y_{it} = A_i(L)\, y_{1t} + B_i(L)\, r_{1t} + C_i(L)\, r_{2t} + D_i(L)\, y_{2t} + F_i(L)\, v_t + u_{it} \qquad i=s,m,l \qquad t=p+1,p+2\ldots T, \tag{5.1}$$

where y_{it} is the dependent variable at time t, y_1 is a 3 x 1 vector of observations on the included dependent variables, y_2 is a k_1 x 1 vector of non-yield variables, r_1 is the 3 x 1 vector of bond yields or returns, r_2 is a k_2 x 1 vector of the relevant opportunity cost variables, v is a 3 x 1 vector of risk terms, and u_{it} is the disturbance term at time t. The polynomial lag coefficients are defined as

$$A_i(L) = (\Sigma_{j=1}^{p} a_{isj}L^j, \quad \Sigma_{j=1}^{p} a_{imj}L^j, \quad \Sigma_{j=1}^{p} a_{ilj}L^j),$$

$$B_i(L) = (\Sigma_{j=0}^{p} b_{isj}L^j, \quad \Sigma_{j=0}^{p} b_{imj}L^j, \quad \Sigma_{j=0}^{p} b_{ilj}L^j),$$

$$C_i(L) = (\Sigma_{j=0}^{p} c_{i1j}L^j, \quad \Sigma_{j=0}^{p} c_{i2j}L^j, \quad \ldots \Sigma_{j=0}^{p} c_{i\,k2\,j}L^j),$$

$$D_i(L) = (\Sigma_{j=0}^{p} d_{i1j}L^j, \quad \Sigma_{j=0}^{p} d_{i2j}L^j, \quad \ldots \Sigma_{j=0}^{p} d_{i\,k1\,j}L^j),$$

and
$$F_i(L) = (\Sigma_{j=0}^{p} f_{isj}L^j, \quad \Sigma_{j=0}^{p} f_{imj}L^j, \quad \Sigma_{j=0}^{p} f_{ilj}L^j),$$

where p is the maximum lag length. When fully expanded, the dimensions of A, B, C, D, and F for the i-th equation are 3p, 3(p+1), k_2(p+1), k_1(p+1) and 3(p+1) vectors of unknown parameters, respectively. All T observations of the i-th equation can be written as

$$y_i = Z\beta_i + u_i \qquad i=s,m,l. \tag{5.2}$$

y_i and u_i are of dimensions (T x 1), Z = (y_1', r_1', r_2', y_2', ν') is a T x K matrix of the right-hand side variables[1], and β_i is the K x 1 vector of unknown parameters. For example, the first 3p elements of β_i correspond to the parameters in A_i associated with the lagged dependent variables, and the last 3(p+1) elements correspond to the parameters in F_i. The system of three demand equations is

$$\begin{bmatrix} y_s \\ y_m \\ y_l \end{bmatrix} = \begin{bmatrix} Z & 0 & 0 \\ 0 & Z & 0 \\ 0 & 0 & Z \end{bmatrix} \begin{bmatrix} \beta_s \\ \beta_m \\ \beta_l \end{bmatrix} + \begin{bmatrix} u_s \\ u_m \\ u_l \end{bmatrix}$$

or

$$y_1 = \bar{Z}\beta + u \tag{5.3}$$

where $y_1 = (y_s'\ y_m'\ y_l')'$ and $u = (u_s', u_m', u_l')'$ are of dimension (3T x 1), $\bar{Z}$ is a 3T x 3K matrix, and $\beta = (\beta_s', \beta_m', \beta_l')'$ is a 3K x 1 vector of parameters. It is assumed that $E(u_i)=0$ and $E(u_iu_j') = \sigma_{ij}I_T$, for i, j =s, m, l. In other words, there exists contemporaneous correlation between the disturbance terms across equations, but no correlation over time. The covariance matrix for the complete vector u can be written as

[1] K=1 + 3p + 3(p+1) + k_2(p+1) + k_1(p+1) + 3(p+1), including the intercept term.

$$\Omega_{uu} = E \begin{bmatrix} u_s \\ u_m \\ u_l \end{bmatrix} \begin{bmatrix} u_s' & u_m' & u_l' \end{bmatrix} = \Sigma_{uu} \otimes I_T \tag{5.4}$$

where the 3 x 3 covariance matrix is

$$\Sigma_{uu} = \begin{bmatrix} \sigma_{ss} & \sigma_{sm} & \sigma_{sl} \\ \sigma_{ms} & \sigma_{mm} & \sigma_{ml} \\ \sigma_{ls} & \sigma_{lm} & \sigma_{ll} \end{bmatrix} \tag{5.5}$$

Auxiliary Equations

The structural demand equations are estimated jointly with the following system of auxiliary equations needed to predict the yield differentials and their variability from period to period. It is assumed that the Treasury bill rate, RTB, is exogenously determined. Further, the lagged elements of er_s, er_m, and er_l, and the lagged elements of v_s, v_m, and v_l are available at the start of the decision period and can be treated as predetermined. Granted this simplification, only the current values of er_s, er_m, er_l, v_s, v_m, and v_l are to be replaced by their predictors. All T observations of the i-th auxiliary predictor of expected yield differential can be written as

$$er_i = M_{0i} \Pi_{0i} + e_{0i} \qquad i=s,m,l. \tag{5.6}$$

The system of auxiliary equations is

$$\begin{bmatrix} er_s \\ er_m \\ er_l \end{bmatrix} = \begin{bmatrix} M_{0s} & 0 & 0 \\ 0 & M_{0m} & 0 \\ 0 & 0 & M_{0l} \end{bmatrix} \begin{bmatrix} \Pi_{0s} \\ \Pi_{0m} \\ \Pi_{0l} \end{bmatrix} + \begin{bmatrix} e_{0s} \\ e_{0m} \\ e_{0l} \end{bmatrix}$$

or

$$er_i = M_0 \Pi_0 + e_0 \tag{5.7}$$

where M_{0i} is a k4 vector of predetermined variables, Π_{0i} is a k4 x 1 vector of 'nuisance' parameters and e_{0i} is the error term.[2] It is assumed that the optimal forecast of end-of-period yields depends on some predetermined variables, M_{0i}, believed to be important in predicting bond prices. This includes (i) the previous history of the variable being forecast, er_i, (ii) the relative stocks of Government of Canada bonds in different maturities[3] and (iii) the three-month Treasury bill rate, RTB. The latter reflects other monetary and financial market influences as they affect the overall level of interest rates. It is assumed further that bond holders do not know the end-of-period stock of outstanding bonds and will base their predictions on historical values.[4] It is assumed that $E(e_{0i})=0$ and $E(e_{0i}'e_{0j}') = \sigma_{0ij}I_T$ for i, j =s, m, l. The covariance matrix for the complete vector e_0 can be written as

$$\Omega_{00} = E \begin{bmatrix} e_{0s} \\ e_{0m} \\ e_{0l} \end{bmatrix} \begin{bmatrix} e'_{0s} & e'_{0m} & e'_{0l} \end{bmatrix} = \Sigma_{00} \otimes I_T \qquad (5.8)$$

where, analogous to ([illegible] e 3 x 3 covariance matrix is

$$\Sigma_{00} = \begin{bmatrix} \sigma_{0,ss} & \sigma_{0,sm} & \sigma_{0,sl} \\ \sigma_{0,ms} & \sigma_{0,mm} & \sigma_{0,ml} \\ \sigma_{0,ls} & \sigma_{0,lm} & \sigma_{0,ll} \end{bmatrix} \qquad (5.9)$$

The unobservable risk terms are also modelled as follows:

$$v_i = v^*_i + e_{1i} = M_{1i}\Pi_{1i} + e_{1i}, \quad i=s,m,l \qquad (5.10)$$

where v^*_i is the unobservable risk term. It is the expected variability of the yield differentials associated with the i-th maturity segment of the yield curve. The measured values are

[2] In Friedman and Roley (1979) and Friedman (1980), expected bond yields were modelled as generalized autoregressive expectations. Both authors reported that estimates based on rational expectations proxies gave unsatisfactory results on the basis of the magnitudes and signs of the own-yield coefficients.

[3] The influence of the relative supplies on bond yields has been found to be useful determinants of bond yields by among others Clinton and Masson (1975) and Poitras (1989).

[4] Even if the timing of new bond issues can be anticipated, the size of the new issue, and the maturity mix remain largely unknown.

represented by v, which are in turn based on a weighted average of their own past values, M_{1i}. Making ν a function of its past history in (5.10) forces it to follow Engle's (1982) autoregressive conditional heteroscedastic (ARCH) process. If g is the order of the ARCH process and α_i's are the unknown parameters, a parsimonous auxiliary regression of the unobservable risk term, ν, is

$$\nu_i \quad = \quad \alpha_{0i} \quad + \quad \alpha_i \Sigma_{q=1}^{g} \alpha_q \, \nu_{i,-q} \quad + \quad e_{1i} \qquad i=s,m,l. \tag{5.11}$$

The system of auxiliary equations is

$$\begin{bmatrix} v_s \\ v_m \\ v_l \end{bmatrix} = \begin{bmatrix} M_{1s} & 0 & 0 \\ 0 & M_{1m} & 0 \\ 0 & 0 & M_{1l} \end{bmatrix} \begin{bmatrix} \Pi_{1s} \\ \Pi_{1m} \\ \Pi_{1l} \end{bmatrix} + \begin{bmatrix} e_{1s} \\ e_{1m} \\ e_{1l} \end{bmatrix}$$

or

$$v \quad = \quad M_1 \Pi_1 \quad + \quad e_1, \tag{5.12}$$

where $M_{1it} = (1, \Sigma_{q=1}^{g} \alpha_q v_{it-q})$ and $\Pi_{1i} = (\alpha_{0i}, \alpha_i)'$. Engle has suggested that the parameters α_q decline with the lag length. This is especially so if market participants assign less weight to forecast errors in the distant past than those in the current period. Also, the restrictions $\alpha_0 > 0$ and $\alpha_q \geq 0$, q=1,2,...g, must be satisfied for (5.11) to be reasonable. Setting g=12, we restrict $\alpha_q = (13-q)/78$, q=1,2,...12, so that they sum to unity. It is assumed that $E(e_{1i})=0$ and $E(e_{1i}e_{1j}') = \sigma_{1ij} I_T$ for i, j =s, m, l. The covariance matrix for the complete vector e_1 can be written as

$$\Omega_{11} \quad = \quad E \begin{bmatrix} e_{1s} \\ e_{1m} \\ e_{1l} \end{bmatrix} \begin{bmatrix} e_{1s}' & e_{1m}' & e_{1l}' \end{bmatrix} \quad = \quad \Sigma_{11} \otimes I_T \tag{5.13}$$

where the 3 x 3 covariance matrix is

$$\Sigma_{11} = \begin{bmatrix} \sigma_{1,ss} & \sigma_{1,sm} & \sigma_{1,sl} \\ \sigma_{1,ms} & \sigma_{1,mm} & \sigma_{1,ml} \\ \sigma_{1,ls} & \sigma_{1,lm} & \sigma_{1,ll} \end{bmatrix} \tag{5.14}$$

5.2 Estimation and Testing

Written as a vector of vertically stacked observations, the structural demand equations of interest (5.3) and the auxiliary regressions (5.10) and (5.12) are

$$y_1 = \bar{Z}\beta + u \tag{5.15}$$

$$er_1 = M_0\Pi_0 + e_0 \tag{5.16}$$

$$v = M_1\Pi_1 + e_1 \tag{5.17}$$

where

$$y_1 = (y_s', \quad y_m', \quad y_l')'$$
$$er = (er_s', \quad er_m', \quad er_l')'$$
$$v = (v_s', \quad v_m', \quad v_l')'$$

The left hand side variables are of dimensions (3T x 1). $\bar{Z}$, M_0 and M_1 should be interpreted as possessing block diagonal structures with each block corresponding to the regressors in each of the stacked structural and auxiliary regressions. $\bar{Z}$, M_0, and M_1 are of dimensions 3T x 3K, 3T x $3k_4$, and 3T x 6, respectively. β, Π_0 and Π_1 are the 3K x 1, $3k_4$ x 1, and 6 x 1 vector of unknown parameters. u, e_0, and e_1 are each 3T x 1 vector of stacked disturbances. Equations (5.15)-(5.17) characterize the decision-making process of the bond holder. The bond holder makes decisions about optimum assest demand, y_1, simultaneously with his assessment of expected yield-differentials, er_1, and their variability, ν, given the level of interest rates, RTB.

Formulating bond market behaviour in this manner is not without precedent. In his analysis of the demand for British government securities, Spencer (1981) examined a two equation model consisting of a structural demand and an auxiliary expectations equation. Similar two equation models are estimated by Masson (1978), Roley (1980,1981), and Hoggarth and Ormerod (1985).[5] The system of equations (5.15), (5.16) and (5.17) can be written compactly as

$$y_a = Z_a\beta_a + u_a. \tag{5.18}$$

$y_a = (y_1', er_1', v')'$ is a 9T x 1 vector, Z_a is a 9T x $3K_a$.[6] $\beta_a=(\beta', \Pi_0', \Pi_1')'$ is a $3K_a$ x 1 vector and $u_a=(u', e_0', e_1')'$ is a 9T x 1 vector. The covariance matrix for the complete error vector u_a can be written as

$$E(u_a u_a') = \Omega_a = \Sigma_a \otimes I_T \tag{5.19}$$

where

$$\Sigma_a = \begin{bmatrix} \Sigma_{uu} & \Sigma_{u0} & \Sigma_{u1} \\ \Sigma_{0u} & \Sigma_{00} & \Sigma_{01} \\ \Sigma_{1u} & \Sigma_{10} & \Sigma_{11} \end{bmatrix} \tag{5.20}$$

$$E\begin{bmatrix} u_s \\ u_m \\ u_l \end{bmatrix}\begin{bmatrix} e_{js}', & e_{jm}' & e_{jl}' \end{bmatrix} = \Sigma_{ui} \otimes I_T,\ i=0,1, \tag{5.21}$$

and

[5] Of these studies, only Roley introduced variance terms as risk proxies, but did not explicitly specify an auxiliary equation for it.

[6] $K_a=K+k_4+2$.

$$E\begin{bmatrix} e_{1s} \\ e_{1m} \\ e_{1l} \end{bmatrix}\begin{bmatrix} e_{0s}', & e_{0m}' & e_{0l}' \end{bmatrix} = \Sigma_{10} \otimes I_T. \qquad (5.22)$$

The diagonal blocks in (5.21) refer to the covariance matrices of equations (5.16), (5.17), and (5.18), respectively. The off-diagonal blocks refer to the cross equations covariance matrices. The estimation procedure adopted depends on the restrictions imposed on the elements of the variance-covariance matrix, Σ_a.

Three estimation methods may be considered: the two-step estimator (2SE) of Pagan (1984, 1986), the familiar two-stage least squares (2SLS) estimator, and the three-stage least squares (3SLS) estimator of Zellner and Theil (1962). The 2SE provides a computationally simple procedure in situations with generated regressors which leads to consistent, but possibly less efficient estimators (Pagan, 1986, p. 521). In the present context, the idea can be summarized as follows. The first step is to cater for the current observations of er and ν by estimating the auxiliary equations (5.7) and (5.12), respectively, and forming the predictors $\hat{er}$ and $\hat{\nu}$. The second step is to replace the er and ν in $\bar{Z}$ by their predictors and obtain estimators of the structural parameters of interest, using (5.3). Pagan (1984) has shown that if y depends only on expectational variables, which in turn depend on some predetermined variables, the 2SE is consistent and asymptotically efficient, providing that the nuisance parameters Π_0 and Π_1 are consistently estimated. Even then the variance-covariance matrix of the structural parameters understates the true matrix and is generally inconsistent.[7] This inconsistency is attributed to the failure of the second stage regression to take into account the fact that $\hat{er}$ and $\hat{\nu}$ depend on the nuisance parameters which are themselves random variables. Hence a special computation of the variances will normally be required in order to make valid inferences. For the case where y_i depends on both expectational and non-stochastic regressors, Pagan (1986) shows that the 2SE is not necessarily consistent and will be inefficient when the auxiliary equation is misspecified. Consistency can be achieved only if the non-stochastic

[7] Ibid., p. 226.

regressors are included in the set of predetermined variables in the auxiliary equation.[8] Studies of asset demand which employ a two-step estimation procedure include Spencer (1981) and Hoggarth and Ormerod (1985). In these studies, the expectations of asset returns are investigated using auxiliary regressions. No attempt is made to correct for the least squares standard errors in the second stage regression. The 2SLS technique which formally recognizes the simultaniety between equilibrium trading quantities and asset yields has been employed in all the series of papers put out by Friedman and Roley. OLS was widely used in earlier studies of financial asset demand (e.g. Christofides, 1980), whereas Masson (1978) estimated his model using maximum likelihood methods.[9]

There are obvious difficulties in applying the results derived in Pagan (1984, 1986) to a system of demand equations examined here. In particular, Pagans' results are all in the single equation context and, more importantly, are based on the assumption that the variance-covariance matrix, Σ_a, is diagonal. In the context of the present discussion, this implies, say,

$$\Sigma_a \quad = \quad \text{diag}(\sigma_{ss}, \sigma_{0,ss}, \sigma_{1,ss})$$

and $\bar{Z}$, M_0, and M_1 are no longer block structures, but single equation regressors. Without this simplifying assumption, 2SE losses its most important appeal, computational simplicity. Even for this special case, the adjustments required to produce an asymptotically efficient variance-covariance matrix are not easily computed. Although it will be possible to program the 'correct' covariance matrix, its reliability is doubtful, particularly in the context of a generalized distributed lag model. For this reason, the procedure has not received much use to date.

Even if one resorts to other limited information techniques such as 2SLS to derive the variance-covariance matrix valid for inference-making, Turkington (1985) has shown that for

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[8] Ibid., p. 524.

[9] None of these studies reported standard errors for the long-run equilibrium coefficients.

the special case of Σ_a diagonal, (in a single equation context) 2SLS is asymptotically less efficient than the 2SE. The relative inefficiency of 2SLS is the result of the fact that the first stage regression uses all the predetermined variables including those that are not used in forming expectations. Although interest lies in the structural equations, Turkington observed that if all the right-hand-side variables are not used in forming expectations, there seems little justification to include them in the auxiliary regressions (p. 510). Bowden and Turkington (1986, pp. 34-35) have also shown that if there are two auxiliary regressions, each with predetermined variables, say M_0 and M_1 ($M_0 \neq M_1$), the two-stage procedure will yield consistent estimators only so long as a linear combination of M_0 and M_1 are used to form the predictors in the first stage regressions. However, if the same instrument set is used in both auxiliary regressions, the 2SE is now the familiar 2SLS estimator. If the covariance matrix Σ_a is not diagonal, the 2SE is inconsistent, while 2SLS will continue to be consistent, but asymptotically less efficient relative to 3SLS (Turkington 1985).

Thus 3SLS seems the relevant procedure. Its application provides an asymptotic gain over the single equation methods when the disturbances have non-zero contemporaneous covariances (Theil, 1971, p. 511). The first two stages of the 3SLS procedure provide a consistent estimate of Σ_a. That is,

$$\hat{\Omega}_a = \hat{\Sigma}_a \otimes I_T$$

The 3SLS estimator is obtained by minimizing the quadratic function

$$S(\beta_a) = (u_a)' [\hat{\Sigma}_a \otimes X(X'X)^{-1}X'] (u_a) \tag{5.23}$$

with respect to β_a, where X is the set of instruments. The 3SLS estimator of β_a is given by

$$\hat{\beta}_a = [Z_a' (\hat{\Sigma}^{-1}_a \otimes X(X'X)^{-1}X')Z_a]^{-1} Z_a' (\hat{\Sigma}^{-1}_a \otimes X(X'X)^{-1}X')y_a \tag{5.24}$$

and an estimator of the asymptotic covariance matrix is

$$\mathrm{Var}(\hat{\beta}_a) \quad = \quad [Z_a'(\hat{\Sigma}^{-1}{}_a \otimes X(X'X)^{-1}X')Z_a]^{-1} \qquad (5.25)$$

The 3SLS estimator is asymptotically more efficient than the 2SLS estimator (Zellner and Theil, 1962) and the 2SE (Turkington, 1985). The asymptotic gain from 3SLS occurs when the system of equations is well specified, when the structural disturbances have non-zero contemporaneous covariances and when at least some of the equations are overidentified (Theil, 1971). The gain in asymptotic efficiency comes at the increased risk of inconsistent estimators. In this study, though, inconsistency that may arise from misspecification of the structural demand equations is mitigated somewhat by the use of the general-to-simple methodology to determine the adequacy of the maintained model. As a result, the restricted model will be a reasonable approximation of the data generation process, and the coefficients reasonably estimated. With regard to identification, all the three structural demand equations are overidentified. That is, the number of right hand side variables in each equation is strictly less than the number of predetermined variables in the system which are represented by the matrix of instruments, X. The auxiliary equations have no current endogenous variables appearing as explanatory variables and are automatically identifiable. (Harvey, 1981, pp. 343-345).

Test of Restrictions

Under the regularity conditions (Theil, 1971, ch. 10), the 3SLS estimator β_a defined in (5.24) is consistent. Futhermore, $\sqrt{T}(\hat{\beta}_a - \beta_a)$ has a limiting normal distribution with zero mean and the covariance matrix given by (5.25), and hence provides information necessary for asymptotically valid inferences. Single and joint asymptotic tests of coefficients can be based, respectively, on the normal and chi-square distributions (Dhrymes, 1970, p. 166). Morgan and Vandeale (1974) provide evidence on power to suggest that tests based on the asymptotic normal and chi-square distributions are to be preferred to those based on the t and F distributions.

Test of the validity of the lag restrictions can be done on the basis of the unrestricted estimates only using the Wald tests. Let the explanatory variables in the system be arranged in a K_a-component vector such that the first k_1 elements correspond to the parameters of the first structural demand equation, and so forth. Test of restrictions can take the form $R\ \beta_a \;=\; r$, where R is a J x K_a ($J \leq K_a$) matrix of full row rank, and r is a J-component vector. R has zeros everywhere except for the positions of the parameters of interest. Equating ($\hat{\beta}_a$) with the unrestricted estimator of (β_a), the Wald statistic for a set of J constraints is given by

$$W \;=\; [R\ \hat{\beta}_a - r]'\ [R\ (Z_a'\ (\hat{\Sigma}^{-1}_a \otimes X(X'X)^{-1}X')Z_a)^{-1}\ R']^{-1}\quad [R\ \hat{\beta}_a - r] \tag{5.26}$$

which is distributed as a chi-square with J degees of freedom under the null hypothesis.

5.2.1 Sequential Lag Selection Procedure

One problem with the generalized distributed lag specification is that we have no prior knowledge about the optimum lags on different variables. Even if there are reasons to suppose that the time distribution of impact differs among variables and across equations in the system, Mizon (1977b) observed that imposing such restrictions a priori may complicate the lag selection because of the unequal lag lengths in the maintained model. Incorrectly setting too low a lag length on some variables constitutes an omission of variables problem which can lead to biased and inconsistent estimators (Kmenta, 1986). To lessen this risk, Mizon (1977b) suggested setting the lags in the maintained model equal and then design testing procedures to reflect our priors that some variables may occur with shorter lags than other variables.

The determination of an appropriate lag structure is generally resolved in the context of specific applications. The lag selection may proceed in three ways. First, is to test the lag length of each variable separately using separate t-test. This method is useful in a single equation context with modest number of regressors. Seber (1964) noted that this procedure has poor power properties, except if all the regressors are orthogonal. The second approach is to test down the lag order of all variables simultaneously either across equations or for each equation separately. This approach, however, is too restrictive; it imposes the constraint that the duration of influence on the dependent variable is identical for all the explanatory variables. In this study, the test of time dependence in the sample is done by ordering variables into blocks, arranging the blocks in some hierarchy, and testing down sequentially in a general-to-specific framework.

The general-to-simple specification test procedure may be summarized as follows: Set the initial lag length at the largest feasible value to accommodate a wide range of dynamic behaviour subject to the constraints of degrees of freedom, computational limitations, and the demands for parsimony (Anderson and Blundell, 1982). Next, establish the adequacy of the maintained model through mis-specification tests. Then conduct 'simplification search' (Leamer, 1978) by testing down the hypothesis that restricted versions of the initial specification adequately characterize the data generation process. Hendry (1979, p. 228) describes this method as "intended over parameterization with data-based simplifications".[10]

Having established the adequacy of the maintained model, we employ the sequential test procedure given by Anderson (1971, chp. 3).[11] For example, if for a particular variable, say r_2, the parameter set is $C = (c_0, c_1, c_2, \ldots, c_p)$, then let H_k $(k \leq p)$ stand for the hypothesis that the coefficients $c_k \ldots c_p$ are zero. The sequence of hypotheses is

$$\begin{aligned}
&H_p: c_p = 0 \\
&H_{p-1}: c_p = c_{p-1} = 0 \\
&H_{p-2}: c_p = c_{p-1} = c_{p-2} = 0 \\
&\quad\cdot \\
&\quad\cdot \\
&H_2: c_p = c_{p-1} = c_{p-2} = 0, \ldots, c_2 = 0 \\
&H_1: c_p = c_{p-1} = c_{p-2} = \ldots c_2 = c_1 = 0
\end{aligned} \tag{5.27}$$

where p is the maintained maximum lag length. First, the null hypothesis is tested against the

[10] If the lag lengths are set to be sufficiently large, the disturbance term of the maintained model may be considered as serially independent with zero mean and constant variance (Griliches, 1967).
[11] The test procedure is also outlined in Dhrymes (1981) and Mizon (1977a).

maintained model as the alternative hypothesis. If H_p is not rejected then a second test is carried out for the null hypothesis H_{p-1} against the alternative H_p. Whenever a null hypothesis is not rejected, the sequential test procedure is continued until an hypothesis is rejected. In this sequential procedure, each hypothesis is tested against the immediately preceding one, and not against the maintained hypothesis; that is, in each case the null hypothesis is H_{k-1} and the alternative hypothesis is H_k for $k < p$. If any hypothesis is true, the preceding hypotheses must be true. Therefore, if any hypothesis say, H_k, is rejected, all the succeeding hypotheses (i.e., H_{k-1}, H_{k-2}...) are rejected as well. The test sequence that does not reject all the intermediate null hypotheses up to and including H_1 implies rejection of all systematic dynamics. In which case we do not reject the static or zero order dynamic model.

The step-down procedure may proceed by ordering single variables or blocks of variables in some order of "importance" (Anderson, 1984, pp. 309-310, 389-392). For all the variables in a given block, subtests of the order of dynamics are done simultaneously and sequentially as outlined earlier. As soon as a subtest of the null that the k-th lagged coefficients of a block are zero is rejected, the test of the block is terminated. On the other hand if the null is not rejected, we proceed to test for the null that the coefficients on the (k-1)th lag are zero. If each of the null in the subtest is not rejected, we conclude that that particular block enters the specification with zero order lag. The test then proceeds to the next block of variables and the subtesting is repeated until a subtest leads to a rejection or no subtest leads to rejection. This is the procedure adopted in this study.

The practical problem here is how to order the blocks of variables in (5.1) in some reasonable hierarchy to facilitate testing. To this end, we turn briefly to explore the motives for holding government bonds. The goal is to deduce from these motives what the likely time distribution of the influence of changes in the different explanatory variables on the dependent variable might be. The assumption here is that the optimal order of the lag responses of maturity choice to changes in the explanatory variables has something to do with the motives for holding particular class of bonds. For example, portfolio revisions are expected to be much quicker if the primary decision variables change than if secondary decision variables change. While this approach is unlikely to lead to a uniquely ordered sequence of variables, it provides a reasonable ordering for testing down the dynamics.

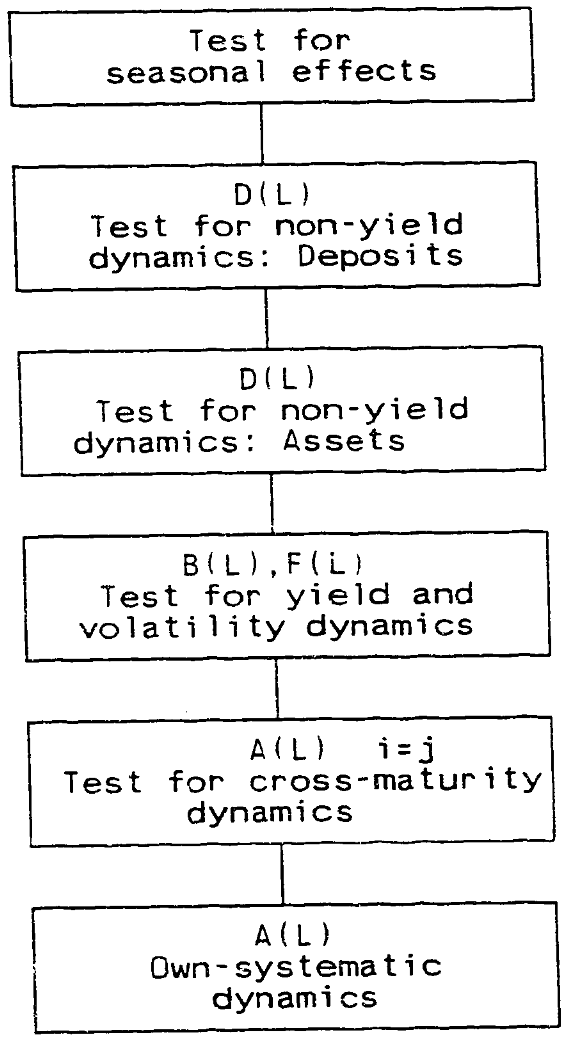
Sequential Testing of Banks' Portfolio Dynamics

Much of the literature on the demand for government securities by the banks suggests there are two motives: (i) as liquidity demand and (ii) as investment demand.[12] Without doubt, these two roles exist side by side, often fuse, and may shift in relative importance over time; consequently, altering the desired maturity-mix of the bond portfolio. To the extent that the banks' bond portfolio behaviour has any implications for credit control, it is because the liquidity accommodating role may dominate the role of government bonds as primary investment instruments. A liquidity hedging motive for bond holdings may be viewed as a variant of one aspect of the precuationary motive for holding money (Terrel and Frazer, 1972). This hedging is essentially a means of reducing the risk of insolvency. In this role, fluctuations in deposits and the demand for bank credit relative to cash reserves, must be offset quickly by opposite fluctuations in open market securities. If that is the case, variations in loan and deposit composition should have faster impacts on bond holdings than variations in yields alone. That is, the coefficients on LLA, BPL, MTG, DD, GVD, TND, and FCD should be significant at earlier lags and possibly at later lags too. The coefficients on the yield-related variables should be expected to have a weaker impact on bond holdings or to be significant only at later lags after the desired liquidity adjustments are complete.

Among the loan and deposit variables, an extreme preferred habitat view of bond market behaviour would ascribe greater explanatory power to deposit variables than to loan variables. The reason is that although fluctuations in deposits and the demand for bank credit generally follow the business cycle, variations in the former are much more volatile, particularly so on a month-to-month basis than fluctuations in the latter. Aversion to insolvency risk will dictate that the banks match the maturity of bond holdings first to the

[12] See Robinson (1962), Levy (1965) and Haslem (1984) for practitioners' views of the motives for holding government securities.

ORDERING OF EXPLANATORY VARIABLES FOR SEQUENTIAL STEP-DOWN TESTING: CHARTERED BANKS



Each subtests of the step-down block procedure is done following the sequence of hypotheses in equation (5.27).

Figure 5.1

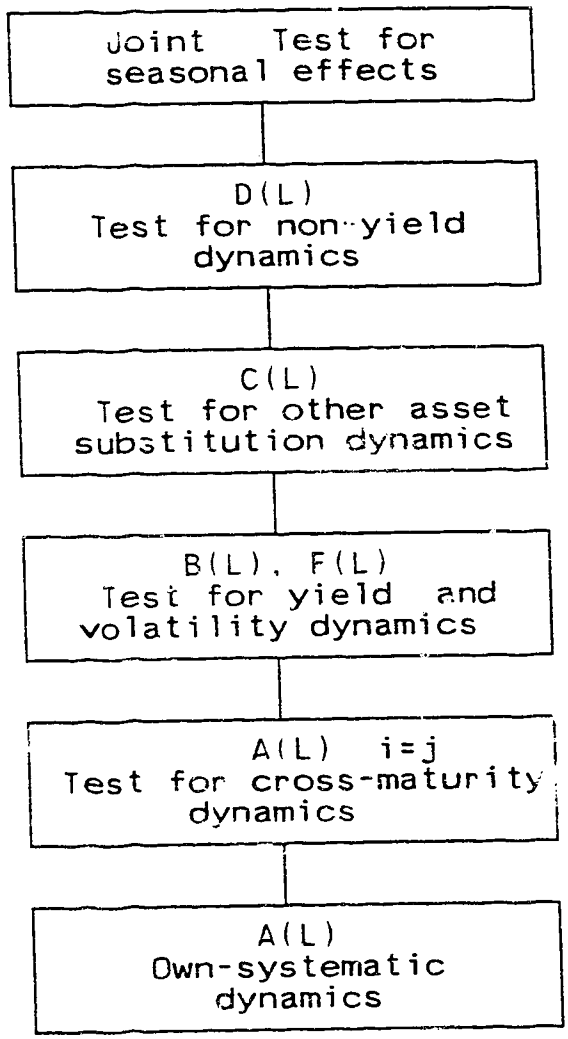
average term to maturity or duration of their deposit liabilities and only secondarily to shifts in the demand for bank credit. Moreover, since loans are generally approved in advance for future disbursements, variations in loan variables should be the lesser upsetting factor in the buying and selling of securities.

Alternatively, if government bonds are held primarily for their "riskless profitability", then in the terminology of the banking literature, the banks' bond portfolio behaviour is likely to "ride or play the yield curve" (Frazer, 1984, p.413). Yield related influences should have much quicker and lasting impact on bond transactions than the impact of deposit flows and credit demands. Based on this discussion, the sequence of the step-down testing procedure identified in figure 5.1 does not seem unreasonable. First, we test for the significance of the seasonal effects not accounted for by the variations in the explanatory variables. The second and third blocks represent tests for the explanatory role and the time distribution of impacts of loan and deposit variables, respectively. The next block tests for the time distribution of the impact of the interest rate and yield related influences, conditional on the result of the preceding blocks. The extent to which movements in bond holdings can be accounted for by passive crossover effects are determined in two stages: first, for the cross stock adjustment effects, and second, for the own-systematic dynamics.

Sequential Testing of Public's Portfolio Dynamics

Except for the near banks, this group of bondholders can be characterized as non-savings type institutions having low or moderate demands for liquidity, long-term investment horizons, and bond portfolio likely to emphasize flexibility and adequate yield. Thus apart from the own-systematic and cross-over effects, we will expect the interest rate or yield-related variables, r_1, v, and r_2, to be more important than the non-yield variables, y_2. Among the yield variables, it is not unreasonable to expect that r_1 and v, would have quicker influence on the demand for bonds than the influences of other relative yields, r_2. The sequence of testing down the public's portfolio dynamics is identified by the blocks in figure 5.2. First, we test for seasonal effects not accounted for by the variations in the included

ORDERING OF EXPLANATORY VARIABLES FOR SEQUENTIAL STEP-DOWN TESTING: NONBANK PUBLIC



Each subtests of the step-down block procedure is done following the sequence of hypotheses in equation (5.27).

Figure 5.2

explanatory variables. The second block tests for the time distribution of impact of the non-yield variables, y_2. The next block represented by the coefficients C(L) tests for the dynamics of portfolio substitution and complementary relationships as determined by the variations in relative returns, r_2. The relative influence of yield-related variables and the general level of interest rates are explored by testing the restrictions on the parameters B(L) and F(L). The last two blocks determine the extent to which variations in bond holdings can be accounted for by cross-over effects and own-systematic dynamics.

It should be noted that even when the null hypothesis of a particular block of variables is rejected, it is possible that not all the coefficients in the order will be significantly different from zero. In search for a more parsimonious specification, the investigator may use the individual t-test to determine which is zero and which is not.[13] To avoid arbitrary deletion of variables we rarely resort to this elimination procedure. Even in those few cases, we still maintain the implicit restriction that if $c_{kjp} \neq 0$ then $c_{kip} \neq 0$ $(i < j)$. While there is no reason why this restriction should necessarily be so (Dhrymes, 1981, p.384), it minimizes the possibility of arbitrary deletion of intervening lags with low separate t values.

The problems involved in the general-to-specific methodology are discussed in Hendry (1979, p. 228). The maintained model could be a special case of the data generation process. Also, the sample size may be too small to permit long lag lengths. Perhaps, a critical drawback is that there is no uniquely best nested or ordered sequence for simplifying the model. In other words the final test outcome may not be invariant to the ordering of the block of variables. Granted this, the test outcome is subject to the discretion of the investigator in ordering the sequence of hypothesis testing. Sensitivity analysis of the final estimates to alternative sequential paths is feasible when the number of regressors are small and the order of lags low.[14]

[13] Mizon (1977a, p. 105) cautions that the choice of significance levels for the separate t tests may be a difficult problem. This is in light of the fact that the implicit significance level of the sequential test changes at each stage of the step-down testing procedure.

[14] Mizon (1977a) provides an analytic illustration of the testing problems involved in the analysis of higher order dynamics in a multivariate regression context. Most applications of the general-to-specific modelling of dynamics are in single equation

A well known complication with the sequential testing procedure is that the implicit significance level changes at each stage of the repeated testing on a given data set. The reason, Anderson(1971) has shown, is that each null hypothesis is a subtest of the preceding null and is therefore more stringent. The result is that the probability of type 1 error (i.e. incorrectly rejecting a true null hypothesis) is monotonically nondecreasing.[15] Suppose γ_i is the significance level for the i-th test in the sequence. The overall significance level α of the implicit test of the k-th hypothesis (i.e., H_k against the maintained hypothesis) is given by the expression (Mizon, 1977a, p. 1226)

$$\alpha = 1 - \Pi_{i=1}^{k}(1-\gamma_i) \tag{5.28}$$

For a given γ_i the overall probability of the type 1 error increases as the test proceeds down the sequence of hypotheses. If the maximum number of hypotheses in the ordered sequence is n, and it is desired that the maximum implicit probability of type 1 error is α^*, then we may choose $\gamma_i=\gamma$, for all i, such that

$$\alpha^* = 1 - (1 - \gamma)^n \tag{5.29}$$

The disadvantage of choosing a high γ, say at the conventional 5 or 10 percent level, in a heavily parameterized model, is that one will reject the null hypothesis less often. The result is an increase in the probability of accepting an overfitted model. Unless the included irrelevant lags are orthogonal to the other included variables, the estimators are inefficient but remain unbiased (Kmenta, 1986). Mizon and Hendry (1980, p. 26) observe that if the consequences of inconsistency are believed to be more serious than those of inefficiency, then choosing a

[14](cont'd) context and use relatively small number of nonstochastic variables, often less than five (see Davidson et al., 1978, Hendry and Mizon, 1980, and Coghlan, 1978). In a systems application, Anderson and Blundell (1982) consider a relatively small model of 3 variables and restrict the dynamics to a first order form. The author is unaware of any study which tests for dynamic specifications in full systems of simultaneous equations context as attempted here.

[15] Ibid, pp. 36-37.

higher γ_i and hence a large implicit α might be reasonable. In this study, we choose $\gamma_i = \gamma = 0.01$ for the sequence of nested testing. From (5.29), this implies the following overall probability of type 1 error $\alpha(k)$ if the testing is terminated at the k-th null hypothesis: $\alpha(3) = 0.03$, $\alpha(4) = 0.04$, $\alpha(6) = 0.06$, $\alpha(10) = 0.095$, and $\alpha(15) = 0.14$. So that the overall significance level of the implicit test of say the 10-th and the 15-th hypothesis, will not exceed 10 and 14 percent, respectively. Setting γ_i small ensures a low probability of accepting a less parsimonious model when it is in fact false.

5.3 Some Further Aspects of Financial Asset Demand Specification

There are some similarities between the analysis of asset demand and that of standard consumer demand. The common scenarios are as follows:

1. in both contexts, we explain the allocation of some predetermined total (income, expenditure, wealth, or investible funds) over a set of choice variables;
2. the demand equations are obtained by (expected) utility maximization and are expected to satisfy standard postulates of consumer behaviour.

The latter are generally summarized in the qualitative properties of demand schedules.[16] For example, symmetry of price effects, adding-up and homogeneity of degree zero in income and prices are minimum general restrictions on consumer demand functions. These restrictions are necessary regardless of the underlying utility function and regardless of whether only a subset of demand equations are of immediate interest. Also, there are restrictions based on the structure of preferences. Additivity, separability and hometheticity all imply restrictions on the derivatives of the demand equation and hence on the substitution and complementary relationships between commodities. [17]

Like most areas of applied econometrics, portfolio allocation models have their unique problems. Frequently, only some subset of demand is thought to be of immediate interest (e.g. the demand for term-differentiated government bonds in this study). All other assets are

[16] Samuelson (1983, chp. V).
[17] See, for example, Brown and Deaton (1972) and Phlips (1983, chp. 3) for analyses of the implications of restrictions on demand functions.

relegated into a residual category and are ignored. A result of this simplification is that adding-up restrictions are unclear and often ignored. Further, the general restrictions based on the structure of preferences are ignored, leaving the nature of substitution and complemenatary relationships to be empirically resolved.[18]

Homogeneity is just as important in consumer demand analysis as it is in monetary analysis. Demand relationships are homogenous of degree one in all dollar magnitudes (de Leeuw, 1965). The doubling of the total investible funds, wealth, or income will, other things equal, double the changes in the holdings of all assets. An obvious difficulty here is the measurement of the scale variable. In principle this should include any real or financial asset regarded by the investor as wealth. Measurement problems necessitate simplifications. For example, demand functions are homogenous of degree one in lagged total deposits for the banks, and lagged weighted average of past GNP for the non-bank public (de Leeuw, 1965); demand functions are homogenous in the net acquisitions of financial assets by the banks (Roley, 1980); and demand functions are homogenous in total deposits minus reserves and mortgages (Masson, 1978). In all cases, the objective is to ensure that rising dollar magnitudes per se do not affect portfolio allocation. In this study the scale variable for the banks is defined as the sum of all deposits less total cash reserves. For the non-bank public, the scale variable is the sum of the monetary base, the book value of domestic-pay government marketable bonds and bills, and domestic non-marketable government debt (Canada Savings Bonds).

Finally, the theoretical desirability of imposing symmetry restrictions in asset demand analysis has been touched upon in the literature. Drawing parallels to consumer behaviour, Royama and Hamada (1967), Aigner (1973) and Clements (1981) decomposed the interest rate effect in asset demand into the pure substitution effects and the general or expected

[18] Some assets may be assumed implicitly to be perfect substitutes, imperfect gross substitutes, gross complements, or as having weak or no complementarity depending on the level of aggregation of assets under consideration. The higher the level of disaggregation the greater the prospects of uncovering a wider range of substitution and complementary relationships.

wealth effect.[19] That is,[20]

$$\partial y_i / \partial r_j \;=\; (\partial y_i / \partial r_j)|_{w} \;-\; y_j(\partial y_i / \partial E(w)) \qquad (5.30)$$

If all risky assets are normal, then $\partial y_i / \partial E(w) > 0$. Analogous to consumer demand analysis, symmetry implies only that $(\partial y_i/\partial r_j)|_w = (\partial y_j/\partial r_i)|_w$. The second term on the right hand side represents the wealth effects. Thus, symmetry will hold if wealth effects are zero or if the proportion of each asset or liability held in the portfolio is small so that individual wealth effects are negligible in the aggregate. White (1975, pp. 116-117) observed that it would seem inconsistent to expect symmetry to hold in a model that admits discrepancies between actual and desired asset holdings. Arguably, the appropriate way to impose symmetry constraints is by way of the long-run equlibrium coefficients not on the short-run coefficients. But imposing these restrictions will turn a simple linear partial adjustment model into a highly non-linear form. Much stronger doubt about symmetry is expressed by Roley (1983). He observed that in the context of the mean-variance portfolio model, symmetry of interest rate effects holds only if investors are assumed to have utility functions exhibiting constant absolute risk aversion. [21] Hence symmetry is not a general property of asset demand. Roley tested for symmetry in the context of the demand for U.S. government securities. Except in the case where the interest rate coefficients were zero, symmetry was rejected in 5 out of 6 cases. He observed further that imposing symmetry led to about a 75 percent decline in the absolute value of interest rate effects, concluding that this may account for the low interest rate effects in other U.S. studies (e.g., Goldfeld, Silber, and Hendershott). Owen (1986) observed that the tendency to exclude from a given demand equation some rates of interest

[19] For example, if $\Lambda_{11}=0$, then the coefficient of r_1 in equation (4.15) reduces to

$$b\Psi_{11}^{-1} - b\frac{\Psi_{11}^{-1} l_1 l_1' \Psi_{11}^{-1}}{l_1' \Psi_{11}^{-1} l_1}.$$

The first term is the pure substitution effect and the second term is the general wealth effect (Aigner, 1973).

[20] y_i is the stock of asset holdings and r_i is the corresponding yield or rate of return.

[21] The number of known and well-behaved utility functions satisfying constant absolute risk aversion is limited to only the negative exponential utility function. Extensive treatment of the nature of utility functions and their risk aversion characteristics can be found in Hakansson (1970) and Merton (1982).

among the 'full' range of financial assets, strengthens the argument that the symmetry of interest rate responses need not hold. Here the shortcomings from the omission of relevant explanatory variables are relevant as the estimators of the coefficients of the included interest rates will be biased and inconsistent (Kmenta, 1986). Unless the excluded and included rates are uncorrelated, or unless we assume limited interaction between certain financial assets, interest rate responses need not be symmetric, even if the complete interactions among financial assets is symmetric.

The discussion illustrates the difficulties which arise in the analysis of asset demand if proper account is to be taken of the qualitative properties of pure consumer demand schedules. The gap between the analyses of the two demand schedules at the applied level reflects, in part, the gap that exists between their respective theoretical constructs. The pure theory of consumer behaviour is developed in the context of equilibrium under certainty for consumable goods. The theory of portfolio behaviour is developed in the context of equlibrium under uncertainty for non-consumable goods. In this study symmetry restrictions are neither imposed nor tested in the generalized distributed lag model. The results of the unrestricted model are reported next in chapter 6.

Chapter 6

EMPIRICAL RESULTS

The empirical results obtained from estimating the generalized distributed lag portfolio model are presented and discussed in this chapter. The first part of the chapter focuses on the chartered banks and the second part on the nonbank public.

6.1 CHARTERED BANKS

For the i-th structural equation, (5.1) specializes to the banks' specification as follows:

$$
\begin{aligned}
y_{it} &= \kappa_0 + D_{i,a}(L)\, y_{2a,t} + D_{i,l}(L)\, y_{2l,t} + B_i(L)\, r_{1t} + F_i(L)\, v_t \\
&\quad + A_i(L)\, y_{1t} + G_i\, SD + u_{it} \\
&\qquad t = p+1, p+2, \ldots T \qquad i = s, m, l.
\end{aligned} \tag{6.1}
$$

The parameters are defined as follows:

$$D_{i,a}(L) = \left(\sum_{j=0}^{p} d_{i,a1,j} L^j,\ \sum_{j=0}^{p} d_{i,a2,j} L^j,\ \sum_{j=0}^{p} d_{i,a3,j} L^j,\ \sum_{j=0}^{p} d_{i,a4,j} L^j \right)$$

$$D_{i,l}(L) = \left(\sum_{j=0}^{p} d_{i,l1,j} L^j,\ \sum_{j=0}^{p} d_{i,l2,j} L^j,\ \sum_{j=0}^{p} d_{i,l3,j} L^j,\ \sum_{j=0}^{p} d_{i,l4,j} L^j \right)$$

$$B_{i,1}(L) = \left(\sum_{j=0}^{p} b_{i,j} L^j,\ \sum_{j=0}^{p} b_{i,s,j} L^j,\ \sum_{j=0}^{p} b_{i,m,j} L^j,\ \sum_{j=0}^{p} b_{i,l,j} L^j \right)$$

$$F_{i,1}(L) = \left(\sum_{j=0}^{p} f_{i,s,j} L^j,\ \sum_{j=0}^{p} f_{i,m,j} L^j,\ \sum_{j=0}^{p} f_{i,l,j} L^j \right)$$

$$A_i(L) = \left(\sum_{j=1}^{p} a_{i,s,j} L^j,\ \sum_{j=1}^{p} a_{i,m,j} L^j,\ \sum_{j=1}^{p} a_{i,l,j} L^j \right)$$

The right-hand side variables are defined as follows:

$$
\begin{aligned}
y_{2a,t} &= (LLA_t, BPL_t, MTG_t, ESR_t)' \\
y_{2l,t} &= (DD_t, GVD_t, TND_t, FCD_t)' \\
r_{1t} &= (RTB_t, er_{s,t}, er_{m,t}, er_{l,t})' \\
v_t &= (v_{s,t}, v_{m,t}, v_{l,t})'
\end{aligned}
$$

$$Y_{1t} = (y_{s,t}, y_{m,t}, y_{l,t})'$$

All variables are as previously defined. For ease of reference, y_{2a} consists of less liquid assets (LLA), business and personal loans (BPL), mortgage loans (MTG), and excess secondary reserves ratio (ESR). y_{2l} consists of demand deposits excluding government deposits- (DD), government deposits (GVD), term and notice deposits (TND), and foreign currency deposits (FCD). r_1 consists of the Treasury bill yield (RTB), and er_s, er_m, and er_l are the yield differentials for short-, medium-, and long-term bonds, respectively. The risk terms are v_s, v_m, and v_l. SD are the monthly seasonal dummies.

Other aspects of the specification are as follows. First, the dependent variables are in logarithm levels of the market value of bond holdings. Second, all other dollar-denominated variables are also expressed in logarithmic form.[1] This means that the coefficients give direct measures of the elasticities although these are constrained to be constant for all ranges of the variables. Third, the yield and interest rate variables are in percentages (e.g., 7.00 for 7 percent) and are entered in levels rather than logarithms, allowing the responsiveness of bond demand to be more elastic with rising rates than they are with falling rates. In other words, rising rates may induce greater portfolio adjustments than a corresponding fall in rates. Finally, all the data used in this study are unadjusted for seasonality.[2] In addition to the variables specified in (6.1), we introduce monthly dummies to represent seasonal variations in bond holdings unaccounted for by seasonal variations in the explanatory variables.

6.1.1 Interpretation of Results

All estimates are based on monthly data from 1969 to 1984. Without any prior information on the lag structure and lag length, we chose p=4 as the maximum lag to which we applied the sequence of tests.[3] The results reported in table 6.1 are based on the

---

[1] All other dollar-denominated variables are at book values. It is assumed that, except perhaps for the mortgage variable, the discrepancies between par and market values for all the banks' asset variables are minor. Data on the market values of these variables are not reported in official statistics.

[2] A detailed description of the data is provided in Appendix B.

[3] Hendry (1979) suggested choosing four or five lags for quarterly data series because of seasonal dynamics. Apart from the degrees of freedom problem, the

data-simplified version of the general unrestricted dynamic portfolio formulation (6.1). The procedure by which the final model is selected follow the sequential testing of the block of variables in figure 5.1 and outlined in chapter 5. For each block of variables, the test proceeds in a piecemeal fashion for each of the structural demand equations. The result is that the estimated lags vary among the blocks and also across equations. With few exceptions, the lags on the variables in each block are the same. The decision to drop lag coefficients on specific variables was based on repeated testing of the coefficients involved. A 1 percent level of significance was used throughout the tests in order to keep the implicit overall level at a reasonable value.

Table 6.2 summarizes the data in table 6.1. These are the sum of the impact and lagged coefficients (i.e., Q(1)) and the equilibrium coefficients ($A(1)^{-1}$ Q(1)). In all the tables, the absolute asymptotic t-values are shown in parentheses. sd_i (i=0,1,2 ..., 11) are the coefficients of the seasonal dummies, where sd_0 represents the intercept term. Since the properties of several diagnostic statistics in the context of the general distributed lag model are unknown, we report the results of several tests performed on the residuals. The rows labelled ACF's are the first twelve sample autocorrelations of the residuals in each equation. Like the seasonal dummies, each row should be read together because the coefficients come from the same equation. The test statistic z(1,i) is based on the system's generalizations of the simple first order autoregressive scheme (Breusch and Godfrey, 1981, p. 81). That is, $U = U_{-12}P + \epsilon$, where $U_t = (u_{st} \cdot u_{mt} \; u_{lt})$ and P is 3 x 3 matrix of autocorrelation coefficients, ρ_{ij}. The errors, ϵ, are normally distributed with zero means and constant covariance matrix. In this vector autoregressive (VAR) process, the disturbance term depends not only on its lagged values, but also upon the lagged values of the disturbances in other structural equations of interest. The statistics z(1,i) tests for serial correlation in each structural equation under the null that H_0: $\rho_{i1} = \rho_{i2} = \rho_{i3} = 0$. z(2,i) also is the statistic for testing the autocorrelation in each equation. The null is $\rho_1 = \rho_2 = 0$ in

[3](cont'd) choice of the lag length is based on the assumption that financial market reactions are likely to have shorter duration. The monthly series should provide more information on the dynamics structure of portfolio behaviour.

Table 6.1
3SLS RESULTS OF THE GENERALIZED DISTRIBUTED LAG
PORTFOLIO MODEL: CHARTERED BANKS

	SHORT TERM BONDS(1-3yrs)		MEDIUM-TERM BONDS(3-10yrs)					LONG-TERM BONDS(10+yrs)				
Variables	j=0	j=1	j=0	j=1	j=2	j=3	j=4	j=0	j=1	j=2	j=3	j=4
Assets												
LLA	-0.1037	0.2637	-0.8010					-0.5852	0.6832	-0.0584	0.5061	-1.1104
	(0.508)+	(1.364)	(6.290)					(1.902)	(1.628)	(0.133)	(1.132)	(3.497)
BPL	-1.2946	2.0487	-1.2955					0.6316	-2.9077	0.7244	2.6317	-4.4413
	(1.7054)	(2.773)	(2.350)					(0.602)	(0.207)	(0.544)	(2.012)	(4.308)
MTG	-1.0192	0.7290	0.2277					0.0309				
	(6.007)	(4.580)	[illegible]					(0.228)				
ESR	-0.0275	0.0407	[illegible]					0.0637	0.0327	-0.0232	-0.1038	0.0309
	(1.293)	(2.019)	(1.110)					(1.834)	(0.993)	(0.647)	(2.960	(1.012)
Deposits												
DD	0.6067	-0.5380	1.0996					1.6772	-0.6752	1.0573	-1.8603	1.6530
	(1.889)	(1.808)	(3.383)					(2.924)	(1.129)	(1.801)	(3.319)	(3.439)
GVD	0.0020	-0.0300	[illegible]					0.1099	-0.0893	0.1280	0.0448	0.0604
	(0.070)	(1.018)	[illegible]					(2.362)	(1.576)	(2.307)	(0.846)	(1.280)
IND	0.3016	-0.6041	2.0300					3.1064	-2.0726	3.7231	-3.1187	2.1511
	(0.470)	(1.018)	(4.019)					(2.754)	(1.557)	(2.837)	(2.469)	(2.291)
FCD	0.3229	-0.3156	0.5421	0.2115	0.3275			0.7214	-0.0583	0.3325	-0.4482	0.4224
	(2.602)	(2.593)	(3.448)	(1.190)	(2.766)			(3.437)	(0.211)	(1.244)	(1.748)	(2.236)

Table 6.1 continued.

	SHORT BONDS		MEDIUM BONDS					LONG BONDS				
Variables	j=0	j=1	j=0	j=1	j=2	j=3	j=4	j=0	j=1	j=2	j=3	j=4
RTB	-0.0022 (0.149)	0.0061 (1.381)	-0.0784 (3.664)	0.0702 (2.826)	-0.0787 (4.437)			-0.1036 (4.331)	0.0402 (1.342)	-0.0481 (1.674)	0.0497 (2.802)	
er(*s*)	-0.0616 (3.836)	0.0456 (4.249)	0.0791 (3.577)	-0.1383 (3.927)	-0.0988 (2.749)	0.0169 (1.301)	-0.0471 (3.696)	0.0120 (0.369)	-0.0916 (2.173)	0.0810 (1.820)		
er(*m*)	-0.0504 (2.477)	0.0198 (1.535)	-0.0309 (1.054)	0.1579 (2.916)	-0.0454 (0.968)	0.0340 (2.088)	0.0130 (0.717)	-0.0969 (2.350)	-0.1300 (2.071)	0.12 (2.197)		
er(*l*)	0.0311 (1.141)	-0.0040 (0.195)	-0.0950 (2.229)	0.0621 (1.166)	-0.1435 (3.346)	-0.0536 (2.324)	0.0225 (1.083)	-0.0896 (1.672)	0.2749 (3.596)	-0.2231 (3.639)		
v(*s*)	0.0097 (1.758)		-0.0047 (0.563)	-0.2271 (4.763)	0.1793 (3.352)			-0.0048 (0.488)	-0.0917 (1.516)	0.1000 (1.480)		
v(*m*)	-0.0137 (2.125)		-0.0056 (0.671)	0.1476 (2.837)	-0.1093 (2.134)			-0.0460 (4.414)	-0.1912 (3.047)	0.0565 (1.010)		
v(*l*)	0.0012 (0.320)		-0.0018 (0.262)	0.0248 (0.646)	-0.039 (1.065)			0.0235 (2.636)	0.2141 (3.830)	-0.1642 (3.063)		
	j=0	j=1	j=2	j=3	j=4	j=5	j=6	j=7	j=8	j=9	j=10	j=11
Intercept(j=0) and seasonal dummies(j=1,11)												
s(s,i)	0.4671 (0.649)	0.0964 (2.869)	0.0895 (2.765)	0.0295 (0.958)	0.0628 (2.084)	0.0746 (2.690)	0.0881 (2.974)	0.0734 (2.447)	0.0679 (2.291)	0.0896 (3.010)	0.0592 (2.096)	0.0882 (3.207)
s(m,i)	-6.5093 (5.582)	-0.0940 (2.949)	-0.0281 (0.831)	0.0486 (1.391)	0.0317 (0.910)	-0.0319 (0.933)	0.0694 (2.085)	0.0541 (1.569)	0.0391 (1.092)	0.0104 (0.288)	0.0245 (0.714)	-0.0962 (3.024)
s(l,i)	-11.051 (5.350)	0.0668 (1.189)	0.0995 (1.510)	0.1236 (2.081)	0.1013 (1.888)	0.0887 (1.607)	0.1753 (3.503)	0.0873 (1.727)	0.1541 (3.113)	0.0831 (1.629)	0.0771 (1.601)	0.0687 (1.671)

table 6.1 continued

Variables	j=0	j=1	j=2	j=3	j=4	j=5	j=6	j=7	j=8	j=9	j=10	j=11
Lagged dependent variables A(L)'												
A(*ss*)		0.9421	-0.0925	0.2379	-0.1804							
		(14.03)	(1.036)	(2.812)	(2.812)							
A(*sm*)		0.1100										
		(4.132)										
A(*sl*)		0.0258										
		(0.903)										
A(*ms*)		-0.2017	0.2350									
		(1.982)	(2.185)									
A(*mm*)		0.5846	0.1900	-0.0761	0.1457							
		(7.724)	(2.181)	(0.962)	(2.242)							
A(*ml*)		0.0913	0.0361	0.0373	-0.2099							
		(1.427)	(0.426)	(0.462)	(3.466)							
A(*ls*)		-0.0394	0.2857									
		(0.351)	(2.297)									
A(*lm*)		-0.2892	0.1761									
		(3.084)	(1.907)									
A(*ll*)		0.8963	-0.2026									
		(11.249)	(2.592)									
Residual Diagnostics												
First 12 Sample Autocorrelations Coefficients												
ACF(*s*)	-0.002	0.028	-0.117	0.120	-0.097	0.073	-0.245	-0.035	-0.105	0.158	0.025	-0.112
ACF(*m*)	-0.005	-0.047	-0.034	-0.008	-0.074	-0.013	-0.126	-0.009	-0.120	0.003	0.002	-0.210
ACF(*l*)	-0.039	-0.079	-0.066	-0.016	-0.082	-0.032	0.030	-0.078	-0.034	-0.064	0.173	-0.178

table 6.1 continued

	short	medium	long
z(1)	4.257	9.067	7.004
z(2)	2.597	8.843	11.558
z(3)	24.584		
z(3,i)	6.706	5.853	10.437
ARCH(6)	8.070	1.571	5.020
ARCH(12)	30.72	20.377	24.392
	0.386	-0.286	0.100
		0.648	-0.507
			0.637

Notes

+ Absolute asymptotic t-values are in parentheses.

1 s(s,l), s(m,l) and s(l,l) are the intercept and the 11 seasonal dummies for the short-, medium-, and long-term demand eqautions respectively.

2. ACF(s,m,l) are the first twelve autocorrelation functions of the residual with estimated standard error of 0.075.

3. z(1)=chi-square(3 degress of freedom(d.f.)), z(2)=chi-square (2 d.f.) z(3)=chi-sq(9 d.f.), and z(3,l)=chi-sq(3.d.f).

4. ARCH(6) and ARCH(12) are chi-square 6 and 12 degrees of freedom respectively.

5. The critical values of chi-square 2, 3, 6, 9, and 12 degrees of freedom are 9.92, 11.34, 16.81, and 26.22 respectively at the 1 percent level of significance.

6. The last three rows are the upper triangular matrix of $\hat{\Sigma}_u$ *(see equation 5.5).*

7. Summary of the sum of the lagged dependent variables.

	Regressors		
Equation	A(.s)	A(.m)	A(.l)
Short(s)	0.9071	0.1100	0.0258
	(28.54)	(4.132)	(0.903)
Medium(m)	0.033	0.8442	-0.0451
	(0.580)	(18.92)	(0.918)
Long(l)	0.2463	-0.1131	0.6937
	(2.645)	(2.204)	(12.68)

the regression $u_{it} = \rho_1 u_{i,t-12} + \rho_2 u_{i,t-24} + \epsilon_{it}$. The statistics z(1,i) and z(2,i) are distributed asymptotically as chi-square with 3 and 2 degrees of freedom on their nulls, respectively. The test statistics z(3) provides the system's analogue of the usual LM test for first order autocorrelation in the residuals of a single equation (Breusch and Godfrey, 1981, pp. 83-86). The original system of structural demand equation (5.14) is augmented by the term $\hat{U}_{-12}P$. z(3) is the Wald test of the null $P = 0$ for the system of structural equations. Z(3,i) is the Wald test of the null $\rho_{i1} = \rho_{i2} = \rho_{i3} = 0$ in each equation separately. ARCH(6) and ARCH(12) are the statistics for the test of autoregressive-heteroskedastic error process (Engle, 1982) These LM tests are computed as the sample size T times the R^2 of the regression of the squared residuals on an intercept and 6- and 12- lagged squared residuals, respectively. The test statistics are distributed asymptotically as Chi-square with 6 and 12 degrees of freedom respectively. The rationale of the ARCH test is to determine whether large or small residuals in each equation follow in clusters.

Using $1/\sqrt{T}$ as an approximation to the standard error of the residual autocorrelations, only 3 of the 36 residual autocorrelations (up to the twelve-order for each equation) exceeded the standard errors by a factor of two. None of the next 13-24 autocorrelation coefficients (not reported here) exceeded the standard errors by a factor of two. The residuals showed no specific process or pattern with regard to sign changes and magnitudes. It is reasonable to assume that the residuals are well-behaved. At the 1 percent level of significance, the hypothesis of zero serial independence among the residuals cannot be rejected by z(1). The hypothesis based on z(2) is marginally rejected for the long-term bond equation. The system's analogue of the LM test is marginally rejected by the statistic z(3). However, the sub-hypotheses of no serial correlation in the individual equations cannot be rejected. The Lagrange multiplier test for the ARCH effects suggests that the null cannot be rejected for ARCH(6). However, testing for the twelve-order ARCH process, the chi-square statistics with 12 degrees of freedom was 30.72 which is highly significant at the 1 percent level for short-term bonds. The tests for the medium- and long -term bond demand equations show no evidence of ARCH effects.

Regression Results

It is convenient to discuss the results in terms of the issues noted earlier in chapters three and five; namely, (1) how do changes in the demand for bank credit and loan expansions affect bond holdings? (2) how do changes in the various deposit categories affect different maturity classes of bond holdings? and (3) what is the sensitivity of bond holdings to changes in interest rate and yield related influences? An examination of the pattern and significance of the lagged coefficients in tables 1 and 2 reveals some important differences.

1. The results do not give any indication of whether changes in deposit, loan, and yield variables can account for significant portion of the fluctuations in short-term bonds over and above that which may be attributed to passive crossovers of longer maturing securities. Even in the long-run (table 6.2), only the mortgage variable (MTG) seems to have any measurable influence. The negative coefficient attached to the mortgage variable implies that when mortgages are acquired the actual purchase is financed by selling short-term government bonds. Silber (1970) and Roley (1980) reported results for the U.S. to suggest that substitutability between government bonds and mortgage holdings are confined to shorter maturities of the former. The relative lack of significance of several of the long-run coefficients suggests that short bonds may lend themselves to multiple roles in the overall scheme of the banks' portfolio behaviour. If this is the case, it may be difficult to find specific variables which determine most closely the nature of transactions in short bonds. The data in figure 1 suggest that the banks have not been passive in rolling over their short bonds either. If the banks had been passive merely rolling over the 1-3 year bonds to less than one year bonds, the proportion of the latter must have been much larger over the years. This observation may also mean that the portfolio selection model, as applied here, may be less appropriate in modelling the demand for short-term securities.[4]

[4] Bosworth and Duesenberry (1973) made similar observation in their analysis of the demand for U.S. government securites by institutional investors.

Table 6.2
CHARTERED BANKS: SUMMARY OF IMPACT, LAGGED, AND LONG-RUN EQUILIBRIUM COEFFICIENTS

Variable	Sum of Lagged Coefficients[1]			Equilibrium Coefficients[2]		
	Short 1-3yrs	Medium 3-10yrs	Long 10+yrs	Short 1-3yrs	Medium 3-10yrs	Long 10+yrs
LLA	0.1600 (1.804)	-0.8010 (6.290)	-0.5647 (2.796)	1.7268 (1.657)	-5.1442 (3.052)	-1.8438 (2.770)
BPL	0.7541 (2.084)	-1.2955 (2.350)	-0.7443 (1.033)	8.1374 (1.513)	-8.3196 (2.064)	-2.4304 (1.034)
MTG	-0.2901 (3.871)	0.2277 (2.099)	0.0309 (0.228)	-3.1313 (2.722)	1.4260 (2.216)	0.1008 (0.230)
ESR	0.0132 (0.799)	0.0274 (1.110)	0.0003 (0.010)	0.1427 (0.686)	0.1761 (1.035)	0.0010 (0.010)
DD	0.0686 (0.403)	1.0996 (3.383)	1.8520 (3.388)	0.7409 (0.378)	7.0619 (2.156)	6.0468 (3.054)
GVD	-0.0280 (1.473)	0.0507 (2.012)	0.2540 (4.829)	-0.3027 (1.428)	0.3261 (1.676)	0.8293 (4.971)
TND	-0.302 (0.970)	2.0300 (4.019)	3.6993 (4.291)	-3.2644 (0.999)	13.0370 (2.621)	12.0780 (4.044)
FCD	0.0724 (0.128)	0.4261 (3.754)	0.9698 (5.204)	0.0781 (0.127)	2.7368 (2.357)	3.1667 (4.815)
RTB	0.0038 (0.446)	-0.0869 (5.253)	-0.0617 (2.897)	0.0419 (0.459)	-0.5583 (3.507)	-0.2016 (2.961)
er_s	-0.0160 (0.096)	0.0089 (0.247)	-0.0031 (0.071)	-0.1729 (0.865)	0.0571 (0.247)	-0.0103 (0.071)
er_m	-0.0306 (1.450)	0.1285 (2.274)	-0.1059 (1.704)	-0.3305 (1.248)	0.8256 (2.274)	-0.3460 (1.710)

Table 6.2 continued

Variable	Sum of Lagged Coefficients[1]			Equilibrium Coefficients[2]		
	Short 1-3yrs	Medium 3-10yrs	Long 10+yrs	Short 1-3yrs	Meduim 3-10yrs	Long 10+yrs
er_1	0.0271 (1.227)	-0.2075 (3.203)	-0.0374 (0.78[illegible])	0.2924 (1.076)	-1.3327 (3.203)	-0.1223 (0.759)
v_s	0.0097 (1.785)	-0.0525 (1.552)	0.0035 (0.091)	0.1049 (1.586)	-0.3377 (1.552)	0.0115 (0.091)
v_m	-0.0113 (2.125)	0.0327 (0.903)	-0.1807 (4.454)	-0.1227 (1.7[illegible]3)	0.2100 (0.903)	-0.5902 (4.235)
v_l	0.0013 (0.320)	-0.0163 (0.811)	0.0752 (3.369)	0.0135 (0.318)	-0.1052 (0.811)	0.2456 (3.748)

1. The sum of the coefficients are analogous to testing the null hypothesis that the sum of the impact and lagged coefficients over the maximum lag length is zero.
2. The equilibrium coefficients are based not on the full system but on individual equations. That is, the equibrium estimates of the i-th equation are computed by the formula

$$\Xi_i = A^{-1}_{ii}(1)\ Q_i(1)$$

The standard errors of the long-run coefficients are based on results stated by Goldberger, et al. (1961). Let Ξ be a vector of a K long-run parameters which is a function of an n x 1 parameters β which are consistent. Then if

$$\sqrt{n}\ [\ \hat{\beta}) \ - \ \beta] \sim N[0,\ \hat{\Omega}_a]$$

and since Ξ is a function of β, it follows that

$$\sqrt{T}\ [\ \hat{\Xi} \ - \ \Xi] \sim N[0,\ J'\ \hat{\Omega}_a\ J]$$

where J is the K x n Jacobian of the function

$$J = \partial\Xi/\partial\beta.$$

2. The time distribution and pattern of the coefficients for medium bonds are different among the block of variables. With the exception of FCD, the changes in loans and deposits variables seem to have only contemporaneous effects. Less liquid assets (LLA), consisting mostly of corporate securities,[5] show significant immediate and long-run substitution with medium bonds. Judging by the long-run coefficients, the elasticity of substitution between business and personal loans and medium bonds is greater than the substitution of the latter with LLA. No clear-cut explanation can be offered for the complementarity between mortgages and medium bonds, except to note that the illiquidity of mortgages make them a risky investment. Increased acquisition of the relatively safer medium bonds lessen the overall risk of the asset portfolio. Finally, the coefficients on the yield variables are significant at both lower and higher lags. The exceptions are the risk coefficients which appear to have no significant impact at the lag of zero. The significance of the RTB, er_m and er_l variables in table 6.2 suggest that the occasional humps and inversions of the yield curve affect the banks' transactions in the medium term segment of the bond market, albeit slowly.

3. The optimal lag lengths are longer in the long-term bond equation. Three of the deposit coefficients have significant 4-period lags. The asset variables with significant 4-period lag coefficients are LLA and BPL. The lag patterns contrast with those in the short and medium bond equations. With the exception of MTG, the coefficients on the loan variables are significant only at later lags. The behavioural implication in the difference in the lag structure is that although long bonds may be liquidated to accommodate liquidity needs, this will occur only after adjusting medium bonds to some desired level and only if the stimulus for liquidity needs persist. Although the business and personal loans (BPL) show significant substitution relationship with medium bonds, the latitude for substitution appears limited with long bonds. The deposit coefficients are not only significant, but also exhibit lags longer than those of the short and medium bond equations. Except for

[5] About 80 to 90 percent of less liquid assets in the banks' portfolio are corporate securities with provincial and municipal securities issued directly to the banks or purchased from third parties making up the remainder.

the Treasury bill rate, the coefficients on the yield-related variables are significant up to 2 periods. However, the sum of the coefficients and the equilibrium coefficients are insignificant, except for the coefficents attached to v_m and v_l. The result suggest that while the demand for long bonds may respond much more quickly to changes in the structure of the yield curve, only the overall level of interest rates and degree of variability of the yield curve seem to matter in the long run. It is not immediately obvious why the yield differentials should be irrelevant. However, it is reasonable to expect that if the banks should have preference for long bonds, that preference should be based on lower volatility of yield rather than incentives for interest-sensitive arbitrage, if only to ensure minimum capital losses.

4. The finding that less liquid assets (mostly corporate securities) may be held as complementary to short bonds and as substitutes for medium and long bonds supports, in part, Masson's (1978) findings of substitutability between corporate and government bonds. What is new about our results are the complementarity with short-term bonds and the fact that the elasticity of substitution with medium bonds is about 2.7 times greater than with long bonds.

5. The results also show that the deposit composition matters. For short bonds, test of equality of the lag coefficients suggest that the benefits of disaggregation seem only marginal. The benefits of disaggregation appears stronger for medium bond holdings and even stronger for long bond holdings. The individual long-run coefficients suggest that variations in governments deposits have the least effect on the demand for government bonds. The long-run coefficients for GVD are significant only in the long bond equation, although the sum of the lagged coefficients is significant in explaining the demand for medium and long bonds in the short-run. The results provide only weak evidence in judging whether or not the banks treat federal deposits as embodying fixed term characteristics.

6. Finally, the fact that several of the explanatory variables and the lagged dependent variables enter the data-simplified model with lags greater than one highlight the role