ESSAYS ON THE FINANCIAL MANAGEMENT OF PENSION FUNDS

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by

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ABSTRACT

The dissertation deals with four issues affecting Employer Sponsored Pension Plans: a) the rationale for their existence and growth, b) the impact of taxation on funding decisions, c) the development of an investment model for such funds, and d) the evaluation of the historical investment performance of 83 Canadian pension funds. The proposed investment model integrates the fund's assets with the firm's assets. It is operationalized for four Canadian firms, using a universe of 192 common stocks and eleven bond portfolios. The results indicate that the optimal pension fund is firm-specific, in terms of both asset mix and security selection. The evaluation of investment performance emphasizes the equity portfolios of the 83 Canadian funds. The results show non-superior performance by these funds; the conclusions are robust across holding periods, benchmarks, performance measures and time periods. The study has major implications for the funding and investment policies of the pension funds and their investment performance.

RESUME

Cette thèse porte sur quatre aspects qui affectent les les régimes de pension parrainés par l'employeur: a) l'explication de leur existence et de leur croissance, b) l'impact du régime fiscal sur les décisions de contribution, c) l'élaboration d'un modèle d'investissement pour ces fonds, et d) l'évaluation de l'évolution historique de la performance des investissements de 83 régimes de pension canadiens. Le modèle d'investissement suggéré groupe les avoirs du régime à ceux de la firme. Ce modèle a été mis en application chez quatre compagnies canadiennes, représentant un portefeuille composé de 192 types d'actions ordinaires et de 10 types d'obligations. Les résultats concluent que l'optimisation du régime de pension dépend de la firme aussi bien sur le plan du mélange des avoirs que de la sélection des sécurités. L'évaluation de la performance des investissements porte sur l'équité du portefeuille de 83 régimes de pension canadiens. Les résultats démontrent que ces régimes ne présentent pas une performance supérieure et que, durant la période considérée, les résultats sont consistants avec les portefeuilles de référence, les mesures de performance et les périodes de référence. Cette étude a un impact déterminant sur la nature des investissements et des politiques d'investissement dans les régimes de pension, ainsi que sur leur performance.

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CHAPTER 1. INTRODUCTION AND OVERVIEW

A. INTRODUCTION

This dissertation is concerned with Employer Sponsored Pension Plans (ESPPs).[1] Four issues surrounding these ESPPs are of particular interest: a) the rationale for their existence and continuing growth, b) the impact of taxation on their funding decisions, c) the development of an investment policy model for these pension plans and d) the empirical investigation of the historical performance of a sample of Canadian ESPPs. Most of the issues dealt with herein are applicable to ESPP's in other industrialized countries. An effort is made to compare and contrast the Canadian and U.S. situation wherever possible. While the empirical analysis is restricted to Canadian data, it can be applied to the U.S. situation with few changes.

B. ESPPs AND THE ECONOMY

B-1. Importance of ESPPs

ESPPs have been part of the Canadian economy for over 100 years. However, the Income Tax Acts of 1919 and 1945 provided a major impetus for their growth.[2] The total number of employees belonging to Canadian ESPPs grew from 1.6 million in 1970 to 2.3 million in 1978.[3] Trusteed pension plans have become the most favoured method of fund asset management covering 1.7 million employees in the private sector.[4]

The contractual provisions determining the payment of pension benefits from these ESPPs have changed over time. In 1978, for example, 36 percent of the employees were covered by a Flat Benefit Type Plan, followed by the Final Average Earnings Plan (25.2%) and Career Average Earnings

Plan (23.2%).[5] Despite growing government involvement in the overall pension environment (through the old age security, Canada and Quebec pension plans and the Guaranteed Income Supplement Programs), ESPPs still form the major source of retirement income for the majority of the Canadian work force.[6]

The assets of trusteed ESPPs have grown accordingly, from $7.6 billion in 1970 to $21.5 billion in 1979.[7] This growth in pension fund assets has made these plans an important sector of Canadian capital markets. Contributions to these pension funds (public and private sector combined) have risen from 12 percent of gross savings in the early 1960's to almost 20 percent by 1977. Similarly, fund assets have risen from the equivalent of one-fifth of GNP in the early 1960's to roughly one-third by 1977. A study by the Economic Council of Canada (1977) estimates that by 2031, these assets would be equal to two-thirds of Canadian GNP. Moreover, the study noted that these assets are highly concentrated in a few large funds: a mere 49 funds hold approximately two-thirds of all trusteed pension plan assets. Investigation of the impact of such high growth rates and the concentration of pension asset holdings on the efficiency of capital markets, therefore, provides a promising area for future research.

B-2. <u>ESPP and the Sponsor-Firm</u>

Establishment of an ESPP essentially creates a liability for the firm in the form of future benefit payments. The sponsor-firm can either pay these benefits as they arise (pay as you go plan) or contribute to a pre-established pension fund. The level of the pension liability, the level of the fund assets and the expected stream of contributions obviously affect the firm's profits and thus its market value. A Financial Executive Institute (1980) survey of 205 large Canadian firms showed that their fund assets and unfunded liabilities represented, on average, 29 and 33 percent of shareholders equity, respectively. In seventy-five percent of the respondent firms, the present value of the expected benefit payments exceeded the shareholders' equity.[8] The ability of the sponsor-firm to pay the pension benefits when due also concerns employees and the government (which probably would have to pay for these benefits directly or indirectly in the event of failure).

C. OVERVIEW OF THE STUDY

Chapter 2 of this study analyzes existing paradigms to explain the rationale behind the establishment and growth of the ESPPs, beginning with the concepts of pensions as deferred wages and as a tool to reduce turnover costs. The impact of the tax treatment of the pension contributions on the ESPPs is discussed next: both in the absence of the individual Registered Retirement Savings Plans (RRSPs) and then in their presence. The study then addresses such factors as the insurance aspect of the pension plan and the effect of unionism on their growth. Finally, it presents an analysis of the economics of using an underfunded pension plan as disguised debt. The chapter concludes with suggestions for future research.

Chapter 3 is mainly concerned with the effects of taxes on the funding decisions of a pension plan. It begins with a review of the models which view the pension plan as a tax arbitrage opportunity for the firm's shareholders. These tax arbitrage models also affect the nature of the pension fund's investments and the capital structure of the firm. To clarify the exact effects of taxation on the pension funding decision, the chapter analyses the impact of the advance funding decision on the value of the firm's assets. Both the non tax-deductible and tax-deductible funding decisions are analysed. In this part of the analysis the opportunity cost of advance funding is assumed to be the after-tax return on the firm's assets. Next, the effects of external financing on the benefits from advance funding are discussed. A discussion of the limitations and the implications of the analysis conclude the chapter.

Chapter 4 begins with a review of the previous investment policy models and proposes an investment policy model for the firm's pension plan. The model proposed herein assumes that the firm's management views the pension fund as part of its total assets and chooses an investment policy to maximize a preference function $G(E(\tilde{W}), V(\tilde{W}))$ with $\partial G/\partial E > 0$, $\partial G/\partial V < 0$ and E and V referring to the expected value and the variance of $\tilde{W}$. $\tilde{W}$ refers to the combined, end of period cash flows arising out of the funds' investment and the firm's operating assets. The model also assumes that the optimal funding level and the nature of the operating assets are exogenous to the model. Next, the constraints of the model and its formulation, along with a discussion of its limitations and implications are discussed. The model is then operationalized, using a sample of Canadian common stocks and bonds typically selected by pension funds and is demonstrated for four Canadian firms. The impact of varying the parameters is analyzed through sensitivity analysis. The conclusions and implications of such a model are discussed at the end of the chapter.

Chapter 5 is primarily concerned with an empirical evaluation of the historical performance of a sample of Canadian pension funds. It emphasizes the equity portfolios of these funds and evaluates performance on the basis of existing theoretical developments. The chapter opens with a discussion of the performance measures used in the study and the measurement of the return and risk parameters employed therein. The data base and the empirical design are discussed next. The empirical results for the equity portfolios and some preliminary results for total fund performance are presented. The chapter ends with the conclusions.

Chapter 6 discusses overall conclusions, strategy implications and suggestions for future research.

APPENDIX A

COMMON PENSION TERMINOLOGY

A pension plan is an arrangement to provide post-retirement payments (pension benefits) to the employees by the employer. In this study, the main emphasis is on pension plans sponsored by a private (i.e. non-governmental) employer.

ESPPs generally fall into two categories, depending upon the organization that manages the pension fund assets. A trusteed pension plan is generally managed by a trustee, whereas an insured plan is managed by an insurance firm. The primary difference between the two types of plans is that in the latter, pension benefits are fixed and plan management resembles that of a simple life insurance annuity contract. In a trusteed plan the benefits are generally not known until the actual payment of the benefits, and these may depend upon wage earnings and number of years of employment. These plans form the majority of existing plans.

These trusteed pension plans can be further classified into two groups according to the choice of the benefits formula:

Trusteed Pension Plans
- Defined Contribution Plan
- Defined Benefit Plans
  - Flat Benefit
  - Career Average
  - Final Average

Defined Contribution Plan:

The firm contributes a fixed percentage of the employee's wage each year to the pension fund. The actual pension benefits received by the employees depend upon the amount of contributions and the investment return during the years of their employment. This plan is similar to an RRSP, which can be established by the employees on their personal account.

Flat Benefit Plan:

The plan provides a fixed pension benefit depending upon the years of employment, e.g. an annual pension of $300 times the number of years of employment.

Career Average:

The benefits under this plan depend upon average earnings and years of employment, e.g. an annual pension equal to 2% of earnings averaged over the entire employment years times the years of employment.

Final Average Plan:

This is similar to a career average plan, except the earnings are averaged over only the last few years of employment (generally, 5 years). This plan can either be indexed or nonindexed.

Financing of a Pension Plan:

The financing (funding) methods refer to the firm's plans for the ultimate payment of the pension benefits. A firm may decide on a pay as you go plan under which it pays the benefits when due from that year's profits, or it may decide to contribute to a pension fund. If it decides to contribute, then it creates a separate pension fund to accumulate these contributions. The annual amount of contributions to the pension fund depends upon the expected investment return, expected salary increases, mortality and termination estimates and choice of an actuarial cost method. The actuarial cost method determines the pattern of contribution, once the amount of benefits is estimated. The most common method used in Canada is termed as Unit Credit Funding Method in which the firm's contributions generally increase every year. In the U.S., the Entry Age Normal Cost Method is frequently used; this method requires the firm to contribute an equal proportion of the estimated benefits each year. There are, of course, variations of these methods. Basically these methods determine the timing and amount of future contributions to the fund by the firm based on the estimated present value of the future pension liabilities.

Unfunded Liability of the Pension Plan:

An unfunded liability occurs when the value of the pension fund and the future contributions are expected to fall short of the estimated future benefits. A change in the actuarial cost method (thus changing the amount of future contributions) could obviously change the level of unfunded liability quite substantially. To better understand the unfunded liability, it is generally separated into three parts.

An experience deficiency is that part of the unfunded liability that results from the plan's actuarial assumptions being violated by actual experience. Such a deficiency may arise, for example, when wages rise more rapidly than assumed or investment returns are less than originally assumed.

A past-service deficiency results from the recognition of employee service prior to the plan's inception or from improvements made to the plan after its inception.

A current-service deficiency reflects the contributions determined by the existing actuarial cost method. In Canada, pension benefit legislation sets out the time period during which past service or experience deficiencies must be funded.

Three other terms are frequently referred to in the pension literature, namely, portability, vesting and locking in.

Portability enables employees to carry their promised pension benefits from one firm to another when changing jobs.

Vesting generally refers to the right of employees, should they change jobs prior to retirement, to receive all or part of the pension benefits associated with the contributions made to a pension plan on their behalf by the firm, whether those benefits are taken in cash or as a deferred pension.

In Canada, however, vesting is now usually associated with a mandatory locking-in provision which prevents the employees from withdrawing either their own or their firm's contributions in cash. They must accept a deferred pension - that is, a pension that is payable only at the normal age of entitlement, usually 65.

CHAPTER 1 - FOOTNOTES

1. This dissertation emphasizes private sector pension plans, without reference to such plans in the public sector.

2. For a detailed history, see Economic Council of Canada (1979), Task Force Report (1979).

3. Most of the data in this section comes from Statistics Canada, Cat. #74-401 and #74-201.

4. A trusteed pension plan, by definition, is managed by trustees appointed by the sponsor-firm. The firm may also choose an insured plan offered by an insurance company. The emphasis here is on the former category of ESPPs.

5. Appendix A at the end of this chaper briefly explains a number of pension related terms.

6. See the Task Force Report (1979).

7. In constant 1970 dollars (CPI adjusted), the 10 year annual growth rate is 3.5 percent.

8. In the U.S., Regan (1977) has noted that for 40 large U.S. firms, the pension contributions in 1976 amounted to 20 percent of pre-tax profits and registered, on average, a 15 percent annual increase in the 1969-1975 period.

9. Some of the problems arising in this context have been discussed previously. For example, see Dreher (1981) for the valuation method of liabilities; Wilson (1979) and Oldfield (1977) for the effects of unfunded liabilities on the share prices of the firms; Gerwitz and Phillips (1978) for the method of determination for the funding level; Regan (1980) for the impact of future contributions on firm valuation; Baur (1974), Winklevoss (1974) for the impact of vesting provisions; and Archibald (1981) for the difficulties in interplan comparisons.

CHAPTER 2. RATIONALE BEHIND EMPLOYER SPONSORED PENSION PLANS

A. INTRODUCTION

Employer Sponsored Pension Plans (referred to as ESPPs) have existed for more than 100 years. Their growth during the past forty years has resulted in an explosive growth in the literature on almost every aspect of ESPPs.

The purpose of this chapter is to analyze the predominant paradigms, which seek to explain the existence of ESPPs in the private sector. Government-supported pensions, old age supplements and public sector pensions are not considered. Also, since there are many paradigms, the analysis conducted herein concentrates on those paradigms which are based upon the economic (monetary) aspects of ESPPs.

Two issues need to be considered in the analysis. The first is to explain the introduction and growth of ESPPs on the basis of the behaviour of economic agents in society; the second is the provision of a proper framework for ESPP analysis. Before proceeding with such an endeavour, a word of caution is in order. This study does not claim that conclusions reached are entirely free of the researcher's biases, nor that the analysis resolves the issue in its entirety. The study is intended, however, to clarify some important aspects of the problem and, in addition, to provide a useful framework for future research.

B. PENSIONS AS DEFERRED WAGES

The concept of pensions as deferred wages is summarized by de Roode (1913) as follows:

"Theoretically, the simplest way of dealing with labour would be the payment of a money wage, requiring the employee to provide for the hazards of employment and his old age. ..... In order to get a full understanding of old-age and service pensions, they should be considered a part of the real wages of a workman. ..... A pension system considered as part of the real wages of an employee is really paid by the employee, not perhaps in money, but in foregoing of an increase in wages which he might obtain except for the establishment of a pension system."

Under this paradigm, the individual employee decides in a perfect labour market, how to allocate his total wage between current and deferred components in order to maximize his utility.[1] His current wage would reflect the terms of the pension agreement. By establishing an ESPP, an employer may capture some economies of scale and provide pooling of risks for the employee group.[2] This paradigm provides a good approximation to actual contractual agreements for defined-contribution (money purchase) plans with immediate vesting and employee-controlled investment portfolios.

Unfortunately, most real world pension contracts work differently, therefore, the proper valuation of 'deferred wages' becomes quite difficult. For example, consider a typical funded pension agreement in a simple one-period, no-tax environment. The firm promises to pay the employee a deferred wage (pension benefit) of L_2 at the beginning of the next period and a current wage W_1 at the beginning of this period.[3] The firm establishes a pension fund with assets, A_{p1}, which will be used to pay for the deferred wage, L_2. The actual value of the pension fund will depend upon the (future) uncertain return on the fund's assets. If employee's claim under a pension contract is limited to the fund assets, the value of such a contract to the employee can be written as:

$$V = W_0 + PV_1(L_2) - PV_1(\text{Put}(A_{p1}, L_2, \sigma(\tilde{R}_p))) \quad \ldots 2.1$$

where PV_1 is the present value operator for the beginning of period 1 and $\tilde{R}_p$ is the rate of return on the pension fund portfolio and σ (•) is its standard deviation. The 'Put' recognises the possibility that the pension benefits may fall short of the promised benefits. It will have a zero value only if the plan is fully funded and invested in risk free assets. Otherwise, the employee will receive L_2 if $\tilde{A}_{p2} > L_2$ and $\tilde{A}_{p2}$ if $\tilde{A}_{p2} < L_2$. The value of $\tilde{A}_{p2}$ will depend upon level of A_{p1} ($\partial V/\partial A_{p1} > 0$) and on the riskiness of the return on the invested assets ($\partial V/\partial \sigma(\tilde{R}_p) < 0$). W_1 will be determined by the riskiness of the put option and the employee's preferences. The demand for a pension, therefore, is determined solely by the employee; since the firm is a passive agent. If, however, the employee's claim extend beyond the fund's assets to the company's underlying assets, then the value of such a contract can be written as:

$$V = W_1 + PV_1(L_2) - PV_1(\text{Put}(A_{p1} + E_{a1}, L_2, \sigma(\tilde{R}_{pa}))) \quad \ldots 2.2$$

where E_{a1} is the value of the firm's assets at the beginning of the this period and $\tilde{R}_{pa}$ is the return on the firm's plus the fund's assets, and $\sigma(\tilde{R}_{pa})$, its standard deviation, which will depend upon $\sigma(\tilde{R}_p)$, $\sigma(\tilde{R}_a)$ and $\text{cov}(\tilde{R}_p, \tilde{R}_a)$. The valuation will, of course, be more complex, but the essential principles remain the same.[4] The employee will receive L_2 if $L_2 < \tilde{A}_{p2}+\tilde{E}_{a2}$ and $\tilde{A}_{p2}+\tilde{E}_{a2}$ if $L_2 > \tilde{A}_{p2}+\tilde{E}_{a2}$, where $\tilde{E}_{a2}$ is the value of the firm's assets at the beginning of next period. Now the employee will not only be concerned with the riskiness of the fund's assets, but also with that of the firm's assets and the covariance between the two. A rational and fully informed labour market would properly value the pension contract in determining its demand for ESPPs.[5]

The valuation by an individual employee of a wage contract with the attached pension agreement may be very difficult, since, a typical contract does not provide immediate vesting and (in the case of defined benefit plans) depends upon the wage path and working life of the employee. Furthermore, these contracts are negotiated for a group (for example, as part of a union contract) rather than for each individual and are compulsory.[6] These group negotiated contracts partition the total wage package into a current and a deferred portion for an entire group of employees. Whether individual preferences are well served by this aggregation is open to question.[7]

The delayed vesting provision of these group contracts have led some to view these in familial or paternalistic terms.[8] It is argued that existence of the stringent vesting rules imply that pensions are gifts for long and faithful service and also enable the employer to maintain the loyalty of younger workers.[9] In addition, it is clear that employees who leave their employer before their benefits are vested are subsidizing those who remain because pension benefits are treated as deferred wages for an entire (homogenous) group of employees. A necessary condition for unanimous acceptance of this type of contract is either that the workers face a distribution of wage rates, imperfect information and search costs for alternative jobs, or that the firms have a degree of monopolistic power.[10]

Whether or not individual employees treat pensions as deferred wages and adjust their personal portfolios accordingly is an important part of this issue. If it can be shown that participation in an ESPP serves as a substitute for personal saving, then it may be reasonable to conclude that individual employees treat pensions as deferred wages.[11] Three important papers in this area are those by Cagan (1965), Katona (1970) and Munnel (1976).

Cagan's analysis includes three categories of employees, namely a) those without ESPPs, b) those with unvested ESPPs and c) those with vested ESPPs. Comparing the first two categories, Cagan finds that participation in an ESPP stimulated personal savings, suggesting that expected pension benefits are complements to (rather than substitutes for) personal savings. Cagan attributes this finding to a 'recognition effect' by which participation in an ESPP makes the employee aware of his future retirement needs. Analysis of the third category, however, indicated that personal savings decline when fully vested rights are acquired, which Cagan claims is evidence of a 'belated' substitution effect. Katona, on the other hand, concentrates on the differences between the personal savings of the non-covered versus the covered employees. No attempt is made to analyze vested employees separately. He also finds that pension benefits comlement personal savings, and hypothesizes the existence of a 'goal gradient', where ESPPs make financial security an attainable goal and thus result in higher savings.

Munnel's results contradict those of both Katona and (partially) Cagan. Using a larger and better monitored sample along with significantly better statistical tools, she concludes that (expected) pension benefits act as substitutes (and not complements) to other forms of personal savings. Her analysis indicates that, ceteris paribus, employees with ESPPs have smaller personal savings than employees without ESPPs. Munnel also finds that the substitution effect is much more pronounced for those employees who have vested benefits than for those with unvested pensions. This agrees with Cagan's second finding.[12]

In summary, it appears that the individual employee considers his (expected) pension benefits to be a part of his savings portfolio only when the actual receipt of those benefits becomes more certain (i.e., when those benefits are completely or nearly vested). If this is so, then the deferred wage theory cannot fully explain the introduction and historical growth of pension plans with stringent vesting requirements. Recent moves by labour sector to reduce vesting requirements, however, may suggest that the deferred wage concept plays a major role in wage negotiations.

C. PENSIONS AND TURNOVER COSTS

Viewing of pensions (with delayed vesting) as a device for minimizing turnover costs can be attributed to Becker (1975, p.34) who claims that,[13]:

> "A pension plan with incomplete vesting privileges penalizes employees who quit before retirement and thus provides an incentive - often an extremely powerful one - not to quit. At the same time, pension plans 'insure' firms against quits for they are given a lump sum - the non-vested portion of payments - whenever a worker quits."

In advancing this viewpoint, Becker assumes that each firm provides the employee with firm-specific human capital (SHC) whose value is defined as the difference between a) the discounted value of the employee's marginal product in his present firm and b) his maximum discounted marginal product, net of transfer costs, in alternative firms. This can be expressed by the equation:

$$SHC_j = \sum_{t=1}^{n} [MP_{jt} - (MP_{it} - C_{it})](1 + r)^{-t} \qquad \text{........2.3}$$

where j is the present firm, i is the alternative firm, MP is the marginal product, C_i is the transfer cost of transfering from firm j to firm i and r is the discount rate.[14]

To answer the question, "Who pays for such firm-specific human capital?", assume, for simplicity, that all firm-specific human capital is gained in the beginning of period 1. If the firm pays for all the associated costs,[15] then it would receive the returns on this investment in training only if the employee does not leave the firm. If the worker pays for these costs (by accepting a lower initial wage in the hope of obtaining higher-than-alternative wage after training), he will need a guarantee that the firm will allow him to collect the return on his investment by paying him an appropriate wage in later periods. In the absence of these costs (or firm-specific human capital), the standard neoclassical analysis will hold. Turnover, however, will be an important consideration when such costs are present. It can be argued that, when turnover is a real concern, both the employee and the firm can share the costs of and benefits from the investment in firm-specific human capital by effectively using a pension agreement with delayed vesting.

A number of other issues still remain unanswered. For example, is the sharing of investment optimal? Hoshimoto (1981) argues that sharing of the investment in training actually "depends on the existence in the post-investment years of costs of evaluating and agreeing on the worker's productivities in the firm and elsewhere." (p.475).[16] This implies that both parties have an incentive to decide about the optimal sharing agreement before undertaking the investment in training costs. To reach such an optimal ex-ante sharing agreement may in practice be difficult because the value of the employee's marginal product is not just uncertain but unknown, and is also likely to be valued differently by each party. In such an environment, it may be difficult to prespecify an optimal sharing contract without agreeing in advance on the use of some external objective economic indicator as a proxy for the employee's post-training marginal product.[17]

Another area of concern to both parties is the moral hazard-adverse selection issue. Moral hazard arises when, in the post-investment period, with only the employee investing in acquisition of the firm-specific human capital, the firm may refuse to share the difference between the employee's marginal product in this firm and his marginal prodúct in another firm. The employee then suffers an ex-post loss on his investment. Traditional arguments suggest that the firms will not behave in such a manner, because, if labour markets are informationally efficient, the firm's reputation as a 'good' employer will be eroded, thereby affecting the future wages it must pay to attract new workers. These arguments, however, ignore one important aspect of the bargaining process, the seniority rule.[18] In most cases, seniority prevents the firm from reducing the wages of (or firing) more experienced employees, especially when their benefits (or pensions) are about to be vested.

The adverse selection problem arises when employees quit in the post-investment period, after the firm has made the entire investment in training. Salop and Salop (1976) claim that a delayed vesting provision essentially works as a Two Part Wage (TPW, consisting of current and deferred wages) to minimize turnover costs. The analysis assumes that there are positive, firm-specific turnover costs to firms in a perfectly competitive labour market. Individuals differ exogenously in the probability of their quitting. The problem for the firm, therefore, is to identify the slow quitters from amongst its applicants. If the firm tries to attract slow quitters with high wages, every available worker will apply.[19] Alternatively, the firm can use a TPW as a self-selection device to attract slow quitters, while discouraging fast quitters from applying. With different firm-specific turnover costs, different TPW's will emerge and each worker will receive an equilibrium wage based on his 'quitting' potential.[20] The firm, however, may prefer to make such a contract with an entire homogeneous employee group, rather than individual contracts with each employee. The more homogeneous the group, the lower will be the cost of such a contract to the firm. Once the firm decides on a total wage package, it is entirely possible, however, that some cross subsidization may occur between fast and slow quitters.[21]

Whether pensions are the best instrument available for reducing the firm's turnover costs is another unresolved and complex issue. The optimal wage arrangement depends upon: employee preferences; the magnitude of the required investment during the training period; the alternative wage distributions available to the employee; the type of sharing arrangement during the post-investment period; and the economic power of each party during wage negotiations.[22] Cymrot (1978) argues that, in general, the delayed vesting pension arrangement may be less costly to the firm because 1) it is a contingency payment payable only to non-quitters, 2) it enables the firm (ex-ante) to distinguish between fast quitters and slow quitters, 3) delayed vesting provides an extremely strong disincentive to quit because the value of the pension increases with the number of years of employment and 4) it gives the firm some flexibility in financing the deferred wages.

D. PENSIONS AND TAXATION

The special tax treatment of ESPPs has often been cited as a major reason for their growth (and even their existence) during the past four decades.[23] In Canada, four major pieces of legislation have affected ESPPs. The income tax act of 1919 and its subsequent amendment in 1944 allowed an employee to deduct, from his income, any contributions to a pension fund. This legislation also allowed the employer to claim the funding of past liabilities as a tax-deductible business expense. The excess profits tax and the wage freeze (but without any restriction on an increase on pension agreements) during World War II also enhanced the appeal of pension plans as an indirect way for employers to raise employees' total renumeration.

Prior to 1957, pension plans provided a lower tax alternative by which employees could save for retirement. In 1957, the creation of Registered Retirement Savings Plans (RRSPs) allowed individual employees to augment their personal pension savings through tax-deductible contributions. RRSPs have since become an immensely popular alternative to ESPPs. It will be argued, later in this section, that the creation of RRSPs provides an incentive to change ESPPs from 'defined-contribution' to 'defined-benefit' plans.

The tax treatment of both ESPPs and RRSPs rests on three principles: 1) The tax-deductibility of contributions to both from that year's earnings up to a specified limit,[24] 2) the non-taxability of earnings on both ESPP and RRSP assets; and 3) the taxability of the income when received as pension benefits (or withdrawn from an RRSP). The following discussion analyzes the impact of this tax treatment on ESPPs in the pre- and post-RRSP period.

D-1. Pre-RRSP Period[25]

To analyze the effect of the tax treatment on the ESPP (in the absence of an RRSP), assume the following simple scenario. An employee plans to work for T years and wishes to save $1 today from his before-tax income to contribute to his retirement income.[26] His personal tax rates during these years are $T_{p,t}$, t=1, ... n, and his investment return on \$1 will be r_t, t=1, n. He must choose between a) saving and investing \$1 from his after-tax wages and b) asking the employer to establish an ESPP on his behalf.

If the employee saves on his own behalf, he can invest only $(1-T_{p,1})$ toward his retirement. The value of this saving, at the beginning of his retirement age, year n+1, will equal,[27]

$$V_{S,T+1} = (1 - T_{p,1}) \prod_{t=1}^{n} [(1 + r_t(1 - T_{p,t})] \quad ...2.4$$

If he saves through an ESPP, however, he can save \$1 but only pays taxes at n+1 on the receipt of benefits. The value of an ESPP, $V_{E,n+1}$ can then be expressed as:

$$\begin{aligned} V_{E,n+1} &= (1 - T_{p,n+1}) \prod_{t=1}^{n} (1 + r_t) \\ &= (1 - T_{p,1}) \prod_{t=1}^{n} (1 + r_t) \\ &\quad + (T_{p,1} - T_{p,n+1}) \prod_{t=1}^{n} (1 + r_t) \end{aligned} \quad ...2.5$$

The advantage of saving through an ESPP over personal savings can, therefore, be expressed (subtracting 2.4 from 2.5) as

$$\begin{aligned} V_{E,n+1} - V_{S,n+1} &= (1 - T_{p,1}) [\prod_{t=1}^{n} (1 + r_t) \\ &\quad - (1 + r_t(1 - T_{p,t}))] \\ &\quad + (T_{p,1} - T_{p,n+1}) \prod_{t=1}^{n} (1 + r_t) \end{aligned} \quad .....2.6$$

In equation 2.6, the first term results from the non-taxability of the pension fund earnings and is positive. The second term results from the difference between the individual's tax rates during his working and retirement life, and will generally be positive. If the employee and the firm 1) work out an adequate sharing arrangement for this gain, and 2) follow an identical investment policy chosen by the employee for the fund assets, then the employee will demand and the firm will supply an ESPP.[28] Therefore, a fully-portable, immediately-vested ESPP will benefit both parties.[29]

Of course, this simple scenario does not fully explain real world arrangements which are characterized by limited portability and stringent vesting requirements of the ESPPs and also the availability of other personal tax deferral investment opportunities. It may not, therefore, be possible to view an ESPP in terms of a simple neoclassical, utility-maximizing concept. Rather, it needs to be viewed as a combination of the tax effect and the employer's desire to minimize turnover costs. Even though the essence of the tax arbitrage argument will still hold, the nature of the sharing agreement will be more complex. In the absence of turnover costs and vesting arrangements, the employee will prefer to hold in the pension fund those assets which are taxed higher as part of a personal portfolio (such as bonds) and hold the lower-taxed assets (such as preferred shares) in his personal portfolio.[30] If the ESPP forms his entire portfolio, then he will want to hold a diversified ESPP portfolio. In general, whenever the corporate tax rate is higher than the employee's personal tax rate, a mutually beneficial sharing arrangement will increase the incentive for the establishment of ESPPs.

D-2. Post-RRSP Period

The establishment of an RRSP by the employee changes the above analysis. RRSPs enjoy the same tax treatment as an ESPP, therefore, the ESPPs will lose much of their attractiveness as tax-preferred investment. If the rationale behind ESPPs was based entirely upon pure tax arbitrage arguments, then the number of ESPPs might have been expected to decrease. One puzzling fact still remains: even though RRSPs appeared on the scene some twenty-five years ago, ESPP growth has hardly been affected.

There has, however, been a gradual, but noticeable, shift from defined-contribution plans (which RRSPs can easily duplicate) to defined-benefit plans.[31] The benefits derived from the latter generally depend upon both the wages earned immediately prior to retirement and the length of service to the firm, rather than upon the investment returns on the ESPP assets. In effect, a defined-benefit plan provides the employee with a wage-indexed investment opportunity not otherwise available. Furthermore, if real wages are constant, then such a plan provides the employee with a partial hedge against inflation. Employees will, therefore, prefer ESPPs because they supply an otherwise unavailable inflation-linked opportunity. Moreover, as these plans accrue benefits late in the employee's career, firms may find them an attractive way to reduce turnover costs (Bulow, 1979).[32]

Before concluding that defined-benefit plans may now represent optimal pension plans, two factors must be taken into account. First, contrary to certain beliefs (Task Force Report, 1979) a defined-benefit plan is <u>not</u> inherently superior to a defined-contribution plan. In the former, the ultimate receipt and the level of benefits depends upon the funding level and the financial health of the firm at the time of the employee's retirement; while in the latter, the employee can, at any time, easily calculate the present worth of his plan. Furthermore, the type of plan affects the wage-sharing arrangement between the employee and the firm. Bulow (1979) and Pesando (1982) argue that in order to get such a wage indexed pension benefit, the employee must accept a lower current wage. While this may be true, it is not obvious how the employee or the firm can evaluate the exact amount of the wage reduction. For example, assume that the competitive wage is W and the employee accepts W-C in exchange for a defined-contribution plan and W-B for a defined-benefit plan where B > C. He may also be willing to accept W-I for an indexed (during the post-retirement period) defined benefit plan. The problem for both employee and firm then is to determine 'I','B' and 'C'. If the value of 'I' or 'B' can be agreed upon by both parties, then defined benefit plans will exist.

Thus, the ultimate choice of the type of plan is firm-employee specific and no general conclusions can be drawn that apply to every firm in the corporate sector. It will, of course, be highly unlikely that a firm will want to index the plan for an already retired employee as it will be unable to extract any wage concessions from him.[33] The inability to reduce a retired employee's wage, Pesando (1982) claims, provides direct support for the deferred wage argument. It should be noted, however, that contract negotiations between the union (or employee group) and the firm are aimed at maximizing the utility of the active employees and shareholders, both groups will, therefore, place a low priority on indexing the benefits of already retired employees.

In summary, it can be argued that the tax arrangements for ESPPs have had an important effect on their growth. This is not to say that the demand and supply of such plans can be explained solely through the tax arbitrage mechanism, other viewpoints likely have some explanatory power.

E. OTHER FACTORS

There are three additional rationales for ESPPs: the insurance aspect of ESPPs, the growth of labour unionism and ESPPs as a source of disguised debt.

E-1. Pensions and Insurance

Odle (1974) claims that the underlying operational principle of an ESPP is the pooling of risks. In labour surplus economies, which are generally characterized by imperfect capital (and insurance) markets, the firm provides an insurance function for its employees at a price that is lower than that available in the conventional insurance market. In addition, the firm frees the individual employee from complex portfolio management problems. Thus, an individual employee does not have to face the unpleasant task of predicting the time of his death, so that he can draw down his accumulated savings at an appropriate rate.[34] Given the types of insurance and capital markets found in North America, where individuals can buy competitively priced annuities, however, this rationale is not likely to be a primary reason for the existence of ESPPs.

E-2. Pensions and Unionism

Traditionally, the Neo-Marxian models of the economy have had difficulty explaining the growth of pensions and employees' demands for pensions, since pensions seem to be a capitalist device to bind the employees to long-term contracts through stringent vesting requirements.[35] The central theme in the more recent neo-Marxian literature is that any positive change in the wage bargain (such as the introduction of an ESPP) has a cost in terms of reduced production.[36] Since labour is already getting the minimum wage (by definition), most, if not all, of the costs must be borne by capital. Thus, any pension plan concession represents a gain for labour in its constant class struggle with management.

In the same vein, Carter and Marshall (1967) argue that non-wage benefits, such as pensions, have been important indicators of union strength. These benefits make it possible for unions to avoid wage competition between firms in an industry. This is achieved by establishing uniform wage rates geared to marginal firms and then extracting additional benefits on the basis of each firm's ability to pay additional wages disguised as non-wage benefits.[37]

The essential difference between the neoclassical and neo-Marxian concepts of ESPPs rests upon who bears the cost of an ESPP. In both systems, ESPPs can exist, as they provide benefits to either the firm (neoclassical 'turnover' argument) or the employee (neo-Marxian 'added concession' argument).

E-3. Pension Plan as Disguised Debt

It is also possible to explain the rapid growth of ESPPs, along with their underfunded status, by viewing the underfunded pension plan as a disguised form of debt. To illustrate this argument, consider the following scenario:

Assume that the firm needs \$X at the beginning of each year for the next n-1 years. The firm expects to pay the principal and the accumulated interest at the end of n years. It is considering two options for raising this amount. Option 1 is to issue pure discount bonds each year at interest rate i_b through the capital market, and option 2 is to reduce the employees wages each year by promising the repayment of the loaned amount in the form of pension benefits. Assuming a willingness of the employees to lend (indirectly through the wage reduction) at the rate i_e, then:

Option 1: External debt through a series of pure discount bonds.

At the end of n years, the firm's after tax payments are:

$$= X[ni_b + (n-1)i_b + \ldots + i_b](1-T) + nX$$

$$= Xi_b \left[\frac{n(n+1)}{2}\right] (1-T) + nX \qquad \ldots\ldots\ 2.7$$

Option 2: Reduce wages (borrow from employees)

For each dollar of financing the firm must borrow 1/(1-T) dollars from the employees. At the end of n years, the after tax cost of the pension benefits are:

$$= \left[\frac{X\ i_e}{(1-T)} \frac{n(n+1)}{2} + \frac{nX}{(1-T)}\right] (1-T)$$

$$= Xi_e \left[\frac{n(n+1)}{2}\right] + nx \qquad \ldots\ldots\ 2.8$$

Option 2 is similar to a pay as you go or an underfunded plan and has a higher cost than option 1 if $i_b(1-T) < i_e$. Clearly, a firm which uses the reduction in wages rather than the issuance of debt to finance asset expansion must consider the tradeoff between $i_b(1-T)$ and i_e.

It is possible that, in the presence of capital rationing, firms may resort to borrowing from employees, who in turn will become silent partners in the funding of the firm.

The rate at which an employee (or a group of employees) would be willing to lend the funds to the firm will depend upon the alternative investment opportunities available to him. In the absence of schemes, such as RRSPs, the employee would be willing to hold the firm's debt indirectly (i.e. through the ESPP) rather than in his taxable personal portfolio. A tax-arbitrage situation similar to the one described in section D-1 would then arise.

If an RRSP is available to the employee, however, he may wish to hold the firm's debt directly (in his RRSP portfolio) rather than indirectly (in an ESPP). Holding the debt directly will provide him with essentially the same riskiness as that faced by other debt holders, whereas holding it indirectly involves the risk of wealth transfers to the shareholders. The latter would arise due to the non-enforceability of the pension contract in the case of (possible) firm bankruptcy.

If the firm promises to pay the benefits under a career average or final earnings plan, then an employee may wish to lend at a rate lower than i_b due to the perceived attractiveness of such a wage-linked asset in his portfolio. In such a case, the firm must compare the costs of borrowing from an employee to a wage-indexed bond. But if the pension benefits are non-enforceable and are of a flat benefit type, an employee with a RRSP will require a rate of return higher than i_b. This will diminish the attractiveness of underfunded pension plans as a source of disguised debt financing.

F. CONCLUSION

This chapter analyzed the rationale for the existence of ESPPs. The main issues examined were: a) who pays for the services offered by ESPPs and b) how does the supply of and demand for ESPPs affect the framework for analyzing the issue. The lack of empirical research about the impact of ESPPs (and the type of benefit payment scheme) on wage differential has hampered the resolution of these issues.

While it is apparent that ESPPs have evolved due to a combination of factors, it is difficult to diminish the importance of tax incentives in explaining their growth. It is hypothesized here that the existence of RRSPs will affect the nature of the plans being offered. Depending upon the expectations of both employees and firms about future wage uncertainty, the plans offered will be either defined-benefit or defined-contribution. The availability of RRSPs will, however, reduce the attractiveness of delayed vesting defined contribution plans. It can also be hypothesized that employees will demand a defined-benefit plan and will be willing to pay a premium (via a wage reduction) for a partially wage-indexed investment opportunity. Whether an appropriate premium scheme can be mutually agreed upon by employer and employee remains to be determined.

A number of issues require further research. These include: a) have pension plans restricted labour mobility and thus output?; b) can a simple neoclassical framework be used to analyze ESPPs (formed essentially as a group contract)? and c) if not, how can a union negotiate the tradeoff between current and deferred wages?; d) how do the investment aspects and the non-enforceability of pension benefits affect the negotiations? and e) how do shareholders and employees value the firm's pension plan and its fundedness?

CHAPTER 2 - FOOTNOTES

1. This reflects the neoclassical model in which the atomistic individual makes utility-maximizing decisions (see for example, Marshall et al., 1976, Pesando & Rea, 1977).

2. The employer may operate the ESPP at cost (i.e., the deferred wage component will be an optimal premium for the payment of the promised benefits) and thus charge lower premiums than those available from profit-oriented insurance companies which can also provide a similar plan.

3. This model is based on Sharpe (1976).

4. See Treynor et al. (1976), pp.124-125 for an illustration of the valuation process. For a pure equity firm R_a, return on the firm's assets, can be substituted for by R_e, the rate of return on equity.

5. By comparing the present value of a straight contract with that with an attached pension contract.

6. Most union contracts fix the current wage for each category of workers leaving no room for individual negotiation.

7. Schiller and Weiss (1977) provide some evidence that, ceteris paribus, the larger the pension benefits to which workers are entitled, the lower the current wage.

8. See Asimakopulos and Weldon (1970), Ascah (1980), Asimakopulos (1981), Queen's study (1938).

9. Ascah (1980), p.82.

10. These arguments have been recognized in the literature. See Stigler (1972), Holt & David (1976), Brunner and Meltzer (1970), Phelps (1970), Asimakopulos and Weldon (1970).

11. The concern here is on the 'micro' issue. The effect of pension plans on aggregate savings is another well-debated issue in the literature. See, for example, Barro (1978), Boyle & Murray (1979), Feldstein (1976), Munnel (1974).

12. None of the three studies however looked at the wage differential that may exist due to an unvested pension plan.

13. Oi (1962) also expresses similar thoughts.

14. It is not entirely clear how this 'r' can be determined, since it may be firm and employee specific. Becker states that r is the market discount rate, whereas Parsons (1972, p.1121) claims that it is the risk-free interest rate.

15. The worker still receives a wage equal to his marginal product in some other firm, but actually produces less in the present firm as a result of time lost during training.

16. Donaldson & Eaton (1976) claim that for the firm the shared investment is an optimal entrapment of its employees; Eastman (1977) subsequently points out that this claim is a result of their unconventional definition of investment.

17. For example, in one of the United Mine Workers' contracts, the pension benefits are calculated on a per ton of coal produced basis. In general, however, the errors in estimation and choice of an appropriate indicator will create problems. For further elaboration on these issues and some of the alternatives, see Hoshimoto and Yu (1980).

18. See Levinson (1966) and references cited therein; in particular, Dunlop (1957) and Lewis (1963).

19. This is similar to the classic problem of 'lemons' mentioned by Akerlof (1970).

20. If such an equilibrium eventually appears, restrictions on labour mobility will not cause any loss in efficiency per se.

21. It is not easy to say which group benefits or loses from a group contract. Although nonquitters may, in part, pay for the turnover costs of the fast quitters, they also receive part of the deferred wages of the fast quitters. See Salop (1973).

22. As cited by Cymrot (1978), Schiller & Wise (1977) provide weak evidence that pension arrangements provide some reduction in turnover costs.

23. See Harbrecht (1959), Holland (1969), McGill (1979, pp.23-25), Cymrot (1978).

24. As of 1982, the limits for RRSP contributions are the lower of 20 percent of earned income or $5500 for individuals who do not belong to an ESPP or $3500 less the contributions to a pension plan. See Revenue Canada Bulletin #IT-24R4.

25. The "Pre-RRSP period" refers to the period when personal savings for retirement were treated like other savings for tax purposes.

26. The employee's saving decision is exogenous to the discussions herein.

27. It is assumed that his earnings are taxed at the end of each year.

28. Under such a sharing arrangement the employee will accept a lower gross wage with an ESPP provision than he would without an ESPP provision.

29. Cymrot (1980) analyzes the benefits in an inflationary setting and claims that inflation unambiguously increases pension demand (p.186).

30. Assuming that the prices of preferred shares and bonds do not already reflect this tax advantage.

31. See the Task Force Report, Government of Canada, 1979, p.47.

32. Due to the $3500 limit on RRSPs for those belonging to ESPPs, there is still another tradeoff. An employer can limit the employee's contribution to an ESPP while simultaneously increasing his contribution. In such a case, employee can only invest $3500 minus his contribution to ESPP in his RRSP as a tax deductible contribution instead of the $5500 limit. This would increase the desirability of such a pension plan for slow quitters, and would penalize fast quitters who otherwise may have saved up to $5500 (i.e. those whose gross income was over $17000/year). This will increase the attraction of ESPPs for reducing turnover costs.

33. This may be the reason behind the private sector's reluctance to adopt the government initiative of extending post-retirement indexing to retired employees.

34. See Denton et al. (1981).

35. Draimin (1982) provides an excellent analysis of the importance of wage bargaining in a neo-Marxian model of the economy. See especially, pp.83-92.

36. See Remlinger (1971), Gough (1975) and the other references cited in Draimin (1982).

37. From the firm's viewpoint, non-wage benefits may be preferable to an equivalent increase in current wages, because of the various kinds of added costs which increase with wages (such as CPP and QPP contributions) do not increase with non-wage benefits.

CHAPTER 3. PENSION FUNDS AND TAX ARBITRAGE OPPORTUNITIES

A. INTRODUCTION

Funds invested in ESPPs receive favourable tax treatment in two ways. First, a firm's contributions to such a fund are tax-deductible within the limits imposed by the government. Second, the investment returns on the fund's assets are not taxed. These two factors have important implications for the firm's funding decisions of an ESPP. If it is also recognized that 1) the interest paid on the firm's debt is tax-deductible and 2) that personal tax rates on interest income may be substantially higher than that on equity income, then pension funds provide the firm's shareholders with valuable tax-arbitrage opportunities under some restricted circumstances. These tax considerations have implications for the funding and investment decisions of an ESPP.

This chapter starts with the arguments of Black (1980) and Tepper (1981) which suggest a fully-funded, all-debt pension fund. Assuming the pension funding decision as an alternative to investment in the firm's operating assets, both non-deductible and tax-deductible advance funding decisions are analyzed within a certainty framework. The limitations and implications of this analysis are then discussed. Next, the chapter deals with the issue of external (debt) financing and its effect on the pension funding decision, and concludes with a discussion of its implications.

B. PENSION FINANCE AND CORPORATE FINANCE

A pension fund established under an ESPP legally belongs to the beneficiaries. According to fiduciary rules, it should be invested solely for their benefit. On-going firms with defined benefit plans must, however, pay pension benefits whenever they arise and must do so either from the pension fund assets or by increasing the firm's contributions. It is possible, therefore, to argue that under the assumptions 1) of zero probability of bankruptcy and 2) that pension payments are similar to debt payments, the pension fund assets are actually the assets of the firm and should be treated as such. The concept of an 'augmented' balance sheet (Table 3.1), which was popularized by Treynor (1980)[1] accomplishes such an integration.

Table 3.1

AUGMENTED BALANCE SHEET
(ALL ASSETS AT CURRENT MARKET VALUES)

Pension Fund Balance Sheet	(1 - T) Pension Fund Assets	(1 - T) Present Value of Pension Liabilities
Corporate Balance Sheet	Corporate Assets	Corporate Liabilities Corporate Equity (residual)
	Total Assets	Total Liabilities

In Table 3.1, the pension fund assets and liabilities are adjusted by (1-T) simply because a decrease (or increase) of $1 in liabilities can be offset by an increase (or decrease) of $(1-T) in the firm's contributions.

B-I. Taxation on Corporate Debt

In the plan proposed by Black (1980), the firm sells stocks from the pension fund and buys bonds with the proceeds.It simultaneously issues new debt and buys back its own shares with the proceeds. The actual proportions of this buy-and-sell process are adjusted to ensure that there is no change in the leverage of the augmented balance sheet. All that remains, therefore, is the tax effect.[2] Black claims that the firm would benefit by effecting only the pension fund switch and that the capital structure change is needed simply as 1) a hedge against the long run excess return of equities over bonds and 2) to keep the leverage of the consolidated balance sheet unchanged. Actually the benefits are a direct result of earning before tax interest on the pension fund and paying after tax interest on the firm debt. The major source of gain is the tax deductibility of the interest on the firm's debt.[3] In other words, the firm is using the pension fund to increase its debt capacity while maintaining overall leverage by shifting the fund's assets into bonds.

According to Black, this switch from stocks to bonds would provide additional benefits by 1) reducing the volatility in the present value of the firm's contributions, 2) increasing the value of the firm, 3) reducing the risk of the stock and 4) reducing the risk of default on the firm's bonds. He states That this is because 'the stocks are worth more when times are good and less when times are bad' (p.22). Thus stocks add to the firm's leverage and result in contributions to a pension fund being higher just when the firm can least afford them. If that is the case then it is clearly an important aspect of the pension fund investment strategy, but does not necessarily imply that the fund can only invest in bonds. The firm can also achieve a desired risk-return trade off by accounting for the economic relationship between the returns on the assets in the fund and the firm's assets. A Markowitz type of optimization would select either stocks or bonds depending upon their expected returns and variability but it is difficult to predetermine the optimal portfolio in the manner suggested by Black.[4]

Five other issues require further clarification.[5] First, Black's plan only applies to very healthy firms with zero probability of bankruptcy. Note that even though the leverage in the 'augmented' sense is unchanged, the fund assets cannot be used to satisfy the firm's debt holders in the event of bankruptcy, unless the fund is overfunded. Even in the case of termination of an overfunded plan, the issue of ownership of the 'excess' assets is not entirely clear as shown by the recent A&P case.[6] Second, the empirical work of Arnott and Gersovitz(1980) shows that there is a positive cross-sectional correlation between the firms' debt-equity ratios and the level of underfunding of their pension plans.[7] This means that Black's plan would provide extra benefits if, and only if, the pension fund provides the sole opportunity for increasing the firm's debt level. Third, in the U.S., the trustees under the Employment Retirement Insurance Securities Act (ERISA) are required to select a diversified portfolio which, expert opinion asserts, must contain more than one type of security

(Langbein and Posner, 1976, 1977). Fourth, it is hypothesized that having a well-funded ESPP may prompt the firm's employee group to negotiate for the benefit improvements over and above those previously contracted.[8] Fifth, in the case of bankruptcy, the beneficiaries' claims extend only to the fund's assets; full funding as suggested by Black would thus create a wealth transfer from bond holders (and also the shareholders) to the beneficiaries. These issues not withstanding, Black's plan is essentially a useful extension of the Modigliani-Miller (1958) world with corporate taxes but extended to include tax-exempt pension plans.

B-2. Personal Taxation

Black's proposal is silent on an important issue: the personal tax code. Based on Miller's analysis (1977), Tepper (1981) has treated the pension fund as a tax-exempt mutual fund for the firm's shareholders and concludes (as in the previous section) that the pension fund should be fully funded and invested only in debt securities.[9] Tepper assumes that 1) the personal tax rate on equity investment is less than that on interest income, 2) corporate assets and pension fund assets can be fully integrated, and 3) shareholders can costlessly change the leverage of their personal portfolios. With these assumptions, shareholders can utilize the pension fund to transform their higher taxed interest income into a lower taxed equity income. This is achieved by investing the fund's assets in debt securities and simultaneously reducing the debt holdings in their personal portfolios.[10] The crucial element in the analysis is the existence of differential personal tax rates and the ability of the firm's shareholders to reduce their personal taxes via the pension fund. Tepper's conclusions are similar to Miller's in that, the economic gains of this strategy are an increasing function of the difference between the personal tax rates on bonds and equities.[11]

Two implicit assumptions in Tepper's analysis deserve further attention. First, Tepper assumes that similar tax reduction opportunities are not available to the individual. This assumption directly contradicts the Miller and Scholes (1978) tax avoidance proposals (such as insurance policies; see p.343). One must, therefore, assume (albeit arbitrarily) that some investors are able to 'launder out' personal taxes on dividends, but cannot simultaneously avoid taxes on interest income so that the pension fund acts as a vehicle for avoiding these taxes. Second, it must also be assumed that the tax avoidance and agency costs of tax arbitrage via the pension fund are smaller than those involved in personal arbitrage. More specifically, in the terminology of Barnea et al (1981), if the costs involved in tax avoidance are assumed to be an increasing function of the amount of tax-sheltered income utilized by the investor, then one must show that the pension fund provides a less costly tax shelter than that achieved in the personal portfolio. According to Revenue Canada taxation data, however, the vast majority of these investors who are the contributors to ESPPs and RRSPs do not put aside the full allowable amount. Contributions are, in fact, well below the maximum (see Daly and Wrage, 1978). If, in addition, these individuals also hold relatively undiversified portfolios, then they may prefer to use the firm's pension fund to provide diversification rather than tax arbitrage opportunities. The applicability of Tepper's analysis, therefore, depends strongly upon the nature of individual portfolios, the degree of availability of tax shelters to individuals, the tax code and the nature of the capital markets.

C. TAXATION AND THE ADVANCE FUNDING DECISION

A firm with an ESPP and an established pension fund may, under the limits set by the government, increase the fund assets by advance funding. The analysis in the previous section dealt with the effects of external financing and personal taxation on the advance funding decision. In general, advance funding results in a transfer of dollars from corporate assets into the pension fund. The marginal cost of such a transfer clearly depends upon the source of additional financing and/or the return from the alternative use of the transferred amount. If the capital structure and the dividend policy of the firm is believed to be optimal (and thereby exogenous to the advance funding decision), then the alternative return available to the firm is the after-tax rate of return on the firm's assets.[12] The effects of the advance funding decision can then be analyzed by investigating its impact on the total assets of the firm at the end of a pre-determined horizon. Assuming that the firm is an on-going concern and that the advance funding decision has no impact on its labour negotiations, the analysis can be conducted as follows:[13]

Notation

The following notation will be used throughout this analysis.

R_a	Rate of return on the firm's assets
R_i	Rate of return on the pension fund's investments
R_b	Rate of return the firm has to pay on borrowed money
T,K	Corporate tax rate
R_a^T	After tax rate on the firm's assets = $(1 - T)R_a$
R_b^T	After tax cost of debt = $(1 - T)R_b$

I_b^T After tax dollar interest paid on the firm's borrowings

A_n Firm assets at the beginning of year n

P The amount of advance funding from the firm to the pension fund at the beginning of year 1

F_n Pension fund assets at the beginning of year n

C_n Contribution by the firm to the pension fund at the beginning of year n

Z Change in assets at year n by a dollar of advance funding at the beginning of year 1

Y_n^i Sum of an annuity of one dollar for n years at rate i

At the beginning of year one, the firm's and the fund's assets are A_1 and F_1, respectively, and that the firm's contributions to the fund are expected to be C_1, C_2 ...., C_n in years 1, 2, ... n respectively. These contributions and the subsequent earnings from the assets are expected to result in a fund value of F_{n+1} at the end of year n, from which the pension benefits are to be paid. (This situation is referred to as the base case.) The firm wishes to analyze the tax effects of advance funding of the plan by an amount P at the beginning of year 1 and adjusting the final contribution, C_{n+1}, to guarantee the same level of fund assets, F_{n+1}. This advance funding may or may not be tax-deductible.[14] If it is not tax deductible, it is assumed that the earnings still accumulate tax-free while in the pension fund. These two situations are used to distinguish between the effects of initial tax deductibility from those of tax-free accumulation of earnings.

C-1. Non-Tax-Deductible Advance Funding

At the beginning of year one, the firm's assets decrease and the fund's assets increase by P such that:

$$A'_1 = A_1 - P$$
$$F'_1 = F_1 + P \quad \ldots\ldots 3.1$$

At the end of n years before adjusting the final contribution, firm's and fund's assets are given by:

$$A^*_{n+1} = (A_1 - P)(1+R_a{}^T)^n = A_1(1+R_a{}^T)^n - P(1+R_a{}^T)^n$$
$$= A_{n+1} - P(1 + R_a{}^T)^n \quad \ldots\ldots 3.2$$

$$F^*_{n+1} = (F_1 + P)(1 + R_i)^n = F_{n+1} + P(1 + R_i)^n \quad \ldots\ldots 3.3$$

At the end of year n, the firm reduces its contribution by $P(1 + R_i)^n$; so that the fund's assets are again equal to F_{n+1}. The firm incurs a tax liability only on the accumulated earnings which is:

$$= T\,P[(1 + R_i)^n - 1] \quad \ldots\ldots 3.4$$

Adjusting the firm's assets for this tax liability, 3.2 can be written as:

$$A'_{n+1} = A_{n+1} - P(1 + R_a{}^T)^n + P(1 + R_i)^n$$
$$- T\,P[(1 + R_i)^n - 1]$$
$$= A_{n+1} + P(1 - T)[(1 + R_i)^n - 1] - P[(1 + R_a{}^T)^n - 1] \quad \ldots\ 3.5$$

The advantage of advance funding at the end of n years is:

$$A'_{n+1} - A_{n+1} = P(1 - T)[(1+R_i)^n - 1] - P[(1+R_a{}^T)^n - 1] \quad \ldots\ 3.6$$

The first term on the right hand side represents the benefits earned through the accumulation of tax-free returns earned on the pension fund assets; the second term represents the income that could have been earned in the absence of advance funding. The benefits of one dollar of advance funding can be written as:

$$Z = (1 - T)[(1 + R_i)^n - 1] - [(1 + R_a^T)^n - 1] \quad \ldots 3.7$$

The size of Z depends upon various combinations of T, n, R_i and R_a. Partial differentiation of 3.7 shows that

$$\frac{\partial Z}{\partial R_a} = -(1 - T).n.(1 + R_a^T)^{n-1} < 0 \text{ for } T > 0 \quad \ldots 3.8a$$

$$\frac{\partial Z}{\partial R_i} = (1 - T).n.(1 + R_i)^{n-1} > 0 \text{ for } T > 0 \quad \ldots\ldots 3.8b$$

$$\frac{\partial Z}{\partial n} = (1 - T)(1 + R_i)^n.\ln(1 + R_i) - (1+R_a^T)^n.\ln(1 + R_a^T) > 0 \text{ if } R_i > R_a^T \quad \ldots 3.8c$$

$$\frac{\partial Z}{\partial T} = n.R_a.(1+R_a^T)^{n-1} - [(1+ R_i)^n-1] < 0 \text{ if } R_i < R_a^T \quad \ldots 3.8d$$

Equations 3.8a and 3.8b are self explanatory. Equation 3.8c shows that Z increases with increases in the horizon if $R_i > R_a^T$ and decreases if it is less. For relatively short horizons, the tax on the deferred earnings, $T[(1 + R_i)^n - 1]$, is not very significant compared to the value of the tax free earnings from the advance funding, $(1+R_i)^n$.[15] The benefits are obtained mainly through the subsequent reduction in contributions.[16]

The benefits from delaying the contribution adjustment also depend upon the tax rate.[17] An increase in the tax rate affects the benefits in two ways. It decreases both the value of the tax-free returns earned on the pension fund assets at the time of the contribution adjustment at the end of year n (first term on the right hand side of 3.7) and the after-tax returns on the firm's assets (second term of 3.7). For realistic values of R_i and R_a, however, the decrease in the first term is larger than the decrease in the second term. For example, when R_i = 12% and R_a = 10% for N = 20, the benefits decrease (but are still positive) as T goes from 30% to 50%. The reverse situation occurs when R_i = 12% and R_a = 14% and n = 20. The benefits increase from -2.92$ per dollar of advance funding at T = 30 percent to -1.04$ when T = 50 percent. The overall benefits of non-tax-deductible advance funding thus depend upon the interaction between R_i, R_a, n and T.[18]

C-2. Tax-Deductible Advance Funding

In this case, the firm need only transfer (1 - T) dollars in order to increase its contributions by one dollar.[19] Assuming that tax deductibility is allowed at the time of contribution, the assets of the firm and the fund can be expressed as:

$$A'' = A_1 - P(1 - T)$$
$$F'' = F_1 + P \qquad \text{3.9}$$

The assets at the end of n years (before adjustment) become[20]

$$A^*_{n+1} = A_{n+1} - (1 - T)P(1 + R_a T)^n$$

and

$$F^*_{n+1} = F_{n+1} + P(1 + R_i)^n \qquad \text{3.10}$$

At the end of n years, the firm decreases its contribution by $P(1 + R_i)^n$ which is fully taxable (as opposed to the previous case where $P[(1 + R_i)^n - 1]$ was taxable). The firm's assets after the adjustment can be expressed as:

$$A''_{n+1} = A_{n+1} + P(1 - T)(1 + R_i)^n - P(1 - T)(1 + R_a^T)^n \quad \ldots\ldots\ldots 3.11$$

The advantage of one dollar of advance funding then is:

$$Z = (1 - T)(1 + R_i)^n - (1 - T)(1 + R_a^T)^n$$
$$= (1 - T)\,[(1 + R_i)^n - (1 + R_a^T)] \quad \ldots\ldots 3.12$$

The benefits are the product of the after-tax advance funding amount and the difference between the compounded rates of return, R_i and R_a over the horizon period, n.

Partial differentiation of 3.12 illustrates the effect of each of the variables on the benefits of advance funding:

$$\frac{\partial Z}{\partial \bar{R}_a} = -(1 - T)^2.n.(1 + R_a^T)^{n-1} < 0 \text{ for } T > 0 \text{ and } R_a > 0 \quad \ldots 3.13a$$

$$\frac{\partial Z}{\partial \bar{R}_i} = (1 - T).n.(1 + R_i)^{n-1} > 0 \text{ for } T > 0 \text{ and } R_i > 0 \quad \ldots . 3.13b$$

$$\frac{\partial Z}{\partial \bar{n}} = (1 - T)(1 + R_i)^n.\ln(1 + R_i) - (1 - t)(1 + R_a)^n.\ln(1 + R_a^T)$$

$$> 0 \text{ if } R_i > R_a^T \quad \ldots\ 3.13c$$

$$\frac{\partial Z}{\partial \bar{T}} = [(1 - T).n.R_a(1 + R_a^T)^{n-1}] - [(1 + R_i) - (1 + R_a^T)^n$$

$$> 0 \text{ if } R_a^T > 0 \qquad > 0 \text{ if } R_i < R_a^T \quad \ldots . 3.13d$$

In general, for $R_i > R_a^T$, advance funding is beneficial. An increase in the tax rate decreases both terms on the right hand side of equation 3.12. For two identical firms facing different tax levels, the benefits from the advance funding will be lower for the firm with the higher taxes. This is because the higher tax rate decreases the benefits from accumulating more than the benefits from investment in the firm's assets. Similar to the last case, the benefits depend on the levels of R_i and R_a^T, the value of T and the length of the horizon period, n.

C-3. Effects of Initial Tax Deductibility

The benefits of initial tax-deductibility can easily be obtained by subtracting 3.7 from 3.12

$$\Delta Z = T[(1 + R_a^T)^n - 1] \qquad \ldots 3.15$$

The benefits depend only on R_a, T and n. Although the benefits seem to increase with n, it is important to note that the advantage will be worthless if the firm never realizes the tax credit by adjusting the final contribution. The benefits also depend critically upon the tax rate faced by the firm at year n. The tax rate change may arise from a variety of sources, such as basic changes in the corporate tax rate, write-off patterns, the tax rate for the accumulated earnings on the fund's assets, etc. For a firm faced with such a tax change, the advance funding decision can be examined, by assuming a change from T to K, at the end of year n.

C-4. Effects of a Change in Corporate Tax Rate

With non-tax deductible advance funding, 3.6 can be rewritten as:

$$A'_{n+1,K} = A_{n+1} + (1 - K)P[(1 + R_i)^n - 1] - P[(1 + R_a T)^n - 1] \quad \ldots\ldots\ldots\ldots\ldots\ 3.16$$

If $K > T$, the advantage of advance funding is reduced. For example, when $K = 1.2T$ with $T = 30\%$, $R_a = 10\%$, $R_i = 10\%$ and $n = 20$, the benefits are reduced by 30% (from 1.14 to .80). In general, the reduction in benefits is higher if $R_i > R_a T$. In certain cases, the tax rate increase may actually result in negative benefits.

For tax deductible advance funding, 3.11 becomes:

$$A''_{n+1,K} = A_{n+1} + (1 - K)P(1 + R_i)^n - (1 - T)P(1 + R_a T)^n \quad \ldots\ldots\ldots\ldots\ldots\ 3.17$$

When $K = 1.2T$ with $T = 30\%$, $R_a = 10\%$, $R_i = 10\%$ and $n = 20$, the benefits are now reduced by 20% (from 2.0 to 1.60). This smaller reduction is a direct result of the initial tax deductibility.

The combined effects of the tax change and initial tax deductibility for one dollar of advance funding can be expressed (subtracting 3.16 from 3.17) as:

$$\Delta Z = T(1 + R_a T)^n - K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3.18$$

This shows that a tax rate increase may offset the advantages of the initial tax deductibility of advance funding - especially for moderate levels of R_a, T and K.[21]

In general, the uncertainity in the future tax rates must be considered when making the advance funding decision. More specifically, with a tax rate change at the end of m years, where m < n, 3.18 can be expressed as

$$Z = T(1 + R_a{}^T)^m (1 + R_a{}^K)^{n-m} - K \quad \ldots\ldots\ldots\ldots\ldots \quad 3.19$$

A comparison of equation 3.18 and 3.19 shows that the earlier the tax increase occurs, the lower the benefits to be obtained from the advance funding.

C-5. Pay As You Go Versus Funded Plan

The analysis in section C-2 can be extended to a pay as you go plan (essentially an unfunded plan). The choice to underfund depends upon the expected values of R_i, R_a and the firm's effective tax rate T. If $R_a{}^T < R_i$, the firm may choose a funded plan.[22] If $R_a{}^T > R_i$, the firm will want to underfund, but the employees of the firm (for reasons explained in the last chapter) may demand an increase in current wages. If so, the firm would have to compare this increase with the advantages of non-funding.

C-6. Limitations of the Advance Funding Analysis

The above analysis isolated the benefits of the initial tax-deductibility of contributions and the non-taxability of the fund earnings. Two major limitations of the analysis are its assumption of certainty and the definition of the alternate opportunity to advance funding.

In a world of certainty with taxes and perfect competition in product market, all the firms will have highly levered capital structure and $R_a \cong R_b \cong R_f \cong R_i$. In such a world, the tax advantages of advance funding would prompt the firms to have a fully funded plan (as $R_i > R_a{}^T$) financed with debt. Uncertainty about the future values of R_a, R_i, T, n and legal restrictions on the contribution level and the fund's investments require the firms to weigh the tax effects and the returns on their funds' assets against the return on their firms' assets. The selection of securities in the fund portfolio will depend upon the risk (variance of returns) of the securities selected and the correlation of their return streams with the return on the firm's assets. The actual choice of the 'risk' level will affect the shareholders' valuation of the firm and the employees' valuation of the wage contract.[23]

It is very difficult to define the exact opportunity cost in an advance funding decision. Where advance funding is non-tax-deductible, the firm can compare the advantages of other tax deferrals, such as investment in other firm's equity or in real estate.[24] Such an investment would result in direct shareholder control over the assets, which might be particularly significant in the presence of an agency such as the PBGC. It is then entirely possible that many firms would consider underfunding a superior strategy.[25] Another alternative to tax-deductible advance funding may be repurchase of the firm's own shares. This may however be difficult because a) the firm may have to pay high premiums, b) if done regularly it may be viewed as a dividend payment and taxed accordingly and c) as the benefits must be paid at the end of n years, the sellers of the shares may benefit at the expense of the long-term shareholders.[26]

This analysis assumes that the firm has reached its optimal capital structure and/or there is external capital rationing. As shown in section B, the relaxation of either of these constraints may have a significant effect on the conclusions reached above. To analyze the impact of external financing on the advance funding decision, it is important to separate the benefits derived from each of the three sources, tax-deductibility of initial contributions, tax-free earnings on the fund's assets and external (debt or equity) financing. This analysis is carried out in the next section.

D. DEBT FINANCING AND ADVANCE FUNDING

D-1. Non-Tax-Deductible Advance Funding

At the beginning of year one, the firm borrows P at R_b for n years and invests in the fund such that

$$\begin{aligned} A_1' &= A_1 \\ F_1' &= F_1 + P \quad \ldots\ldots 3.20 \end{aligned}$$

At the end of each year, the firm pays interest on the principal from its earnings. For example, at the end of year one (beginning of year two):

$$\begin{aligned} A_2' &= A_1 + A_1 R_a(1 - T) - R_b P(1 - T) \\ &= A_1(1 + R_a{}^T) - I_b{}^T \end{aligned}$$

and $$F_2' = F_2 + P(1 + R_i) \quad \ldots\ldots 3.21$$

Similarly at the end of year n (before the principal payment and any contribution adjustment):

$$\begin{aligned} A^*_{n+1} &= A_1(1+R_a{}^T)^n - I_b{}^T[(1+R_a{}^T)^{n-1} \\ &\quad + (1+R_a{}^T)^{n-2} + \ldots\ldots + 1] \\ &= A_{n+1} - I_b{}^T Y_n R_a{}^T. \quad \ldots\ldots 3.22a \end{aligned}$$

and $F^*_{n+1} = F_{n+1} + P(1 + R_i)^n$ 3.22b

where $Y_n R_a^T$ is the sum of an annuity of one dollar for n years at R_a^T. The first term on the right hand side of (3.22a) represents the assets in the absence of debt financing and the second term represents the reduction due to annual interest payments on the debt. At the end of n years, the firm decides to reduce its contributions by $P(1 + R_i)^n$ (so that the fund assets equal F_{n+1} again) and to repay the principal. Therefore,[27]

$$A'_{n+1} = A_{n+1} - I_b^T Y_n R_a^T - P + P(1 + R_i)^n - TP[(1 + R_i)^n - 1] \quad \text{.................3.23}$$

The benefits of one dollar of advance funding can be expressed as:

$$Z = [(1+R_i)^n - T(1+R_i)^n + T] - (R_b^T Y_n R_a^T + 1) \quad \text{......3.24}$$

The advantage of one dollar of debt financing over internal financing can be expressed by subtracting (3.7) from (3.24) as

$$\Delta Z = [(1 + R_a^T)^n - 1][1 - R_b/R_a] \quad \text{..................3.25}$$

Thus, external financing will be preferred to internal financing if $R_b < R_a$. This preference, however, exists whether or not the firm has a pension fund. A more detailed explanation of this argument is deferred to the next section.

D-2. Tax-Deductible Advance Funding

In this case, the firm can deduct the amount of advance funding for tax purposes. Assuming that the firm can take the deduction at the beginning of year one,[28] the firm's assets at the end of year one can be expressed as:

$$A''_2 = (A_1 + TP)(1 + R_a{}^T) - R_bP$$
$$= A_2 + TP(1 + R_a{}^T) - R_b{}^TP \quad \ldots\ldots\ldots\ldots\ldots\ldots 3.26$$

and $F''_2 = F_2 + P(1 + R_i)$

Similarly, at the end of year n (before the contribution adjustment),

$$A^*_{n+1} = A_{n+1} + TP(1+R_a{}^T)^n - I_b{}^TY_n{}^Ra^T \quad \ldots 3.27$$

The second term on the right hand side of 3.27 represents the return on the tax deductible initial contribution. Now, the firm reduces its contribution by $P(1 + R_i)^n$ and repays the principal, so that,

$$A''_{n+1} = A_{n+1} + TP(1 + R_a{}^T)^n - I_b{}^T Y_n{}^Ra^T$$
$$+ (1 - T)P(1 + R_i)_n - P \quad \ldots\ldots\ldots 3.28$$

The benefits from one dollar of advance funding are:

$$Z = T(1+R_a{}^T)^n+(1-T)(1+R_i)^n-(R_b{}^TY_n{}^Ra^T+1) \quad \ldots 3.29$$

The first term on the right hand side of equation 3.29 represents the compounding of the tax subsidy of the advance funding at a rate equal to the return on the firm's assets. The second term represents the earnings on the fund's assets on an after-tax basis, while the third term represents the cost associated with the interest payment on the debt and the repayment of the principal.

Substracting 3.29 from 3.24 yields the benefits of one dollar of tax deductible initial contribution:

$$\Delta Z = T[(1 + R_a T)^n - 1] \quad \text{.........................3.30}$$

These benefits are independent of either R_i or R_b and are the same as those obtained from internal financing (see 3.15). The benefits of initial tax deductibility, therefore, are independent of the nature of financing used.

Comparing 3.30 with 3.12, the benefits of external financing with tax-deductible advance funding can be expressed as:

$$\Delta Z = [(1 + R_a T)^n - 1][1 - R_b/R_a] \quad \text{.................3.31}$$

which again is identical to 3.25. This means that the benefits of external financing are identical, whether or not advance funding is tax-deductible, and would simply depend upon the difference between R_b and R_a. Also, these benefits exist whether the external financing is used for pension funding or investing in the firm's assets.

More specifically, if the firm borrows \$P for n years at the beginning of year one and invests in assets, the benefits from the borrowing can be expressed as follows:

At the end of year one,

$$Z = P(1 + R_a T) - R_b T P \quad \text{......................3.32}$$

at the end of year two,

$$= [P(1+R_a{}^T)-R_b{}^TP]+R_a{}^T[P(1+R_a{}^T)-R_b{}^TP]-R_b{}^TP$$

$$= P(1+R_a{}^T)^2-R_b{}^TP[(1+R_a{}^T)+1] \quad \ldots\ldots\ldots\ldots\ 3.33$$

at the end of year n, after the repayment of the principal, the benefits per dollar of debt:

$$= (1+R_a{}^T)^n-R_b{}^T[(1+R_a{}^T)^{n-1}+(1+R_a{}^T)^{n-2}+\ldots+1]-1$$

$$= (1+R_a{}^T)^n-R_b{}^TY_n{}^{R_a{}^T}-1$$

$$= [(1 + R_a{}^T)^n - 1] [1 - R_b/R_a] \quad \ldots\ldots\ldots\ 3.34$$

which is identical to 3.31. Thus, benefits of external financing are identical whether the borrowed amount is used for investment in assets or the pension fund. Thus, the pension funding issue and the capital structure issue can be treated separately. The advance funding decision is beneficial if $R_i > R_a{}^T$ and is independent of the source of financing.[29] The actual amount of the benefits would depend upon whether the advance funding is non-tax deductible (equation 3.7) or tax deductible (equation 3.12).

E. EQUITY FINANCING AND ADVANCE FUNDING

For expositional purposes, assume that the firm issues equity to finance its advance funding. Also assume (for comparative purposes) that, after n years, the firm buys back the equity. Assume that the cost of equity is R_e. The analysis is similar to that in the last section except that $R_b{}^T$ is substituted by R_e (see Table 3.1). The arguments for or against the equity financing are associated with the capital structure decision of the firm. The conclusions are similar to those in the previous section: no extra benefits are obtained from using equity financing for advance funding rather than for internal use.

Table 3-1

BENEFITS OF ONE DOLLAR OF ADVANCE FUNDING

Source of Financing

Tax Treatment	Internal	Debt	Equity
Advance Funding Non Tax Deductible	$(1-T)[(1+R_i)^n-1]-[(1+R_a^T)^n-1]$ 3.17	$[(1+R_i)^n-T[(1+R_i)^n-1] - R_b^T Y_n^{R_a^T}$ 3.34	$(1-T)[(1+R_i)^n-1]-R_e Y_n^{R_a^T}$
Advance Funding Tax Deductible	$(1-T)(1+R_i)^n-(1-T)(1+R_a^T)^n$ 3.22	$(1-T)(1+R_i)^n+T(1+R_a^T)^n - (R_b^T Y_n^{R_a^T}+1)$ 3.39	$(1-T)(1+R_i)^n+T(1+R_a^T)^n -(R_e Y_n^{R_a^T}+1)$
Net Effect of the Initial Tax Deductibility	$T[(1+R_a^T)-1]$ 3.25	$T[(1+R_a^T)^n-1]$ 3.40	$T[(1+R_a^T)^n-1]$
Tax Change T -> k Advance Funding Non Tax Deductible	$(1-k)[(1+R_i)^n-1]-[(1+R_a^T)^n-1]$ 3.26	$(1-k)[(1+R_i)^n-1] - R_b^T Y_n^{R_a^T}$	$(1-k)[(1+Ri)^n-1] -R_e Y_n^{R_a^T}$
Tax Change t -> k Advance Funding Tax Deductible	$(1-k)(1+R_i)^n-(1-T)(1+R_a^T)^n$ 3.27	$(1-k)(1+R_i)^n+T(1+R_a^T)^n - (R_b^T Y_n^{R_a^T}+1)$	$(1-k)(1+R_i)^n+T -(R_e Y_n^{R_a^T}+1)$
Net Effect of Tax Change and Initial Tax Deductibility	$T(1+R_a^T)^n-k$ 3.28	$T(1+R_a^T)^n-k$	$T(1+R_a^T)^n-k$

F. SUMMARY

This chapter analyzed the impact of taxation on pension funding and investment decisions. It first discussed the effects of external financing and of personal taxation on the funding and investment decision, in the context of the models proposed by Black and Tepper. In Black's model, the benefits are a direct result of tax-deductible interest on the debt issued by the firm. The plan has merit if, and only if, the pension fund provides the sole opportunity to increase the firm's debt load. Tepper's analysis is based upon a tax-avoidance scheme; its results apply to a case in which individuals cannot 'launder out' the tax on interest income in their own portfolios and so use the pension fund as a tax-exempt mutual fund.

Next, the advance funding decision was analyzed in a certainty framework which assumed that the alternative to advance funding is investment in the firm's assets. Even though it presented no formal analysis of uncertainty, the chapter did discuss most of the relevant issues. It showed that the advance funding decision depends upon the expected rate of return on the fund's assets and the firm's assets and the expected tax rate.

Discussion of the issue of external financing for advance funding of the plan followed. It was shown that the financing decision (external or internal) can be separated from the funding decision. The benefits from external financing are the same irrespective of whether these funds are used for advance funding of the pension plan or for additional investment in the firm's assets. Debt (or equity) financing provides additional benefits if, and only if, such external financing cannot be undertaken in the absence of the pension fund.

Most of the recent controversy about ESPPs has centered around their level of 'fundedness'. The analysis above shows that, in the certainty case, if the fund can earn a higher before-tax return on the fund than the after-tax return on the firm's assets, the firm should have a fully funded (or an overfunded) plan. The reasons for the existence of an underfunded plan can be 1) inability of fund investments to consistently earn higher returns (i.e. $R_i > R_a^T$), 2) capital rationing for firms with low R_a^T, which does not allow them an opportunity for tax arbitrage, 3) use of an unfunded pension plan as disguised debt which is free from the restrictive covenants associated with traditional debt,[30] 4) possible insurance contracts (such as those available from the Pension Benefit Guarantee Corporation-PBGC in the U.S.) which discourage full funding, and 5) possible employee demands for improved benefits as a result of full funding (or overfunding).

CHAPTER 3 - FOOTNOTES

1. Written under a pseudonym, Walter Bagehot.

2. For example, a firm in a 48% tax bracket, would issue $52 of bonds for every $100 shifted into its pension fund.

3. This can be easily shown by not utilizing the capital structure shift in the example illustrated by Black (1980, p.24). See Love (1980), Ehrbar (1980) and Tepper (1981).

4. An investment policy model developed in the next chapter accounts for such interdependencies.

5. Only major issues are discussed. Other frequently mentioned reasons for firms having underfunded plans are: 1) advantages of off Balance Sheet Liabilities, 2) legal restrictions on funding levels, 3) the fact that funding reduces reported earnings in the short term and therefore, may have negative effect on market value, and 4) the existence of the PBGC with per employee insurance premiums and limited liability negate the benefits of full funding.

6. In 1981, the A & P company decided to terminate its pension plan which was actuarially 'overfunded'. A & P decided to split the excess funding with its employees, which resulted in a legal case to determine who 'owns' the assets of an 'overfunded' plan.

7. Arnott and Gersovitz further suggest that the underfunding of the pension plan serves as a risk-sharing agreement between the employer and employees. The pension contract will be determined jointly by these two parties and will depend on their relative risk aversion.

8. Such renegotiations are similar to ad-hoc increases to existing beneficiaries and have led some (e.g. Pesando, 1981) to argue that the workers actually have a call option on the investment earnings in excess of the interest rate assumption used to value the plan.

9. The origins of this idea can also be found in Miller and Scholes (1978).

10. His plan also involves increasing the firm's debt to finance the pension fund's investment in bonds. If the interest rate is already grossed up to reflect its tax burden (Miller; 1977, p.267), then the firm can also issue equity to finance the fund's investments.

11. For some criticisms of the Miller's analysis, see DeAngelo and Masulis (1980), Patterson (1980), Taggart (1980), Barnea et al. (1981).

12. Some limitations of this assumption are discussed at the end of this section. Note that the assumption that the alternative rate of return is the after-tax rate of return on the firm's assets also implies capital rationing at least in the short term.

13. This part of the analysis closely follows Jackson (1977).

14. It is also possible to fund the plan in advance by one contribution, with the tax deductions to be spread over say 10 years. See, McGill (197), pp.463-471.

15. For example, when $T=.4$, $n=5$, $R_1=12\%$, the tax on the deferred earnings is 17% of the advance funding accumulation

16. This means that plan termination before n years will actually result in a loss to the bondholders and shareholders. If an agency such as the PBGC is formed during the n years, it may not be beneficial to the firm to have fund assets substantially in excess of 30 percent of the net worth at plan termination time.

17. Many Canadian firms actually increased the funding levels of their pension plans to avoid the excess profits tax imposed during and shortly after World War II.

18. Numerical analysis can be easily conducted to determine the effects of various values of these parameters on Z.

19. There are certainly limits to the amount of advance funding that can be tax-deductible. It is assumed that this limit is not exceeded by the amount of advance funding considered here.

20. If the tax deduction is allowed only at the end of the year, then 3.10 can be written as
$A^*_{n+1} = A_{n+1} - P(1 + R_a{}^T)^n + TP(1 + R_a{}^T)^{n-1}$

21. For example, when $R_a = 10\%$, a change in tax rate from 30% to 50% would make the benefits negative for n less than 8 years.

22. This is often cited in the literature as the main reason for the existence of the funded plans (McGill, 1979).

23. If it is assumed that capital markets are efficient and that shareholders hold fully-diversified portfolios and have all the relevant information about the firm and the pension plan, then the investment policy of the fund may have only a minimal effect on the firm's valuation.

24. The first alternative is quite attractive for U.S. firms, where only 15 percent of the dividends received by the firm from its equity investments are taxable, resulting in about a 7 percent tax on the dividend income.

25. See Da Motta (1979) and Bulow (1979) for an elaboration of this concept.

26. This will be the case where the firm will have to pay the benefits when due. This payment will reduce the amount available to the shareholders at that time. Of course in perfect markets with complete information about the future benefit payouts, such conflict will not arise.

27. The tax effects are same as for 3.5.

28. If the tax deduction is allowed only at the end of the year 3.28 can be expressed as:
$A''_{n+1} = A_{n+1} + TP(1 + R_a T)^{n-1} - I_b T Y_n R_a T$
Also, see footnote 20.

29. The effect of a tax change in 3.15 and the combined effects of a tax change and the initial tax deductibility in 3.18 are identical whether the funding is internal or external, and, therefore, need not be discussed again.

30. The beneficiaries cannot initiate bankruptcy proceedings for underfunding. Moreover, they have a vested interest in the continuation of the firm's operations.

CHAPTER 4: A MODEL FOR PENSION FUND INVESTMENT

A. INTRODUCTION

A firm's pension fund investment policy affects its shareholders, employees (as beneficiaries), management and, to a certain extent, the government. Because of such a diverse clientele, recommended policies have ranged from a high-risk pension fund portfolio to one which is all debt (and presumably low-risk). Simultaneous changes in the firm's capital structure and its pension fund portfolio have also been advocated to take advantage of the tax code.

The model proposed in this chapter maximizes a mean-variance preference function based on the combined end of period value of the fund's and the firm's assets subject to a risk constraint. It integrates the pension fund portfolio and the firm's operating assets, based on the theoretical developments in the area of financial intermediation[1] and the portfolio implications of non-marketable human wealth.[2] The pension fund's investment policy in this model depends upon the nature of the returns on the firm's operating assets. The model assumes a given level of fund's and firm's assets and then investigates the implications for the portfolio composition of the fund's assets. Once the model is operationalized for a sample of representative Canadian firms, the study analyzes the implications of the model's solutions.

The chapter is organized in four sections, beginning with a brief review of the existing models on investment policy. Next, the rationale and the formulation of the proposed model and its limitations are described. The model is then operationalized for four representative Canadian firms. Finally, the results are analyzed in terms of their strategic implications.

B. REVIEW OF EXISTING INVESTMENT POLICY MODELS

B-1. Consumption-Investment Approach[3]

This approach treats pension contributions and fund investments as the counterparts of personal consumption and investments respectively.[4] The optimization criterion is the minimization of the multiperiod expected opportunity cost of the firm's pension fund contributions. Once the multiperiod cost function has been specified, the optimum multiperiod contributions are determined by equating the expected marginal cost of contributions (adjusted for the expected return on the pension fund portfolio) to the firm's intertemporal opportunity cost of contributions. Proponents of this position claim that this approach integrates the investment and contribution decision for the firm's pension fund.

Two major efforts in this area are by Tepper (1972) and Hill (1978) and are discussed below:

B-1-1. Tepper's Model[5]

Assuming a convex additive multiperiod cost function, Tepper's two-period model can be expressed as:

$$\min \quad \phi = V(C_1) + E[V(C_2)]\,\beta \qquad 4.1$$

subject to

$$C_1 > \max\,(0,\ A_1\min + B_1 - M_1)$$
$$C_2 > \max\,(0,\ A_2\min + B_2 - M_2)$$

where ϕ = the objective function

C_t = level of contribution at the beginning of period t

$V(C_t)$ = a monotonically increasing ($V'(C_t) > 0$) and convex ($V''(C_t) > 0$) cost function

B_t = benefits paid in period t

M_t = market value of the pension portfolio at the beginning of period t

β = discount factor reflecting the firm's intertemporal opportunity cost of contribution (1/1+r type)

ρ_{kt} = gross return (1+r type) on pension portfolio k during period t

$A_{t\ min}$ = minimum required level of pension assets in period t determined by the actuarial assumptions

The optimal contribution stream can be determined by:

$$V'(C_1^*) = \beta \cdot E\,(V'(C_2^*)\ \ \rho_{k1}) \quad \ldots\ldots\ldots\ldots\ldots 4.2$$

Where C_1^* and C_2^* are the optimal contributions which depend upon the firm's discount factor for the next period's contributions, β , and the rate of return on the fund's portfolio. Operationally, this requires solving 4.2 for all possible portfolio returns and simultaneously choosing c_1^*, c_2^* and the portfolio so as to minimise ϕ . In a multiperiod context, it requires recursive dynamic programming and knowledge of the portfolio returns and expected costs for all future periods.

The inclusion of uncertainty and the nature and determination of the cost function require further discussion. Since Tepper assumes that $V'(C_t)$ and ρ_{kt} are independent, he gives no explicit consideration to the impact on ρ_{kt} of the effect of the uncertainty in the capital market return, and of the firm's cost of contributions on the contribution stream. The model first requires that one choose a pension fund portfolio and then determine the contribution level by discounting the expected return on this portfolio by the appropriate rate. Uncertainty in the portfolio return enters the solution only as:

> "A positive change in the mean will decrease, and a positive change in the standard deviation will increase, the expected costs of providing pension benefits." (Tepper 1972, p.132)

Although Tepper's model recognizes the interaction between pension contributions and pension fund investments, it has limited practical value.

B-1-2. Hill's Model

Hill (1978) and Frankfurter and Hill (1980) have tried to extend Tepper's model by assuming a linear cost function and minimizing the present value of the firm's contributions to its pension fund over a pre-specified horizon. Their objective function is expressed as:

$$\text{Min} = \sum_{t=1}^{n} d_t r_{0t} C_t \qquad \text{4-3}$$

where C_t = level of contributions in beginning of period t

r_{ot} = the firm's discount rate or opportunity cost of contribution in period t

$d_t = \prod_{t=2}^{n} (1+r_{ot})^{-1}$ for $t \neq 1$

= 1 for t = 1

t = 1, 2, ... n where n is the pre-specified horizon date

The actual minimization process is carried out in five steps. First, the firm selects the securities to be included in the pension fund portfolio. Second, it calculates the mean-variance efficient frontier for each period.[6] Third, it selects an appropriate risk level for the pension fund portfolio and then calculates the expected return and the composition of the portfolio for each period in the planning horizon. Fourth, it estimates the opportunity costs of contributions for each period. Fifth, using the knowledge of expected returns on the pension fund portfolio and the cost of contributions, the contributions are optimized to minimize their present value. The minimization is only carried out after setting the constraints representing minimum funding levels, cash flow, risk level and upper limit on investment on each security.

One of the major problems with Tepper's model was the specification of a convex cost function, which led either to very complex intermediate solutions or to very simple extreme cases. Hill argued based on developments in the cost of capital area[7], that firms are expected to face linear cost functions (constant marginal costs) for capital and thus the objective function can be made linear. With a linear objective function, however, nothing distinguishes the pension contributions from any other cash outflows. The problem thus becomes similar to a working capital management issue and must be solved on a firm-wide basis rather than in isolation as Hill chose to do.

Another serious deficiency with both Hill's and Tepper's cost functions is that they both ignore the non-taxability of returns earned on the pension fund. Their comparisons of the cost of contributions and the pension fund returns are, therefore, not valid. Although they both recognize the tax deductibility of contributions, their empirical work does not adequately investigate its impact.[8] If the after-tax cost of contributions is used as the opportunity cost in Hill's five models (1978,p.144), the optimal solutions would most probably be corner solutions[9]; i.e., all contributions would be added to the pension fund at the beginning of the planning horizon and no optimization would be necessary.

Hill's treatment of the changing nature of the firm's opportunity cost (discount rate) and uncertainty in the investment returns on the pension fund portfolio assets must also be considered. Hill avoids exploring the interrelationship between the discount rate and the expected return on investment by specifying them arbitrarily. Instead of integrating the choice of a discount rate into the pension fund portfolio selection process, the model treats the discount rate as exogenous. In addition, the pension fund portfolio selection decision is completely independent of the contribution decision. More specifically, in her model, two firms with the same risk constraint but very different multi-period discount rate streams will choose identical portfolios: only the timing and the amount of the contributions will differ.[10] Thus, the inclusion of uncertainty in Hill's model is identical to that in Tepper's model. In both models, the 'efficient' frontier is determined independent of the nature of the return on the firm's assets. Neither of the models addresses the issue of pension fund portfolio selection. No efforts are made to include the interaction between the discount rate (r_{ot}) and the pension fund portfolio return in the portfolio selection process.

In summary, Hill's extension of Tepper's model has provided some useful guidelines for pension planning by identifying the constraints and the institutional setting. It does not provide adequate guidelines for the pension fund portfolio selection problem.

B-2. <u>Option Theory - Application</u>

This approach (Sharpe, 1976; Treynor et al., 1976) views the establishment of the pension funding and investment policy as a game between shareholders and employees (as beneficiaries).[11] Consider the impact of this approach on both uninsured and insured funds.

B-2-1. Uninsured Fund

Assume that at the beginning of the next period, employees hold a contract to receive a retirement benefit of L_2. Let the value of pension fund assets at the beginning of each period be A_1 and A_2, respectively, such that $A_2 = A_1 (1 + \tilde{r})$, where $\tilde{r}$ is the uncertain one-period return on the fund. The actual amount the employees will receive can then be given by L_2:

$$L_2^* = L_2 \text{ if } A_2 \geq L_2$$
$$= A_2 \text{ if } A_2 < L_2 \quad \ldots\ldots 4.4$$

In effect, the employees have sold a put option on the fund's assets with an exercise price of L_2. The uncertainty of r will be reflected in the value of the put and will be a function of A_1, L_2, variance of $\tilde{r}$ and the remaining life of the option (in this case one period). If the beneficiaries' claims extend only to the pension fund assets (such as is the case in Canada), then the firm can increase the value of the put by investing in those securities which have a large expected variance.[12]

If the employees can increase the value of their claims by extending them to the firm assets, the option framework can still be used to evaluate these claims. The variance in this case can be expressed as a combination of the risk associated with the pension fund assets and with the assets of the firm and the correlation between the two.[13] If the employees cannot adjust their current wages to account for risk, then the firm will want to underfund and/or increase the riskiness of the fund's assets.

B-2-2. Insured Fund

This case assumes that the pension benefits are insured by an external insurance agency. The insurance premiums will offset any change in the funding or investment policy of the fund, and there will be no single optimal funding policy.[14] In the absence of a competitively determined insurance premium, the firm will have an incentive to underfund and/or invest in riskier assets.

B-2-3. Summary

The main positive implication of this approach lies in the recognition that pension benefits can be analyzed in the framework of option theory. In the absence of an insurance contract, a firm which expects no adjustment in the wage contracts with its employees will invest in risky assets or underfund the pension plan. Alternatively a firm which treats pension benefits as fixed liabilities (or whose employees can renegotiate the wage package), the option theory approach gives no guidance for investment policy. So long as the wages and the contribution rates and insurance premiums can be negotiated, the policy implications of the options framework (namely, underfund and/or increase the riskiness of the pension fund) have limited relevance to the trusteed pension plans.

B-3. Simulation Approach[15]

This heuristic approach tries to select a proper equity-bond mix for the pension fund portfolio by integrating four elements: 1) the unique liability and benefit provisions of the plan; 2) the requirements of the plan sponsor regarding risk and return; 3) the legal and internal constraints on the level of funding and contributions; and 4) current and future capital market conditions. Sensitivity analysis is used to evaluate the impact of each of the four elements on the firm's current and future financial health.[16]

The most significant contribution of the simulation approach has been the explicit recognition of the relationship between alternative asset mixes and pension contributions. There are, however, four major deficiencies. First, these models depend on forecasts of expected long term investment returns and pay inadequate attention to the pension fund's liabilities. The models have suggested very similar equity bond mixes (typically 60/40) for plans with widely different liability characteristics.[17] Moreover, the indicated equity bond mixes depend critically upon the quality of the forecasts used.[18]

Secondly, these models ignore the earning characteristics of the pension sponsor. It is quite conceivable that, by choosing appropriate securities for the pension portfolio, the firm may be able to achieve an adequate risk-return trade-off while simultaneously achieving a satisfactory stream of future pension contributions.

Thirdly, these models rely exclusively on the total variance of the fund portfolio as the risk measure, thereby ignoring the relationship between the returns earned on the pension fund assets and those earned on the firm's operating assets. More specifically, implicit in these models is the assumption that the cost of contributions for the firm remains constant, regardless of their magnitude and timing and that the management of the fund's assets and the firm's operating assets is completely separable. Finally, no guidelines are provided for asset selection within each category; thus no provision is made for evaluating the impact of changes that could be made within each asset category.

B-4. Tax Arbitrage Approach

As discussed in detail in the last chapter, Black (1980) and Tepper (1981) have concentrated exclusively on the taxation aspects of pension plans and have advocated a fully-funded, all-debt pension fund.[19] In their argument, the pension fund assets are treated as part of the firm's assets and the all-debt pension fund investment is financed by firm-issued debt.

It is interesting to note the difference between the conclusions derived from the tax arbitrage approach and from the option theory approach. In the tax arbitrage approach, the pension fund is invested only in bonds (traditionally considered to be risk-free). The firm derives its benefits from the reduction in its taxes. In contrast, the option theory approach suggests that the pension fund should be invested in risky assets only, and the firm benefits at the expense of the beneficiaries. These contrasting conclusions are not surprising. The tax arbitrage approach assumes that the benefits are to be paid with certainty, therefore, its objective is to take maximum advantage of the tax treatment associated with the pension fund and the firm debt. On the other hand, since the option approach treats the pension benefits as being risky, its objective is to transfer as much risk as possible to the beneficiaries for the benefit of the shareholders.

B-5. Summary

The four approaches discussed above clearly indicate the diversity of views regarding a pension fund's investment policy. The consumption-investment approach claims to integrate the contribution and investment decisions, but fails to account for the relationship between capital market rates of return and opportunity costs. The option framework concentrates on the ability of the firm to benefit at the expense of its employees or an insurance agency. The simulation approach depends critically on forecasts and may lead to very similar asset mixes for firms with strikingly different types of earnings and pension liabilities. It also provides no guidance for the optimal composition of the pension fund portfolio. The tax arbitrage approach is based entirely on the tax minimization principle. It assumes that the pension fund and firm can be completely integrated and that other, less costly, ways of tax arbitrage are unavailable to (or exhausted by) the firm and its shareholders.

C. MODEL FOR PENSION FUND INVESTMENT

C-1. Introduction

It is well known that, in a world of homogeneous expectations, investors will hold identical (market) portfolios of risky assets and a particular firm's choice of its portfolio of assets will involve market value maximization. If 'home-made' diversification is assumed to be costless, then investors' attitudes towards risk will have no direct influence on an individual firm's investment portfolio decisions. If, however, there are market imperfections and investors have heterogeneous expectations (with obviously heterogeneous portfolios), then under uncertainty, ~~the~~ conditions required for shareholder unanimity will not be satisfied.[20]

Traditional attempts to model a firm's behaviour under uncertainty and imperfect markets have been based either on the firm's production function or on maximization of an institutional utility function.[21] The latter is particularly popular in the area of financial intermediation and is used in the model proposed below. These models typically use mean-variance type utility functions. The limitations of such models have been discussed in the literature.[22] The limitations specific to the model proposed here are discussed in section C-4.

This model assumes that the firm's management views the pension fund as part of its total asset mix and chooses an investment policy that maximizes the following preference function: $G(E(\tilde{W}), V(\tilde{W}))$ with $\partial G/\partial E > 0$ and $\partial G/\partial V < 0$ where $E(\tilde{W})$, $V(\tilde{W})$ are the expected value and the variance of W. In this function, W refers to the combined end of period value of the fund's assets (minus the benefit payments) and the firm's operating assets. It is further assumed that both the funding level and the nature of the firm's operating assets are fixed during the period under consideration.[23] Some of the issues confronted in determining an optimal funding level are discussed in the last chapter. Thus, the use of the preference function requires the maximization of the returns on the fund's assets subject to a 'consolidated' risk constraint. This 'consolidated' risk is a combination of the risk of the securities in the fund portfolio (their variance) and the covariance of their returns with the returns on the firm's operating assets (see section D).

C-2. Assumptions and Constraints

In order to develop the basic model in the next section, the following additional constraints and assumptions are made. First, it is assumed that the pension benefits are riskless and thus are treated as a fixed liability for the firm.[24] This means that the firm cannot transfer risk from its stockholders and bondholders to the beneficiaries, therefore, no conflict of interest exists between these two parties.[25] Secondly, it is assumed that the pension fund's investment policy is the only decision to be considered. The nature and amount of investment in the firm's operating assets are exogenously given. The combined effect of these two assumptions is such that the preference function can be specified as maximizing the end-of-period cash flows from the fund's assets subject to a risk constraint.

Thirdly, although pension plan liabilities are generally long term in nature, the analysis of the portfolio selection problem is conducted in a single-period framework. The implications of such simplification have already been well documented in the literature.[26] Previous attempts to develop operational, multi-period optimizations using dynamic programming (Bogue and Roll, 1975) have required the determination of intertemporal discount rates (Robicheck and Myers, 1966) which has severely limited their use. Rubinstein (1976) and Bhattacharya (1981) have shown the stationarity conditions (for the risk free rate, market price of risk and aggregate utility functions) required to extend a single period valuation formula to a multi-period setting. Though the model developed here optimizes over a single period horizon, extensions to a multi-period horizon are feasible (but difficult) provided that estimates of probability distributions of risk and return parameters for all future periods are available.[27]

Fourthly, it is assumed that the legal and trusteeship arrangements restrict investment by a pension fund to a limited set of marketable assets[28] and adherence to the 'prudent man' rule.[29] Although the implications of these restrictions for 'proper investment policy' are not clear, it is hypothesized that, they require the fund to have some minimum degree of diversification in its portfolio.

Finally, as is customary in studies of this kind, it is assumed that each pension fund acts as a price-taker in the securities market and that the prices of these securities are determined exogenously.[30]

C-3. Model Formulation

The objective of the proposed pension fund investment model is to maximize a preference function $G(E(\tilde{W}), V(\tilde{W}))$, where E is the expected value, V is the variance and $\tilde{W}$ is the aggregate end-of-period value of the fund's assets and the firm's operating assets subject to the fund's budget constraint.[31] As noted earlier, both the level and composition of the firm's operating assets and the level of fund's assets is 'fixed' during the time period under consideration.

Notation:

Let Y_a be the value of the firm's operating assets
Y_p be the value of the pension fund assets, at the beginning of the period
$Y_T = Y_a + Y_p$ denote the 'consolidated' assets of the firm

$Y(n \times 1)$ is a vector which describes the fund's investments in each of n risky assets
Y_i > 0 for all i $i = 1, \ldots, n$
B is the fund's investment in risk free assets,

$B > 0$ [32], that is, $\sum_{i=1}^{n} Y_i + B = Y_p$

$U(n \times 1)$ is the vector of expected returns ($1+\tilde{r}$ type) on these n risky assets, where
$U = [E(\tilde{R}_1), E(\tilde{R}_2), \ldots\ldots E(\tilde{R}_n)]$
[illegible] is the expected return on the firm's operating assets, $E(\tilde{R}_a)$.

R_f	is the risk-free rate (1+r type)
Σ	is the (n x n) covariance matrix of the rates of return on the risky assets, $Cov(R_i, R_j)$, for i, j = 1, ...n
$\Sigma(\tilde{R}_a)$	is the (n x 1) covariance vector of the rates of return on the n risky assets with the rate of return on the firm assets, $Cov(\tilde{R}_i, \tilde{R}_a)$, i = 1, ...n
$V(\tilde{R}_a)$	is the variance of the distribution of $\tilde{R}_a$
$\underline{1}$	is n x 1 vector of ones

The stochastic value at the end of the period of the consolidated assets can be expressed as:

$$W = \sum_{k=1}^{n} Y_k R_k + BR_f + Y_a R_a \quad \text{.........4.5}$$

The expected value and its variance can be expressed as:

$$E(W) = Y' U + BR_f + Y_a Z \quad \text{........4.6}$$
$$V(W) = Y' \Sigma Y + Y_a^2 V(R_a) + 2Y_a Y' \Sigma(R_a) \quad \text{........4.7}$$

Thus, the pension fund's portfolio selection problem can be expressed as:

$$\text{Maximize } G[E(\tilde{W}), V(\tilde{W})] \quad \text{.........4.8}$$
$$\text{Subject to } Y_p - Y'\underline{1} - B = 0$$

The Lagrangian form of the model is given by

$$L = G[E(\tilde{W}), V(\tilde{W})] + M[Y_p - Y'\underline{1} - B] \quad \text{............4.9}$$

where M is the lagrangian multiplier.

Differentiating with respect to Y and B yields the following set of simultaneous equations:

$$\frac{\partial L}{\partial M} = \frac{\partial G}{\partial E} \cdot U + 2 \frac{\partial G}{\partial V} [\Sigma Y + Y_a \Sigma (\tilde{R}_a)] - M \underline{1} = 0 \quad ..4.10a$$

and $$\frac{\partial L}{\partial B} = \frac{\partial G}{\partial E} \cdot R_f - M\underline{1} = 0 \quad ....4.10b$$

Elimination of M yields the fund's demand for risky assets as:[33]

$$Y = \frac{1}{2} \frac{\partial V}{\partial E} \Sigma^{-1} [U - R_f \underline{1} - 2Y_a \frac{\partial E}{\partial V} \Sigma (\tilde{R}_a)]$$

or $$Y = \frac{1}{2} \frac{\partial V}{\partial E} \Sigma^{-1} (U - R_f \underline{1}) - Y_a \Sigma^{-1} \Sigma (\tilde{R}_a) \quad ....4.11$$

Equation 4.11 shows the impact of the stochastic nature of the return on the firm assets on the composition of the fund's portfolio. The riskiness of the pension assets is evaluated in terms of their own variance and their covariance with the return on the firm's assets. An asset k can be termed as 'diversification preferred' if $Cov(\tilde{R}_k, \tilde{R}_a) < 0$, since a negative value indicates that the asset k is likely to have a higher return when the return on the firm's asset is low. Similarly, if $Cov(\tilde{R}_k, \tilde{R}_a) = 0$, the asset will be 'diversification-neutral' and with $Cov(\tilde{R}_k, \tilde{R}_a) > 0$, the asset will be termed 'diversification-averse.'

The demand for the k^{th} risky asset can be expressed as:

$$Y_k = \frac{1}{2} \frac{\partial V}{\partial E} \sum_{h=1}^{n} S_{kh} [E(\tilde{R}_h) - R_f] - Y_a \sum_{h=1}^{n} S_{kh} \cdot Cov(\tilde{R}_h, \tilde{R}_a) \quad ....4.12$$

where S_{kh} is the kh^{th} element of the matrix Σ^{-1}.

Some interesting properties of the demand for risky asset can be derived from equation 4.12: expressing $Cov(\tilde{R}_h, \tilde{R}_a) = \rho_{ha} \sigma_h \sigma_a$ where ρ_{ha} is the correlation coefficient and σ_h, σ_a are the respective standard deviations,

$$\frac{\partial Y_k}{\partial \rho_{ka}} = -S_{kk} \cdot Y_a \sigma_k \sigma_a < 0 . \quad \ldots\ldots\ldots\ldots\ldots 4.13$$

Thus, if all else is held constant, then the larger the correlation coefficient between the return on the risky asset and the return on the firm's assets, the smaller the fund's demand for that asset. Similarly,

$$\frac{Y_k}{\partial \sigma_a} = - S_{kk} \cdot Y_a \rho_{ka} \sigma_k > 0 \text{ if } \rho_{ka} < 0 \ldots\ldots 4.14$$

That is, the fund's demand for a 'diversification-preferred' asset increases as the variability of the return on the firm's assets increases.

The proportion of investment in the k^{th} asset, X_k, can be easily calculated by dividing Y_k by the $\sum_{k=1}^{n} Y_k$. It is obvious that the optimal demand for the k^{th} asset is a function of $V(\tilde{R}_k)$, $Cov(\tilde{R}_k, \tilde{R}_a)$ and Y_p, implying that the optimal composition of the fund's portfolio will be firm specific. The selection of a risky asset k, for the fund portfolio depends upon $E(\tilde{R}_k)$, $V(\tilde{R}_k)$, $Cov(\tilde{R}_k, \tilde{R}_a)$, Y_a (or Y_p since $Y_a+Y_p=Y_T$) and its covariance with the existing pension fund portfolio. Thus, the same asset will face differential demand by different firms.

C-4. Limitations of the Model

The model determines the optimal fund portfolio subject to a 'consolidated' risk constraint, which is the combination of the fund portfolio's variance, the variance on the return of the firm's assets and the covariance between the two. The particular choice of this 'consolidated' risk level determines the actual return on the fund's portfolio and, therefore, the firm's contribution to the pension fund. If a firm wants to maintain a target funding level, the choice of the 'consolidated' risk level will then affect both the contribution stream to the pension fund and the cash flows available to the firm's shareholders.

The exact effects of the particular choice of the 'consolidated' risk level and the resultant cash flow will depend upon the shareholders' preferences and their portfolios. If the firm's shareholders hold well-diversified portfolios, the effect of a change in the risk level may be only of secondary importance. It may, however, involve 1) knowledge of the new risk characteristics and 2) transaction costs to regain the desired risk characteristics. For investors who hold undiversified portfolios, a substantial change in the risk level of the fund's portfolio may involve costly offsetting transactions to achieve home-made diversification. Unless some specific assumptions are made about the shareholders of the firm and their portfolios, it is not possible to specify a unanimously approved risk level.

If it is assumed that shareholders do not or cannot diversify on their own (due to information costs, transaction costs, etc.) then the proposed model can be thought of as a vehicle to achieve diversification benefits which may be less costly than the home-made variety for the firm's shareholders.[34] This also applies to the case where the firm's shares are held by a shareholder, (or a group of homogeneous shareholders), who has put all his wealth in the firm's shares and is unable to diversify his own portfolio. In the case of widely held public firms, the choice of the 'consolidated' risk level and thus the ultimate choice of the pension fund portfolio will have to be determined by the firm's management.

Even though the ideal unanimously preferred 'consolidated' risk level cannot be pre-specified, some observations can be made about the maximum and minimum risk strategies. If the assumption of riskless benefits is relaxed, then (similar to the option theory approach) the firm should choose the maximum risk srategy to benefit the shareholders by the transfer of risk to the employees. The employees on the other hand would prefer the minimum risk strategy.[35]

To analyze the set of conditions which result in both the employees and shareholders agreeing on the choice of a particular risk level may be determined as follows: Assume that a) the expected pension benefits form a substantial portion of the employees' wealth, b) employees have an implicit claim on both the fund's and the firm's assets (that is when the fund's assets are not sufficient to pay the promised benefits, the firm will increase its contributions), c) the employees can negotiate their current wage and d) the shareholders hold diversified portfolios. In such a situation, a shift from the minimum risk level would prompt the employees to adjust their current wage so as to reflect their higher risk adjusted discount rate (compared to that of the shareholders). If they do this, then shareholders may unanimously agree that a minimum risk policy for selecting the risky assets in the portfolio is optimal. Such a policy will decrease total current wages thereby benefitting the shareholders, who in turn will adjust the risk level of their individual portfolios to suit their preferences.

D. OPERATIONALIZATION OF THE MODEL

Operationally, equation 4.9 can be expressed as:

$$\underset{Y_i}{\text{Minimize}} \sum_{i=1}^{m}\sum_{j=1}^{m} Y_i Y_j \operatorname{Cov}(\tilde{R}_i,\tilde{R}_j) + Y_a^2 V(\tilde{R}_a) + 2\sum_{i=1}^{m} Y_i Y_a \operatorname{Cov}(\tilde{R}_i,\tilde{R}_a) - M\left(\sum_{i=1}^{m} Y_i E(\tilde{R}_i) + Y_a E(\tilde{R}_a)\right) \quad \ldots 4.15$$

Subject to $\quad Y_i \geq 0 \quad i = i, \ldots m$

$$\sum_{i=1}^{m} Y_i + Y_a = Y_T$$

Dividing equation 4.15 by Y_T^2 and the constraints by Y_T, the model can be expressed in percentage form as:

$$\underset{X_i}{\text{Minimize}} \sum_{i=1}^{m}\sum_{j=1}^{m} X_i X_j \operatorname{Cov}(\tilde{R}_i,\tilde{R}_j) + 2\sum_{i=1}^{m} X_i X_a \operatorname{Cov}(\tilde{R}_i,\tilde{R}_a) - M\left(\sum_{i=1}^{m} X_i E(\tilde{R}_i) + X_a E(\tilde{R}_a)\right) \quad \ldots 4.16$$

Subject to $\quad X_i > 0 \quad i = i, \ldots n$

$$\sum_{i=1}^{m} X_i + X_a = 1$$

where X's denote the values expressed as a fraction of total assets, that is $X_i = Y_i/Y_T$ for all i's and $X_a = Y_a/Y_T$

Given that the nature of and investment in the firm's operating assets is exogenous to the investment model, the terms $X_a^2 V(R_a)$ and $X_a E(R_a)$ can be discarded from equation 4.16. Now the model can be expressed as:

$$\underset{X_i}{\text{Minimize}}\ L = \sum_{i=1}^{m}\sum_{j=1}^{m} X_i X_j \operatorname{Cov}(\tilde{R}_i,\tilde{R}_j) + 2\sum_{i=1}^{m} X_i X_a \operatorname{Cov}(\tilde{R}_i,\tilde{R}_a) - M\sum_{i=1}^{m} X_i\, E(\tilde{R}_i) \quad \ldots 4.17$$

$$\text{Subject to} \qquad X_i > 0 \qquad i = i, \ldots m$$

$$\sum_{i=1}^{m} X_i = X_p$$

where X_p is the fraction of the total assets invested in the pension fund.

Note that this specification is identical to maximizing the cash flows (or returns) from the fund portfolio subject to a 'consolidated' risk constraint, $\sum_{i=1}^{m}\sum_{j=1}^{m} X_i X_j \operatorname{Cov}(\tilde{R}_i,\tilde{R}_j) + 2\sum_{i=1}^{m} X_i X_a \operatorname{Cov}(\tilde{R}_i,\tilde{R}_a)$. The second term in this risk constraint makes the composition of the optimal fund portfolio a function of the funding level (through X_a) and the nature of the firm's operating assets (through $\operatorname{Cov}(\tilde{R}_i,\tilde{R}_a)$).

The objective function in equation 4.17 is quadratic in the X_i's and thus requires inversion of an nxn covariance matrix, which would make it difficult to implement for large n. The nature of the problem is similar to Markowitz's (1952) formulation of an individual's portfolio selection problem, except for an additional linear covariance term. the presence of this term prevents the objective function from being linearized along the lines described by Stone (1973). Efficient quadratic programming algorithms, however, now exist to solve this problem for moderately large n.[36]

Operationalization of the model requires 1) the estimates of expected risk and return parameters for all the securities, 2) control of the number of securities, n, for computational feasibility and economy, and 3) knowledge of the desired degree of diversification due to trusteeship and/or legal constraints.

D-1. Estimation of the Parameters

Ideally, the estimates of the risk and return parameters should be their expected values, based upon the decision maker's current expectations. In all published empirical studies of this type, the returns and variances are assumed to be intertemporally stationary so that the estimates obtained from historical values are used as unbiased estimates of expected future values. The same procedure is followed here. In practice, the model user who thinks he has better estimates can easily use them instead of these historically-derived figures.

D-2. Computational Feasibility by Grouping of Securities

A typical pension fund manager may analyze a large number of securities for possible inclusion in the portfolio. To include such a large number of securities in a quadratic programming algorithm is, however, not computationally feasible. In this study, therefore, the number of securities is reduced by forming homogeneous groups of securities.[37] These homogeneous groups are then used as quasi-securities in the portfolio selection stage to reduce the computational requirements. Previous approaches to grouping have been based on accounting-type variables, industry classification and/or the stochastic return on the securities. Recent advances in clustering algorithms make it possible to group the securities in an n-dimensional space, without resorting to either the multi factor based or the traditional market model based grouping procedures.[38] The details of the traditional grouping procedures and those of the Howard-Harris clustering algorithm used in this study are described in Appendix B at the end of this chapter.

D-3. Degree of Diversification

The degree of diversification selected will determine the minimum number of securities (groups) that must be included in the portfolio and it depends upon the legal trusteeship requirements and preferences of the fund management. This study assumes that a portfolio of at least 15 groups (quasi-securities) will provide adequate diversification. This simply adds additional constraints to the optimization problem by imposing upper limits on the individual X_k's. To assess the effects of this constraint, an unconstrained optimization is also conducted.

E. THE DATA BASE

Pension funds in Canada invest in a variety of assets such as common stocks, government and corporate bonds, mortgages, T-bills, etc. They are restricted by law to investment only in 'eligible' securites. The securities employed in this study attempt to represent the securities that could be held by a typical Canadian pension fund.[39] The optimization process will be based on the quarterly returns on 192 common stocks and 11 bond indices. Only the common stocks will be grouped, since the bond indices already represent homogeneous groupings. The process for selecting the clusters of common stocks is described next.

E-1. Common Stock Sample

Trusteed Canadian pension funds can, according to the Pension's Act, invest in common shares of only those firms which a) have paid dividends or b) earned at least four percent of the book value of these shares for at least four out of the last five years. It is, therefore, possible to identify those securities which have met these criteria during each year in the sample period. Another clause in the Pension's Act, generally referred to as the 'basket' clause, allows the fund to invest up to seven percent of its book value in ineligible securities. A typical, well-diversified pension fund, therefore, is not severely constrained by the eligibility clause. To reduce the selection difficulties, it will be assumed that the security universe for a typical pension fund can be adequately described by the securities which are represented in the Toronto Stock Exchange's index of three hundred securities (TSE 300).[40]

The liquidity of a particular security is of concern to pension fund managers, a fact borne out by discussions with pension fund managers. To account for these liquidity considerations, the TSE 300 stocks were further segregated based on their historical trading frequency. It was assumed that for inclusion in the sample, a stock must be traded either every day of the month or at least 25 days during each month from 1970-1979. This criteria reduced the number of stocks in the study sample to 192.[41] These 192 securities thus chosen are assumed to represent an adequate selection for a typical pension fund.[42] The quarterly returns at time t for each of these stocks are calculated by using the following formula:

$$r_{it} = \frac{P_{it} - P_{it-1} + D_{it}}{P_{it-1}} \qquad \text{4.1}$$

where P_i is the price of the security and D_i is the per share dividend both measured at time t. The data for price and dividend were obtained from the Laval tape for the time period 1969-1979.[43]

E-2. Bond Sample

Traditionally, pension funds hold part of their assets in fixed term securities (see FEI surveys 1978, 1980). To incorporate these securities in the pension fund portfolio, eleven bond indices were included in the sample (see Table 4-1). For the five corporate bond indices, holding period returns were available from the research report published by McLeod, Young and Weir (1981). To calculate the returns on the remaining bond portfolios, it was assumed in this study that a bond in each category is purchased at the beginning of each period, and that it had a coupon rate corresponding to the prevailing yield. The bond was then assumed to have been sold at the end of the period at a price (less .05 percent for transaction costs) corresponding to the yields prevailing at that point in time. The interest income calculations were based on the yield at the beginning of the period. The holding period return was calculated by substituting interest income for dividends into 4.21.

Table 4-1

DESCRIPTION OF THE BOND SAMPLE

	Maturity	Source	Assumed Maturity	Quarterly Average Return (%)	Quarterly Standard Deviation (%)
1) Provincial	-	MYW*	-	1.78	1.80
2) Municipals	-	MYW*	-	1.94	1.97
3) Utilities	-	MYW*	-	1.90	1.92
4) Industrial	-	MYW*	-	1.88	1.90
5) Corporate	-	MYW*	-	1.89	1.91
6) Government of Canada	1-3 yrs.	Bank of Canada Series #B14009	2 yrs.	1.53	1.55
7) "	3-5 yrs.	Series #B14010	4 yrs.	1.51	1.53
8) "	5-10 yrs.	Series #B14011	8 yrs.	1.46	1.48
9) "	10+ yrs.	Series #B14013	15 yrs.	1.37	1.39
10) Guaranteed Investment Certificate	5 yrs.	Series #B14023	5 yrs.	1.95	1.97
11) Conventional Mortgage	5 yrs.	Series #14024	5 yrs.	2.33	2.36

Note: * McLeod Young Weir Limited, "Comparative Investment Returns," 1980 Update, March 10, 1981.

E-3. Grouping of the Securities

The 192 stocks were grouped into 37 clusters using the Howard-Harris clustering algorithm. The criterion used to determine the exact number was the heuristic tradeoff between the percentage decrease in within group variance V_w, and the increase in the number of groups B). The decrease in V_w, however, was found to be discontinuous as the number of clusters increased. Keeping the limitations of the size of the quadratic programme in mind, 37 groups solution was assumed as "optimal." Tables 4-2 shows the decrease in the variance as the number of clusters increase from 31 to 40 clusters. The number and the names of securities in each group of the final cluster solution is reported in the appendices C and D, respectively. The 37 groups of common stocks and the 11 bond indices, are then used as quasi-securities in the quadratic programming algorithm.

Table 4-2

OF GROUPS AND % DECREASE IN V_w

# of Groups	Marginal % Decrease in V_w	Cumulative Remaining V_w %
31	.800	45.918
32	1.064	44.854
33	.425	44.429
34	.743	43.686
35	1.198	42.488
36	.388	42.100
37	.594	41.506
38	.514	40.972
39	.410	40.562
40	.379	40.183

E-4. Determination of the Covariance Terms

The determination of the covariance between the grouped securities and the firm's operating assets requires data on the stochastic quarterly cash flows from the firm's operating assets, since the model has a one quarter horizon. Ideally, the firm's management will know the exact nature of these cash flows in the past, as well as the estimate for the next period.[44] To determine the quarterly covariance, the estimates of their standard deviations and the correlation coefficient between the returns are needed. If audited quarterly data of the returns on the operating assets of the sample firms was available, the covariance term can be directly estimated. But since such audited data were not available, the following procedure was used to estimate the covariance terms. Firstly, a proxy for the annual returns on the firm's assets was obtained by dividing the net income reported in the annual reports, adjusted for pension contributions, by total assets at the end of the previous year.[45] Secondly, the correlation coefficients on each of the 48 groups and on the sample firms' assets were calculated based on ten years annual (1970 -1979) returns. Thirdly, it was assumed that the variance of the quarterly returns on the firm's assets is .25 times the variance of the annual returns.[46] Finally, the quarterly covariance was calculated as a product of the correlation coefficient, the quarterly standard deviation of the group return and the quarterly return on firm's assets.

E-5. Selection of Sample Firms

Four representative firms were chosen in order to study the impact of the proposed investment model on the composition of the pension fund portfolio. The firms were selected on the basis of: 1) availability of data about their pension fund market values and annual contributions; 2) availability of published annual data; 3) a wide range of ratios of pension fund assets to total assets; 4) widely different return characteristics for the firm's operating assets; and 5) different average covariances between firm returns and group returns. The basic data for the selected firms are shown in Table 4-3.

Table 4-3

BASIC DATA ON SELECTED FIRMS

	Firm #			
	1	2	3	4
Industry	Mining	Agriculture & Food Products	Paper & Pulp	Packaging & Stationary
1979				
Total Assets, Y_T (Millions)	Gt.than 1000	$100 < Y_T < 300$	$50 < Y_T < 100$	$50 < Y_T < 100$
$X_a = Y_a/Y_T$ (%)	90.9	89.7	86.6	74.9
$X_p = Y_a/Y_T$ (%)	9.1	10.3	13.4	25.1
Contribution as				
% After Tax Earnings	7.4	8.5	7.5	32.6
% Dividends Paid	23.3	16.6	37.0	53.8
1970-1979				
Average Annual After Tax Earnings (Million $)	163.7	10.5	1.6	2.6
Average Net Contributions (Million $)	6.65	1.25	.32	.73
Quarterly				
$E(R_a)$ %	2.89	2.40	2.00	3.59
$V(R_a)$ %	13.17	4.28	18.05	13.03

F. MODEL DEMONSTRATION AND EMPIRICAL RESULTS

F-1. Model

The portfolio selection problem as solved can be expressed as:

$$\text{Min} \quad - M \sum_{i=1}^{48} X_i E(\tilde{R}_i) + \sum_{i=1}^{48} \sum_{j=1}^{48} X_i X_j \operatorname{Cov}(\tilde{R}_i, \tilde{R}_j)$$
$$+ 2 \sum_{i=1}^{48} X_i X_a \operatorname{Cov}(\tilde{R}_i, \tilde{R}_a) \quad \ldots\ldots\ldots\ldots\ldots\ldots 4.22$$

Subject to

$$X_i \geqslant 0 \qquad i = 1, \ldots\ldots 48$$

$$\sum_{i=1}^{48} X_i = X_p$$

$X_i < F_i$ where $F_i = X_p/15$ for $i,j = 1, \ldots\ldots 48$

The model generates an efficient frontier by varying M.[47] Once the composition of the portfolios are known from the quadratic programming solution, the 'consolidated' return and risk can then be calculated by adding the return and variance of the firm's assets respectively.

F-2. Basic Set of Results

The model described by equation 4.22 was tested for the four sample firms described in Table 4-3. For each of the four firms an efficient frontier of 'consolidated' return versus 'consolidated' risk was developed. In order to meet the diversification requirements, the fund portfolio must contain at least 15 groups (that is, no more than 6.67% of the portfolio can be invested in any one group). No additional constraints are placed on the minimum proportion of debt in the fund portfolio.[48] For each firm, seven to ten portfolios on the efficient frontier were generated.[49] The expected return and the variance of return on the firm's assets and the levels of fund's and firm's assets are treated as given. Tables 4-4 to 4-7 show the results for each of the four firms.

In each table, the consolidated return is given by $X_a E(\tilde{R}_a) + X_p E(\tilde{R}_p)$, where $X_a E(\tilde{R}_a)$ denotes the return from the firm's assets and $X_p E(\tilde{R}_p)$ denotes that from the fund's portfolio. Thus, Row 1 =Row 2 + Row 3. The values of $X_a, X_p, E(\tilde{R}_a)$ and $V(\tilde{R}_a)$ are reported at the top of each table. The consolidated variance is $X' \Sigma X + X_a{}^2 V(\tilde{R}_a) + 2X_a X' \Sigma (\tilde{R}_a)$ of equation 4.7, so that Row 4= Row 5 + Row 6 + Row 7. Each of these three components are reported separately as the variance of the pension fund $(X' \Sigma X)$, the covariance $2X_a X' \Sigma (\tilde{R}_a)$, and the variance of the firm's assets, $X_a{}^2 V(\tilde{R}_a)$. The total number of groups in each of the portfolios and the number of the individual groups is reported next.[49] The following are also reported for each of the portfolios: a) the actual number of common stocks and bonds in the portfolios, and b) the bonds as a fraction of the total fund portfolio. These selected efficient portfolios are reported in increasing order of 'consolidated' variance. It is important to note that because of the covariance term no direct comparisons can be made across firms on the basis of the 'consolidated' risk and return figures.

Tables 4-4 to 4-7 show the composition of firm specific optimum portfolios. For example, for firm #1 (Table 4-4), none of the portfolios contains any bonds and the average pension portfolio contains 60 stocks. This firm has a relatively flat efficient frontier with 'consolidated' returns ranging from 2.849% to 3.077% and 'consolidated' variance ranging from 4.954 to 6.863. The returns on the fund portfolio, however, vary from 2.48% to 5% (see note 2,

Table 4-4). At least 15 groups are included in each of the portfolios, and eight of the groups are present in both the minimum and the maximum variance portfolios.[50] The pension fund portfolio has also enabled the firm to decrease the 'consolidated' variance below the variance of the return on the firm's assets, while simultaneously allowing for a larger expected return.

In comparison to firm #1, firm #2 (Table 4-5) has approximately the same proportion of fund assets to total assets, X_p, and expected returns on firm's assets, $E(R_a)$, but a smaller variance of assets returns, $V(R_a)$. The portfolio composition for this firm, however, is quite different. In most cases, the firm has bonds in its portfolio. Only four groups are common to the minimum and maximum variance portfolios of firms #1 and #2. This suggests that the choice of a particular risk level substantially affects the portfolio composition. Even though firm #2's $V(R_a)$ is smaller than that of firm #1, its portfolios contain a significant proportion of bonds, indicating the importance of the covariance term for this firm. Portfolio compositions for the two firms are also quite different. For example, the overall return on the fund portfolio is similar for portfolio #2 for firms #1 (2.86%) and #2 (2.73%), but the two portfolios have only five common groups. Moreover, in the case of firm #2, the fund has 44% debt in its portfolio.

Firm #3 (Table 4-6) has a lower expected return on the firm's assets, $E(R_a)$ but comparable variance of asset returns, $V(R_a)$ to firm #1. For firm #3, however, each portfolio still contains bonds and again only 4 groups are common between the minimum and maximum variance portfolios.

Firm #4 (Table 4-7) is characterized by a relatively large pension fund portfolio ($X_p = .251$) and a higher $E(R_a)$

and $V(R_a)$ as compared to the other firms. Firm #4's portfolios consist mainly of common stocks and on average these portfolios have 79 securities.[51] There are eight common groups between the extreme portfolios (#1 and #8) and the return on the fund portfolio varies from 2.82% to 5%.

It is interesting to compare the minimum and maximum variance portfolios across the sample firms. In the minimum variance portfolios, the only group common to all the four firms was #25 (this group consists of the common stocks of Cadillac Fairview, Canadian Occidental and Ivaco Industries). Comparing the firms pairwise, the maximum number of groups common to two firms (firm #1 and #4) were 12 and the minimum number of groups common to two firms were 4 (firms #1 and #2, and firms #2 and #4). The individual proportion of each of the groups in these portfolios was, however, quite different.[52] For intermediate risk levels, the composition of the portfolios are also quite different. The comparisons clearly show the impact of the covariance term (equation 4.13) on the fund's demand for particular types of assets.

In summary, these sets of results show the optimal portfolio composition of the pension funds is significantly affected by the nature of the firm assets, the proportion of the fund assets, X_p and the choice of 'consolidated' risk level. Sensitivity analysis is now conducted to study the impact of change in some of the parameters on the portfolio composition.

Table 4-4

OPTIMAL PORTFOLIO COMPOSITION: FIRM #1 X_a = .909 $E(R_a)$ = 2.885 $V(R_a)$ = 13.170
X_p = .091

Pension Fund Portfolio #	1	2	3	4	5	6	7
Consolidated Return (%)	2.849	2.883	2.891	2.919	2.971	2.994	3.007
Weighted Return on the Pension Fund (%)	.226	.260	.269	.296	.349	.372	.455
Weighted Return on the Firm's Assets (%)	2.622	2.622	2.622	2.622	2.622	2.622	2.622
Consolidated Variance (%)	4.954	5.103	5.146	5.175	5.383	5.592	6.863
Weighted Variance of the Pension Fund (%)	1.748	1.822	1.888	1.838	1.721	1.678	1.563
Covariance (%)	-7.676	-7.601	-7.624	-7.545	-7.220	-6.968	-5.582
Weighted Variance of the Firm's Assets (%)	10.882	10.882	10.882	10.882	10.882	10.882	10.882
Total # Groups in the Pension Portfolio	17	17	16	16	17	17	15
Portfolio Composition*	3,4,6,9, 11,13,15, 16,18,21, 23,25,26 27,31,32, 34	3,4,6,9, 11,13,15, 16,18,21, 23,25,26, 27,31,32, 34	3,4,6,9, 11,13,15, 16,21,23, 25,26,27, 31,32,34	3,4,6,9, 11,13,15, 16,21,23, 25,26,27, 31,32,34	3,4,6,9, 11,13,15, 16,17,21, 22,23,24, 25,26,27, 32	3,4,6,9, 11,13,15, 16,17,21, 22,23,24, 25,26,27, 32	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	57:0	57:0	53:0	53:0	63:0	63:0	58:0
% Debt in Pension Portfolio	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: 1) Group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

2) The actual return on the pension fund assets is given by the weighted return divided by X_p, e.g. for portfolio #1, R_p = .226/.091 = 2.48%

Table 4-5

OPTIMAL PORTFOLIO COMPOSITION: FIRM #2 X_a = .897 $E(R_a)$ = 2.399 $V(R_a)$ = 4.275
X_p = .103

Pension Fund Portfolio #	1	2	3	4	5	6	7	8	9
Consolidated Return (%)	2.442	2.433	2.504	2.529	2.573	2.608	2.636	2.660	2.667
Weighted Return on the Pension Fund (%)	.271	.281	.353	.377	.422	.456	.484	.508	.515
Weighted Return on the Firm's Assets (%)	2.152	2.152	2.152	2.152	2.152	2.152	2.152	2.152	2.152
Consolidated Variance (%)	2.936	2.970	3.293	3.432	3.798	4.115	4.448	4.857	5.280
Weighted Variance of the Pension Fund (%)	.538	.586	.777	.858	1.127	1.254	1.345	1.675	2.002
Covariance (%)	−1.042	−1.055	−0.924	−0.866	−0.769	−0.578	−0.337	−0.259	−0.162
Weighted Variance of the Firm's Assets (%)	3.440	3.440	3.440	3.440	3.440	3.440	3.440	3.440	3.440
Total # Groups in the Pension Portfolio	18	20	16	16	17	17	16	16	15
Portfolio Composition*	6,8,9,16, 22,24,25, 29,37,38, 39,40,41, 42,43,44, 45,46	6,8,9,13, 16,22,23, 24,25,29, 37,38,39, 40,41,42, 43,44,45, 46	6,8,9,13, 22,23,24, 25,29,37, 38,39,44, 45,46,48	1,6,8,9, 13,22,23, 24,25,26, 37,38,39, 45,46,48	1,3,5,6, 8,9,10, 13,22,23, 24,25,26, 37,38,39, 48	3,5,6,8, 9,10,12, 13,17,22, 23,24,25, 26,37,39, 48	3,5,6,8, 9,10,12, 13,17,22, 23,24,25, 26,37,38	3,5,6,9, 10,12,13, 15,17,22, 23,24,25, 26,37,48	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	50:9	54:9	47:6	86:5	105:3	65:2	65:1	58:1	58:0
% Debt in Pension Portfolio	45.5	43.8	34.6	28.7	16.0	12.2	6.1	2.7	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

Table 4-6

OPTIMAL PORTFOLIO COMPOSITION: FIRM #3 $X_a = .866$ $E(R_a) = 2.003$ $V(R_a) = 18.05$
$X_p = .134$

Pension Fund Portfolio #	1	2	3	4	5	6	7	8
Consolidated Return (%)	2.031	2.054	2.078	2.110	2.142	2.185	2.330	2.404
Weighted Return on the Pension Fund (%)	.297	.320	.343	.376	.408	.451	.596	.670
Weighted Return on the Firm's Assets (%)	1.735	1.735	1.735	1.735	1.735	1.735	1.735	1.735
Consolidated Variance (%)	9.242	9.414	9.644	9.859	10.272	10.565	12.603	15.309
Weighted Variance of the Pension Fund (%)	1.810	1.881	2.045	2.231	2.782	2.809	3.230	3.389
Covariance (%)	-6.105	-6.003	-5.938	-5.908	-6.046	-5.780	-4.165	-1.617
Weighted Variance of the Firm's Assets (%)	13.537	13.537	13.537	13.537	13.537	13.537	13.537	13.537
Total # Groups in the Pension Portfolio	17	17	16	16	16	16	17	15
Portfolio Composition*	1,3,8,9, 12,13,16, 21,25,28, 31,33,36, 38,39,40, 46	1,3,8,9, 12,13,16, 21,25,28, 31,33,36, 38,39,40, 46	1,3,8,9, 12,13,16, 21,25,28, 31,33,38, 39,40,46	1,3,8,9, 12,13,16, 21,25,28, 31,33,37, 38,39,40	1,3,4,8, 9,12,13, 16,21,24, 25,28,31, 33,37,39	1,3,4,8, 9,12,13, 16,21,24, 25,28,31, 33,37,39	3,4,6,9, 10,12,13, 15,16,17, 21,22,24, 25,28,33, 37	3,4,5,6, 9,10,12, 13,15,17 22,24,25, 26,37
# Common Stocks: # Bond Indices	93:4	93:4	90:4	95:3	106:1	106:1	68:0	58:0
% Debt in Pension Portfolio	26.7	25.5	22.9	15.6	6.7	5.3	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

Table 4-7

OPTIMAL PORTFOLIO COMPOSITION: FIRM #4 $X_a = .749$ $E(R_a) = 3.585$ $V(R_a) = 13.03$
$X_p = .251$

Pension Fund Portfolio #	1	2	3	4	5	6	7	8
Consolidated Return (%)	3.393	3.400	3.613	3.690	3.765	3.801	3.856	3.940
Weighted Return on the Pension Fund (%)	.708	.715	.928	1.005	1.080	1.116	1.171	1.254
Weighted Return on the Firm's Assets (%)	2.685	2.685	2.685	2.685	2.685	2.685	2.685	2.685
Consolidated Variance (%)	4.378	4.396	4.887	5.141	5.544	5.814	6.666	9.432
Weighted Variance of the Pension Fund (%)	10.042	10.063	10.308	10.325	10.364	10.405	10.458	11.890
Covariance (%)	-12.974	-12.976	-12.730	-12.494	-12.129	-11.902	-11.102	-9.768
Weighted Variance of the Firm's Assets (%)	7.310	7.310	7.310	7.310	7.310	7.310	7.310	7.310
Total # Groups in the Pension Portfolio	20	20	19	18	17	16	17	15
Portfolio Composition*	1,2,3,4, 6,10,11, 15,17,18, 21,25,27, 28,31,32, 33,34,37, 41	1,2,3,4, 6,10,11, 15,17,18, 21,25,27, 28,31,32, 33,34,37, 41	2,3,4,6, 10,11,13, 15,17,18, 21,24,25, 26,27,28, 32,33,37	3,4,5,6, 10,13,15, 17,18,21, 24,25,26, 27,28,32, 33,37	3,4,5,6, 10,13,15, 17,18,24, 25,26,27, 28,32,33, 37	3,4,5,6, 10,13,15, 17,23,24, 25,26,27, 28,33	3,4,5,6, 10,12,13, 15,17,22, 23,24,25, 26,27,28, 37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	109:1	100:1	82:0	75:0	72:0	68:0	66:0	58:0
% Debt in Pension Portfolio	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

F-3. Sensitivity Analysis

F-3-1. The effect of a Change in the Firm's Operating Assets:

To study the impact of the nature of the firm's operating assets on its pension fund, two artificial firms are created from the four firms described in the last section.[53] Because of the similarity in their asset sizes and the nature of their businesses, the assets and the earnings of firms #3 and #4 are aggregated to create firm #5. The relevant values of the key variables for this firm are $X_a = .844$, $X_p = .156$, $E(R_a) = 2.666\%$, and $V(R_a) = 10.775$. The covariance of the firm's assets with each of the security groups is recalculated using the procedure described in section E-4.

Similarly, firm #6 is created by merging firms #2 and #4. These two firms are selected because of their widely different return characteristics. The problem, however, is that firm #2 is 10 times larger than firm #4 and, if merged directly, dominates the return characteristics of the merged firm. To overcome this problem, the assets of firm #2 over the period 1969-1979 (inclusive) are deflated so as to make its 1979 assets equal to those of firm #4.[54] This results in $X_a = 0.816$, $X_p = 0.184$, $E(R_a) = 2.71\%$ and $V(R_a) = 3.975$ for firm #6. Tables 4-8 and 4-9 show the pension fund portfolios for firms #5 and #6, respectively. The portfolio compositions of the pension portfolio of firm #5 can now be compared to those for firms #3 and #4. The effect of the change in the nature of the firm's operating assets on the portfolio composition is quite obvious. Concentrating on the minimum variance portfolios, it can be seen that there are 11 common groups between firms #3 and #5, and 9 between firms #4 and #5.[55] The proportion of debt in the pension fund is now only 7%. Similar trends are observed when table

4-9 is compared with Tables 4-5 and 4-7. In most of the cases, changing the nature of the firm's operating assets has had a significant impact on the portfolio composition of the pension funds. This suggests that any change in the firm's operating assets will, under the assumption of this model, require a new investment strategy for its pension fund.

Table 4-8

OPTIMAL PORTFOLIO COMPOSITION: FIRM #5 X_a = .844 $E(R_a)$ = 2.666 $V(R_a)$ = 10.775
X_p = .156

Pension Fund Portfolio #	1	2	3	4	5	6	7	8	9	10
Consolidated Return (%)	2.593	2.615	2.651	2.722	2.759	2.880	2.895	2.996	3.004	3.030
Weighted Return on the Pension Fund (%)	.343	.365	.401	.472	.508	.630	.645	.746	.754	.780
Weighted Return on the Firm's Assets (%)	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250
Consolidated Variance (%)	4.130	4.266	4.538	5.191	5.316	5.931	6.103	7.462	7.727	8.617
Weighted Variance of the Pension Fund (%)	3.337	3.426	3.598	4.091	4.048	4.029	4.030	4.518	4.516	4.593
Covariance (%)	-6.883	-6.835	-6.735	-6.575	-6.408	-5.773	-5.603	-4.732	-4.464	-3.651
Weighted Variance of the Firm's Assets (%)	7.675	7.675	7.675	7.675	7.675	7.675	7.675	7.675	7.675	7.675
Total # Groups in the Pension Portfolio	17	17	17	17	17	16	17	15	16	15
Portfolio Composition*	1,3,4,8, 11,12,15, 16,21,25, 28,31,33, 38,39,40, 41	1,3,4,8, 11,12,13, 15,16,21, 25,28,31, 33,37,38, 39	1,3,4,8, 11,12,13, 15,16,21, 25,28,31, 33,37,38, 39	1,3,4,8, 11,12,13, 15,16,21, 24,25,28, 31,33,37, 39	1,3,4,6, 8,12,13, 15,16,17, 21,24,25, 28,31,33, 37	1,3,4,6, 8,12,13, 15,16,17, 21,24,25, 28,33,37	1,3,4,6, 9,10,12, 13,15,16, 17,21,24, 25,28,33, 37	3,4,6,9, 10,12,13, 15,17,22, 24,25,26, 28,37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,28,37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	94:4	100:2	100:2	108:1	109:0	108:0	106:0	60:0	62:0	58:0
% Debt in Pension Portfolio	16.5	13.3	8.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

Table 4-9

OPTIMAL PORTFOLIO COMPOSITION: FIRM #6 X_a = .816 $E(R_a)$ = 2.710 $V(R_a)$ = 3.975
X_p = .184

Pension Fund Portfolio #	1	2	3	4	5	6	7	8	9
Consolidated Return (%)	2.753	2.757	2.767	2.934	2.949	3.022	3.047	3.101	3.126
Weighted Return on the Pension Fund (%)	.547	.551	.561	.728	.743	.816	.841	.895	.920
Weighted Return on the Firm's Assets (%)	2.206	2.206	2.206	2.206	2.206	2.206	2.206	2.206	2.206
Consolidated Variance (%)	1.348	1.350	1.360	1.767	1.899	2.477	2.897	3.675	4.341
Weighted Variance of the Pension Fund (%)	4.155	4.144	4.123	4.109	4.252	4.575	5.079	5.778	6.390
Covariance (%)	-5.454	-5.440	-5.410	-4.989	-5.000	-4.745	-4.829	-4.750	-4.695
Weighted Variance of the Firm's Assets (%)	2.647	2.647	2.647	2.647	2.647	2.647	2.647	2.647	2.647
Total # Groups in the Pension Portfolio	21	22	22	19	16	18	17	16	15
Portfolio Composition*	1,2,3,4, 6,8,11, 15,17,18, 24,25,27, 28,31,32, 33,37,40, 41,42	1,2,3,4, 6,8,11, 13,15,17, 18,24,25, 27,28,31, 32,33,37, 40,41,42	1,2,3,4, 6,8,11, 13,15,17, 18,24,25, 27,28,31, 32,33,37, 40,41,42	1,3,4,6, 8,11,13, 15,17,23, 24,25,26, 28,33,37, 39,41,42	1,3,4,6, 13,15,17, 23,24,25, 26,28,33, 37,39,41	1,3,4,5, 6,9,10, 12,13,15, 17,23,24, 25,26,28, 37,48	1,3,4,5, 6,9,10, 12,13,15, 17,23,24, 25,26,28, 37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,28,37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	115:3	116:3	116:3	110:3	100:2	103:1	103:0	62:0	58:0
% Debt in Pension Portfolio	14.6	14.6	14.6	12.1	10.6	4.1	0.0	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

F-3-2. The Effect of Relaxing the Diversification Constraint:

The results in the previous section assumed a maximum limit of 6.67% for investment in individual groups. To study the impact of this limit on the solutions, unconstrained optimization was conducted for firms #2 (Table 4-10) and #4 (Table 4-11). The results show that the relaxation of this limit allows the firms more flexibility with regard to their 'consolidated' risk. The maximum variance portfolio for both the firms is formed by investing in only group #13 (Harlequin Ltd.). For firm #2, the minimum variance unconstrained portfolio now contains no bonds at all, clearly indicating that the high proportion of bonds observed in Table 4-5 is a result of the diversification constraint and not due to the preferential variance-covariance characteristics of bonds. The relaxation of the diversification constraint also affects the risk-return trade-off and the optimal number of securities in each portfolio. For example, for comparable 'consolidated' variance (such as portfolio #5 in Table 4-5 and #4 in table 4-10), the 'consolidated' return and the return on the unconstrained portfolio is higher than that under the constrained case by 0.15% and 0.90%, respectively. Portfolio #5 in Table 4-5 consists of 23 common stocks compared to 105 stocks and 3 bond portfolios in portfolio #4 in Table 4-10. Similar conclusion can be drawn by comparing Tables 4-11 and 4-6 for firm #4. Due to a large proportion of fund's assets to consolidated assets, X_p, firm #4 can significantly alter its 'consolidated' risk-return characteristics by investing in a reduced number of securities. The removal of the diversification constraint results in an increase of 0.2% in the consolidated return and 0.8% in the pension fund return (compare #4 in Table 4-11 with #7 in Table 4-6). For both firms, the removal of the diversification constraint results in a significant increase in the expected return for equivalent risk levels. Moreover, they become equity portfolios quite in contrast to the typical asset mixes of Canadian pension funds (see FEI Surveys 1978, 1980).

Table 4-10

OPTIMAL PORTFOLIO COMPOSITION:
- UNCONSTRAINED: , FIRM #2

X_a = .897 $E(R_a)$ = 2.399 $V(R_a)$ = 4.275
X_p = .103

Pension Fund Portfolio #	1	2	3	4	5	6	7	8	9	10
Consolidated Return (%)	2.411	2.418	2.508	2.667	2.725	2.820	2.891	2.942	3.024	3.058
Weighted Return on the Pension Fund (%)	.259	.266	.356	.515	.573	.668	.739	.790	.872	.906
Weighted Return on the Firm's Assets (%)	2.152	2.152	2.152	2.152	2.152	2.152	2.152	2.152	2.152	2.152
Consolidated Variance (%)	2.300	2.319	2.715	3.795	4.297	5.197	6.033	6.751	8.115	8.926
Weighted Variance of the Pension Fund (%)	1.284	1.293	0.482	1.628	1.772	2.329	3.073	3.800	5.195	6.041
Covariance (%)	-2.424	-2.413	-1.207	-1.273	-0.915	-0.572	-0.480	-0.489	-0.519	-0.554
Weighted Variance of the Firm's Assets (%)	3.440	3.440	3.440	3.440	3.440	3.440	3.440	3.440	3.440	3.440
Total # Groups in the Pension Portfolio	5	5	5	7	7	5	5	4	2	1
Portfolio Composition*	8,9,22, 24,25	8,9,22, 24,25	8,9,22, 24,25	6,9,13, 22,24,25, 37	6,9,13, 22,24,25, 37	6,13,24, 25,37	6,13,24, 25,37	6,13,25, 37	6,13	13
# Common Stocks: # Bond Indices	25:0	25:0	25:0	23:0	23:0	18:0	18:0	10:0	2:0	1:0
% Debt in Pension Portfolio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

Table 4-11

OPTIMAL PORTFOLIO COMPOSITION
- UNCONSTRAINED: FIRM #4

$X_a = .749$ $E(R_a) = 3.585$ $V(R_a) = 13.03$
$X_p = .251$

Pension Fund Portfolio #	1	2	3	4	5	6	7
Consolidated Return (%)	3.322	3.372	3.813	4.059	4.255	4.623	4.893
Weighted Return on the Pension Fund (%)	0.637	0.687	1.128	1.373	1.570	1.937	2.208
Weighted Return on the Firm's Assets (%)	2.685	2.685	2.685	2.685	2.685	2.685	2.685
Consolidated Variance (%)	4.187	4.429	5.372	6.500	9.065	19.706	36.003
Weighted Variance of the Pension Fund (%)	11.390	11.712	11.638	11.522	13.704	21.812	35.873
Covariance (%)	-14.512	-14.592	-13.576	-12.332	-11.949	-9.416	-7.180
Weighted Variance of the Firm's Assets (%)	7.310	7.310	7.310	7.310	7.310	7.310	7.310
Total # Groups in the Pension Portfolio	12	12	13	10	8	5	1
Portfolio Composition*	2,3,4,6, 11,15,17, 18,27,28, 32,33	2,3,4,6, 11,15,17, 18,27,28, 32,33	3,4,5,6, 10,13,15, 17,18,27, 28,33,37	3,4,5,6, 10,13,15, 17,28,37	3,5,6,10, 13,15,17, 37	3,5,6,13, 17	13
# Common Stocks: # Bond Indices	47:0	47:0	49:0	36:0	29:0	16:0	1:0
% Debt in Pension Portfolio	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

F-3-3. The Effect of Changes in X_p:

To study the impact of a change in the funding level on the portfolio composition, the proportion of the pension fund to consolidated assets for firm #4 was arbitrarily increased from 25% to 33%, all else remaining constant.[56] The diversification constraint is again assumed to be binding. The results are shown in Table 4-12. With this increase in relative fund size, the firm obviously has more flexibility with regard to the 'consolidated' risk-return trade-off. It is interesting to note that this has also resulted in an increased proportion of bonds in the pension portfolio but relatively little change in the equity groups. The results indicate that for this particular firm, an increase in X_p results in a change in asset mix from an all equity portfolio to a mixed debt-equity portfolio. An increase in the funding level of its pension fund will, therefore, result in fundamental changes in the portfolio composition of the optimum portfolios and will be firm specific.

Table 4-12

OPTIMAL PORTFOLIO COMPOSITION
- EFFECT OF X_p: FIRM #4

X_a = .665 $E(R_a)$ = 3.585 $V(R_a)$ = 13.03
X_p = .335

Pension Fund Portfolio #	1	2	3	4	5	6	7	8	9
Consolidated Return (%)	3.234	3.264	3.521	3.685	3.815	3.848	3.940	4.015	4.058
Weighted Return on the Pension Fund (%)	.850	.880	1.137	1.301	1.431	1.464	1.556	1.631	1.674
Weighted Return on the Firm's Assets (%)	2.384	2.384	2.384	2.384	2.384	2.384	2.384	2.384	2.384
Consolidated Variance (%)	3.780	3.831	4.996	6.091	7.510	8.016	9.977	12.484	15.354
Weighted Variance of the Pension Fund (%)	10.066	10.123	11.888	13.211	14.492	14.849	16.348	18.674	21.162
Covariance (%)	-12.048	-12.054	-12.655	-12.882	-12.744	-12.595	-12.333	-11.952	-11.570
Weighted Variance of the Firm's Assets (%)	5.762	5.762	5.762	5.762	5.762	5.762	5.762	5.762	5.762
Total # Groups in the Pension Portfolio	23	22	21	20	18	17	18	16	15
Portfolio Composition*	1,2,3,4, 6,10,11, 15,17,18, 21,27,28, 31,32,33, 34,37,40, 41,42,47, 48	1,2,3,4, 6,10,11, 15,17,18, 21,27,28, 32,33,34, 37,40,41, 42,47,48,	1,2,3,4, 6,10,11, 13,15,17, 18,24,25, 27,28,32, 33,37,41, 47,48	1,3,4,5, 6,10,13, 15,17,18, 24,25,26, 27,28,32, 33,37,47, 48	1,3,4,5, 6,10,13, 15,17,24, 25,26,27, 28,33,37, 47,48	1,3,4,5, 6,10,13, 15,17,24, 25,26,27, 28,33,37 48	3,4,5,6, 10,12,13, 15,17,22, 23,24,25, 26,27,28, 37,48	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,28,37	3,4,5,6, 9,10,12, 13,15,17, 22,24,25, 26,37
# Common Stocks: # Bond Indices	106:5	105:5	112:3	114:2	107:2	107:1	66:1	62:0	58:0
% Debt in Pension Portfolio	25.3	24.3	14.4	10.2	7.0	6.7	5.9	0.0	0.0

Note: * group numbers 1 through 37 are equity groups and 38 to 48 are bond portfolios.

G. CONCLUSIONS AND IMPLICATIONS

In this chapter, a pension fund investment policy model was developed. Operationally, the model maximizes the returns on the fund portfolio subject to a 'consolidated' risk constraint. The model is similar in spirit to those in the financial intermediation literature and the portfolio implications of non-marketable human wealth. The model is tested with a universe of 192 common stocks and 11 bond indices for 4 sample Canadian firms for which data was readily available. After presenting the basic results, sensitivity analysis was conducted to test the impact of varying some important parameters on the model solution.

The overall results indicate that the optimal fund portfolios should be firm specific and will differ widely for different firms. Any change in the risk level, the nature of the firm's operating assets and/or the funding level must be accompanied by a change in the portfolio composition of the pension fund. Moreover, it is not necessary for all the firms to hold bonds in their fund portfolio (even in the minimum variance case) because an all equity portfolio is more efficient. This has some important implications for the fund's asset mix decisions.

The portfolio composition of the fund will differ for different firms even for the same 'fund' risk. Thus, a firm following the investment policy suggested by this model will have to interpret the standard portfolio performance measures for the evaluation of its fund performance more carefully. Specifically, since the optimal fund portfolios are firm specific, the use of the usual portfolio measures based on a market index as a benchmark portfolio is open to question.

The role of a fund manager, according to this model, involves supplying estimates of expected return, variance and covariance for individual securities and then the model solution will determine the preferred proportion of stocks and bonds for the fund. Unless these estimates are frequently revised, the fund will follow a ''passive' investment strategy.

The investment policy for a pension fund under this model, therefore, integrates the fund with the firm and considers fund management as an integral part of firm management.

APPENDIX B

GROUPING PROCEDURES AND HOWARD - HARRIS ALGORITHM

A. GROUPING PROCEDURES

Grouping procedures based on the stochastic return on the securities have been most popular, due to the availability and parsimony of the required data. Actual groupings have been based on either the generalized factor model (as in the arbitrage pricing theory framework) or on the traditional single factor market model.

A-1. Multi-Factor Grouping

It is theoretically possible (along the lines suggested by Roll and Ross, 1981 and Reinganum, 1981) to resort to one of the many factor analysis techniques to identify the basic underlying factors in security returns and then to partition the securities into homogeneous groups based on their factor loadings. The empirical results using this technique (though still in their infancy) show that the factors critically depend upon the sample size and the nature of the securities in the sample and that they are not generalized to all subsamples (Gibbon, 1981; Kryzanowski and To, 1983, forthcoming). Therefore, the use of factor analytical techniques will have to wait until more comprehensive and extensive testing of factor congruence is conducted.

A-2. Market Model Based Grouping

two procedures based on the market model have been employed to efficiently group securities.

A-2-1. Parameter Type Grouping

The parameter type grouping technique involves 1) using a market model to get four descriptive statistics, α, σ_α, β and σ_β for each security (where α and β are the intercept and slope of the market model, and σ_α, σ_β are ~~their~~ respective standard errors), 2) using these four descriptors in a factor analysis to derive significant factors and 3) using these significant factors in the cluster analysis to form groups.[1] The use of the four descriptors, instead of just a β value, allegedly avoids the problems of estimation errors mentioned by Frankfurter et al. (1971, 1976). The approach, however, has two major drawbacks. First, it assumes that the residual variance of every security is insignificant, and secondly, that the covariance between the residuals of any two securities is zero. Both assumptions have little empirical support especially in the Canadian context.[2] Covariance type grouping procedures have been proposed in order to overcome such exclusive reliance on the market model .

A-2-2. Covariance Type Grouping

Based on the work of King (1966), Cohen and Pogue (1967) and Elton and Gruber (1970, 1971), Farrel (1974) has suggested a procedure which groups securities on the basis of their collinearity statistics. The procedure involves: 1) using the market model to derive the residuals, 2) obtaining a correlation matrix of residuals for all securities in the sample; and 3) forming groups, using a stepwise clustering procedure on this residual correlation matrix. Although this procedure explicitly accounts for residual covariance, it still depends upon the market model and one-dimensional clustering. To avoid such dependence this study therefore uses the Howard-Harris hierarchical clustering algorithm to achieve the grouping of securities in an n-dimensional space.

B. HOWARD - HARRIS CLUSTERING ALGORITHM

This algorithm achieves the clustering of securities by using an objects-by-variables matrix as data and the criterion of minimum within-group variance at each level of clustering.[3] The input data for this study consists of the quarterly securities returns, which are treated by the algorithm as variables. The algorithm can be briefly described as follows:[4]

Let the number of objects (securities) being clustered equal n, each object being measured by N variables (quarterly returns). Let the objects be denoted by R_1, R_2, ... R_n, each R_i being a vector (R_{i1}, ... R_{iN}) in an N-dimensional space. Let P(S, p) represent a p-fold partitioning of the set S into disjoint subsets, L, M, and so on. The problem of hierarchical clustering may then be stated as follows: given a set of objects R_i's, partition S into subsets that are simultaneously as internally homogeneous and as mutually dissimilar as possible, where dissimilarity between R_i and R_j is defined as (euclidian distance):

$$|(R_i - R_j)|^2 = \sum_{k=1}^{m} |(R_{ik} - R_{jk})|^2 \qquad \text{..........4.18}$$

The total variance, V_T, of all n members in S can be written as:

$$V_T = \frac{1}{2N} \sum_{k=1}^{m} \sum_{j=1}^{m} |(R_i - R_j)|^2 \qquad \text{........4.19}$$

which can be divided into a within-group variance, V_w, and a between-group variance, V_B where V_w can be obtained by

$$V_w = \sum_{L \varepsilon P(S,p)} V_L \qquad \text{..........4.20}$$

The criterion for optimally partitioning S into P groups is: find P(S, p) so that V_w is a minimum. The optimal number of clusters will be determined heuristically depending upon the tradeoff between parsimony (i.e. fewer clusters) and the decrease in within-group variance, V_w.

APPENDIX B - FOOTNOTES

1. Frankfurter and Phillips (1980) use this technique to form 40 groups of 522 securities in a two dimensional cluster analysis. An identical procedure is followed by Hill (1978).

2. See Levy (1978), Jensen (1972), Friend et al.(1978). Kryzanowski and To (1982), Morin (1980) deal with the Canadian situation.

3. Many techniques are available for clustering longitudinal data. For a review, see Cormack (1971).

4. The discussion which follows is entirely based on Green and Rao (1972), pp.207-208.

APPENDIX C

OF SECURITIES IN EACH GROUP FOR 37 CLUSTER SOLUTION

Group #	# of Securities
1	42
2	8
3	11
4	3
5	2
6	1
7	1
8	9
9	1
10	6
11	1
12	1
13	1
14	1
15	2
16	7
17	1
18	4
19	3
20	7
21	3
22	4
23	3
24	8
25	3
26	9
27	2
28	4
29	12
30	10
31	1
32	3
33	7
34	2
35	1
36	3
37	5

APPENDIX D

COMMON STOCK SAMPLE AND CLUSTER

CLUSTER #	CO #	TICKER	NAME
1			
	7	ALC	ALGOMA CENTRAL
	8	ALG	ALGOMA STEEL
	11	B	BELL CANADA
	16	BCS.A	B.C. SUGAR 'A'
	17	BCT	B.C. TELEPHONE
	18	BL.A	BRASCAN 'A'
	19	BMO	BANK OF MONTREAL
	21	BNS	BANK OF NOVA SCOTIA
	29	CCT.A	CDA CEMENT
	31	CDL.A	CORBY'S DISTILLERIES 'A'
	35	CGT	CONSUMERS GAS
	40	CK.C	CDA PACKERS INC.
	42	CL	CANRON INC 'A'
	44	CM	CDN IMP BANK OF COMMERCE
	46	CMG.A	CANADA MALTING
	49	CPW.A	CALGARY POWER 'A'
	59	CU	CANADIAN UTILITIES
	65	DFS.A	DOFASCO 'A'
	69	DMS	DOMINION STORES
	76	FGC.A	FEDERAL INDUSTRIES LIMITED 'A'
	78	FMC	FORD OF CANADA
	81	GHL	GREYHOUND LINES CANADA
	84	GST	GENSTAR
	92	HOL.A	HOLLINGER-ARGUS
	97	IAC	I.A.C.
	101	IMS.A	IMASCO
	102	INL	INLAND NATURAL GAS
	103	IPL.A	INTERPROV PIPELINE
	114	LBT.A	LABATT,JOHN 'A'
	125	MTT	MARITIME T & T
	127	NBT	THE NEW BRUNSWICK TELEPHONE COMPANY
	130	NFL.A	NEWFOUNDLAND LIGHT & POWER COMPANY L
	147	RIN.A	REDPATH INDUSTRIES
	153	RY	ROYAL BANK
	154	SBG.A	STEINBERGS 'A'
	161	STE.A	STELCO 'A'
	163	STR	STANDARD BROADCASTING
	164	TD	TORONTO-DOMINION BANK
	169	TMP.A	TRANSMOUNT PIPELINE
	177	UNG.A	UNION GAS 'A'
	182	WDS.A	WOODWARD STORES 'A'
	183	WGW.A	WALKER-GOODERHAM

CLUSTER #	CO #	TICKER	NAME
2			
	51	CRI	CRAIGMONT MINES
	75	FCL	FALCONBRIDGE COPPER LIMITED
	77	FL.A	FALCONBRIDGE NICKEL
	79	GBM	GIBRALTAR MINES
	124	MP	MCINTYRE MINES
	143	PPT	PINE POINT MINES
	155	SE.A	SHERRITT GORDON
	165	TEK.A	TECK CORPORATION 'A'
3			
	9	AQT	AQUITAINE CANADA
	22	BVI	BOW VALLEY INDUSTRIES
	25	CAS	CANADIAN SUPERIOR OIL
	68	DMP	DOME PETROLEUM
	91	HBO	HUDSON BAY OIL & GAS
	96	HYO	HUSKY OIL
	132	NMC	NUMAC OIL & GAS
	137	PCP	PAN CANADIAN PETROLEUM
	170	TPN	TOTAL PETROLEUM
	181	WBI	WESTBURNE INTERNATIONAL INDUSTRIES L
	188	WPL	WESTCOAST PETROLEUM LIMITED
4			
	36	CHO	CANADIAN HOMESTEAD OILS LIMITED
	38	CID	CHIEFTAIN DEVELOPMENT
	129	NCO	NORTH CANADIAN OILS LIMITED
5			
	67	DML	DICKENSON MINES LIMITED
	176	UKH	UNITED KENO HILL MINES LIMITED
6			
	146	RGO	RANGER OIL CANADA
7			
	60	CUE	CANADIAN CELLULOSE COMPANY LIMITED
8			
	32	CDP	CANADA PERMANENT
	56	CT.A	CANADA TRUSTCO
	57	CTR	CANADIAN TIRE CORPORATION LIMITED
	58	CTR.A	CANADIAN TIRE 'A'
	86	GY	GUARANTY TRUST
	134	NT	NATIONAL TRUST
	158	SRC.A	SCOTT RESTAURANT
	166	TG.A	TRADERS GROUP 'A'
	192	ZEL	ZELLER'S 'A'
9			
	47	CNW	CANADA NORTH WEST LAND
10			
	52	CRK	CAMPBELL RED LAKE
	64	DEN	DENISON MINES
	66	DM	DOME MINES
	144	PTM	PRESTON MINES LIMITED
	148	RMN	ROMAN CORPORATION LIMITED
	150	ROM	RIO ALGOM

CLUSTER #	CO #	TICKER	NAME
11			
	30	CDG	CONSUMERS DISTRIBUTING
12			
	179	VIP	VULCAN INDUSTRIAL PACKAGING LIMITED
13			
	93	HQE.A	HARLEQUIN 'A'
14			
	34	CFY	CONSOLIDATED CANADIAN FARADAY LIMITE
15			
	55	CSW	CDA SOUTHERN PETROLEUM
	178	UTC	UNITED CANSO OIL & GAS LIMITED
16			
	5	AGR.A	AGRA INDUSTRIES 'A'
	73	ELF	E-L FINANCIAL
	88	HAY.A	HAYES-DANA
	94	HRD.A	HARDING CARPETS 'A'
	115	LDM.A	LAIDLAW TRANSPORTATION LIMITED 'A'
	120	MHP.A	MACLEAN HUNTER 'X'
	151	RSS.A	REED STENHOUSE 'A'
17			
	186	WMI	WESTERN MINES LIMITED
18			
	109	KER.A	KERR-ADDISON
	131	NGX	NORTHGATE EXPLORATION
	136	OSH.A	OSHAWA GROUP 'A'
	157	SR	STEEP ROCK IRON MINES LIMITED
19			
	112	L.A	LOBLAW CO.
	113	L.B	LOBLAW COMPANIES 'B'
	187	WN	WESTON, GEORGE
20			
	1	A	ABITIBI-PRICE
	15	BCF	B.C. FOREST PRODUCTS
	26	CB.A	CON-BATHURST 'A'
	70	DTC	DOMTAR INC.
	82	GL	GREAT LAKES FOREST PROD.
	117	MB	MACMILLAN BLOEDEL
	185	WLW	WELDWOOD
21			
	14	BCD	BRAMALEA LIMITED
	89	HBC	HUDSON BAY COMPANY
	116	MAS	S.B. MCLAUGHLIN ASSOCIATES LIMITED
22			
	3	ACK	ACKLANDS
	152	RU.A	RUSSEL, HUGH 'A'
	168	TIH	TOROMONT INDUSTRIES
	189	WRL	WESTEEL-ROSCO
23			
	99	ICL	INDAL
	110	KPT.B	KEEPRITE INC.
	145	RCL	REICHHOLD CANADA
24			
	83	GOC	GULF CANADA
	98	ICG	INTER-CITY GAS
	100	IMO.A	IMPERIAL OIL 'A'
	106	IU	I.U. INTERNATIONAL

CLUSTER #	CO #	TICKER	NAME
	121	MO	MURPHY OIL COMPANY LIMITED
	139	PFC	PETROFINA
	156	SHC	SHELL CANADA
	172	TXC	TEXACO CANADA
25			
	33	CFV	CADILLAC FAIRVIEW
	61	CXY	CANADIAN OCCIDENTAL PETROLEUM LIMITE
	107	IVA.A	IVACO INDUSTRIES
26			
	23	CAB.A	CDN.CABLESYSTEMS 'A'
	24	CAE.A	CAE INDUSTRIES LIMITED
	37	CHY	COMMONWEALTH HOLIDAY INNS OF CANADA
	45	CMC	CANADIAN MARCONI COMPANY
	62	CYV	CYPRUS ANVIL MINING CORPORATION
	71	DTX.A	DOMINION TEXTILE
	95	HSC	HAWKER SIDDELEY
	175	UCC	UNION CARBIDE CANADA
	184	WJX.A	WAJAX 'A'
27			
	10	ASM	ASAMERA INC.
	191	YB	YELLOWKNIFE BEAR MINES LIMITED
28			
	87	GZM	GAZ METROPOLITAIN
	128	NCN	NORCEN ENERGY RESOURCES
	142	PPL	PEMBINA PIPELINES
	190	WTC	WESTCOAST--TRANSMISSION
29			
	53	CRL	CRAIN, R.L.
	72	DUP	DUPONT OF CANADA 'A'
	80	GDS.A	GENERAL DISTRIBUTORS 'A'
	85	GWL	GREAT WEST LIFE
	118	MCL	MOORE CORPORATION
	122	MOL.A	MOLSON COMPANIES 'A'
	123	MOL.B	THE MOLSON COMPANIES LIMITED 'B'
	159	SSI	SLATER STEEL
	160	SSR	SIMPSON-SEARS A
	162	STM.A	SOUTHAM INC
	167	THM.A	THOMSON NEWSPAPERS 'A'
	180	VO	SEAGRAM
30			
	6	AL	ALCAN ALUMINIUM
	20	BMS	BRUNSWICK MINING & SMELTING CORP.LTD
	28	CCL	CELANESE CANADA
	39	CIL	CANADIAN INDUSTRIES INC.
	43	CLT	COMINCO
	90	HBM.A	HUDSON BAY M & S
	126	N.A	INCO
	133	NOR.A	NORANDA MINES

CLUSTER #	CO #	TICKER	NAME
	138	PDL	PLACER DEVELCPMENT
	173	TXG	TEXASGULF
31			
	108	KAP	KAPS TRANSPORT
32			
	12	BBD	BOMBARDIER INCCRPORE
	27	CCH.A	CAMPBELL CHIBOUGAMAU MINES LIMITED '
	174	TZC	TRIZEC CCRPORATICN
33			
	2	AB	ASBESTCS CCRPCRATICN
	41	CKB	CARLING O'KEEFE
	50	CRH	CRUSH INTERNATIONAL
	54	CSR	CASSIAR RESOURCES
	74	EML	EMCO
	104	IS.A	INVESTORS GROUP 'A'
	149	ROC	ROTHMANS CANADA
34			
	140	PNV	PATINC N.V.
	141	POW.A	POWER CORP.
35			
	111	KSR	KAISER RESOURCES
36			
	4	ACO.A	ATCO 'I'
	13	BCC.A	BETHLEHEM COPPER
	119	MF	MASSEY FERGUSON
37			
	48	CP	CANADIAN PACIFIC
	63	DBR	DOMINION BRIDGE
	105	ISP	INTERPROVINCIAL STEEL & PIPE CORP. L
	135	NVA.A	NOVA AN ALBERTA CORP 'A'
	171	TRP	TRANSCANADA PIPELINE

CHAPTER 4 - FOOTNOTES

1. See, for example, Sealy (1980) and references cited therein.

2. See Mayers (1972), Rorke (1979).

3. See Tepper (1972, 1974), Hill (1978), Frankfurter and Hill (1981).

4. For developments in the personal consumption-investment area, see Mossin (1968), Fama (1970), Hakansson (1970), and Long (1974).

5. Tepper's study (1972) can be divided into two parts. The first part formulates the liability structure, based on the plan design and actuarial assumptions about employment level and wage rates. The second part analyzes the optimal funding and investment decision. Only the second part is reviewed here as it is the only part which is directly relevant to this dissertation.

6. Hill uses a two-step approach to create the efficient frontier. She first groups the individual securities by cluster analysis (see Frankfurter & Phillips, 1980 for details) and then linearizes the individual group variances by using the market model. She wrongly claims that the validity of her linearization approach is shown by Stone (1973).

7. Modigliani and Miller (1958), Hirshleifer (1965), Farrar and Selwyn (1967) et. al.

8. Only Hill has attempted the required empirical analysis.

9. Hill uses a before-tax cost of contributions ranging from 10 to 12 percent whereas the expected return on the portfolio is 10.357% (p.168). If a tax rate of 40% is assumed, it is obvious that all contributions will be added in period one.

10. Keenan (1981) has similar thoughts on Hill's approach. He states "(the main assumption behind Hill's objective function is that) timing pays because of expected differences in risk-adjusted returns available to the firm and its pension fund, but in such a market one must more strongly justify the utility of a present value cost contribution minimization objective. It may be, for example, that in such markets observed smoothness of profit growth is important for shareholder valuation - implying a different sort of pension funding policy."

11. The main objective of this approach was to investigate the implications of the insurance scheme proposed under ERISA in the U.S. For further details see, Da Motta (1980).

12. It can also be increased by decreasing A_1.

13. See Treynor et. al. 1976, pp.124-125 for a simple example illustrating this situation.

14. L_2* and A_1 can be known at the beginning of the insurance contract whereas A_2 can be known only at the end of the period as it is a function of r.

15. For more details, see Schwimmer and Malca (1976), Tepper (1977), Bergstorm and Frashure (1977), Ezra (1979), Tierney (1980).

16. For a description of some of the competing sophisticated models, see Kingsland (1982) or Winklevoss (1982).

17. See Rohrer (1978).

18. In the U.S., most of these models use the Ibbotson and Sinquefield study (1976).

19. Actually, Morgan Stanley, the U.S. investment-banking firm recommended a similar program to its client firms several years ago. "The program was a great resounding flop" according to one of its directors (Ehrbar, 1981, p.124).

20. This problem is dealt with in the shareholder unanimity literature. Baron (1979) and Nielsen (1976) have shown the strict and extremely limiting assumptions that must be made to arriving at unanimous decisions, particularly in imperfect markets.

21. This rules out a number of behavioural managerial organization goals (Simon, 1959), as well as management-shareholder conflicts (Jensen and Meckling, 1976) and the social welfare aspects of firm's decisions (Jensen and Long, 1972; Stiglitz, 1972; Merton and Subrahmanyam, 1974; Stigum, 1976).

22. See Kane and Malkiel (1965), Michaelson and Goshay (1967), Parkin (1970), Pyle (1971, 1972), Cannon (1977), Sealy (1980), Hart and Jaffe (1974) and Kane and Buser (1979).

23. One may view the funding level as a choice variable. In practice, however, the ratio of fund to firm assets varies within a very narrow range from period to period.

24. This is in direct contrast to the option approach, which was discussed in the last section.

25. Some effects of relaxing this assumption are developed later in the discussion on the choice of an appropriate risk level for the pension fund.

26. See Tobin (1958), Mossin (1968), Pogue (1970), Crane (1971), Hakansson (1971).

27. Banz and Miller (1980) provide a technique through which state-contingent claims specify the value of a multi-period stream as weighted sums across both time and states. They suggest the use of the Black-Scholes option pricing formula to arrive at the appropriate state prices. The task is quite formidable if market imperfections and varying tax structures are allowed for.

28. Criteria for including securities are well defined by various provincial governments and are very similar in nature between provinces. For a brief description, see Ezra (1980), pp.23-25.

29. The prudent man rule stipulates that fiduciaries must act 'with the care, skill, prudence and diligence under the circumstances then prevailing that a prudent man acting in a like capacity and familiar with such matters would use in conducting an enterprise of like character and with like aims.'

30. While it is possible that a change in the portfolio composition for a particularly large Canadian pension fund may have some price effect, such exceptions are ruled out.

31. The assumption of a mean-variance preference function is restrictive in that it ignores higher moments of the distribution. Merton (1971) and Samuelson (1970), however, have indicated the fairly general conditions under which such an assumption is valid.

32. Restrictions on short selling and margin imply positive X_i's and B.

33. Equation 4.11 is similar to the portfolio implications of non-marketable human wealth (Mayers, 1972; Rorke, 1979) and of stochastic cash demand (Chen, 1977).

34. See Kane and Buser (1976) for an elaboration of this concept.

35. This will also be preferred by the insurance companies, such as the Pension Benefit Guarantee Corporation (PBGC) in the U.S. and the Ontario Government's Guarantee Fund proposed under Bill 241, passed in December 1980.

36. This study utilizes the Product Form Quadratic Programming Code (RS - QPF 4) developed by Rand Corporation.

37. The main limitations are the memory size and the availability of computer time, both of which are scarce resources.

38. Many techniques are available for clustering longitudinal data. For a review, see Cormack (1971).

39. Obviously, it is not possible to represent a typical pension fund portfolio. In practice, a fund can easily designate the securities it intends to include in its portfolio without affecting the basic procedure.

40. Informal discussions with people in the pension fund investment community and the Department of Insurance suggest that this assumption is valid for almost all funds. A typical pension fund has about 30 to 50 common stocks in its portfolio.

41. These 192 stocks are either Fat or moderately traded stocks, see, Fowler et. al. (1980) for further details.

42. In practice, a pension fund manager can always specify the universe of stocks to be included in the fund portfolio.

43. Laval Tape is a popular name for a data file containing the stock market returns on approximately 900 Canadian securities from 1963-1979. For details, see Morgan and Turgeon (1978).

44. To calculate these cash flows, the exact data on working capital, depreciation, other non-cash expenses (such as investment tax credit) etc. are required. Although these are readily available to the firm's management and thus could be easily substituted into the process for determining the covariances, they are impossible for an outsider to obtain.

45. Total assets are expressed in book value terms and include both the current and fixed assets. Returns based on only the fixed assets showed almost identical results.

46. This assumes that a) the quarterly covariances are stable, b) the cross-quarter covariance terms (between group return and firm return) are zero, and c) the quarterly pairs of returns are independent. Without the actual quarterly data, the bias introduced by such an approximation is impossible to estimate.

47. The objective of the Quadratic algorithm used here is

$$\text{Minimize} \quad -MPX + X'QX$$

where M is a scalar, P and X are vectors and Q is a symmetric matrix. Due to the presence of the covariance term, this was transformed to

$$\text{Minimize} \quad -M[P - 2X_a \operatorname{Cov}(R_i, R_a)/M]X + X'QX$$

The optimization process was conducted by varying M from 0.05 to 400.00.

48. If needed, this additional restriction can be easily incorporated by adding a constraint such as minimum

$$\text{debt proportion} < \sum_{i=38}^{48} X_i < \text{maximum debt proportion.}$$

49. Note that because of the diversification constraint the minimum number of groups must be 15.

50. It is important to note that these portfolios will not be monotonically related to variance only. The frontier is efficient in terms of the variance + covariance terms.

51. The large number of common stocks in portfolios #1 and #2 is due to the inclusion of group 1, which contains 42 stocks.

52. The 12 common groups for firm #1 and #4 constitute approximately 57% of the total portfolio.

53. The model can best be tested for firms which actually merged. The model is, however, tested here by creating artificially merged firms due to the lack of such data.

54. This procedure allows for divergent growth rates in the assets of each firm during that period.

55. Seven groups are common for firm #3 and firm #4 in the minimum variance portfolios and five out of these seven groups are present in the case of firm #5.

56. No assumptions are made about the source of this increase in the funding level. In most cases, such an increase would result in either a change in the firm's operating assets and/or the capital structure and thus would probably change $E(R_a)$ and $V(R_a)$ and $Cov(R_i, R_a)$.

CHAPTER 5. AN EMPIRICAL TEST OF CANADIAN PENSION FUND PERFORMANCE

A. INTRODUCTION

In recent years, the private pension plan system and its management have come under increasing scrutiny from the Canadian government, labour unions, and the general public. Many factors have contributed to this scrutiny, including a steady increase in the average age of the Canadian population, combined with prolonged periods of high inflation, high interest rates and stagnant business conditions. The rapid growth in the aggregate asset size of these funds, and thus the rapid growth of their alleged influence on the Canadian capital markets, has also attracted outside attention.

Sponsor firms of these plans have placed increased emphasis on the skilled management of the pension fund assets, because the failure of these assets to generate the returns anticipated by corporate treasurers and outside actuaries results in increase in firm's contributions to the plan. Competition for managing these assets has also led to increasing scrutiny of the historical performance of the investment managers. If skilled and active management of fund assets provides consistent superior performance than a passive investment in a widely diversified portfolio (such as an index portfolio), it has implications for the efficiency of the Canadian capital markets. Performance evaluation of these investment managers, therefore, will provide answers to these important issues.

For this purpose, a number of 'performance' measurement services have been established to evaluate the returns earned by various assets classes (e.g. equities) of each pension fund. Their periodic (generally quarterly) evaluations are based solely on the returns earned by the assets. With this evaluation scheme, a pension fund whose ex-post returns are in the upper half of the sample evaluated is considered a 'good' performer; one whose ex-post returns are in the lower half is considered a 'poor' performer.

Surprisingly little research has been published about the risk-adjusted performance of this important sector of the capital markets. This lack of research persists, despite the development of risk-adjusted performance measures[1] and their application to the portfolio performance evaluation of mutual funds.[2] This chapter provides the empirical analysis of performance of a sample of Canadian private pension funds. Since equities form a significant proportion of the assets in these portfolios, the chapter mainly deals with the equity portion of the sample portfolios. Preliminary tests are conducted for evaluating the performance of these funds on a total fund return basis. The impact of the recent controversy[3] about the inherent ambiguity and biases of CAPM-based performance measures is evaluated by using several different and realistic benchmark portfolios and alternate risk-adjusted measures of portfolio performance.

The empirical analysis is conducted by treating the pension fund portfolio like a mutual fund.[4] Performance is evaluated using concepts drawn from traditional capital market theory. Although it would be interesting to analyze the fund's performance after accounting for the nature of the earnings of the fund sponsor, the data for such an analysis were not available. The evaluation of the bond portfolios was also beyond the scope of this study, primarily because of the nature of the existing data and well-known methodological problems. (See, Percival, 1974 and Reilly & Joehnk, 1976).

The chapter begins with a brief summary of the development of the traditional mean-variance based performance measures. Various single period performance measures based on asymmetrical return distributions are then discussed. The attention is then focused on the methodology of measuring the returns and the selection of the appropriate time horizon and the benchmark portfolios. The chapter concludes with a description of the data base, empirical design and results.

B. SYMMETRIC DISTRIBUTIONS

B-1. Security Selection

The mean-variance framework, developed in the seminal works of Markowitz (1952) and Tobin (1958) has had a major influence on the investment performance measurement. Sharpe (1964), Lintner (1965), Mossin (1966) popularized a reward-to-variability measure to analyze investment performance. The measure assumed that the best-managed portfolio in a universe of well-diversified portfolios is the one which has the highest $(E(\tilde{R}_p) - R_f)/\sigma_{R_p}$ ratio (where $E(R_p)$ and σ_{R_p} are the expected return and standard deviation of the returns on the portfolio, and R_f is the risk free rate). If there is no systematic deviation between ex-ante expectations and ex-post realizations, ex-post realizations can be used instead of ex-ante values to evaluate portfolio performance.

Two additional performance measures have been proposed: the reward-to-volatility measure (Treynor, 1965) and the predictability measure or Alpha (Jensen, 1969,1972). The reward-to-volatility measure uses the ratio of $(E(\tilde{R}_p-R_f)$

to β_p, where β_p is the systematic risk of the portfolio. The predictability measure, α_p is given by:

$$(\tilde{R}_{pt} - \tilde{R}_{ft}) = \alpha_p + \beta_p(\tilde{R}_{mt} - \tilde{R}_{ft}) + \tilde{e}_{pt} \quad \text{..........5.1}$$

where $\tilde{R}_{mt}$ is the return on the market portfolio in period t, and all the other terms are as previously defined.

Using these three measures, numerous studies have evaluated the performance of mutual funds. The overwhelming conclusion of these studies is that mutual funds have not been able to 'outperform' the market after adjustment for risk.[5] However, as discussed more fully below, many issues have been raised regarding the validity of these findings.

B-2. Market Timing

Several authors (e.g. Treynor & Mazuy, 1966) have argued that both the reward-to-volatility and the predictability measures assume that the fund manager engages only in security selection and does not engage in market timing. If this is not the case, then β_p in 5.1 must have a random coefficient specification. In an attempt to evaluate market timing abilities, Treynor and Mazuy tested the following specification:

$$\tilde{R}_{pt} = \alpha_p + \beta_p \tilde{R}_{mt} + C_p \tilde{R}_{mt}^2 + \tilde{e}_{pt} \quad \text{.................5.2}$$

They hypothesized that a statistically significant and positive C_p would suggest a desirable change in the systematic risk. Only one of the 57 funds in their study showed a significantly positive value for C_p. Two subsequent studies by Pohlman et al. (1978) and Fabozzi and Francis (1979) investigated the market timing abilities of fund managers before advancing (bull) or declining (bear) markets. Neither found evidence of superior market timing ability. Kon and Jen (1978,1979) argued that the changes in β_{pt} in equation 5.1 should be investigated using a switching regression technique. Using such a technique, they found that, on average mutual fund managers selected superior portfolios but that no individual manager did so consistently.

Recently, Merton (1981), Henriksson and Merton (1981) have proposed both non-parametric and parametric tests to measure the market timing ability of fund managers.[6] In the parametric test, market timing ability is evaluated using:

$$\tilde{R}_{pt} - \tilde{R}_{ft} = \alpha_p + \beta_{p1} (\tilde{R}_{mt} - \tilde{R}_{ft}) + \beta_{p2} [\text{Max} (0, \tilde{R}_{mt} - \tilde{R}_{ft})] + \tilde{e}_{pt} \quad \ldots\ldots 5.3$$

where β_{p2} is a measure of a manager's market timing ability. While their specification is much simpler than that of Kon and Jen, it still captures the effects of market timing on overall performance. This specification will be used herein to detect the market timing abilities of a sample of Canadian pension fund managers.

C. ASYMMETRIC RETURN DISTRIBUTIONS

The performance measures reviewed above were based on the underlying assumption of a mean-variance world with symmetric return distributions (or quadratic preference functions). According to some authors, therefore, this assumption is not valid in practice, performance measures must account for asymmetrical return distributions.[7]

C-1. Semi-Variance and Half-Variance

Markowitz (1959), Quirk and Sapsonik (1962), Mao (1970), Swalm (1966) have all suggested that semi-variance is a proper measure of risk. This measure supposedly captures the financial manager's intuitive notion of risk as a probability of failing to meet some minimum target. The semi-variance of the returns of portfolio p, below some exogenously-specified target return R_{min}, is defined as:

$$SVR_p = \int_{-\infty}^{R_{min}} (\tilde{R}_p - \tilde{R}_{min})^2 \, f_p(\tilde{R}_p) \, dR_p \quad \text{.................5.4}$$

where $f_p(\tilde{R}_p)$ represents the probability density function of $\tilde{R}_p$.[8] Traditional development has assumed that the target rate R_{min} is equal to the risk free rate so that the corresponding performance measure is the ratio of excess return to semi-variance.

The measure reward to half-variance has also been proposed (Klemkosky, 1973). In this case, R_{min} is replaced by the mean return of the distribution in 5.4. The appropriate choice of a particular measure depends upon the form of the aggregate utility function determining equilibrium prices of assets in the capital market, which is essentially an empirical issue.

C-2. Mean-Variance-Skewness

Some attempts have also been made to account for the third moment of the return distribution in performance measurement. For example, if investors have a cubic utility function, portfolio p is at least as attractive as the benchmark portfolio, m, if

$$\frac{E(R_p) - R_f}{\sigma_{R_p}} > \frac{E(R_m) - R_f}{\sigma_{R_m}} \quad \text{..........................5.5a}$$

$$\frac{M_{3,R_p}}{\sigma_{R_p}} > \frac{M_{3,R_m}}{\sigma_{R_m}} \quad \text{..................................5.5b}$$

where M_{3,R_p} and M_{3,R_m} are the cube roots of the third moment of the return distributions of R_p and R_m, respectively.[9] Since a portfolio manager may prefer a smaller reward-to-variability ratio in order to have a higher skewness, comparisons based only on equation 5.5a will give biased results. Empirical studies by Arditti (1971) and Ang and Chua (1979) have found some evidence of such a preference by mutual fund managers.

C-3. <u>Systematic Skewness</u>

Assuming that decreasing marginal utility of wealth and non-increasing absolute risk aversion are observed investor characteristics, Kraus and Litzenberger (1976) argued that aversion to standard deviation and preference for skewness are general attributes of all investors having such preference functions.[10] Using the similarity between the Kraus and Litzenberger valuation model and the CAPM for the development of a portfolio performance measure, Ang and Chua (1979) formulated the following ex-post version of the Kraus-Litzenberger model:

$$\tilde{R}_{pt} - \tilde{R}_{ft} = ERI_p + C_{p1}(\tilde{R}_{mt} - \tilde{R}_{ft}) + C_{p2}(\tilde{R}_{mt} - \bar{R}_m)^2 + \tilde{e}_{pt} \quad \ldots\ldots 5.6$$

where ERI_p is the excess return measure for a managed portfolio.[11].

In a recent paper, Friend and Westerfield (1980, p.898) claim that there is some (albeit inconclusive) evidence that investors may pay a premium for positive skewness. Although more empirical verification is needed to confirm such an assumption,[12] ERI_p will be used as one measure of portfolio performance.

C-4. Mean Absolute Deviation

The use of mean absolute deviation (MAD), defined as $\frac{1}{N}\sum_{t=1}^{N}|\tilde{R}_{pt} - R_{min}|$ (where N is the number of periods under consideration and R_{min} is the risk free, mean or other exogenously-specified return), was proposed by the Bank Administration Institute Study (1968) as a risk surrogate for the performance measurement of pension funds. It was argued that because of the Pareto-Levy distribution exhibited by the returns on capital assets, MAD may be more stable than the standard deviation.[13]

C-5. Stochastic Dominance

Stochastic dominance rules examine the entire distribution of returns in comparing portfolios. Thus, they claim to improve on other measures which use only the first two or three moments of the distribution in testing relative performance.[14] The stochastic dominance criterion requires no assumptions about the mathematical form of the distributions nor about the investors' preference functions. Despite this elegance, empirical studies have found that measures based on stochastic dominance criteria offer relatively little improvement over the traditional mean-variance or mean-semi-variance approach, especially, for approximately normal return distributions (such as those of well-diversified portfolios).[15] Further, the use of such a criterion requires significantly more information and computation. A stochastic dominance criterion will, therefore, not be used herein.

D. MEASUREMENT OF RETURN AND RISK

D-1. Bias in Performance Measures

The usefulness of each performance measure depends upon the assumptions underlying its development. Some empirical studies (Friend and Blume, 1970; Ang and Chua, 1979) have shown that performance measures, especially those based on the mean-variance framework, have exhibited a systematically biased relationship with the corresponding risk measures. Various causes for this bias have been proposed, including the existence of unequal lending and borrowing rates, assumptions about the holding period and assymetrical distributions. The significance of these empirical results has varied considerably, depending upon the methodology, the data base and the time period used. This study investigates the nature of the bias exhibited by the data base employed herein and its impact, if any, on the performance evaluation results.

D-2. The Investment Horizon

One problem in using performance measures lies in the difference between the actual portfolio investment horizon and the holding period (or differencing interval) used to calculate the risk measure.[16]. Some (Jensen, 1972; Cheng and Deets, 1973; Lee, 1976) have argued that if continuously compounded returns (log returns) are used then the risk measures may be independent of the actual investment horizon. In this study, therefore, both arithmetic and log returns are used to investigate the extent of this problem. To analyze the sensitivity of the performance measures to the investment horizon, three short term horizons (one, two and four quarters) are investigated in this study. As the available data covers only 40 quarters, effects of using longer than four quarter horizons can not be investigated. In practice, fund managers are often periodically evaluated on their short-term performance, as highlighted by the attention given to quarterly reports by pension sponsors. In this study, the adequacy of such short-term horizons is accepted.

D-3. Choice of the Benchmark Portfolio

All of the performance measures discussed above are based upon the evaluation of performance relative to an exogenously specified benchmark (or comparison) portfolio. The use of such specification has come under some criticism, especially for the CAPM based measures.[17]

First, it has been argued that CAPM is an untestable theory (Roll, 1977) and therefore performance measures based on such a theory may not be valid. It is proposed (Ross, 1978a, 1978b; Roll 1980) that a more general framework of the Arbitrage Pricing Theory (APT) should be used. Unfortunately, the APT cannot easily be made operational. First, it does not, a priori, define the meaning of each factor.[18] Second, there is no knowledge of the equilibrium rewards associated with each factor. Third, the factors depend critically on the sample size and the time period under consideration.[19] Unless these problems are resolved APT cannot be used for performance measurement.

The second issue relates to the determination of the slope and the intercept of equation 5.1. Roll argues that as these estimates depend upon the benchmark, the rankings of the portfolios based on these measures (the Treynor and Jensen measures, respectively) may be completely reversed by seemingly innocuous changes in the composition of the benchmark portfolio. These arguments imply that the robustness of the benchmark portfolios and the portfolio rankings must be empirically investigated.

Some empirical work has tried to answer these issues. Rudd and Rosenberg (1980, p.605) have shown that the four most commonly used equity indices in the U.S. are correlated at more than the .981 level.[20] The four benchmarks used in this study are correlated at more than the 0.9656 level (see, section E-2 and table 5-2a). Peterson and Rice (1980) have also shown that the rankings of fifteen randomly selected portfolios (in their study) were not significantly different at the .001 level of significance when based on four different benchmark indices. They claim that, contrary to Roll's criticisms, "little serious injustice is committed in the process (of using different indices for portfolio evaluation)." Similar tests are conducted in this study to analyze the robustness of the rankings of the sample portfolios.

The resultant rankings of the managed portfolios must be viewed with two caveats in mind. First, it cannot be claimed that either the benchmarks or the fund portfolios are efficient.[21] Second, it should be possible to invest in such a benchmark portfolio without any special knowledge of capital markets or special need for forecasting the returns.[22]

D-4. Exogenous Constraints

Measurement of the Rate of Return (TWR)

Returns will be measured using the Time Weighted Rate of Return(TWR), which is independent of the timing of the firm's contribution to the pension fund.

Ideally, the exact dates of all contributions and the exact market value of the fund assets prior to the contribution date should be known in order to exactly calculate this return precisely using the following expression:[23]

$$i = [\ln(\frac{CMV}{OMV}) + \sum_{j=1}^{m} \ln(\frac{V_j}{V_j + C_j})] \qquad \ldots\ldots\ldots\ldots 5.7$$

where c_j is the j^{th} cash contribution,

- $j = 1, \ldots\ldots m$
- OMV and CMV are the beginning and end of the period market values of the fund, respectively
- i is the continuously compounded TWR for the period
- V_j is the market value of the fund an instant before the cash contribution. The portfolio is conceived as being liquidated at its market value prior to each contribution and a new portfolio purchased with the proceeds plus the additional contribution.

If the actual date of the j^{th} contribution is unknown, then the market value, V_j, must be estimated. The impact of the use of such estimates on the calculation of i can be analyzed by using the discrete form equation (see footnote 23), and expressing the change in the rate of return, R_i for an estimate V_i as:

$$\frac{\partial R}{\partial V_i} = \frac{CMV}{OMV} \cdot \prod_{\substack{j=1 \\ j \neq i}}^{m} \frac{V_j}{V_j + C_j} \cdot \frac{\partial}{\partial V_i} \frac{V_i}{V_i + C_i}$$

$$= \frac{CMV}{OMV} \cdot \prod_{\substack{j=1 \\ j \neq i}}^{m} \frac{V_j}{V_j + C_j} \quad \frac{V_i + C_i - V_i}{(V_i + C_i)^2}$$

$$= \frac{CMV}{OMV} \cdot \prod_{\substack{j=1 \\ j \neq i}}^{m} \frac{V_j}{V_j + C_j} \quad \frac{V_i}{V_i + C_i} \cdot \frac{C_i}{V_i(V_i + C_i)}$$

$$= \frac{R \cdot C_i}{V_i(V_i + C_i)}$$

$$\frac{\partial R}{R} = \frac{C_i}{V_i + C_i} \cdot \frac{\partial V_i}{V_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.8$$

In other words, the percentage error of the TWR, i.e. ($\partial R/R$), is equal to the product of the percent cash flow and the percent error in the valuation. If each term is small, the the product will be even smaller: for example, if C_i is 10% of $(V_i + C_i)$, then a 5 percent error in valuation will give rise to a .5 percent error in the estimation of the TWR.

In practice, the exact amount of each contribution is known, but neither its exact date nor the market value of the fund on that date is generally known. In the absence of this information, these values have to be estimated. The quality of the estimates depends upon four basic factors: the length of the interval between precise market valuations, the precision with which the dates of relevant cash flows are reported, the volatility of the value of the fund's assets and the relative magnitudes of the contribution and the fund's market value.

To overcome these problems, a Linked Internal Rate of Return method (Dietz 1966) is commonly used to calculate the TWR. In this method, the TWR is calculated by averaging the Internal Rates of Return over the smallest subperiods for which the data is available. Each subperiod rate has a weight proportional to the length of time which it represents in the overall measurement period. Either the arithmetic or the geometric mean of these Internal Rates of Return can then be used to represent the TWR.[24]

In this study, the calculation of TWR is based upon the data reported by the funds (generally monthly) to the measurement service. If only quarterly reports are submitted, then the TWR is calculated by assuming a mid-quarter contribution. The exact nature of the bias cannot be determined but will be quite small due to the relatively small ratio of contributions to the market values of the funds for the sample used here (see table 5-1).

E. DATA BASE AND EMPIRICAL DESIGN

E-1. The Data Base

The data base for this study consisted of the market values and the returns of 83 private Canadian pension funds for the period 1970-1979. 77 of these funds had portion of their funds invested in Canadian stocks during this period. Data for these funds were provided on a confidential and proprietary basis by one of Canada's prominent performance measurement firms. The two criteria used to select the specific funds were a) that continuous quarterly data be available for the period 1970-1979, and b) that the fund chosen be the only pension fund associated with the sponsoring firm.[25]

For each fund, the data base consisted of two files:

(1) The Market Value File

This file contained the quarterly market values of each pension fund's individual asset classes (i.e., cash, bonds, Canadian equities, non-Canadian equities, and mortgages). For each asset class, the purchases, sales and investment income for each quarter was identified. At the end of 1979, the total asset value of the 83 funds was $3.2 billion, or approximately fifteen percent of the total asset value of all private, Canadian, trusteed pension plans. Table 5-1 shows the yearly aggregate values for all asset classes.

(2) The Return File

The return file consisted of both the time weighted rate of return and the internal rate of return achieved by each asset class for each fund, on a quarterly basis from the fourth quarter, 1969, to the fourth quarter, 1979, inclusive.

Table 5-1

AGGREGATE MARKET VALUES OF 83 FUNDS IN MILLION $

	Cash&S.T.	Bonds	CDN.Equi.	NC.Equi.	BV.Mtg.	Mkt.Mtg.	Net.Cont.	Total Mkt.
1969	41.63	340.05	288.66	77.99	34.18	35.72	10.91*	818.23
1970	34.05	387.90	313.73	71.15	44.42	44.33	38.01	895.57
1971	34.72	445.56	402.15	79.29	41.20	58.73	42.60	1061.65
1972	43.22	454.02	584.75	90.89	45.68	71.32	51.37	1289.89
1973	79.73	439.12	581.80	72.84	43.73	85.97	45.00	1303.19
1974	114.93	452.37	455.01	48.73	53.01	98.11	74.02	1222.16
1975	96.37	562.76	557.06	85.77	68.35	122.26	102.10	1492.57
1976	102.69	693.05	655.84	126.87	99.39	202.80	179.86	1880.65
1977	177.45	833.05	701.12	120.05	102.14	269.70	135.82	2203.51
1978	331.27	906.82	849.49	145.03	75.23	357.26	142.07	2665.10
1979	471.57	1045.52	1022.79	224.19	80.39	362.22	128.60	3206.69

Note: * Available only for the 4th quarter.

E-2. The Benchmark Portfolios Used

Four benchmark portfolios (indices) were constructed. They were designed to: (1) enable analysis of the 'robustness' of the 'performance measures,' and (2) incorporate the thinly traded nature of the Canadian stock market (Fowler et al., 1979, 1980). The benchmarks are:

1) TSE300: This is constructed by adjusting the official TSE300 index for the expected dividend yields. It is a "floating trading supply" weighted index, which approximates market value weights.

2) Global index: This is a value weighted arithmetic average index comprising all the securities on The Laval file (see Morgan & Turgeon, 1978). This index contains up to 984 securities. Dividends are included in the computation of the index.

3) FM index: This is a value weighted (corresponding to the TSE300 weights) index consisting of 192 securities that are either Fat or moderate in terms of their frequency of trading. Only those securities with a thin trading number higher than 0.9 are selected (see Fowler et al., 1980).

4) FAT index: This value weighted index consists of the 50 securities which traded every day on the Toronto Stock Exchange during the period 1970-1977.

Any of these benchmark portfolios may represent the universe of securities which would be considered for investment by a typical pension fund. Discussions with the performance measurement service firm (which supplied the data), as well as with some of the pension fund investment managers, suggest that the TSE 300 securities would generally include all the securities considered by a pension fund. For those funds where liquidity is a primary concern, the FM index or the FAT index can be considered a more appropriate benchmark portfolio. Table 5.2a shows the mean, standard deviation and the correlation matrix for each of these benchmark portfolios. Table 5-2b shows the histograms of the quarterly mean returns and standard deviations of the sample funds. The histogram for mean returns show that the majority of the funds are clustered between 2.14% and 2.88%.

Table 5-2a

MEANS, STANDARD DEVIATIONS AND CORRELATION MATRIX OF BENCHMARK PORTFOLIOS

	Correlation Matrix			Mean	S.D.
	Global	FM	FAT	%	%
A) Monthly Returns					
TSE300	0.9739	0.9797	0.9656	.93	4.84
Global		0.9889	0.9701	1.00	4.88
FM			0.9890	0.84	4.72
FAT			-	0.93	4.58
B) Quarterly Returns					
TSE300	0.9931	0.9914	0.9918	2.77	8.11
Global		0.9887	0.9742	3.04	8.56
FM			0.9884	2.50	7.88
FAT			-	2.78	7.29
C) Semi-Annual Returns					
TSE300	0.9952	0.9963	0.9840	5.77	13.27
Global		0.9913	0.9703	6.33	14.15
FM			0.9868	5.17	12.61
FAT			-	5.70	11.50
D) Annual Returns					
TSE300	0.9939	0.9984	0.9842	11.85	19.83
Global		0.9929	0.9682	13.16	21.97
FM			0.9830	10.45	17.75
FAT			-	11.53	15.89

Table 5-2b

HISTOGRAM OF MEANS AND STANDARD DEVIATIONS OF THE SAMPLE FUNDS - QUARTERLY RETURNS

Mean Range %	#	Standard Deviation Range %	#
1.97 - 2.13	5	5.17 - 5.63	1
2.14 - 2.28	10	5.64 - 6.08	1
2.29 - 2.43	15	5.64 - 6.54	2
2.44 - 2.58	16	6.55 - 7.00	3
2.59 - 2.73	17	7.01 - 7.46	14
2.74 - 2.88	10	7.47 - 7.91	27
2.89 - 3.03	1	7.92 - 8.37	18
3.04 - 3.18	1	8.38 - 8.83	8
3.19 - 3.33	1	8.84 - 9.29	1
3.33 - 3.48	1	9.30 - 9.74	2
Average 2.52	77	7.75	77

E-3. The Return Calculations

The performance evaluation procedure considers the equity portfolios of the 77 pension funds in the return file for which the Time Weighted Returns (geometric and logarithmic) were available for all forty quarters between January 1970 and December 1979. Three holding periods (one, two and four quarters) are investigated. The yield on 3-month T-bills (series B140007, CANSIM, Statistics Canada) was used as a proxy for the risk free rate. The tests were also conducted on real returns by deflating the nominal returns by the Consumer Price Index (series D484000, CANSIM, Statistics Canada).

E-4. Performance Measures Used

The performance measures reported are:

1) Reward to Variability Measure- Sharpe

$$S_p = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft})/\sigma_{Rp} \ldots\ldots\ldots\ldots 5.9$$

where σ_{Rp} is the standard deviation of portfolio p's return.

2) Reward to Volatility Measure - Treynor

$$T_p = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft})/\beta_p \ldots\ldots\ldots\ldots 5.10$$

where β_p is the systematic risk of portfolio p.

3) Predictability Measure - Jensen

$$\alpha_p = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft}) - \beta_p \cdot \text{Average } (\tilde{R}_{mt} - \tilde{R}_{ft}) \ldots\ldots\ldots\ldots 5.11$$

where α_p and $\tilde{\beta}_p$ are given by 5.1

4) Market Timing Performance - C_p

C_p is estimated by using the characteristic equation 5.2

$$\tilde{R}_{pt} = \alpha_p + \beta_p \tilde{R}_{mt} + C_p \tilde{R}_{mt}^2 + \tilde{e}_{pt} \quad .....5.12$$

Statistically significant positive values of C_p would denote positive market timing ability of the portfolio manager.

5) Market Timing Measure - β_{p2}

The characteristic equation used (from equation 5.3) is:

$$\tilde{R}_{pt} - \tilde{R}_{ft} = \alpha_p + \beta_{p1} (\tilde{R}_{mt} - \tilde{R}_{ft}) + \beta_{p2} [\text{Max}(0, \tilde{R}_{mt} - \tilde{R}_{ft})] + \tilde{e}_{pt} \quad ....5.13$$

β_{p2} significantly greater than 0 would signify a positive forecasting ability on the part of the portfolio manager.[26]

6) Reward to Semi-Variance Measure (RSV)

$$RSV = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft}) / \sqrt{SVR_p} \quad ....5.14$$

where SVR_p is the semi-variance of the returns of portfolio p defined in 5.4, with R_{min} selected to be R_{ft}.

7) Reward to Half-Variance Measure (RHV)

$$RHV = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft}) / \sqrt{HVR_p} \quad ....5.15$$

where the mean value of the portfolio returns R_{pt} is substituted for R_{min} in 5.4.

8) Reward to Mean Absolute Deviation Measure (RMA)

$$RMA = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft})/MAD \ldots\ldots\ldots 5.16$$

where MAD is the mean absolute deviation.

9) Excess Return Measure

$$ERI_p = \text{Average } (\tilde{R}_{pt} - \tilde{R}_{ft}) - C_{p1} \text{ Average } (\tilde{R}_{mt} - \tilde{R}_{ft}) - C_{p2} \text{ Average } (\tilde{R}_{mt} - \bar{R}_m)^2 \ldots 5.17$$

where C_{p1} and C_{p2} are the coefficients from (5.6)

10) Mean-Variance-Skewness Measure (MVS)

Using (5.5a) and (5.5b), portfolios which did not satisfy (5.5a), but which satisfied (5.5b) can be identified. A large number of funds satisfying such a rule would indicate that some portfolios had a preference for skewness over the reward-to-variability ratio.

F. EMPIRICAL RESULTS

The results are presented in three sections. The first section presents the performance evaluation, the second and third investigate the degree of ambiguity in these measures and the robustness of the Treynor and Jensen measures with respect to the choice of the benchmark portfolio.

F-1. Performance Evaluation Tests

F-1-1. Test Period January 1970 - December 1979

Tables 5-3a, 5-3b, 5-3c summarize the results of the performance evaluation tests for each of the three holding periods (one, two and four quarters, respectively) and indicate the number of portfolios which outperformed the benchmark (the indices). The latter are noted under each risk measure.

Table 5-3a

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED
THE BENCHMARK PORTFOLIO (JANUARY 1970 TO DECEMBER 1979)
FOR A 1 QUARTER HOLDING PERIOD

	Performance Measure										
	Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	RMA	ERI	MVS	Av.Ret.
Real Geometric Return Index Used:											
TSE300	12	19	19	1	1	12	12	14	39	14	12
Global	5	10	10	2	3	7	6	5	9	33	3
FM	41	49	50	1	1	41	41	35	52	8	41
FAT	8	15	15	1	1	9	9	8	31	14	12
Nominal Geometric Return Index Used:											
TSE300	12	19	19	1	1	12	12	13	36	16	13
Global	5	10	10	2	3	7	7	4	12	35	3
FM	41	50	50	1	1	41	41	35	51	9	41
FAT	8	15	15	1	1	9	9	8	26	17	12
Real Log Return Index Used:											
TSE300	15	18	18	2	1	14	13	15	29	17	12
Global	7	10	11	2	3	9	8	8	8	38	3
FM	41	43	43	1	2	41	41	39	49	12	41
FAM	8	13	14	1	1	8	9	8	27	13	9
Nominal Log Return Index Used:											
TSE300	15	18	18	2	1	14	14	14	33	18	12
Global	7	12	11	4	3	9	9	8	9	42	3
FM	41	43	43	1	2	41	41	38	46	11	41
FAT	8	14	14	1	1	8	9	8	25	15	9

Number of the funds in the sample = 77

Table 5-3b

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED
THE BENCHMARK PORTFOLIO (JANUARY 1970 TO DECEMBER 1979)
FOR A 2 QUARTER HOLDING PERIOD

	Performance Measure										
	Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	RMA	ERI	MVS	Av.Ret.
Real Geometric Return Index Used:											
TSE300	14	17	17	0	0	13	12	12	30	32	12
Global	4	8	7	0	0	5	4	5	23	38	3
FM	40	45	45	0	0	41	41	38	54	19	42
FAT	7	14	14	0	0	7	7	7	37	19	15
Nominal Geometric Return Index Used:											
TSE300	13	18	17	0	0	13	13	12	34	24	12
Global	5	8	7	0	0	5	5	4	29	27	3
FM	40	45	46	0	0	41	41	35	50	15	42
FAT	7	14	14	0	0	7	7	7	27	27	15
Real Log Return Index Used:											
TSE300	14	17	17	0	0	15	14	14	26	35	12
Global	6	11	10	0	0	6	6	8	21	39	3
FM	41	43	42	0	0	40	40	38	46	19	41
FAT	6	10	10	0	0	6	6	7	29	13	9
Nominal Log Return Index Used:											
TSE300	14	17	17	0	0	15	15	12	30	21	12
Global	6	10	10	0	0	6	7	8	25	24	3
FM	42	43	42	0	0	40	40	38	44	15	41
FAT	6	9	10	0	0	6	6	6	27	19	9

Number of the funds in the sample = 77

Table 5-3c

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED
THE BENCHMARK PORTFOLIO (JANUARY 1970 TO DECEMBER 1979)
FOR A 4 QUARTER HOLDING PERIOD

	Performance Measure										
	Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	RMA	ERI	MVS	Av.Ret.
Real Geometric Return Index Used:											
TSE300	12	16	16	2	2	11	11	11	24	45	13
Global	6	7	7	1	0	4	4	4	28	25	3
FM	38	42	40	6	6	45	45	30	24	32	45
FAT	5	8	6	4	5	6	6	4	7	65	18
Nominal Geometric Return Index Used:											
TSE300	13	16	16	2	2	12	11	11	27	36	13
Global	6	7	7	1	0	4	4	4	28	24	3
FM	38	43	41	4	6	45	45	29	29	30	44
FAT	5	7	7	2	5	6	5	4	11	53	17
Real Log Return Index Used:											
TSE300	12	13	13	2	3	12	11	11	19	50	12
Global	8	9	10	0	0	9	9	5	19	38	3
FM	36	37	36	6	7	39	40	30	22	36	41
FAT	4	5	5	0	5	5	5	4	5	65	9
Nominal Log Return Index Used:											
TSE300	12	13	13	2	3	12	11	11	21	48	12
Global	9	10	10	0	0	9	9	7	21	38	3
FM	35	36	36	5	7	39	39	30	23	32	41
FAT	4	5	5	2	5	5	4	3	5	59	9

Number of the funds in the sample = 77

The first three mean-variance based measures demonstrate that the pension funds examined have not shown any ability to outperform the market as measured by any of the indices. In addition, only a few funds show market timing ability (as measured by C_p and β_{p2}). The next two measures (RSV and RHV) consider the effect of skewness on performance evaluation. A comparison of the RSV and RHV with the mean-variance measures shows no significant difference between the number of portfolios outperforming the benchmarks. The RMA measure produces results very similar to these for the mean-variance measures.

Using the ERI measure, there is an apparent increase in the number of funds outperforming the benchmark, as compared to the other measures. This was also found by Ang and Chua (1979). Any conclusions based on the ERI measure are suspect for two reasons. First, it must be shown that the underlying valuation model (footnote 10) is applicable to the Canadian securities market. Second, unlike the results of other studies, the ERI measure exhibits significantly higher systematic bias (see the next section of this chapter).

The next measure (MVS) tries to address the criticisms of Arditti (1971). The numbers in that column denote those portfolios which were judged inferior on the basis of the Sharpe measure, but which had higher positive skewness than the benchmark portfolios. These results suggest that fund managers may be willing to give up some expected returns, or to accept more variability, for a higher positive skewness.

The last column shows the number of portfolios which outperformed the benchmark portfolio without any adjustment for risk. Theese results are similar to those derived using the Sharpe measure, suggesting that, even without risk adjustment, the pension funds in this sample have been unable to outperform the market.

In all cases, it matters little whether or not the real or nominal returns are used or whether the geometric or its logarithmic transformation are used. Comparing across the holding periods, no significant changes in the measured performance can be detected. There is a slight decrease in the corresponding numbers for the four-quarter holding period (Table 5-3c) compared with that for the one-quarter holding period (Table 5-3a). One can hypothesize that the fund managers may overemphasize short term results, since they are subject to a regular quarterly assessment of their performance. This overemphasis may then account for the marginal difference between one-quarter and four-quarter results.

In summary, it can be said that these pension fund managers have not exhibited superior performance. A buy-and-hold portfolio of 50 well traded securities would have outperformed more than 80 percent of the fund managers. Both the TSE300 and the value weighted portfolio of all securities outperformed seventy five percent of the fund managers in the sample. On the other hand, almost sixty percent of the managers did better than a widely diversified portfolio of fat and moderately traded securities. The results did not differ significantly mean-variance measures or those accounting for the asymmetry of the return distribution were used (see, footnote 15).

F-1-2. Sensitivity Tests

1) Impact of Thin Trading on the Estimates:

To test whether the performance results based on the mean-variance measures may be biased due to the presence of thin trading, correction techniques suggested by Scholes and Williams (1977) are applied to the mean-variance measures. The tests are only conducted for the nominal geometric returns and for the TSE300 and Global indices. The adjusted risk measures can be expressed as:

$$\sigma_p^* = \sigma_p/(\sqrt{1+2* \rho_{p,1}}) \qquad \text{........5.18a}$$

$$\beta_p^* = (\beta_{p,-1} + \beta_{p,0} + \beta_{p,1})/(1+2\, \rho_{m,1}) \qquad \text{........5.18b}$$

and $$\alpha_p^* = \text{Average}(R_{pt} - R_{ft}) - \beta_p^* * \text{Average}(R_{mt} - R_{ft}) \qquad \text{........5.18c}$$

where $\rho_{p,1}$ and $\rho_{m,1}$ are the first order serial correlation coefficients for the returns on the portfolio p, and the benchmark portfolio m, respectively. The Sharpe; Treynor and Jensen measures were calculated for all the funds and for TSE300 and Global benchmark portfolios. These results and their counterparts from table 5-3a are shown in table 5-4. It is evident that any bias in the performance measures is minimal, and that it does not change the previous conclusions in any significant manner.

Table 5-4

THIN TRADING ADJUSTMENT
THE NUMBER OF FUNDS THAT OUTPERFORMED THE
BENCHMARK PORTFOLIO (JANUARY 1970 - DECEMBER 1979)
FOR A 1 QUARTER HOLDING PERIOD
NOMINAL GEOMETRIC RETURN

Index Used	TSE300			Global		
	Sharpe	Treynor	Jensen	Sharpe	Treynor	Jensen
	15	15	14	6	6	6
From table 5-3a	12	19	19	5	10	10

2) Continuous Adjustment for the Risk-Return Estimates:

The results reported in table 5-3a, b and c are based on the estimates of risk and return measures calculated for the entire period. To test whether the performance results are significantly affected by this particular estimation procedure, a two-step estimation procedure was conducted as follows:

1) Estimate the risk-measure based on the first 20 quarters. 2) Estimate E(R) using a) the average return over the previous 20 quarters and b) the actual return in the next quarter. 3) Using both these return estimates, calculate the performance measures 4) repeat steps 2 and 3 by advancing the measurement period by 1 quarter. 5) Continue the process untill the end is reached at quarter 40 (for 2a) and quarter 39 (for 2b).

Table 5-5 shows the number of funds outperforming the benchmark portfolio for a particular number of quarters. The results are reported for nominal geometric return with the TSE300 as the benchmark portfolio. (Similar results were observed for the other 3 benchmark portfolios and are, therefore, not reported here.) The results can be interpreted as follows:

The value of 10 in the second column and fist row (for step 2a and the Sharpe performance measure) indicates that 10 funds did not outperform the benchmark portfolio based on Sharpe measure for even a single quarter. A value of 33 in the next row indicates that 33 funds outperformed the benchmark portfolios for 1 to 5 quarters, and so on. Overall, the average return as the proxy for E(R) (step 2a), almost 66 percent of the funds did not exhibit superior performance for more than 10 of the 21 quarters. Performance measures based on using the actual return as the proxy for E(R) (step 2b) showed that 55 percent of the funds did not exhibit superior performance for more than 10 of the 20 quarters. These results again support the conclusion that on average the pension funds in this sample have not been able to outperform the market consistently.[27]

Table 5-5

CONTINUOUS ADJUSTMENT ESTIMATES
NUMBER OF FUNDS THAT
OUTPERFORMED THE TSE300 BENCHMARK PORTFOLIO

	Method of E(R) Estimation					
	E(R)=Average Return (Step 2a)			E(R)=Actual Return (Step 2b)		
	Performance Measure			Performance Measure		
# Quarters	Sharpe	Treynor	Av.Ret.	Sharpe	Treynor	Av.Ret.
0	10	9	19	17	18	17
1-5	33	31	27	14	13	13
6-10	19	19	9	10	10	12
11-15	7	11	7	22	21	21
15-x*	8	5	8	8	9	9
y**	0	2	0	6	6	6

Note: * x=20 for step 2a, x=19 for step 2b.
** y=21 " " , y=20 " " .

F-1-3. Split Period Results

To analyze the differences in performance over time, the sample was split into two time periods. In the first half (Jan. 70 - Dec. 74), the ex-post return on the benchmark portfolios was less than the risk free rate of return; in the second half (Jan. 75 - Dec. 79), however, it was significantly higher. Table 5-6a shows the means and standard deviations of the benchmark portfolios and the sample funds for both split periods. Tables 5-6b and 5-6c summarize the results of the performance evaluation tests. It is apparent from these tables that, on average, pension funds fared much better during the 'down-market' period than the 'up-market' period. The fat index outperformed almost all the pension funds in the 'down-market' period, whereas the pension funds did much better in the 'up-market' period. None the less, over the whole period, the fat index outperformed most of the pension funds in the sample. Table 5-6d shows the number of funds which outperformed the benchmark portfolios in both periods. The results show that less than 10% of the funds were consistently superior performers. On average, there was less than a 20% chance that a fund which outperformed the benchmark portfolio in the first half would also outperform the benchmark in the second half. For example, out of the 35 funds which outperformed the TSE300 based on the Sharpe measure (Table 5-6b) in the first half, only 7 outperformed it in the second half. Kendall's correlation coefficients for rankings across the two halves are of the order of -0.20 (Table 5-6e) further suggesting the inconsistency of performance.[28]

Table 5-6a

SPLIT PERIOD SUMMARY STATISTICS
QUARTERLY RETURNS

	Jan. 1970 - Dec. 1974		Jan. 1975 - Dec. 1979	
	Mean %	S.D.%	Mean %	S.D. %
TSE300	0.22	8.53	5.32	6.50
GLOBAL	0.15	9.02	5.92	6.71
FM	0.18	8.47	4.82	6.20
FAT	0.92	7.93	4.63	5.81
ALL FUNDS	0.22	8.49	4.82	6.05

HISTOGRAM FOR THE MEAN RETURN OF THE SAMPLE FUNDS
QUARTERLY RETURNS

Jan. 1970 - Dec. 1974		Jan. 1975 - Dec. 1979	
Range %	#	Range %	#
-0.45 - -0.29	4	3.76 - 4.09	5
-0.28 - -0.13	8	4.10 - 4.42	13
-0.12 - 0.03	10	4.43 - 4.75	17
0.04 - 0.20	18	4.76 - 5.07	22
0.21 - 0.36	16	5.08 - 5.40	9
0.37 - 0.52	5	5.41 - 5.73	9
0.53 - 0.68	8	5.74 - 6.06	1
0.69 - 0.84	4	6.07 - 6.38	0
0.85 - 1.00	1	6.39 - 6.71	0
1.01 - 1.16	3	6.72 - 7.04	1
Average 0.22		4.82	

Table 5-6b

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED
THE BENCHMARK PORTFOLIO (JANUARY 1970 TO DECEMBER 1974)
FOR A 1 QUARTER HOLDING PERIOD

	Performance Measure										
	Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	RMA	ERI	MVS	Av.Ret.
Real Geometric Return Index Used:											
TSE300	34	26	28	2	1	35	34	37	46	23	33
Global	35	30	30	7	5	35	34	37	38	32	40
FM	37	32	32	2	3	38	38	42	50	18	39
FAT	4	3	3	0	0	4	4	4	18	18	3
Nominal Geometric Return Index Used:											
TSE300	35	29	29	3	1	34	35	38	46	21	33
Global	35	30	30	8	5	35	34	38	35	30	40
FM	40	32	32	2	3	39	39	39	49	18	39
FAT	4	3	3	0	0	4	4	4	16	20	3
Real Log Return Index Used:											
TSE300	33	26	26	4	2	33	34	37	34	25	37
Global	35	29	29	8	6	34	34	38	32	31	47
FM	36	30	30	2	4	36	36	40	41	21	40
FAT	3	3	3	0	0	3	3	3	11	20	2
Nominal Log Return Index Used:											
TSE300	33	26	26	3	2	33	33	38	34	24	37
Global	35	29	29	8	6	34	34	38	31	29	43
FM	36	29	30	2	4	36	37	38	39	20	40
FAT	3	3	3	0	0	3	3	3	11	23	2

Table 5-6c

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED THE BENCHMARK PORTFOLIO (JANUARY 1975 TO DECEMBER 1979) FOR A 1 QUARTER HOLDING PERIOD

	Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	RMA	ERI	MVS	Av.Ret.
				Performance Measure							
Real Geometric Return Index Used:											
TSE300	23	32	32	1	0	21	21	23	36	15	11
Global	3	10	9	3	3	7	4	10	7	51	2
FM	43	53	53	1	1	42	40	41	49	13	37
FAT	45	55	55	3	2	46	46	39	48	19	49
Nominal Geometric Return Index Used:											
TSE300	23	32	32	1	0	21	21	23	33	17	11
Global	3	9	9	2	3	7	3	10	7	51	2
FM	41	52	53	1	1	42	40	39	50	12	37
FAT	44	55	55	2	2	46	43	39	46	21	50
Real Log Return Index Used:											
TSE300	23	32	31	1	1	20	21	24	34	18	11
Global	4	10	10	3	5	8	4	10	5	49	1
FM	42	52	53	3	2	43	41	41	47	15	36
FAT	45	55	54	3	4	47	47	39	45	19	48
Nominal Log Return Index Used:											
TSE300	23	31	31	1	1	20	20	24	31	19	11
Global	4	10	10	4	5	8	7	9	7	56	1
FM	42	51	53	2	2	43	40	40	48	13	36
FAT	43	54	54	3	4	47	45	39	42	23	48

Table 5-6d

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED
THE BENCHMARK PORTFOLIO IN BOTH PERIODS
FOR A 1 QUARTER HOLDING PERIOD - NOMINAL RETURNS

	Performance Measure							
Index Used:	Sharpe	Treynor	Jensen	RSV	RHV	RMA	ERI	Av.Ret.
TSE300	7	9	9	8	8	12	11	1
Global	1	1	1	2	1	3	3	0
FM	15	13	17	16	16	19	16	14
FAT	2	2	2	2	2	2	5	1

Table 5-6e

KENDALL'S CORRELATION COEFFICIENT
FOR RANKINGS ACROSS PERIODS
FOR A 1 QUARTER HOLDING PERIOD - NOMINAL RETURNS

Performance Measure			
Sharpe	Treynor	Jensen	Av.Ret.
-0.17	-0.19	-0.20	-0.18

(all significant at 5% level)

F-2. Bias in the Performance Measures

To analyze the bias in the performance measures, each performance measure was cross sectionally regressed against the corresponding risk measure for all three holding periods. Only the results using nominal returns and the TSE300 benchmark are presented since no material differences were found using real returns and other benchmarks. Table 5-7 summarizes the results of these cross sectional regressions.

The first four sets of results correspond to the cross sectional regressions for the performance measures which are independent of the benchmark portfolio. Except for the RHV measure, the relationships are not very important (as demonstrated by low R^2s). The bias is more important in logarithmic returns, but decreases with increasing holding periods. The RHV measure exhibits a strong negative bias. This observation is similar to the findings of Ang and Chua (1979) but contradicts the findings of Klemkosky (1973). The next two sets of results correspond to the CAPM based measures. The regressions show low explanatory powers decreasing with increasing holding periods.[29]

Table 5-7

BIAS IN COMPOSITE MEASURES
REGRESSION RESULTS FOR PERFORMANCE MEASURES WITH RISK MEASURES
JANUARY 1970 TO DECEMBER 1979

	Holding Period (Quarters)					
	(1)		(2)		(4)	
	Geom.	Log	Geom.	Log	Geom.	Log
Sharpe with Std. Dev.						
Intercept	.099*	.123*	.082	.135*	.075	.119
Slope	.038	-.786	.473	-.460	.679	-.052
R^2	.001	.030	.013	.012	.035	.000
RHV with Half Variance						
Intercept	.321*	.270*	.467*	.367*	.597*	.417*
Slope	-3.180*	-3.200*	-3.080*	-2.910*	-2.410*	-2.096*
R^2	.121	.200	.112	.189	.059	.115
RSV with Semi Variance						
Intercept	.199*	.200*	.175*	.202*	.057	.134
Slope	-1.110	-1.970*	.188	-1.060	1.590*	.057
R^2	.019	.080	.001	.028	.064	.000
RAM with M.A.D.						
Intercept	.185*	.208*	.131*	.162*	.123	.144
Slope	-.870	-2.150	.429	-.650	.845	-.034
R^2	.010	.060	.004	.010	.026	.000
Treynor with Systematic Risk						
Index: TSE300						
Intercept	.014*	.014*	.023*	.023*	.023*	.026*
Slope	-.006	-.009*	-.005	-.014*	.017	-.006
R^2	.048	.120	.005	.057	.015	.002
Jensen with Systematic Risk						
Index: TSE300						
Intercept	.003	.005*	.002	.009*	-.016	.005
Slope	-.005*	-.008*	-.006	-.014	.009	-.013
R^2	.041	.101	.011	.068	.004	.013

Table 5-7 (Cont'd)

BIAS IN COMPOSITE MEASURES
REGRESSION RESULTS FOR PERFORMANCE MEASURES WITH RISK MEASURES
JANUARY 1970 TO DECEMBER 1979

	Holding Period (Quarters)					
	(1)		(2)		(4)	
	Geom.	Log	Geom.	Log	Geom.	Log
ERI with Systematic Risk						
Index: TSE300						
Intercept	.002	.002	-.001	.001	.086*	.075*
Slope	-.002	-.004	-.000	-.003	-.098*	-.089*
R^2	.004	.011	.000	.001	.334	.371
ERI with Systematic Risk(1) & Skewness(2)						
Index: TSE300						
Intercept	.000	.001	-.002*	.003	-.023	.007
Slope(1)	.000	.458	.000	-.005	.026	.010
Slope(2)	.001*	-.001*	-.001*	-.003*	-.011*	-.025*
R^2	.458	.509	.590	.649	.722	.666

Note: * denotes significant at 5% level.

Tests on the ERI measures for one and two quarter holding periods show that they exhibit no systematic bias when regressed against the measure of systematic risk. The same tests show significant negative bias for four-quarter holding periods, but the regressions have low R^2s. When ERI is regressed against both the corresponding risk measures simultaneously, highly significant biases and high R^2s are found. This set of results directly contradicts that found in Ang and Chua (1979). One must, therefore, conclude that, without more research into the nature of the risk-return trade-off in the Canadian equities market, the use of ERI in performance measurement may be inappropriate.

Overall results indicate that except for the RHV and ERI measure, the performance measures in this study do not exhibit significant [redacted] relationships with the corresponding risk measures. Also, contrary to previous findings, the performance measures based on the assumption of asymmetric returns do not show a smaller degree of bias when compared to the mean-variance based measures. This suggests that the biasedness of performance measures may be data specific. To analyze whether similar results are obtained for split period results, similar tests are conducted for each period separately. Table 5-8 summarizes these results for nominal returns and using the TSE300 as the benchmark portfolio (since no material differences were found using real returns and other benchmarks).

As with the results in table 5-7, the RHV, RSV and ERI measures show a higher degree of bias than mean-variance based measures. In general, the degree of bias in the first half is higher than that in the second half. This may support the argument of Friend and Blume (1970), that such a bias is the result of a significant difference between the ex-post distribution of return and risk, and their ex-ante magnitudes.

Table 5-8

BIAS IN COMPOSITE MEASURES
REGRESSION RESULTS FOR PERFORMANCE MEASURES WITH RISK MEASURES
SPLIT PERIOD RESULTS

	Holding Period 1 Quarter			
	Jan. 70 - Dec. 74		Jan. 75 - Dec. 79	
	Geometric	Log	Geometric	Log
Sharpe with Std.Dev.				
Intercept	-.309*	-.287*	.533*	.568*
Slope	2.076*	1.330*	-1.440*	-2.450*
R^2	.185	.100	.028	.061
RHV with Half Variance				
Intercept	-.230*	-.219*	2.315*	2.002*
Slope	1.100	.443*	-4.400*	-4.140*
R^2	.032	.009	.424	.442
RSV with Semi Variance				
Intercept	-.406*	-.367*	.906*	.949*
Slope	3.549*	2.210*	-5.780*	-8.130*
R^2	.202	.116	.066	.122
RAM with M.A.D.				
Intercept	-.417*	-.403*	.718*	.767*
Slope	3.682*	2.692*	-3.640*	-5.370*
R^2	.269	.177	.060	.104
Treynor with Systematic Risk				
Index: TSE300				
Intercept	-.044*	-.048*	.037*	.038*
Slope	.034*	-.034*	-.007	-.012*
R^2	.517	.498	.022	.053
Jensen with Systematic Risk				
Index: TSE300				
Intercept	-.011*	-.010*	.003	.007
Slope	.011*	.009*	-.004	-.009
R^2	.174	.142	.011	.040

Table 5-8 (Cont'd)

BIAS IN COMPOSITE MEASURES
REGRESSION RESULTS FOR PERFORMANCE MEASURES WITH RISK MEASURES
SPLIT PERIOD RESULTS

	Holding Period 1 Quarter			
	Jan. 70 - Dec. 74		Jan. 75 - Dec. 79	
	Geometric	Log	Geometric	Log
ERI with Systematic Risk				
1) Index: TSE300				
Intercept	.003	.002	.003	.006
Slope	-.004	-.003	-.005	-.009
R^2	.011	.007	.011	.036
ERI with Systematic Risk(1) and Skewness(2)				
1) Index: TSE300				
Intercept	-.011*	-.010*	.004	.007
Slope(1)	.015*	-.014*	-.006*	-.010*
Slope(2)	-.004*	-.005*	.001*	.001*
R^2	.644	.643	.208	.004

Note: * denotes significance at 5% level.

Finally, the results for the entire period, presented in table 5-7, show an absence of any significant biases in performance measures other than RHV and ERI (in contrast to Klemkosky, 1971; Friend and Blume, 1970; Gaumitz, 1970, Ang and Chua, 1979). No significant changes in the results occur for different horizons and different benchmarks. Some degree of bias is introduced during a period when ex-post returns on the benchmark portfolio are less than the risk-free rate of return. Also in contrast to earlier studies, the relationships are less important than previously reported. These results, therefore, suggest that no significant bias is exhibited by the performance measures tested in this study.

F-3. Ambiguity Due to the Choice of the Benchmark

Empirical results in this section try to answer two questions: 1) Do the rankings of various portfolios differ significantly with the choice of performance measure? and 2) Do the rankings determined by the CAPM-based performance measures differ significantly with the choice of benchmark?

To answer these two questions, Kendall's coefficient of Concordance, W, is used for each set of rankings.[30] This coefficient is used primarily as a measure of 'agreement in rankings.' A value of 1.0 indicates perfect agreement in rankings, while a value of 0.0 indicates perfect disagreement. This coefficient is defined as follows:

$$W = \frac{12}{b^2 k(k+1)(k-1)} \cdot \sum_{j=1}^{k} \left(R_j - \frac{b(k+1)}{2}\right)^2 \quad \text{..........5.19}$$

where b is the number of blocks, k is the number of treatments, and R_j denotes the sum of ranks in the j^{th} treatment for j=1,2,....k. In this study, k equals the number of funds and b equals either the number of performance measures (for question 1) or the number of benchmark portfolios (for question 2).

Tables 5-9a and 5-9b summarize the results of the tests designed to answer the first question. Table 5-9a shows the results for three holding periods and four benchmark portfolios. Three sets of performance measures are tested and the results show a high degree of agreement. The numbers change only slightly for alternative benchmarks, different holding periods or type of returns (geometric or logarithmic). The test also shows that ranking portfolios by mean return may not differ greatly from ranking them by risk-adjusted measures. To test whether similar results apply to each of the split periods, a separate analysis was conducted for a one quarter holding period in the first and second five-year periods. Table 5-9b (column 3) shows an improvement in the correlation when the risk adjusted measures alone are used in all cases. This suggests that, for the funds in this sample, the risk adjustment would have improved the agreement. It further suggests that any of the three mean-variance based measures (Sharpe, Treynor or Jensen) could have been used to rank these portfolios without any serious injustice.

Table 5-9a

KENDALL'S COEFFICIENT OF CONCORDANCE
TEST PERIOD: JANUARY 1970 - DECEMBER 1979
NOMINAL RETURNS

	(1) Holding Period			(2) Holding Period			(3) Holding Period		
Benchmark	1 QTR	2 QTR	4 QTR	1 QTR	2 QTR	4 QTR	1 QTR	2 QTR	4 QTR
TSE300									
Geom.	.9734	.9768	.9746	.9612	.9674	.9759	.9869	.9898	.9950
Log	.9865	.9886	.9876	.9809	.9835	.9860	.9916	.9935	.9954
Global									
Geom.	.9705	.9735	.9710	.9562	.9615	.9697	.9828	.9854	.9905
Log	.9852	.9858	.9858	.9784	.9785	.9821	.9897	.9889	.9922
FM									
Geom.	.9764	.9801	.9775	.9660	.9733	.9807	.9891	.9933	.9970
Log	.9891	.9931	.9894	.9849	.9884	.9902	.9936	.9973	.9981
FAT									
Geom.	.9688	.9706	.9718	.9541	.9582	.9705	.9823	.9821	.9893
Log	.9838	.9832	.9822	.9766	.9751	.9767	.9883	.9862	.9865

Note: (1) includes Av. ret, Sharpe, Treynor, Jensen, RSV, RHV, BAI.
(2) includes Av. ret, Sharpe, Treynor, Jensen.
(3) includes Sharpe, Treynor, Jensen.

Table 5-9b

KENDALL'S COEFFICIENT OF CONCORDANCE
(SPLIT-PERIOD RESULTS)
FOR A 1 QUARTER HOLDING PERIOD
NOMINAL RETURNS

Benchmark	Jan. 70 - Dec. 74 (1)	(2)	(3)	Jan. 75 - Dec. 79 (1)	(2)	(3)
TSE300						
Geometric	.9613	.9485	.9792	.9252	.9122	.9838
Log	.9302	.9078	.9662	.9404	.9306	.9869
Global						
Geometric	.9626	.9497	.9804	.9236	.9057	.9786
Log	.9311	.9082	.9677	.9389	.9243	.9832
FM						
Geometric	.9620	.9484	.9810	.9271	.9187	.9835
Log	.9292	.9048	.9661	.9420	.9362	.9870
FAT						
Geometric	.9608	.9483	.9631	.9255	.9152	.9822
Log	.9327	.9130	.9546	.9398	.9331	.9848

Note: (1) includes Av. ret, Sharpe, Treynor, Jensen, RSV, RHV, BAI.
(2) includes Av. ret, Sharpe, Treynor, Jensen.
(3) includes Sharpe, Treynor, Jensen.

Table 5-10 summarizes the results of tests designed to answer Roll's criticism that performance measures based on the security market line are ambiguous. To address this issue empirically, the agreement in the rankings by Treynor and Jensen measures based on each of the four indices was examined for the entire period and the split period. The results show almost perfect agreement in rankings and are robust to the holding period assumption and the type of return used. Contrary to Roll's criticism, the rankings of portfolios based on substantially different but widely diversified portfolios seem quite robust to the particular choice of index.

Table 5-10

KENDALL'S COEFFICIENT OF CONCORDANCE
UNDER 4 BENCHMARK PORTFOLIOS
NOMINAL RETURNS

	Jan. 1970 - Dec. 1979					
	Treynor			Jensen		
Type of Return	(1)[1]	(2)[2]	(4)[3]	(1)[1]	(2)[2]	(4)[3]
Geometric	.9977	.9986	.9988	.9939	.9924	.9911
Log	.9986	.9989	.9994	.9947	.9926	.9921

1 = Holding Period 1 Quarter
2 = Holding Period 2 Quarters
3 = Holding Period 4 Quarters

	Jan.70-Dec.74		Jan.75-Dec.79	
	Holding Period = 1 Quarter			
Type of Return	Treynor	Jensen	Treynor	Jensen
Geometric	.9984	.9983	.9952	.9907
Log	.9984	.9855	.9962	.9919

G. PRELIMINARY RESULTS FOR TOTAL FUND PERFORMANCE

Previous sections analyzed the performance of the equity portfolios of the sample pension funds. This section presents the analysis for the total fund portfolio based on the total fund returns. These returns represent the weighted average of the returns in each asset class of the fund (see table 5-1). As noted earlier in this chapter, these results are preliminary, because of the problems of designing an appropriate unambiguous benchmark portfolio with which to compare total fund performance. The change in the asset mixes of the fund and the changes within each of the asset groups further complicate the design. Attempts are made to design some 'naive' benchmark portfolios which could easily be replicated by the actual funds. The results are based on all 83 funds in the data base using 1 quarter holding period for the period 1970-1979.

The following are the three 'naive' benchmarks constructed to test the total fund performance. The first is the FM index used in the last section. This is chosen primarily because the equity portfolios of the pension funds outperformed this benchmark by the greatest margin. If similar results are obtained for the total fund returns, it would indicate that the addition of asset groups other than equities has enhanced (or at least equalled) equity performance. The second is created by equally weighting the FM index, the average of all bond indices (#1 through #10 of table 4-2) and the conventional mortgage index (#11 of table 4-2). This benchmark is similar to the average weighting of a typical Canadian pension fund as reported in the FEI survey (1978). The third is found by weighting the returns of the three indices by the actual market values of their asset classes. This benchmark represents a weighted average return where market weights change each quarter.

Table 5-11 reports the results using nominal geometric returns. The results demonstrate that the managers of the pension funds studied herein have not shown any ability to outperform the proxy for the market portfolio. Comparison of the results for the FM index in tables 5-3a and 5-11 indicates that the inclusion of asset groups other than equities has actually reduced the number of pension funds outperforming the FM index on a risk-adjuted basis. The results for benchmark portfolio #2 indicate that a 'naive' strategy of investing in an equally weighted equity, bond and mortgage portfolio has outperformed most of the actively managed funds. The results using benchmark #3 are similar to those obtained using benchmark #1.

Table 5-11

THE NUMBER OF PENSION FUNDS THAT OUTPERFORMED THE BENCHMARK PORTFOLIO (JANUARY 1970 TO DECEMBER 1979) FOR A 1 QUARTER HOLDING PERIOD - TOTAL FUND RETURN

Benchmark Portfolio* #	Performance Measure: Sharpe	Treynor	Jensen	C_p	β_{p2}	RSV	RHV	BAI	MVS	Av.Ret.
1	25	31	31	1	1	25	25	24	7	1
2	6	11	11	1	0	7	7	7	16	14
3	32	37	36	2	0	32	32	32	20	35

*

#1 = FM
#2 = Equally Weighted FM+Bonds+Mortgage Index
#3 = Value Weighted FM+bonds+Mortgage index

H. CONCLUSION

This chapter evaluated in detail the performance of the equity portfolios of Canadian pension funds. Some preliminary results based on the total fund returns were also reported. The performance evaluation was based on ten risk-adjusted measures suggested in the literature. The results were presented for three holding periods, four benchmark portfolios and two types of returns. Separate anlyses were conducted for the entire period's data and subsequently for two sub-periods. Sensitivity tests for the thin trading effect and the estimation procedure were carried out in order to evaluate the robustness of the results. Tests for investigating the bias and ambiguity in these measures were also conducted.

In the case of the equity portfolios it was found that over the entire period from January 1970 to December 1979, pension fund managers have not shown any significant ability to achieve superior performance relative to any of the four benchmark portfolios. The RHV, RSV and RMA measures showed results similar to the ones based on the Sharpe measure. There was also no indication of superior market timing ability of the pension fund managers. The MVS measure provided some indication that fund managers may be concerned with skewness. Overall, the Sharpe, Treynor and Jensen measures provided the results without any loss in generality. The results were found to be quite robust across the assumed holding periods, although some deterioration in performance was found when the holding period was increased from one to four quarters.

The split period analysis showed that the fund managers' performance was slightly better in the 'down-market' period than in the 'up-market' period. On average, however, less than 10% of the fund managers were consistent superior performers. Without additional data on the composition of the portfolios, it is not possible to analyze which funds exhibited consistently superior performance in this sample. Overall, however, there was no evidence of consistent superior performance by the fund managers.

The results of the cross sectional regressions show no significant bias associated with the traditional mean-variance based measures. Contrary to previously reported results, the measures based on the asymmetric return distribution displayed significant biases. The biases were slightly higher during the first half of the time period under consideration. These results indicate that the bias in the performance measures is data specific.

The empirical analysis of the ambiguity of the performance measures showed that the rankings were quite robust to the choice of both particular risk measure and the benchmark portfolio. Analysis over the entire period suggests that the ranking of portfolios based simply on average returns would have been similar to those based on risk-adjusted measures for this particular time period. Split-period analyses, however, suggest that risk adjusted measures would provide a better set of rankings in periods of positive risk-return relationships. Thus, contrary to recent criticisms, the CAPM based performance measures are 'robust' and provide a consistent set of rankings when compared with widely diversified benchmark portfolios.

The preliminary results based on the total fund returns also suggest that the pension funds in this sample have not been able to outperform the three naively selected portfolios. More testing is, however, necessary before any definitive statements can be made.

CHAPTER 5 - FOOTNOTES

1. See, for example, Friend and Blume(1970), Jensen(1969), Lintner(1965), Mains(1977) and Sharpe(1966).

2. See, for example, Ang and Chua(1979), Grant(1976), Jensen(1968), Kon and Jen(1979) and Treynor and Mazuy(1966).

3. See Mayers & Rice(1979), Peterson & Rice(1980), Roll(1978,1980), Rosenberg(1980), Rudd and Rosenberg(1980). Section D-2 of this chapter provides the essence of this controversy.

4. There is strong evidence to suggest that this is indeed the norm. Responses to a confidential survey questionnaire sent to the Canadian pension-sponsoring firms by a prominent performance measurement service, showed that none of the firms explicitly considered the nature of the firm earnings in devising pension fund investment strategy. A similar observation is given in Rudd & Rosenberg (1980, p.598) in the case of U.S. firms.

5. See for example, Treynor (1965), Sharpe (1966), Jensen (1968, 1969), Smith and Tito (1969), Grant (1976), Peasnell etc. (1980). Also see Murphy (1977), Mains (1977), McDonald (1974) for evidence on superior performance.

6. The non-parametric test requires information about the manager's forecast of the return on the market portfolio. Since no such information is available, only the parametric test will be conducted in this study.

7. See, for example, Arditti (1967, 1971, 1975), Hanoch and Levy (1969, 1972), Gaumitz (1970), Ingersoll (1975), Jean (1971, 1973), Lee (1976).

8. Porter (1974), Hogan and Warren (1974), Klemkosky (1973), Nantell and Price (1979) have tried to justify the semi-variance framework by assuming that investors are risk-averse (i.e. have a decreasing marginal utility) for all returns below R_{min} and risk neutral (i.e. have a constant marginal utility) for returns above R_{min}.

9. Levy (1969) has criticized cubic utility as an argument for skewness preference, since cubic utility does not exhibit decreasing marginal utility for all wealth levels.

10. Their framework has led to the following valuation model:

$$\tilde{R}_{it} - \tilde{R}_{ft} = C_{0i} + C_{1i}(\tilde{R}_{mt} - \tilde{R}_{ft}) + C_{2i}(\tilde{R}_{mt} - E(\tilde{R}_{mt}))^2 + \tilde{e}_{it}$$

11. Ang and Chua (1979) have given a rationale for using the benchmark in the form of ex-post market premiums for risk and skewness. Citing Evans and Archer (1968), they argue that if an investor always has an alternative of getting the market return, then the market return must be the minimum return that should be earned.

12. Note that all these studies have been carried out for the U.S. market, no such studies are available for the Canadian market. It is, therefore, assumed that the Canadian markets are similar to the U.S. markets. The actual verification of such an assumption is beyond the scope of this study.

13. The study referred to the empirical research of Mandelbrot (1963) and Fama (1965).

14. For theoretical developments, see Whitmore(1970), Jean(1971), Hanoch & Levy(1969), Hadar and Russel (1969) and for empirical studies see, Levy and Sarnat(1970), Porter and Joy(1974), Porter(1973,1974), Tehranian(1980).

15. The Kolmogrov-Smirnov goodness of fit test conducted here for the sample of the 77 portfolios showed only one fund differing from the normal distribution.

16. See Jensen(1969), Cheng and Deets(1973), Jacob(1973), Lee(1976) for a discussion on the effects of investment horizon on CAPM based risk measures.

17. See, for example, Roll(1978, 1980, 1981), Ross(1978a, 1978b), Fergusson(1980).

18. This is the basis for Mayers and Rice (1979) argument.

19. See Gibbons (1980), Kryzanowski and To (1983, forthcoming) and Roll (1981).

20. This may suggest that the ranking of portfolios will be insensitive to the particular choice of the benchmark portfolio.

21. The efficiency concept is quite often misunderstood. For example, the growth of index funds is sometimes attributed to their mean-variance efficiency. This is

false. Index funds exist to provide a portfolio which corresponds to a broadly based index at a low management fee.

22. Cornell (1980) argues that the CAPM framework, can only be used to differentiate betwen superior and inferior performers relative to the market index used, but no further gradations in the ranking are possible.

23. Note that the discret time compounded rate of return R, can be calculated from i = ln (1 + R).

$$\ln (1 + R) = \ln \left(\frac{CMV}{OMV}\right) + \sum_{j=1}^{m} \ln \frac{V_j}{V_j + C_j}$$

$$\text{or} \quad R = \frac{CMV}{OMV} \cdot \prod_{j=1}^{m} \frac{V_j}{V_j + C_j} - 1$$

24. Use of the arithmetic mean was suggested in the BAI study (1968). The use of the geometric mean is more prevalent since it 1) overcomes the inherent problem with the arithmetic mean and 2) is easier to relate to changes in unit value.

25. This was done in order to avoid the problems associated with multi-manager funds.

26. The significance test for β_{pt} requires that the residuals be normal. Using the Lilliefors test for normality (Pfaffenberger-Patterson, 1977,p.687), the residuals were found to be normally distributed.

27. An additional estimation procedure for risk-return estimates was also performed. In this procedure, the estimates for expected return and risk parameters (such as the standard deviation) were calculated using alternate observations, that is , even (odd) observations were used to estimate risk and odd (even) observations were used to estimate risk. The details of this procedure are described in Roll and Ross (1981). This estimation procedure tries to eliminate the bias, if any, introduced by using the same observations in estimation of return and risk. The results using this procedure,however, were quite ambiguous, depending upon which pair of even-odd observations was used for estimation purposes. Any conclusions based on such a procedure therefore must await additional testing with longer time series data.

28. In this test, the rankings under each measure are compared based on each period. A coefficient of 1.0 indicates perfect consistency and -1.0 indicates perfect inconsistency.

29. As shown by Johnston (1972, p.21) the covariance between α and β will be negative. The degree of bias in this study, however, is much smaller than that found by Friend and Blume (1970).

30. Strictly speaking, 'W' was probably intended primarily as a measure of 'agreement in ranking' in the b blocks, rather than as a test statistics. See Conover(1971) pp.270-271.

CHAPTER 6. MAJOR FINDINGS, IMPLICATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This dissertation has dealt with four issues affecting ESPPs: a) the rationale behind their existence and growth, b) the impact of taxation on their funding, c) an investment policy model for such plans and d) an empirical investigation of historical performance of a sample of Canadian pension funds.

Three main paradigms for the existence of ESPPs were examined. No single paradigm alone explains the ESPP phenomenon, however, one can consider a combination of employee turnover costs and tax advantages as the main forces behind their growth. The establishment of individual RRSPs has important implications for the growth and the nature of ESPPs. In the presence of uncertain inflation and investment returns , employees will be willing to negotiate for the defined-benefit ESPPs in which the retirement income is based on the final average wage, as these plans provide them with wage-indexed income not otherwise available. The employers' willingness to provide such a contract will depend upon the negotiated premium (via current wage reduction), the availability of indexed investment vehicles (such as the indexed bonds available recently in U.K.) and the possibility of government legislation retroactively changing the terms of negotiated contracts. It is possible that a combination of these factors may result in the employer preferring a defined contribution plan, thereby shifting the implicit inflation risk on to the employees.

The lack of empirical data seriously hampers detailed analysis of these issues. Thus, a number of issues, require further research: a) How do the employees and shareholders value ESPPs, b) how do they affect labour negotiations and firm valuation? c) How do vesting requirements and labour turnover affect employee participation in ESPP ? d) What effect, if any, does the employee's personal portfolio have on the fundedness and investment policy of an ESPP? e) how homogeneous is labour in valuing the tradeoff between current and deferred wages? and, f) how would the government's involvement (via an introduction of a compulsory insurance agency, or immediate vesting and post-retirement indexing regulation) affect the future growth of the ESPPs?

The tax treatment of ESPPs affects not only their introduction, but also their funding and investment decisions. The issues become even more complex when personal and corporate taxes are considered. The analysis in Chapter 3 indicates that, from the firm's viewpoint, the advance funding decision may rest primarily upon the expected rate of return on the pension fund's assets and on the firm's operating assets. Only if the pension fund provides the sole opportunity for increasing the firm's debt load, will the financing of the pension fund and the subsequent investment decisions be interlinked.

The determination of the optimal funding level is further cpmplicated by other parameters such as uncertainty in capital and product markets, the firm's existing capital structure, the portfolios and tax positions of its shareholders, the effect of the funding policy on wage negotiations and government regulations. The analysis indicates that, with the existing tax treatment, the pension funds should be fully funded or even overfunded. The reasons for the reported underfundedness of some of the existing plans include a) use of an underfunded pension plan as a risk sharing mechanism between employee and the firm, b) the inability of the firm to negotiate its wage contract when changing the funding level, c) the inability of the fund's investments to earn higher rates of return than available on the firm's operating assets, d) the inability of firms to raise enough capital to fund the pension plan and benefit from possible tax arbitrage, and e) possible future government involvement which would effectively reduce the benefits of full funding.

The model for pension fund's investment policy integrated the pension fund assets with the firm's operating assets. Treating the funding decision and the nature of the firm's operating assets as exogenous to the pension fund investment decision, the model concentrated on maximizing a mean-variance preference function based on the combined end of period value of the fund's assets and the firm's operating assets subject to a 'consolidated' risk constraint. Operationally, this is equivalent to maximizing the return on the fund's portfolio subject to a risk constraint. The optimal composition of the fund's portfolio under this model is firm-specific and the inclusion of a risky asset in the fund's portfolio depends upon the variance of its return, the covariance of its return with the return on the firm's operating assets and with the existing portfolio, the proportion of the fund's assets to total assets, and the choice of the 'consolidated' risk level.

The actual choice of risk level depends upon the firm's management. Several factors must be considered in selecting an appropriate risk level; these include: a) the nature of the portfolios of the firm's shareholders, b) the nature of employees' portfolios and their impact on future wage negotiations, and c) the nature of the firm's operating assets.

The model was operationalized by selecting a universe of 192 Canadian common stocks and 11 bond portfolios. the computational requirements of the quadratic programming are so great that hierarchical clustering was used to group the common stocks into 37 homogeneous groups. The return-risk parameters were estimated from historical data and the impact of the proposed investment model on the pension fund portfolios for four Canadian firms was investigated. The results indicated that the optimal fund portfolios were both firm specific and widely different for different firms with respect to both asset mix and the composition of each asset group. The minimum variance portfolios indicated that it is not necessary for all firms to hold bonds in their pension fund portfolios.

Sensitivity analysis was conducted to study the effect of a) the nature of the firm's operating assets, b) the diversification constraint and c) the proportion of pension fund assets to total assets, on the compostion of their funds' portfolios. The results again showed the importance of firm-specific parameters in portfolio composition. In the absence of any diversification constraint, the proportion of bonds in the fund portfolios decreased considerably. An increase in the funding level for the fourth firm resulted in an increase in bond investment with only minor changes in the compositon of the asset groups.

Several avenues for further research are open. On the theoretical front, the choice of an appropriate objective for the firm facing imperfect capital markets and heterogenous investors (obviously with heterogenous portfolios) and the issue of shareholder unanimity about funding and investment policy are obvious choices. Many empirical problems need further examination. Efficiency criteria need be developed for the various grouping procedures and more work (in the areas of cluster stability and predictive ability) must be done with the hierarchical clustering technique used in this study. Separable programming techniques need be investigated for linearizing the objective function of the model to reduce the computational requirements. Refinements of the process for the determination of the relationship between the returns on the firm's assets and the securities' returns will also improve the optimality of the fund's portfolio. Further extensions are also possible by analyzing a multi-period model to determine the impact of changes in the firm's assets on the long term investment policy for the fund's portfolio. Obviously, the most useful exercise would be the application of this model to the pension fund of a specific firm.

If a firm adopts an investment policy based on the proposed model, it will affect its performance measurement process. First, it will have to evaluate the forecasts of the expected returns and risks of the securities included in the universe in conjunction with the return and risk of the firm's assets. Secondly, as the fund's portfolio is firm specific, a simple comparison of its performance with other funds or market proxy will be inadequate and, therefore, it will have to construct a firm specific benchmark portfolio to evaluate the fund's investment performance.

Finally, the empirical testing of pension fund performance indicates that, during the period 1970-1979, the equity portfolios of the pension funds in the sample have not shown any significant ability to achieve consistently superior performance relative to a 'naive' buy-and-hold portfolio strategy. The conclusions are robust across holding periods, choice of benchmarks, choice of performance measures, time periods, and estimation procedures for the parameters. Preliminary results on the evaluation of total fund returns also indicate non-superior performance by the funds studied.

Further refinements of the study are possible. Additional work is required to improve the risk and return estimation procedure. Total fund performance measures should include the effects of asset mix changes and portfolio turnover. The study can also be extended by investigating the actual composition of the portfolios in each asset group. With better information about the fund composition and investment philosophy, it is possible to create fund-specific benchmarks to improve the evaluation of the total fund performance. This would also be necessary if the funds were to follow the investment model proposed in this study.

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