

CAN CANADIAN INVESTORS STILL BENEFIT FROM INTERNATIONAL DIVERSIFICATION: A RECENT EMPIRICAL TEST

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ABSTRACT

This thesis examines whether Canadian investors can still benefit from international diversification in the period from January 1996 to September 2006, using monthly nominal and real returns for different asset classes of Canada, US, UK, Japan, and Hong Kong.

Under Markowitz's mean-variance analysis framework, we scrutinize the benefit of international diversification in terms of the improvement of expected return and the decrease in standard deviation. Comparing the optimization results from nominal returns and real returns, we find that while the magnitude of improving expected return and reducing risk is quite limited in this period, Canadian investors can still benefit from the international diversification by hedging domestic inflation risk, since the Canadian stock market does not represent their consumption basket well. Our empirical results also indicate that international bonds, compared with international stocks, have stronger power to improve the expected return and to reduce the risk level of portfolio.

DEDICATION

We would like to dedicate this work to our family members. Without their strongest support, this paper would not have been completed.

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1 INTRODUCTION

1.1 International Diversification Debate

Previous studies have discussed the benefits of international diversification. Many academics consider that such benefits are important to investors, while some researchers argue the diversification benefits are decreasing. Our thesis aims to scrutinize whether the benefits from global diversification still exist from a Canadian perspective.

The outstanding performance of the Canadian stock market in recent years makes it a difficult task to convince Canadians to consider foreign investments. However, as of the end of 2005, the Canadian domestic equity market capitalization only represents 3.62%¹ of the total world equity market capitalization. This shows the huge potential for Canadian investors to diversify their holdings internationally.

Moreover, in terms of the distribution of market capitalization, the Canadian stock market primarily concentrates on energy, materials, and financial service industries. This characteristic implies that it is essential for Canadian investors to diversify risks by investing abroad. Otherwise, Canadian investors will inevitably experience business cyclical fluctuation due to the nature of world economy.

Theoretically, the international investing practice is strongly supported by Markowitz's modern portfolio theory and Solnik's international portfolio diversification theory. By investing in foreign securities, Canadian investors can share the growth of global economy and hedge their consumption basket against inflation risk. Even if these advantages seem attractive, the risks of

¹ The source is A-.11 Domestic Market Capitalization, 19/05/2006, World Federation of Exchange Statistics.

and constraints for international portfolio diversification cannot be ignored. In a global capital market, investments are not only subject to currency risk, but there are many barriers like tax issues and inflation issues. These constraints, typically the currency risk and inflation risk will be taken into consideration of our project

1.2 Canadian Investors' Investing Preference

The fact that Canadian investors can take advantage of increasing international portfolio diversification is one thing, but whether they intend to do so is another. In many countries the proportion of portfolio assets that investors allocate to foreign assets is consistently less than mean-variance analysis forecasts – a phenomenon called “home (asset) bias”. Canada is not an exception when it comes to home bias.

Canadian investors prefer to invest in the domestic capital market, even though the most diversified and efficient capital market – the US – is right next door. Table 1 displays Canadian investors' international portfolio investment position in the period 1996-2005. Compared with the substantial domestic investment, the amount that Canadian investors directly hold in foreign stocks and bonds is negligible. Nonetheless, it is notable that Canadian investors in general held much more foreign stocks than foreign bonds, especially between 1996 and 2000, and that the holding of foreign bonds significantly increased during the period of 2001-2005 and the stock position gradually declined at the same time. The change in investing preference partly reflects the different moving of Canadian stock market and of some other foreign markets like US and UK.

Table 1 Canada's International Portfolio Investment Position (CAD\$ mil)

	Foreign Stocks	Foreign Bonds	Total
1996	87010	21263	108273
1997	103780	26586	130366
1998	124151	33254	157405
1999	149040	30734	179774
2000	173572	35640	209212
2001	200892	38870	239762
2002	216307	45392	261699
2003	196920	45740	242660
2004	195573	58567	254140
2005	189175	82374	271549

Source: CANSIM II Series, Table No. 3760037

This investors' preference for domestic over foreign assets has been documented by many authors (including French and Poterba (1991), Tesar and Werner (1994), and Cooper and Kaplanis (1994)). These researchers claim that investors who adopt such biased allocation strategies may suffer from a lower rate of return and higher risk. Many Canadian investors base their decision to diversify internationally on their potential to earn higher excess returns rather than on what the modern portfolio theory predicts. If Canadian investors start to consider diversifying into international markets, they may tend to choose more developed markets like the US, UK and Japan. This is the main reason why we examine 4 foreign developed markets—US, UK, Japan, and Hong Kong in this project, even though it is well known that these markets are highly correlated.

1.3 The Measurement of International Diversification Benefits

In our research, we use two methods to measure the international diversification benefits. The first measure estimates the additional return expected by Canadian investors when moving from an optimal domestic portfolio to the international investment portfolio, holding the risk or standard deviation of both portfolios constant. First, we construct the optimal domestic portfolio,

which is composed of Canadian stock, Canadian bond and Canadian 91 day T-Bills, serving as a benchmark. Second, given the standard deviation of this optimal domestic portfolio, we test the extent of improving expected return by adding international assets, which include stocks and bonds from the markets of U.S, U.K, Japan and Hong Kong.

The second measure of diversification benefits is the reduction in risk from international investments. Similarly, given the expected return of this optimal domestic portfolio, we examine the magnitude of decreasing the standard deviation for the portfolio including international stocks, bonds, or both.

In the section of Data and Methodology, we will elaborate these two measures in the form of mathematics.

1.4 Our Empirical Research

The purpose of our research is to test whether Canadian investors could still benefit from international portfolio diversification in the last decade. Many empirical studies focusing on the potential for benefits from international equity diversification have examined the linkages among various national equity markets using correlation analysis. However, in this thesis we explore whether such benefits existed for Canadian investors in the last decade by comparing the empirical results in terms of nominal return and the Canadian inflation rate-adjusted real return.

Abidin et al. (2004) conducted research on the topic of international diversification benefit from a Malaysian perspective. Their study considered currency risk in the portfolio construction; they also developed a computer programme to plot the efficient frontier for the purpose of their study. In their paper, besides comparing the internationally diversified portfolio to a locally diversified portfolio, countries are also grouped into those of developed and emerging nations to evaluate the benefits of diversifying into a group of countries.

Our research is similar to their study in several respects. For example, we establish a pure domestic optimal portfolio as the benchmark to compare the results from those portfolios with different international assets. We also divide the sample period into sub-periods.

However, our study differs from theirs in four ways. First, we examine the benefits of diversification from the Canadian perspective, where we take into account the impact of the fluctuation of foreign exchange rate on the portfolio returns and the domestic inflation risk. In other words, all the local-currency asset returns had been converted into CAD\$ before being examined. This is derived from two basic behaviours of Canadian investors: the report of their foreign investment income calculated in CAD\$ for their annual income taxation and the coverage of their domestic consumption. Second, we examine the impact of inflation risk on the international asset allocation in the sample period. This is driven by the relatively undiversified nature of the Canadian stock market. Unlike the US stock market, the Canadian stock market is less diversified and highly concentrates in financial, energy and mining industries, which cannot effectively represent the general consumption of Canadian households. One way to hedge inflation risk of their domestic portfolio is to diversify their investment in foreign developed markets, which cover more sectors related to their consumption. While sector research is not conducted in this thesis, we attempt to examine this benefit of international diversification by comparing the optimization results using nominal returns and real returns respectively. Third, our research includes the analysis of Canadian investors' investing preference, by which we select the sample markets. Finally, we adopt geographical diversification and asset-class diversification as well. A risk-free asset, stocks, and bonds are available for Canadian investors to optimize their portfolio.

Our research provides two main contributions. First, we extend the literature on international portfolio diversification from the Canadian perspective rather than from the more traditional U.S. perspective. Second, we provide new evidence for the impact of inflation risk on

international portfolio diversification by comparing results using nominal returns with real returns.

The remainder of this project proceeds as the following: Section 2 reviews past literature on the topic of benefit of international portfolio diversification and modern portfolio theory. Section 3 describes the data sample and elaborates our research methodology. Section 4 presents the empirical results and the comprehensive analysis. Section 5 concludes.

2 LITERATURE REVIEW

2.1 Theoretical Basis

Modern Portfolio Theory (MPT) by Harry Markowitz and theory of international portfolio diversification by Bruno Solnik constitute the theoretical foundation of our study.

Modern Portfolio Theory (MPT) was first introduced by Harry Markowitz in 1952. MPT (commonly referred as mean variance analysis) became a norm among the investment industry. Gupta et al. 2002 outline in their works that MPT has wide application in financial management. They also conclude that MPT is based on the premise that investors pursue high return and low risk.

Markowitz is also the first one who started the study of international diversification within an MPT framework. Later on, with the development of international capital market, the theory of international portfolio diversification was generated. Grubel (1968), who proves that MPT can be applied to cross-border investments and there are benefits to be made through such diversification. Bruno Solnik (1974) put MPT under the international equity scenario and formed theory of international diversification. Solnik also clarifies the difference between global investing and international diversification and he initiates the discussion of the growing importance of industry factors as opposed to country factors in determining portfolio return and risk.

2.2 Research Supporting International Diversification

The existing empirical work on international portfolio diversification benefits usually looks at global diversification benefits from a US investor's perspective (See Huberman and

Kandel (1987), Bekaert and Urias (1996), and DeRoos, Nijman, and Werker (2001) and Li, Sarkar (2001)).

The merits of international diversification were recognized by researchers as far back as the 1960s. Grubel (1968), Lessard (1973), Solnik (1974) and Eun and Resnick (1988) have disclosed the benefits of international diversification by using the framework of mean-variance analysis.

Many other researchers contributed to the support for international diversification among the major global markets. They found that investors would do better by holding a diversified portfolio in international major equity markets, rather than focusing on a single market.

Recent studies on international diversification have included diversification into the emerging markets of Asia Pacific and South America. Bailey and Stulz (1990) researched the potential of international diversification from the perspective of an American investor by looking into the markets of nine Pacific Basin countries such as Australia and South Korea. They found that global diversification is possible when stock markets are not highly correlated and do not move in same trend with each other. Their conclusion is that a portfolio with international contents generates a higher return and reduces overall risk than that of only investing in the US stock market.

Abidin et al. (2004) studied the international diversification benefit from a Malaysian perspective. They collected return data of weekly closing figures of 20 stock market indices over a 17-year period from January 1987 to December 2003. Their main concern of the study is to create a portfolio of stock market indices that maximises return at a given level of risk, or minimises risk at a given level of return. For the purpose of their study, a new computer programme called the Efficient Frontier Calculator has been developed. The programme is able to calculate the weights of assets in an optimal portfolio and plot the efficient frontiers.

Their objectives of the study include evaluating the potential gains through international portfolio diversification from a Malaysian perspective and incorporating the effect of currency exchange rate uncertainty as well as price volatility on international equity investments. However, their findings are not in strong support of international diversification to Malaysian investors.

2.3 Studies Questioning International Diversification

Meanwhile, a number of related studies question the benefits of international diversification from a U.S. perspective. Britten-Jones (1999) demonstrates that the U.S. index is highly correlated to those of developed equity markets like UK, Japan, etc. Therefore the co-movement will diminish the benefit of global investing. Errunza et al. (1999) find that the gains of international diversification can be realized through investing in multinational companies, American depository receipts (ADRs) and country funds, thus the importance of international diversification is decreasing. De Roon et al. (2001) find that the diversification benefits in emerging markets are limited when short-sale constraints are imposed or transaction costs are considered. Ang and Chen (2002) and Ang and Bekaert (2002) point out that international stock market correlations are asymmetric, i.e. correlations are substantially higher in bear markets than during bull markets. This evidence for those who suspect the benefit of international diversification is very strong because investor need the diversification benefits from international investing the most when their domestic market is under a low-return period, if it is not available at this unfavourable time, the idea of international diversification will be in doubt.

Nearly all these studies reach similar conclusion: international diversification benefits are possible for US investors but are often reduced if currency risk and inflation risk are included in the research.

2.4 Research from Canadian Perspective

Research on the benefits of international portfolio diversification from a Canadian perspective is rarely seen from the academic journals. Among the few articles, Kanas (1998) provides evidence that there exist long-run benefits for a Canadian investor from diversifying in the equity markets of the US, Japan, and the six largest European stock markets including those of the UK, Germany, France, Switzerland, Italy and the Netherlands. The evidence Kanas identifies is based on tests for pairwise cointegration between the Canadian national equity index and the equity index for each of the other markets. His motivation for adopting a Canadian investor's viewpoint comes from the fact that a significant part of Canadian investors adopts diversification benefits as the primary criterion in investing outside Canada. Kanas finds that there is a considerable interest both by Canadian investors in foreign equities and by foreign investors in the Canadian equity market.

Kanas' finding of no co-integration can be interpreted as evidence that there are no long-run linkages between the Canadian and each of the other markets, this implies there exist potential gains for a Canadian investor from diversifying in any of those markets. These findings are valuable to Canadian investors and financial institutions.

While Kanas results indicate possible benefit of international diversification for Canadian investors, Marmer (2003) points out over the past 10 years the correlation between international and Canadian equities has increased dramatically. He calculates the correlation between Canadian and foreign Canadian equities using three-year monthly returns to be 0.34 in 1990, 0.56 in 1995 and 0.70 in 2002. Over the three years prior to 2003, non-Canadian equity markets have substantially underperformed Canadian equities, making the case for investing outside of Canada unfavourable.

3 DATA DESCRIPTION AND METHODOLOGY

3.1 Data Description

The data consists of monthly closing price indices for Canada, US, UK, Japan, and Hong Kong from January 1996 to September 2006, giving 129 monthly returns. The selection of these international capital markets is based on Canadian investors' investing preference and geographical dispersion. The Canadian domestic equity portfolio is dominated by three asset classes --- stocks, bonds, and cash--- and is diversified by foreign stocks and bonds. Returns on the bond and stock indices are computed from the closing prices. Then, using the monthly returns, we calculate the sample mean and covariance for each asset and use these as input for the Quadratic Optimization system (QOS-15).

The stock market indices, bond indices, foreign exchange rates, and Month-on-Month percentage change in the Consumer Price Index (CPI) are obtained from Bloomberg. The closing prices of S&P/TSX, S&P 500, FTSE 100, NIKKEI, and Hang Seng are utilized to calculate monthly return of stocks in local currency for Canada, US, UK, Japan, Hong Kong. The bond market proxy is the Merrill Lynch Global Government Index, which tracks the performance of public debt of investment grade sovereign issuers issued and dominated in their own domestic market and local currency. The monthly-end 10-year Merrill Lynch Government Index for Canada, US, UK, and Japan are used to calculate their monthly bond return in local currency. However, this index does not include Hong Kong. Canadian 91 days T-Bill is from the Bank of Canada and used as the domestic money market rate.

3.2 Methodology

The purpose of this paper is to utilize an optimal strategy to identify the potential gains for Canadian investors from international portfolio diversification by improving their expected return and by reducing the risk of portfolio. The nominal returns and real returns are optimized respectively to create efficient frontiers for Canadian domestic portfolio and the international portfolio as well. The optimization results using nominal returns and using real returns will be compared to explain their different diversification effects.

3.2.1 Canadian Perspective

In order to identify the diversification benefit from Canadian investors' perspective, all the local-currency returns of foreign stocks and bonds will be translated in CAD\$ (Canadian dollar term) before being compared with the returns of the Canadian domestic portfolio. To do this, all the local-currency nominal and real returns of foreign stocks and bonds will be adjusted by the monthly foreign exchange rates. The difference in the local-currency returns and the CAD\$-dominated returns reflects the moving of the exchange rate between the local currency and CAD\$.

3.2.2 Consideration of Inflation Risk

The impact of inflation on asset returns is a big issue for international asset allocation from a long-run perspective. For Canadian investors, it is a fact that the Canadian stock market is too concentrated on the sectors like financial service, energy, and materials to reflect the Canadian consumer behaviour. If the inflation rate went up, Canadian investors could not hedge the inflation risk, since they just had very limited choice for the domestic stocks in the sectors related to the consumption, such as retailing, foods, and health care. Thus, how Canadian investors hedge the inflation risk for their domestic portfolio investment has become an important issue. Accordingly, we take into account the inflation risk for Canadian investors and examine the

impact of inflation on international diversification by comparing the empirical results using the nominal returns and using real returns. To calculate the real return of each asset for Canadian investors, the nominal returns will be deducted by the Canadian Month-on-Month percentage change of the Consumer Price Index.

3.2.3 Inclusion of a Risk-Free Asset

Our research includes a risk-free asset for Canadian investors. The main reason of incorporating a risk-free asset for Canadian investors is to create an optimal domestic portfolio that is more realistic, so that its optimal expected return and risk level can be used as the benchmark to measure the effect of international diversification.

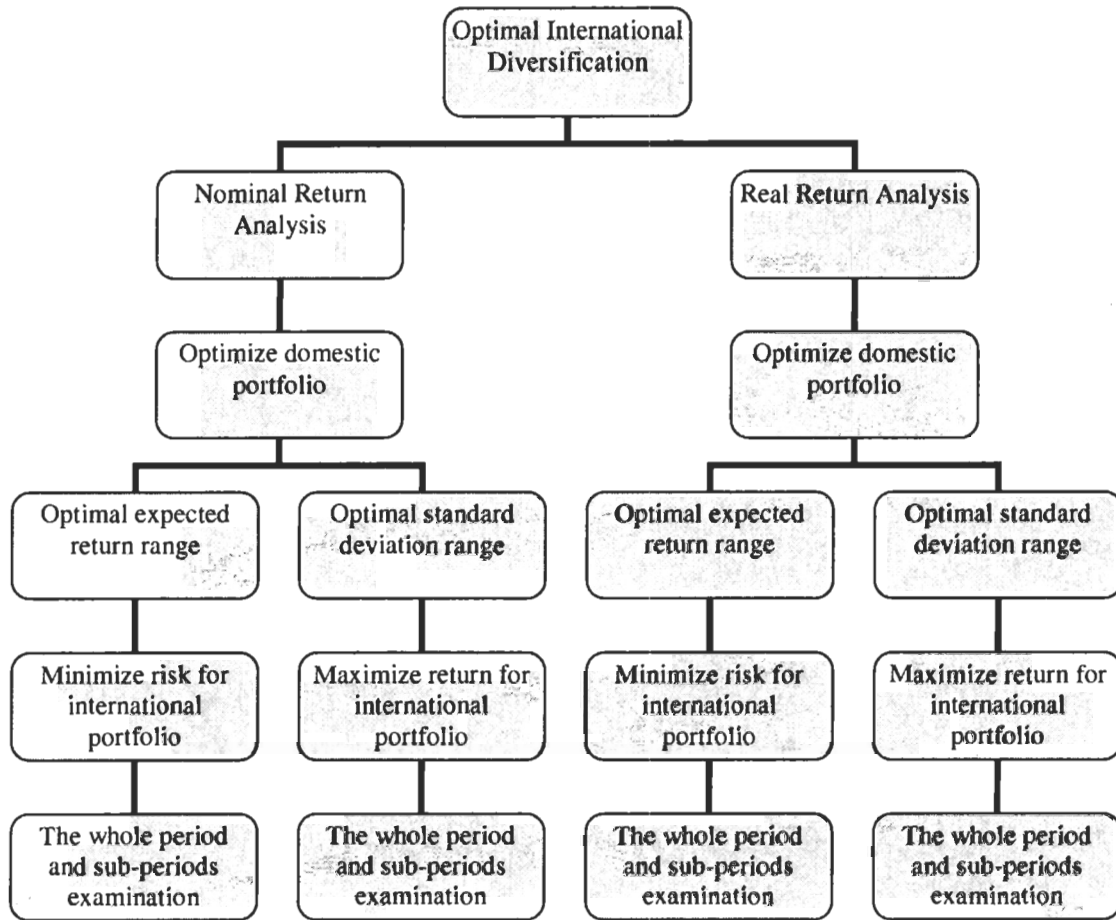
3.2.4 Short-Selling Constraint

While a frictionless market is one of the assumptions in Markowitz's mean-variance framework, we set up the restriction of short-selling in our research. This is driven by two reasons. First, even though this constraint may limit the opportunities that enable Canadian investors to gain excessive returns from the international diversification, we intend to examine the potential benefit of international diversification under restricted conditions. If such potential benefit exists, it can be extrapolated to the results without constraints. Second, while we just examine several highly correlated foreign markets in our research, there are far more foreign markets available for Canadian investors. Even though short-selling is feasible in our sample markets, it may be not applicable to some other countries in reality, especially for some developing countries.

3.2.5 Analytical Framework

The framework of methodology in this paper is shown as the Figure 1 below.

Figure 1 Optimization Steps and Analytical Framework



The optimization process in this paper includes the following steps:

Step 1, given the risk aversion value, optimizes the Canadian domestic portfolio, which includes stock, bond, and cash, to generate the optimal expected return and standard deviation as the benchmark. This process is to maximize mean-variance utility for a given risk aversion coefficient.

$$U = E(r_p) - \frac{\lambda}{2} \sigma_p^2$$

Where,

$E(r_p)$ is the expected monthly return of the portfolio

σ_p^2 is the variance of return of the portfolio

λ is the coefficient of relative risk aversion

Step2 tests the diversified effect by incorporating alone international stocks in two aspects: improving expected return and reducing risk

1) Given the Canadian optimal portfolio's standard deviation, test the extent of maximizing expected return $E(r_p)$ by incorporating international stocks

$$E(r_p) = \sum_{i=1}^n W_i R_i$$

where,

$E(r_p)$ is the expected monthly return of the portfolio, which is the weighted average expected return of each asset

$$\sum W_i = 1$$

R_i is the expected return of asset i

W_i is the weight of asset i in the portfolio and

n is the number of assets in the portfolio

Since we have set the short sales constraint, the weight of asset i , W_i , can not be negative, i.e.

$$0 \leq W_i \leq 1, \text{ for all } i = 1, \dots, N$$

2) Given the Canadian optimal portfolio's expected return, test the extent of minimizing the risk σ_p^2 by incorporating international stocks.

$$\sigma_p^2 = \sum_{i=1}^n \sum_{j=1}^n W_i W_j \sigma_i \sigma_j \rho_{ij}$$

where,

σ_p^2 is the variance of portfolio return, which is the weighted average variance of the portfolio returns

$\sigma_i \sigma_j$ are the standard deviation of asset i and asset j respectively

ρ_{ij} is the correlation coefficient of asset i and asset j

$W_i W_j$ are the weights of asset i and asset j respectively

$0 \leq W_i \leq 1$ and $\sum W_i = 1$ The constraint that short-selling is not allowed and that the portfolio is fully invested

Step 3 examines the diversified benefits by independently incorporating international bonds in the same ways as shown in step 2. In addition to the geographical diversification, this paper is also concerned about the diversification with different asset classes. Comparison of the diversified effects with international stocks and that with international bonds can reflect the different roles that these two kind of assets play in the international diversification.

Step 4 tests the integrative diversification effects with international stocks and bonds by repeating the ways of step 2 or step 3. The purpose of this step is to explore the potential largest extent of benefit for Canadian investors through both geographical diversification and asset-class diversification.

Step 5 compares the diversification effects for the whole period of 1996 – 2006 and two sub-periods as well: 1996 - 2000 and 2001 – 2006

3.2.6 The Calculation Tool

The optimization calculator is the QOS-15 software, which is a limited version of the Quadratic Optimization System (QOS) from Financiometrics Inc., San Francisco, U.S. The QOS constructs portfolios on the Markowitz mean-variance efficient frontier. It has quite a lot of features that enable to build the optimal portfolio with different objectives, such as optimize portfolio for a given risk aversion, maximize expected return for a given standard deviation, and minimize standard deviation for a given expected return. All the monthly returns with corresponding covariance matrix are as the input of the QOS.

4 EMPIRICAL RESULTS AND ANALYSIS

This section is composed by two parts. One is the results and analysis based on nominal return. Another is based on real return.

4.1 Part One: The Results and Analysis Based on Nominal Return

4.1.1 The Whole Period 1996-2006

The summary statistics shown in Table 2 indicate that the monthly mean return of Canadian stocks and bonds outperformed other foreign assets in the period of 1996-2006. The mean returns here have been translated into the CAD\$-dominated returns. Among the foreign assets, UK Bond's mean return is the highest and Japan stock's return is the lowest. The statistic summary to some extent explains why there is resistance among Canadian investors for the international diversification.

Table 2 Statistic Summary 1996-2006

	Mean Return	Median	Standard Deviation
Canada Stock	0.007860	0.014585	0.046594
Canada Bond	0.007929	0.007648	0.021013
Canada Cash	0.003005	0.002812	0.000899
US Stock	0.005008	0.005026	0.040414
US Bond	0.004472	0.003990	0.029680
UK Stock	0.004315	0.005583	0.036257
UK Bond	0.007454	0.005336	0.032522
Japan Stock	-0.002550	-0.002988	0.061032
Japan Bond	0.001851	0.000159	0.037686
HK Stock	0.004245	0.006631	0.071512

The correlation matrix in Table 3 is consistent with other recent research in regard to the international diversification. There is no surprise that Canadian stock and the other developed stock markets are highly correlated. US stock has the highest correlation with Canadian stock with the coefficient 0.66 and Japan stock has the lowest with the coefficient 0.4.

Table 3 Correlation Matrix 1996-2006

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	0.1564	1.0000			
Canada Cash	-0.0743	-0.0547	1.0000		
US Stock	0.6583	0.0622	0.0407	1.0000	
US Bond	-0.3504	0.5878	0.0783	-0.1378	1.0000
UK Stock	0.4863	-0.0068	-0.0454	0.7074	-0.0942
UK Bond	-0.3043	0.3825	0.0056	-0.1184	0.6691
Japan Stock	0.4030	0.0457	-0.0561	0.4055	-0.0511
Japan Bond	-0.1453	0.0975	0.1046	-0.0364	0.3496
HK Stock	0.5939	-0.0043	0.0162	0.5425	-0.2157

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.1324	1.0000			
Japan Stock	0.3283	-0.0677	1.0000		
Japan Bond	0.1040	0.3624	0.2701	1.0000	
HK Stock	0.5094	-0.1401	0.4229	0.0857	1.0000

Panel A of Table 4 shows the optimal domestic portfolio generated by QOS according to the nominal return data. The Expected Return of domestic portfolio ranges from 0.005015 to 0.007922. The standard deviation of domestic portfolio ranges from 0.008183 to 0.020108. Panel B is the optimization result including international assets. When the domestic portfolio is added by international stocks only, the expected return range of the expanded portfolio is almost the same and the corresponding standard deviation range is slightly lower. When being added by the

international bonds only, the new portfolio has a slight improvement on the lower bound of the expected return range with the upper bound unchanged, but its lower bound of the standard deviation range is significantly lower with the upper bound constant. Similarly, added by both international stocks and bonds, the result is the same as that of adding international bonds.

In general, Table 4 illustrates the result that adding international assets to the optimal domestic portfolio will bring Canadian investors benefits of either lowering volatility in the given expected return level or increasing a little bit return level in the given standard deviation level.

Table 4 The Optimization Results 1996-2006

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.005015 – 0.007922	0.008183 – 0.020108
Panel B		
International Stocks	0.005016 – 0.007922	0.008180 – 0.0020106
International Bonds	0.005134 – 0.007922	0.007724 – 0.0020106
International Stocks & Bonds	0.005134 – 0.007922	0.007724 – 0.0020106

Note: We set the risk aversion range from 30 to 1, with 30 points on the frontier.

Table 5 shows the extent of reducing risk by the portfolio included international assets if we hold the expected return level of domestic portfolio at 0.007611. We see from the Table 5 that by adding any international content to the optimal domestic portfolio it can reduce the volatility to some extent, and the strongest effect is found in international bonds.

The benchmark portfolio is the Canadian domestic optimal portfolio which has an expected return of 0.007611, a standard deviation of 0.018793, and a Sharpe Ratio of 0.244303, as shown in Panel A. The optimal weights for different asset classes are 11.49% for Canadian stock, 82.2% for Canadian bond and 6.29% for the cash position, as shown in Panel B.

For the optimal domestic portfolio adding international stocks alone causes the standard deviation to drop a little from 0.018793 to 0.018789 and the Sharpe Ratio increases from 0.244303 to 0.244333. The optimal weights for different asset classes are 11.09% for Canadian

stocks, 82.34% for Canadian bonds, 5.54% for the cash position, and 1.03% for UK stocks. This portfolio only differs from the pure domestic portfolio by adding merely 1% or so UK stock and the weight changes for the three Canadian assets compared with those of the pure domestic portfolio can be ignored

For the optimal domestic portfolio adding international bonds only, the standard deviation drops a further bit from 0.018793 to 0.017738 and Sharpe Ratio increases a further bit from 0.244303 to 0.258817. The weights for different asset classes are 15.08% for Canadian stock, 58.69% for Canadian bond, 4.17% for cash position, and 21.34% for UK bond. This gives us an impression that adding UK bond brings more benefits for diversification compared with that of adding stock only

For the optimal domestic portfolio including both international stocks and international bonds, the diversification effect keeps the same as that of domestic portfolio plus international bond only. The standard deviation drops to the same level of 0.017738 and the Sharpe Ratio keeps the same of 0.258817. All the asset class weights stay exactly the same, namely, 15.08% for Canadian stocks, 58.69% for Canadian bonds, 4.17% for the cash position, and 21.34% for UK bonds.

Table 5 Minimize Risk Given Expected Return 1996-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Standard Deviation				
Expected Return	0.007611	0.007611	0.007611	0.007611
Standard Deviation	0.018793	0.018789	0.017738	0.017738
Sharpe Ratio	0.244303	0.244333	0.258817	0.258817
Panel B: Optimal Weights				
Canada Stock	11.49%	11.09%	15.80%	15.80%
Canada Bond	82.22%	82.34%	58.69%	58.69%
Canada Cash	6.29%	5.54%	4.17%	4.17%
US Stock		0		0
US Bond			0	0
UK Stock		1.03%		0
UK Bond			21.34%	21.34%
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the expected return 0.007611 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Table 6 displays the results of improvement in expected return for the portfolio included foreign assets, given the standard deviation level of the domestic portfolio at 0.018793. We can see from the Table 6 that by adding whatever international content to the optimal domestic portfolio it can increase the return level to some degree.

As shown in the Panel A, for the optimal domestic portfolio adding international stocks only, the expected return increases a little from 0.007611 to 0.007612 and the Sharpe Ratio increases from 0.244303 to 0.244333. The weights for different asset classes are 11.09% for Canadian stocks, 82.36% for Canadian bonds, 5.52% for the cash position, and 1.03% for UK stocks, as illustrated in Panel B. This portfolio only differs from the pure domestic portfolio by

adding merely 1% or so UK stock and the weight changes for the three Canadian assets compared with those of the pure domestic portfolio are not significant

For the optimal domestic portfolio adding international bonds only, the expected return increases further from 0.007611 to 0.007849 and the Sharpe Ratio increases from 0.244303 to 0.244333. The weights for different asset classes are 14.65% for Canadian stocks, 70.64% for Canadian bonds, and 14.71% for UK bonds. This suggests that adding UK bonds gives more benefits for diversification benefits compared with that of adding stock only

For the optimal domestic portfolio including both international stocks and international bonds, the diversification effect keeps the same as that of domestic portfolio plus international bond only. The expected return increases to the same level of 0.007849 and the Sharpe Ratio drops from 0.24303 to 0.089808. All the asset class weights stay exactly the same, namely 14.65% for the Canadian stocks, 70.64% for the Canadian bonds, and 14.71% for the UK bonds.

Table 6 Maximize Expected Return Given Standard Deviation 1996-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.007611	0.007612	0.007849	0.007849
Standard Deviation	0.018793	0.018793	0.018793	0.018793
Sharpe Ratio	0.244303	0.244333	0.243333	0.089808
Panel B: Optimal Weights				
Canada Stock	11.49%	11.09%	14.65%	14.65%
Canada Bond	82.22%	82.36%	70.64%	70.64%
Canada Cash	6.29%	5.52%		0
US Stock		0		0
US Bond			0	0
UK Stock		1.03%		0
UK Bond			14.71%	14.71%
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the standard deviation 0.018793 of the Canadian domestic optimal portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

Combining the effects shown in Table 5 and Table 6, the portfolio included international bond is apparently stronger than that included international stocks in both minimizing risk and maximizing expected return aspects.

4.1.2 The Sub-Period 1996-2000

In order to further look into the diversification benefits in different time periods, we divide the sample period into two sub-periods, one is from 1996 to 2000 and another is from 2001 to 2006. The statistic summary in Table 7 suggests that in the period of 1996-2000, prior the crash of internet bubble, there were strong bullish markets in our sample countries or regions, except for Japan. All the mean returns are higher than their 10-year average level, as are their

standard deviation values. And it is notable that foreign markets, especially US stock and UK bond outperformed Canadian stock and bond respectively.

Table 7 Statistic Summary 1996-2000

	Mean Return	Median	Standard Deviation
Canada Stock	0.0114771	0.0150812	0.0541044
Canada Bond	0.0086348	0.0069812	0.0232128
Canada Cash	0.0036483	0.0038363	0.0006984
US Stock	0.0147857	0.0171093	0.0412164
US Bond	0.0077672	0.0087437	0.0256508
UK Stock	0.0104502	0.0171371	0.0352522
UK Bond	0.0116764	0.0116218	0.0321336
Japan Stock	-0.0041776	-0.0040384	0.0712078
Japan Bond	0.0066830	0.0003888	0.0441260
HK Stock	0.0101998	0.0121769	0.0908645

The correlation matrix in Table 8 indicates that the coefficients are slightly lower than the 10-year average level

Table 8 Correlation Matrix 1996-2000

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	0.1564	1.0000			
Canada Cash	-0.0743	-0.0547	1.0000		
US Stock	0.6583	0.0622	0.0407	1.0000	
US Bond	-0.3504	0.5878	0.0783	-0.1378	1.0000
UK Stock	0.4863	-0.0068	-0.0454	0.7074	-0.0942
UK Bond	-0.3043	0.3825	0.0056	-0.1184	0.6691
Japan Stock	0.4030	0.0457	-0.0561	0.4055	-0.0511
Japan Bond	-0.1453	0.0975	0.1046	-0.0364	0.3496
HK Stock	0.5939	-0.0043	0.0162	0.5425	-0.2157

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.1324	1.0000			
Japan Stock	0.3283	-0.0677	1.0000		
Japan Bond	0.1040	0.3624	0.2701	1.0000	
HK Stock	0.5094	-0.1401	0.4229	0.0857	1.0000

Table 9 shows the optimal domestic portfolio generated by QOS according to the nominal return data. The Expected Return of domestic portfolio ranges from 0.005437 to 0.011447, the standard deviation of domestic portfolio ranges from 0.007677 to 0.053644, as displayed in Panel A. When the domestic portfolio is added by international stocks, the whole expected range of the expanded portfolio significantly improves, but its lower bound of standard deviation is correspondingly higher and its upper bound of standard deviation, however, is lower. The result of adding international bonds is more significant with a dramatically lower standard deviation range. Its lower bound of expected return range is even higher than the result of adding international stocks, but its upper bound is slightly higher the result of domestic portfolio. Combining both of international stocks and bonds, the optimization result is the best in this period, with a significantly improved expected return range and a lower standard deviation range.

Table 9 suggests that investing international assets will bring Canadian investors significant benefits by either lowering volatility at the given expected return level or increasing expected return at the given standard deviation level in the period 1996-2000.

Table 9 The Optimization Results 1996-2000

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.005437- 0.011447	0.007677- 0.053644
Panel B		
International Stocks	0.006908 -0.014786	0.010326-0.040866
International Bonds	0.007638 -0.011622	0.011444 -0.023301
International Stocks & Bonds	0.008486 -0.014786	0.012592 -0.040866

Note: We set the risk aversion range from 30, with 30 points on the frontier.

Panel A of Table 10 presents the degrees of decreasing risk by adding international assets, if we hold the expected return level of the domestic portfolio at 0.008946. Compared with the effect of the whole period, the result of 1996-2000 suggests that the portfolio including international assets can significantly reduce the risk level.

Table 10 Minimize Risk Given Expected Return 1996-2000

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Standard Deviation				
Expected Return	0.008946	0.008946	0.008946	0.008946
Standard Deviation	0.022952	0.016911	0.015255	0.013809
Sharpe Ratio	0.229522	0.309421	0.343062	0.377664
Panel B: Optimal Weights				
Canada stock	15.65%	0	18.95%	4.17%
Canada Bond	81.67%	36.56%	6.96%	6.87%
Canada Cash	2.68%	28.45%	30.11%	38.09%
US Stock		25.45%		20.07%
US Bond			0	0
UK Stock		9.74%		0
UK Bond			42.71%	29.22%
Japan Stock		0		0
Japan Bond			1.27%	1.58%
HK Stock		0		0

Note: Given the expected return 0.008946 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Panel A of Table 11 illustrates the extent of improving expected return by holding foreign assets if we hold the standard deviation level of the domestic portfolio at 0.022952. Similarly, there is an apparent advantage for holding foreign assets to improve the expected return.

Table 11 Maximize Expected Return Given Standard Deviation 1996-2000

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.008946	0.010815	0.011563	0.012393
Standard Deviation	0.022952	0.022952	0.022952	0.022952
Sharpe Ratio	0.229522	0.0309321	0.297748	0.358997
Panel B: Optimal Weights				
Canada Stock	15.65%	0	30.25%	6.87%
Canada Bond	81.67%	49.46%	1.75%	8.25%
Canada Cash	2.68%	3.28%		0
US Stock		34.26%		34.10%
US Bond			0	0
UK Stock		13.00%		0
UK Bond			68%	49.19%
Japan Stock		0		0
Japan Bond			0	1.59%
HK Stock		0		0

Note: Given the standard deviation 0.022952 of the Canadian domestic optimal portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

From the tables and analysis above, we can conclude that in this period, Canadian investors can significantly benefit from the international diversification by improving expected return and by reducing risks. We also notice that international bonds have stronger power to improve expected return and decrease risks and Canadian portfolio can be well diversified by US stock and UK bond.

4.1.3 The Sub-Period 2001-2006

As shown in Table 12, all the mean returns in this period are largely lower than those of the period of 1996-2000. And clearly, the returns of Canadian stocks and bonds dominate the international counterparts.

Table 12 Statistic Summary 2001-2006

	Mean Return	Median	Standard Deviation
Canada Stock	0.0047674	0.0111531	0.0392025
Canada Bond	0.0073246	0.0081925	0.0190845
Canada Cash	0.0024551	0.0022617	0.0006537
US Stock	-0.0033525	-0.0015246	0.0380461
US Bond	0.0016550	0.0003419	0.0326580
UK Stock	-0.0009319	-0.0026946	0.0365318
UK Bond	0.0038430	0.0008301	0.0326483
Japan Stock	-0.0011574	-0.0011221	0.0512597
Japan Bond	-0.0022806	-0.0012995	0.0308905
HK Stock	-0.0008470	0.0012289	0.0495152

The correlation matrix in Table 13 illustrates the changes in correlation between Canadian stocks and other assets. Unlike those in 1996-2000, the correlation coefficients of UK stocks, Japan stocks, and Hong Kong stocks increase and the US's correlation is slightly lower during this period. This result is similar to other research results that indicate the increasingly high correlation among the developed stock markets over the last decade.

Table 13 Correlation Matrix 2001-2006

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	-0.0915	1.0000			
Canada Cash	-0.2163	-0.0241	1.0000		
US Stock	0.6633	-0.2043	-0.0356	1.0000	
US Bond	-0.4700	0.6650	0.0673	-0.2745	1.0000
UK Stock	0.5610	-0.1193	-0.0801	0.7707	-0.1742
UK Bond	-0.3357	0.4284	-0.0052	-0.2709	0.6628
Japan Stock	0.4647	0.0198	-0.1483	0.3878	-0.0799
Japan Bond	-0.2917	0.2671	0.0615	-0.1123	0.4696
HK Stock	0.6393	-0.1406	-0.1116	0.7142	-0.2093

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.0355	1.0000			
Japan Stock	0.3505	-0.1204	1.0000		
Japan Bond	0.0271	0.5033	0.0119	1.0000	
HK Stock	0.6383	-0.1073	0.4594	-0.0475	1.0000

Table 14 shows the optimal domestic portfolio generated by QOS according to the nominal return data. As illustrated in Panel A, the Expected Return of domestic portfolio ranges from 0.004890 to 0.007325, the standard deviation of domestic portfolio ranges from 0.008990 to 0.018946. The optimization results shown in Panel B suggest that there is no diversification benefit in this period, no matter on lowering volatility or improving expected return. This outcome can be explained by the return-risk profile of each foreign asset shown in Table 13.

Table 14 Optimization Result 2001-2006

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.004890 – 0.007325	0.008990 – 0.018946
Panel B		
International Stocks	0.004890 – 0.007325	0.008990 – 0.018946
International Bonds	0.004890 – 0.007325	0.008990 – 0.018946
International Stocks & Bonds	0.004890 – 0.007325	0.008990 – 0.018946

Note: We set the risk aversion range from 30 to 1, with 30 points on the frontier.

Table 15 and Table 16 further prove that there is no international diversification benefit in terms of nominal return for Canadian investors during this period. The foreign assets weights are all zero.

Table 15 Minimize Risk Given Expected Return 2001-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks & Bonds
Panel A: Standard Deviation				
Expected Return	0.007107	0.007107	0.007107	0.007107
Standard Deviation	0.017348	0.017347	0.017347	0.017347
Sharpe Ratio	0.173482	0.173621	0.173621	0.173621
Panel B: Optimal Weights				
Canada Stock	8.50%	8.51%	8.51%	8.51%
Canada Bond	91.50%	91.49%	91.49%	91.49%
Canada Cash	0	0	0	0
US Stock		0		0
US Bond			0	0
UK Stock		0		0
UK Bond			0	0
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the expected return 0.007107 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Table 16 Maximize Expected Return Given Standard Deviation 2001-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.007107	0.007107	0.007107	0.007107
Standard Deviation	0.017348	0.017348	0.017348	0.017348
Sharpe Ratio	0.173482	0.173501	0.173501	0.173501
Panel B: Optimal Weights				
Canada Stock	8.50%	8.50%	8.50%	8.50%
Canada Bond	91.50%	91.50%	91.50%	91.50%
Canada Cash	0	0	0	0
US Stock		0		0
US Bond			0	0
UK Stock		0		0
UK Bond			0	0
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the standard deviation 0.017348 of the Canadian domestic optimal portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

Summarizing the nominal return analysis, we find that Canadian investors in general can benefit from international portfolio diversification in the whole period 1996-2006. However, for different sub-periods, the diversification effect is varied. In the period 1996-2000, Canadian investors can significantly improve expected return and reduce risk level by investing international stocks and bonds, due to the outstanding performance of foreign capital markets. In contrast, in the period 2001-2006, the empirical result suggests that Canadian investors can gain nothing from the international capital markets. This is derived from two critical factors. One is the outstanding performance of Canadian equity market. From the third quarter of 2002 to the second quarter of 2006, the S&P/TSX Composite Index soared by 88%, becoming the second best performance across the industrialized countries. Another important factor is the remarkable appreciation of Canadian dollar against most of the international currencies, noticeably in the last

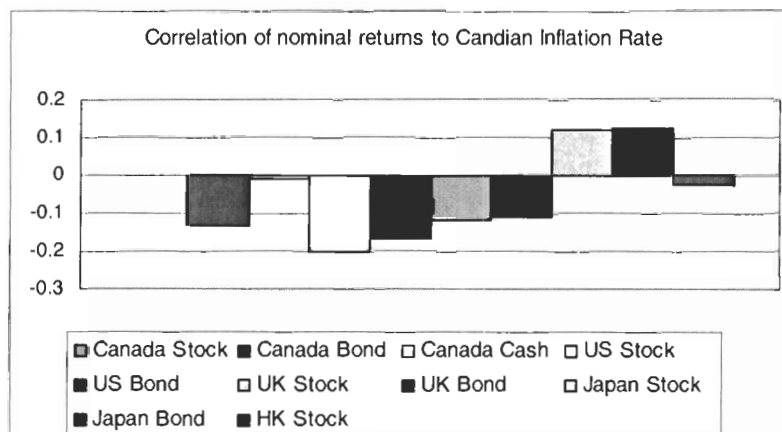
three years. With that being said, the Canadian economy has been experiencing a very sweet moment in its history thanks to the booming world economy in recent years, especially the more eye-catching emerging giants like China and India, which bid up the commodity price and help the Canadian equity market, which is highly dominated by its natural resource industry.

4.2 Part Two: The Results and Analysis Based on Real Return

4.2.1 The Whole Period 1996-2006

This part examines the impact of inflation risk on asset returns and thus on the asset allocation strategy by comparing with the empirical results using nominal returns. In order to analyze the impact of inflation for Canadian investors, the nominal returns dominated in CAD\$ have been reduced by the Canadian inflation rates. As illustrated in Figure2, the correlation of Canadian stocks with the Canadian inflation rate is close to zero, so that it cannot be clearly shown in the figure (the actual position is supposed to be at the left side of Canadian bond). This is strong evidence indicating that the Canadian stock market cannot reflect the consumer purchasing patterns, since the Canadian stock market primarily concentrates on three sectors, financial service, energy, and resource, which are not directly related to the public consumers. It is hard for Canadian investors to hedge inflation risk via domestic stock market.

Figure 2 Correlation of Nominal Returns to Canadian Inflation Rate



Compared with the nominal returns, all the real returns of the assets in the sample are relatively lower with various extents, as displayed in Table 17.

Table 17 Statistic Summary 1996-2006

	Mean Return	Median	Standard Deviation
Canada Stock	0.0061570	0.0129801	0.0467022
Canada Bond	0.0062254	0.0061795	0.0216478
Canada Cash	0.0013020	0.0009370	0.0032822
US Stock	0.0033049	0.0033558	0.0411610
US Bond	0.0027692	0.0030019	0.0303621
UK Stock	0.0026114	0.0074385	0.0367667
UK Bond	0.0057506	0.0051119	0.0330065
Japan Stock	-0.0042526	-0.0030295	0.0607300
Japan Bond	0.0001480	-0.0024137	0.0374143
HK Stock	0.0025418	0.0044271	0.0716636

The correlation coefficients in Table 18 are slightly higher than those of nominal returns during the period 1996-2006.

Table 18 Correlation Matrix 1996-2006

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	0.1698	1.0000			
Canada Cash	0.0450	0.2463	1.0000		
US Stock	0.6633	0.1086	0.2734	1.0000	
US Bond	-0.3237	0.6095	0.2764	-0.0915	1.0000
UK Stock	0.4921	0.0339	0.1833	0.7173	-0.0557
UK Bond	-0.2855	0.4070	0.1941	-0.0804	0.6807
Japan Stock	0.3994	0.0409	-0.0825	0.4049	-0.0490
Japan Bond	-0.1490	0.0994	-0.0138	-0.0228	0.3532
HK Stock	0.5959	0.0115	0.0718	0.5455	-0.19609

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.1570	1.0000			
Japan Stock	0.3255	-0.0683	1.0000		
Japan Bond	0.1094	0.3642	0.2608	1.0000	
HK Stock	0.5124	-0.1264	0.4223	0.0863	1.0000

Table 19 shows the optimal domestic portfolio generated by QOS according to the real return data. As shown in Panel A, the Expected Return of domestic portfolio ranges from 0.003222 to 0.006219, the standard deviation of domestic portfolio ranges from 0.008760 to 0.020714.

In Panel B, the optimization results suggest that investing in international stocks can not improve the expected return range and lower the standard deviation range. However, investing in foreign bonds improves the lower limit of the expected return with keeping the upper bound of expected return unchanged. This result is similar to the result based on nominal return. For the standard deviation range, similarly, including international stocks cannot change the range, but

investing in the foreign bonds narrows the standard deviation range with a higher lower bound of standard deviation.

Table 19 Optimization Result 1996-2006

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.003222 – 0.006219	0.008760 – 0.020714
Panel B		
International Stocks	0.003222 – 0.006219	0.008760 – 0.020714
International Bonds	0.003450 – 0.006219	0.009208 – 0.020714
International Stocks & Bonds	0.003450 – 0.006219	0.009208 – 0.020714

Note: We set the risk aversion range from 30 to 1, with 30 points on the frontier.

Table 20 provides the extent of minimizing risk, if we hold the expected return level of domestic portfolio at 0.005817. The optimization result demonstrates that the portfolio including international bonds has a lower standard deviation value versus the benchmark portfolio. The extent that risk is reduced is very close to that calculated for nominal return, with 1% improvement of weights for domestic assets.

Table 20 Minimize Risk Given Expected Return 1996-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks & Bonds
Panel A: Standard Deviation				
Expected Return	0.005817	0.005817	0.005817	0.005817
Standard Deviation	0.019051	0.019049	0.018069	0.018069
Sharpe Ratio	0.247663	0.247664	0.262769	0.262769
Panel B: Optimal Weights				
Canada Stock	11.63%	11.63%	15.82%	15.82%
Canada Bond	80.24%	80.23%	57.36%	57.36%
Canada Cash	8.13%	8.14%	6.08%	6.08%
US Stock				0
US Bond			0	0
UK Stock		0		0
UK Bond			20.74%	20.74%
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the expected return 0.005817 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Panel A of Table 21 provides the results of improving expected return by adding various international assets, if we hold the standard deviation level of the domestic portfolio at 0.019051. We can tell from Table 21 that only including international bonds to the domestic portfolio can moderately increase the expected return. The extent that expected return is improved is almost the same as that derived from nominal return. However, as shown in Panel B, the optimal weight changes significantly, with the UK Bond increasing by approximately 50% in terms of the real return, compared with the weights in nominal return.

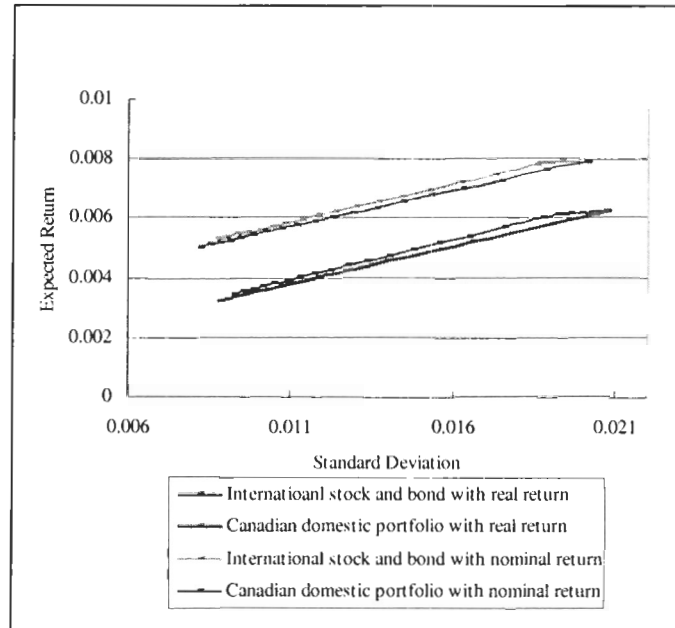
Table 21 Maximize Expected Return Given Standard Deviation 1996-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.005817	0.005817	0.006075	0.006075
Standard Deviation	0.019051	0.019051	0.019051	0.019051
Sharpe Ratio	0.247663	0.247663	0.262330	0.262330
Panel B: Optimal Weights				
Canada Stock	11.63%	11.64%	16.70%	16.70%
Canada Bond	80.24%	80.24%	60.67%	60.67%
Canada Cash	8.13%	8.12%	0.71%	0.71%
US Stock		0		0
US Bond			0	0
UK Stock		0		0
UK Bond			21.94%	21.94%
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the standard deviation 0.019051 of the Canadian domestic optimal portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

Compared with the empirical results using nominal return, the optimization results based on real returns indicate the approximate extent of improving expected return and of lowering risk level. However, the foreign assets account for a larger proportion in the optimal weight for improving expected return in the real return scenario.

Figure 3 1996-2006 Efficient Frontiers



The efficient frontiers plotted in Figure 1 summarize the whole period analysis with real return. In most of time, the frontier including international stocks and bonds dominates the frontier of Canadian domestic assets. At the same expected return level, the portfolio that includes international stocks and bonds has less risk than Canadian domestic portfolio does. At the same risk level, the portfolio investing in international stocks and bonds can gain higher return. However, the expected return of the portfolio including international stocks and bonds cannot overpass the upper limit of the expected return of Canadian domestic portfolio.

4.2.2 The Sub-Period 1996-2000

As we did in the Part One, we divide the sample period into two sub-periods, one is from 1996 to 2000 and another is from 2001 to 2006. As shown in Table 22, all the mean returns are higher than their 10-year average level, except for that of Japan stocks. Compared with the nominal returns in the same period, the real returns of all the assets are lower.

Table 22 Statistic Summary 1996-2000

	Mean Return	Median	Standard Deviation
Canada Stock	0.0098500	0.0164172	0.0538585
Canada Bond	0.0070077	0.0064380	0.0231837
Canada Cash	0.0020212	0.0018418	0.0023542
US Stock	0.0131586	0.0181093	0.0413788
US Bond	0.0061401	0.0061268	0.0258020
UK Stock	0.0088231	0.0156059	0.0351944
UK Bond	0.0100493	0.0114851	0.0324316
Japan Stock	-0.0058047	-0.0082247	0.0704931
Japan Bond	0.0050559	-0.0020706	0.0435122
HK Stock	0.0085727	0.0065851	0.0906466

Table 23 provides summary statistics of the correlation structure among different asset classes during the period 1996-2000. Compared with those of nominal return, the correlation of foreign stock real return with the Canadian stock real return and the correlation of foreign bond real returns to Canadian bond real returns almost did not change.

Table 23 Correlation Matrix 1996-2000

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	0.3178	1.0000			
Canada Cash	-0.1218	-0.0167	1.0000		
US Stock	0.6646	0.2945	0.0167	1.0000	
US Bond	-0.2789	0.5275	0.0873	-0.0115	1.0000
UK Stock	0.4218	0.0923	-0.0959	0.6214	-0.0160
UK Bond	-0.3082	0.3494	0.0983	-0.0058	0.6847
Japan Stock	0.3587	0.0344	-0.2834	0.4420	-0.0454
Japan Bond	-0.0929	-0.0491	-0.2336	-0.0422	0.2207
HK Stock	0.5744	0.0538	-0.0841	0.4619	-0.2816

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.2197	1.0000			
Japan Stock	0.3174	-0.0376	1.0000		
Japan Bond	0.1244	0.2278	0.4157	1.0000	
HK Stock	0.4537	-0.1931	0.4104	0.1242	1.0000

Table 24 shows the optimization result for the pure Canadian domestic portfolio and the portfolio incorporated with foreign assets. As shown in Panel A, the Expected Return of the domestic portfolio ranges from 0.003859 to 0.009850 and the standard deviation of the domestic portfolio ranges from 0.007985 to 0.053400. The investment in foreign stocks, bonds, or both, can significantly improve the lower bound of expected return, but just the investment in foreign stocks and in both foreign stock and bond can greatly improve the upper bound of the expected return, as displayed in Panel B. This suggests that stock markets, compared with bond markets, in general performed outstandingly in this period. For the moving of standard deviation range, investing in foreign securities can narrow down the risk range by improving the lower bound of standard deviation and significantly decreasing the upper bound of risk level. The standard deviation range is narrowed, partly due to the relatively higher level of return and volatility for

each asset in this period. Compared with the empirical result based on the nominal return in this period, the moving of expected return range and standard deviation range is almost the same. In general, the empirical result in Table 24 demonstrates that Canadian investors significantly gain the benefits from international diversification on both improving expected return and decreasing risk level.

Table 24 Optimization Results 1996-2000

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.003859 -- 0.009850	0.007985 -- 0.053400
Panel B		
International Stocks	0.005290 – 0.013159	0.010555 – 0.041027
International Bonds	0.006024 – 0.009994	0.011631 – 0.023403
International Stocks & Bonds	0.006819 – 0.013159	0.012761 – 0.041027

Note: We set the risk aversion range from 30 to 1, with 30 points on the frontier.

Panel A of Table 25 presents the magnitude of minimizing risk by investing in foreign assets, given the expected return level of the optimal domestic portfolio at 0.007368. There is no doubt that investing in overseas stocks and bonds can effectively decrease the risk level. Compared with the result of nominal return, the extent of minimizing risk is very close, however, the foreign assets account for a little bit larger weight in the optimal portfolio, as shown in the Panel B. For example, for the portfolio including international stocks and bonds, the foreign assets totally account for 51.22% in terms of real return but 50.87% in nominal return analysis.

Table 25 Minimize Risk Given Expected Return 1996-2000

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Standard Deviation				
Expected Return	0.007368	0.007368	0.007368	0.007368
Standard Deviation	0.023057	0.017179	0.015500	0.014197
Sharpe Ratio	0.230570	0.311953	0.346187	0.381739
Panel B: Optimal Weights				
Canada Stock	16.16%	0	19.29%	5.11%
Canada Bond	81.87%	37.74%	8.21%	8.11%
Canada Cash	1.97%	26.96%	27.90%	35.36%
US Stock		24.53%		19.25%
US Bond			0	0
UK Stock		10.77%		0
UK Bond			41.53%	28.59%
Japan Stock				0
Japan Bond			3.08%	3.38%
HK Stock				0

Note: Given the expected return 0.007368 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Panel A of Table 26 provides the extent of improving expected return, if we hold the standard deviation level of the domestic portfolio at 0.023057. Similarly, there is no doubt that international diversification can significantly improve the expected return for Canadian investors. And it is notable that the optimal weight of this period is significantly different from that of the whole period between 1996 and 2006. For instance, for the portfolio including international stock and bond, compared with the weights of the period 1996-2006, the weight of foreign assets is approximately 85%, much more than the weight of 21.94% for foreign assets in 1996-2006. In addition, as we discussed above, compared with the nominal return scenario, foreign assets account for 84.91% in real return, almost the same as 84.88% in nominal return.

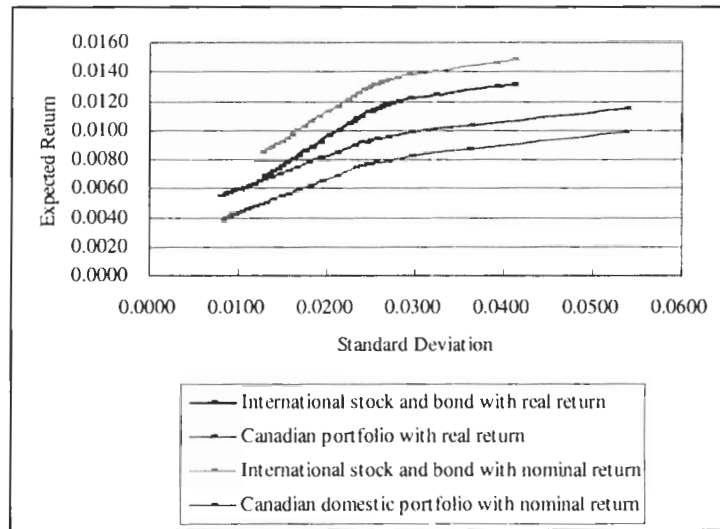
Table 26 Maximize Expected Return Given Standard Deviation 1996-2000

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.007368	0.009197	0.009936	0.010721
Standard Deviation	0.023057	0.023057	0.023057	0.023057
Sharpe Ratio	0.230570	0.310720	0.0294588	0.349699
Panel B: Optimal Weights				
Canada Stock	16.16%	0	30.76%	7.7%
Canada Bond	81.87%	50.38%	1.49%	7.39%
Canada Cash	1.97%	2.31%	0	0
US Stock		33.35%		33.60%
US Bond			0	0
UK Stock		13.96%		0
UK Bond			67.61%	48.66%
Japan Stock		0		0
Japan Bond			0.14%	2.66%
HK Stock		0		0

Note: Given the standard deviation 0.023057 of the Canadian domestic optimal portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

From the tables and analysis above, we can find that in this period, Canadian investors can significantly benefit from the international diversification by improving expected return and by reducing risks, as shown in the efficient frontiers in Figure 4. We also notice that international bonds have stronger power to improve expected return and decrease risks.

Figure 4 1996-2000 Efficient Frontiers



4.2.3 The Sub-Period 2001-2006

Table 27 presents the statistic summary of the monthly real returns dominated in Canadian dollars for each asset during the period of 2001-2006. The mean return of each asset is in general lower than their 10-year average level. The summary statistics suggest that Canadian stock and Canadian bond absolutely dominated all the other assets in this period, after being deflated by the Canadian inflation rate.

Table 27 Statistic Summary 2001-2006

	Mean Return	Median	Standard Deviation
Canada Stock	0.0029993	0.0118933	0.0397165
Canada Bond	0.0055565	0.0060131	0.0203914
Canada Cash	0.0006870	0.0002145	0.0038157
US Stock	-0.0051207	-0.0031234	0.0393388
US Bond	-0.0001131	-0.0001454	0.0336983
UK Stock	-0.0027000	-0.0054119	0.0374977
UK Bond	0.0020749	-0.0032465	0.0332837
Japan Stock	-0.0029255	-0.0025634	0.0514369
Japan Bond	-0.0040487	-0.0032995	0.0309957
HK Stock	-0.0026151	-0.0007711	0.0502455

Table 28 provides summary of the correlation structure among different asset classes during the period 2001-2006. It indicates that the correlation between Canadian stock and other foreign stocks is slightly higher than that in terms of nominal return, as are the bond markets.

Table 28 Correlation Matrix 2001-2006

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond
Canada Stock	1.0000				
Canada Bond	-0.0276	1.0000			
Canada Cash	0.1438	0.4184	1.0000		
US Stock	0.6781	-0.0904	0.3743	1.0000	
US Bond	-0.4086	0.6909	0.3345	-0.1935	1.0000
UK Stock	0.5771	-0.0282	0.2858	0.7843	-0.1088
UK Bond	-0.2938	0.4621	0.2196	-0.2028	0.6795
Japan Stock	0.4714	0.0517	0.0570	0.4029	-0.0519
Japan Bond	-0.2678	0.2951	0.0977	-0.0645	0.4897
HK Stock	0.6502	-0.0689	0.2080	0.7244	-0.1579

	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
UK Stock	1.0000				
UK Bond	0.0793	1.0000			
Japan Stock	0.36351	-0.1001	1.0000		
Japan Bond	0.0598	0.5154	0.0195	1.0000	
HK Stock	0.6511	-0.0694	0.4687	-0.0211	1.0000

Table 29 shows the optimal domestic portfolio generated by QOS according to the real return data. The Expected Return of domestic portfolio ranges from 0.002839 to 0.005557, the standard deviation of domestic portfolio ranges from 0.009687 to 0.020243, as illustrated in Panel A. The empirical result shown in Panel B indicates that the investment in foreign assets can not change the expected return range and the standard deviation range at all. We cannot find any benefit from the international portfolio investment.

Table 29 Optimization Results 2001-2006

Optimization	Expected Return Range	Standard Deviation Range
Panel A		
Domestic Portfolio	0.002839 – 0.005557	0.009687 – 0.020243
Panel B		
International Stocks	0.002839 – 0.005557	0.009687 – 0.020243
International Bonds	0.002839 – 0.005557	0.009687 – 0.020243
International Stocks & Bonds	0.002839 – 0.005557	0.009687 – 0.020243

Note: We set the risk aversion range from 30 to 1, with 30 points on the frontier.

Panel A of Table 30 provides the degree of risk reduction by investing overseas, if we hold the expected return level of the domestic optimal portfolio at 0.005332. It turns out that the foreign assets cannot reduce risk for Canadian investors. This result is the same as that based on nominal returns.

Table 30 Minimize Risk Given Expected Return 2001-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+Inter. Stocks & Bonds
Panel A: Standard Deviation				
Expected Return	0.005332	0.005332	0.005332	0.005332
Standard Deviation	0.018694	0.018693	0.018693	0.018693
Sharpe Ratio	0.186944	0.187080	0.187080	0.187080
Panel B: Optimal Weights				
Canada Stock	8.77%	8.78%	8.78%	8.78%
Canada Bond	91.23%	91.22%	91.22%	91.22%
Canada Cash	0	0	0	0
US Stock				0
US Bond			0	0
UK Stock		0		0
UK Bond			0	0
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the expected return 0.005332 of the Canadian domestic optimal portfolio, we test the standard deviation of the portfolio including international assets and the corresponding weights.

Panel A of Table 31 shows the extent of maximizing expected return by foreign portfolio investment, given the standard deviation level of the domestic portfolio at 0.018694. Similarly, the optimization result suggests that no foreign asset can improve the expected return in this period, as shown in Panel B.

Table 31 Maximize Expected Return Given Standard Deviation 2001-2006

Optimal Portfolio	Canadian Domestic	+International Stocks	+International Bonds	+International Stocks& Bonds
Panel A: Expected Return				
Expected Return	0.005332	0.005332	0.005332	0.005332
Standard Deviation	0.018694	0.018694	0.018694	0.018694
Sharpe Ratio	0.186944	0.140952	0.186758	0.140952
Panel B: Optimal Weights				
Canada Stock	8.77%	8.77%	8.77%	8.77%
Canada Bond	91.23%	91.23%	91.23%	91.23%
Canada Cash	0	0	0	0
US Stock		0		0
US Bond			0	0
UK Stock		0		0
UK Bond			0	0
Japan Stock		0		0
Japan Bond			0	0
HK Stock		0		0

Note: Given the standard deviation 0.018694 of the Canadian domestic portfolio, we test the expected return of the portfolio including international assets and the corresponding weights.

From the tables and analysis above, like the result in terms of nominal return analysis, no diversification effect could be found, since Canadian stock and bond outperformed all the other foreign assets.

In summary for the real return analysis, the optimization results for the whole period imply that Canadian investors obtain moderate benefits from international diversification.

However, the magnitudes of the diversification benefits of are various in different sub-periods. In the period of 1996-2000, the power of international diversification is much stronger than that of the period 2001-2006. While the magnitude of the diversification effect from the real return is similar to that from nominal return, the Canadian CPI adjustment changes the weights of the optimal portfolio. As Table 21 illustrates, in order to maximize the expected return given the same standard deviation level of the domestic optimal portfolio, it turns out that UK bond needs to account for 21.94% of the optimal weight, much higher than 14.71% in the form of nominal return. This suggests that in order to offset the negative impact of inflation on the domestic portfolio return, Canadian investors need more foreign assets. This difference can definitely provide evidence to demonstrate the impact of inflation risk on international asset allocation.

5 CONCLUSION

Based on the nominal return and real return analysis for the whole period 1996-2006 and two sub-periods, we conclude that Canadian investors still can benefit from international diversification. While different country selection and specific time period may lead to various empirical results, our empirical research is conducted under restricted conditions that will largely limit the opportunities to improve expected return. For example, the sample consists of highly correlated foreign markets. The period examined is in the time horizon that Canadian stock market in general outperformed its international counterparts. Short-selling transaction is not allowed.

While the extent of improving expected return and reducing standard deviation in general is moderate in our sample period, we find an important merit of international diversification for Canadian investors, that is, hedging the domestic inflation risk. Since the Canadian stock market does not reflect consumption patterns well, Canadian investors can gain from international diversification to offset the negative impact of inflation on the return of the domestic portfolio. In our optimization results for real returns, given the same standard deviation value of the domestic optimal portfolio, international assets account for a much larger weight in the optimal portfolio compared with those based on nominal returns.

This empirical result is consistent with the inherent needs of the Canadian stock market to disperse risk. Over the past four years, energy has contributed for half the increase in the S&P/TSX Composite Index, while financials have accounted for one-third of the gain, leaving the other 8 major industry groups to contribute the remaining 20%. Currently, financial service, energy, and resources sectors account for over 70% of market capitalization of Canadian stock

market, but the sectors that directly relate to consumers, such as consuming products and health care, just have much lower weights. Thus, Canadian investors can not hedge some inflation risk through domestic stock market and will have to do so via foreign capital markets.

Another important finding is that international bonds have a stronger power than international stocks to improve expected return and to reduce risk for Canadian investors. In our empirical results, the magnitude of maximizing expected return and of minimizing risk by investing in foreign bonds is stronger than that of investing in international stocks. As we discussed in the nominal return analysis for the whole period, compared with domestic optimal portfolio, the portfolio including international stocks almost does not change anything. However, the portfolio including international bonds can reduce risk and improve return as well. In real return results, similarly, international stocks do not change anything, but international bonds help to improve expected return as well as to reduce risk.

One possible reason is that the outstanding performance of Canadian equity market during the sample period, especially in the most recent four year, results in that all the rest sample stock markets can not establish an optimal portfolio to compete with Canadian stocks. However, with the relatively lower volatility, foreign bonds are definitely possible to reduce the risk level of Canadian investors' portfolio. A positive sign is shown in Table 1, where the investment in foreign bonds has been increasingly growing since 2002 up to date.

There is no doubt that Canada is an attractive place to invest due to its healthy economy. Canadian investors have benefited from a bull market in commodities since 2002, and we believe prices for energy products and base metals will generally continue to keep stay at relatively high levels over the next few years. But this does not detract from the recommendation that investors hold a more diversified portfolio into international markets.

Appendix A Covariance Matrix

1. 1996-2006 Nominal Return Covariance Matrix

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
Canada Stock	0.0021541	0.0001519	-0.0000031	0.0012299	-0.0004808	0.0008150	-0.0004575	0.0011372	-0.0002532	0.0019633
Canada Bond	0.0001519	0.0004381	-0.0000010	0.0000524	0.0003637	-0.0000051	0.0002594	0.0000581	0.0000766	-0.0000064
Canada Cash	-0.0000031	-0.0000010	0.0000008	0.0000015	0.0000021	-0.0000015	0.0000002	-0.0000031	0.0000035	0.0000010
US Stock	0.0012299	0.0000524	0.0000015	0.0016205	-0.0001640	0.0010284	-0.0001544	0.0009924	-0.0000551	0.0015557
US Bond	-0.0004808	0.0003637	0.0000021	-0.0001640	0.0008740	-0.0001005	0.0006408	-0.0000919	0.0003880	-0.0004543
UK Stock	0.0008150	-0.0000051	-0.0000015	0.0010284	-0.0001005	0.0013043	0.0001549	0.0007209	0.0001410	0.0013105
UK Bond	-0.0004575	0.0002594	0.0000002	-0.0001544	0.0006408	0.0001549	0.0010494	-0.0001334	0.0004407	-0.0003234
Japan Stock	0.0011372	0.0000581	-0.0000031	0.0009924	-0.0000919	0.0007209	-0.0001334	0.0036958	0.0006163	0.0018314
Japan Bond	-0.0002532	0.0000766	0.0000035	-0.0000551	0.0003880	0.0001410	0.0004407	0.0006163	0.0014092	0.0002291
HK Stock	0.0019633	-0.0000064	0.0000010	0.0015557	-0.0004543	0.0013105	-0.0003234	0.0018314	0.0002291	0.0050740

2. 1996-2006 Real Return Covariance Matrix

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
Canada Stock	0.0021641	0.0001704	0.0000069	0.0012652	-0.0004555	0.0008385	-0.0004368	0.0011240	-0.0002584	0.0019791
Canada Bond	0.0001704	0.0004650	0.0000174	0.0000961	0.0003975	0.0000268	0.0002886	0.0000534	0.0000799	0.0000178
Canada Cash	0.0000069	0.0000174	0.0000107	0.0000367	0.0000273	0.0000219	0.0000209	-0.0000163	-0.0000017	0.0000168
US Stock	0.0012652	0.0000961	0.0000367	0.0016810	-0.0001135	0.0010771	-0.0001084	0.0010044	-0.0000350	0.0015967
US Bond	-0.0004555	0.0003975	0.0000273	-0.0001135	0.0009147	-0.0000618	0.0006769	-0.0000898	0.0003982	-0.0004232
UK Stock	0.0008385	0.0000268	0.0000219	0.0010771	-0.0000618	0.0013412	0.0001891	0.0007211	0.0001494	0.0013397
UK Bond	-0.0004368	0.0002886	0.0000209	-0.0001084	0.0006769	0.0001891	0.0010809	-0.0001359	0.0004463	-0.0002968
Japan Stock	0.0011240	0.0000534	-0.0000163	0.0010044	-0.0000898	0.0007211	-0.0001359	0.0036593	0.0005880	0.0018239
Japan Bond	-0.0002584	0.0000799	-0.0000017	-0.0000350	0.0003982	0.0001494	0.0004463	0.0005880	0.0013889	0.0002298
HK Stock	0.0019791	0.0000178	0.0000168	0.0015967	-0.0004232	0.0013397	-0.0002968	0.0018239	0.0002298	0.0050955

3. 1996-2000 Nominal Return Covariance Matrix

Canada Stock	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
0.0028777	0.0004038	-0.0000046	0.0014625	-0.0003718	0.0008011	-0.0005257	0.0014018	-0.0001746	0.0027893	
0.0004038	0.0005297	-0.0000027	0.0002719	0.0003071	0.0000767	0.0002495	0.0001059	-0.0000216	0.0001314	
-0.0000046	-0.0000027	0.0000005	-0.0000075	-0.0000011	-0.0000083	0.0000005	0.0000004	0.0000004	-0.0000007	
0.0014625	0.0002719	-0.0000075	0.0016700	-0.0000225	-0.0000468	0.0008851	-0.0000237	0.0013108	-0.0000549	0.0017163
-0.0003718	0.0003071	-0.0000011	-0.0000225	0.0006468	-0.0000161	-0.0000237	0.0005500	-0.0000353	0.0002663	-0.0006319
0.0008011	0.0000767	-0.0000083	0.0008851	-0.0000161	0.0012217	0.0002391	0.0010151	-0.0000444	0.0008260	0.0014445
-0.0005257	0.0002495	-0.0000046	-0.0000237	0.0005500	0.0002391	0.0010151	-0.0000444	0.0049846	0.0013300	-0.0005482
0.0014018	0.0001059	0.0000011	0.0013108	-0.0000353	0.0008260	-0.0000444	0.0049846	0.0013300	0.0019141	0.0026473
-0.0001746	-0.0000216	0.0000004	-0.0000004	0.0002663	0.0002158	0.0003331	0.0003331	0.0013300	0.0019141	0.0005275
0.0027893	0.0001314	-0.0000007	0.0017163	-0.0006319	0.0014445	-0.0005482	0.0026473	0.0005275	0.0081164	

4. 1996-2000 Real Return Covariance Matrix

Canada Stock	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
0.0028516	0.0003901	-0.0000152	0.0014560	-0.0003910	0.0007860	-0.0005293	0.0013390	-0.0002141	0.0027568	
0.0003901	0.0005284	-0.0000009	0.0002778	0.0003102	0.0007411	0.0002583	0.0000554	-0.0000487	0.0001113	
-0.0000152	-0.0000009	0.0000054	0.0000016	-0.000052	-0.0000078	0.0000074	-0.0000462	-0.0000235	-0.0000177	
0.0014560	0.0002778	0.0000016	0.0016832	-0.000121	0.0008897	-0.0000077	0.0012677	-0.0000748	0.0017035	
-0.0003910	0.0003102	0.0000052	-0.0000121	0.0006545	-0.0000143	0.0005633	-0.0000813	0.0002436	-0.0006475	
0.0007860	0.0000741	-0.0000078	0.0008897	-0.0000143	0.0012176	0.0002466	0.0007742	0.0001873	0.0014230	
-0.0005293	0.0002583	0.0000074	-0.0000077	0.0005633	0.0002466	0.0010340	-0.0000847	0.0003161	-0.0005582	
0.0013390	0.0000554	-0.0000004	0.0012677	-0.0000813	0.0007742	-0.0000847	0.0048851	0.0012538	0.0025781	
-0.0002141	-0.0000487	-0.0000235	-0.0000748	0.0002436	0.0001873	0.0003161	0.0012538	0.0018612	0.0004816	
0.0027568	0.0001113	-0.0000177	0.0017035	-0.0006475	0.0014230	-0.0005582	0.0025781	0.0004816	0.0080775	

5. 2001-2006 Nominal Return Covariance Matrix

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
Canada Stock	0.0015146	-0.0000675	-0.0000055	0.0009750	-0.0005930	0.0007918	-0.0004235	0.0009202	-0.0003481	0.0012229
Canada Bond	-0.0000675	0.0003589	-0.0000003	-0.0001462	0.0004085	-0.0000820	0.0002631	0.0000191	0.0001552	-0.0001310
Canada Cash	-0.0000055	-0.0000003	0.0000004	-0.0000009	0.0000014	-0.0000019	-0.0000001	-0.0000049	0.0000012	-0.0000036
US Stock	0.0009750	-0.0001462	-0.0000009	0.0014265	-0.0003361	0.0010557	-0.0003317	0.0007453	-0.0001301	0.0013260
US Bond	-0.0005930	0.0004085	0.0000014	-0.0003361	0.0010511	-0.0002048	0.0006965	-0.0001318	0.0004669	-0.0003335
UK Stock	0.0007918	-0.0000820	-0.0000019	0.0010557	-0.0002048	0.0013152	0.0000417	0.0006469	0.0000301	0.001379
UK Bond	-0.0004235	0.0002631	-0.0000001	-0.0003317	0.0006965	0.0000417	0.0010505	-0.0001986	0.0005002	-0.0001710
Japan Stock	0.0009202	0.0000191	-0.0000049	0.0007453	-0.0001318	0.0006469	-0.0001986	0.0025895	0.0000186	0.001491
Japan Bond	-0.0003481	0.0001552	0.0000012	-0.0001301	0.0004669	0.0000301	0.0005002	0.0000186	0.0009404	-0.0000716
HK Stock	0.0012229	-0.0001310	-0.0000036	0.0013260	-0.0003335	0.0011379	-0.0001710	0.001491	-0.0000716	0.0024162

6. 2001-2006 Real Return Covariance Matrix

	Canada Stock	Canada Bond	Canada Cash	US Stock	US Bond	UK Stock	UK Bond	Japan Stock	Japan Bond	HK Stock
Canada Stock	0.0015545	-0.0000221	0.0000215	0.0010443	-0.0005390	0.0008470	-0.0003828	0.0009492	-0.0003249	0.0012788
Canada Bond	-0.0000221	0.0004098	0.0000321	-0.0000715	0.0004679	-0.0000213	0.0003091	0.0000535	0.0001838	-0.0000696
Canada Cash	0.0000215	0.0000321	0.0000143	0.0000554	0.0000424	0.0000403	0.0000275	0.0000110	0.0000114	0.0000393
US Stock	0.0010443	-0.0000715	0.0000554	0.0015251	-0.0002528	0.0011403	-0.0002617	0.0008035	-0.0000776	0.0014112
US Bond	-0.0005390	0.0004679	0.0000424	-0.0002528	0.0011191	-0.0001356	0.0007511	-0.0000888	0.0005041	-0.0002636
UK Stock	0.0008470	-0.0000213	0.0000403	0.0011403	-0.0001356	0.0013857	0.0000976	0.0006911	0.0000686	0.0012091
UK Bond	-0.0003828	0.0003091	0.0000275	-0.0002617	0.0007511	0.0000976	0.0010917	-0.0001690	0.0005241	-0.0001144
Japan Stock	0.0009492	0.0000535	0.0000110	0.0008035	-0.0000888	0.0006911	-0.0001690	0.0026074	0.0000308	0.001939
Japan Bond	-0.0003249	0.0001838	0.0000114	-0.0000776	0.0005041	0.0000686	0.0005241	0.0000308	0.0009468	-0.0000325
HK Stock	0.0012788	-0.0000696	0.0000393	0.0014112	-0.0002636	0.0012091	-0.0001144	0.001939	-0.0000325	0.0024880

Appendix B Important Output of QOS

1. 1996-2006 Nominal Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International Stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0050153	0.0081827	0.2454813	0.0050159	0.0081836	0.2455088
2	0.0050838	0.0084616	0.2453864	0.0050844	0.0084626	0.2454140
3	0.0051571	0.0087605	0.2452948	0.0051577	0.0087615	0.2453225
4	0.0052359	0.0090817	0.2452063	0.0052365	0.0090827	0.2452341
5	0.0053207	0.0094277	0.2451210	0.0053214	0.0094288	0.2451489
6	0.0054123	0.0098016	0.2450388	0.0054130	0.0098027	0.2450669
7	0.0055116	0.0102067	0.2449599	0.0055123	0.0102078	0.2449881
8	0.0056194	0.0106471	0.2448842	0.0056202	0.0106484	0.2449125
9	0.0057371	0.0111278	0.2448117	0.0057379	0.0111291	0.2448401
10	0.0058660	0.0116544	0.2447423	0.0058668	0.0116558	0.2447708
11	0.0060078	0.0122338	0.2446762	0.0060087	0.0122352	0.2447048
12	0.0061645	0.0128744	0.2446133	0.0061654	0.0128759	0.2446420
13	0.0063387	0.0135863	0.2445536	0.0063396	0.0135879	0.2445824
14	0.0065333	0.0143822	0.2444971	0.0065342	0.0143839	0.2445260
15	0.0067522	0.0152777	0.2444439	0.0067532	0.0152795	0.2444728
16	0.0070003	0.0162929	0.2443938	0.0070014	0.0162949	0.2444228
17	0.0072839	0.0174534	0.2443470	0.0072851	0.0174554	0.2443761
18	0.0076111	0.0187926	0.2443034	0.0076123	0.0187948	0.2443325
19	0.0079202	0.0200577	0.2406924	0.0079012	0.0199780	0.2397359
20	0.0079202	0.0200578	0.2206354	0.0079202	0.0200578	0.2206354
21	0.0079202	0.0200579	0.2005785	0.0079202	0.0200579	0.2005785
22	0.0079202	0.0200580	0.1805217	0.0079202	0.0200580	0.1805217
23	0.0079202	0.0200581	0.1604651	0.0079202	0.0200581	0.1604651
24	0.0079203	0.0200584	0.1404087	0.0079203	0.0200584	0.1404087
25	0.0079203	0.0200588	0.1203525	0.0079203	0.0200588	0.1203525
26	0.0079204	0.0200594	0.1002969	0.0079204	0.0200594	0.1002969
27	0.0079205	0.0200605	0.0802421	0.0079205	0.0200605	0.0802421
28	0.0079207	0.0200630	0.0601890	0.0079207	0.0200630	0.0601890
29	0.0079210	0.0200701	0.0401401	0.0079210	0.0200701	0.0401401
30	0.0079220	0.0201082	0.0201082	0.0079220	0.0201082	0.0201082

(continued)

Efficient Frontier						
	International Bond			International stock and bond		
Frontier Point	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0052588	0.0086621	0.2598625	0.0052588	0.0086621	0.2598625
2	0.0053356	0.0089577	0.2597729	0.0053356	0.0089577	0.2597729
3	0.0054179	0.0092745	0.2596863	0.0054179	0.0092745	0.2596863
4	0.0055063	0.0096149	0.2596028	0.0055063	0.0096149	0.2596028
5	0.0056015	0.0099816	0.2595222	0.0056015	0.0099816	0.2595222
6	0.0057043	0.0103778	0.2594447	0.0057043	0.0103778	0.2594447
7	0.0058156	0.0108071	0.2593702	0.0058156	0.0108071	0.2593702
8	0.0059367	0.0112739	0.2592987	0.0059367	0.0112739	0.2592987
9	0.0060687	0.0117832	0.2592302	0.0060687	0.0117832	0.2592302
10	0.0062134	0.0123412	0.2591647	0.0062134	0.0123412	0.2591647
11	0.0063724	0.0129551	0.2591023	0.0063724	0.0129551	0.2591023
12	0.0065483	0.0136338	0.2590429	0.0065483	0.0136338	0.2590429
13	0.0067437	0.0143881	0.2589866	0.0067437	0.0143881	0.2589866
14	0.0069620	0.0152314	0.2589332	0.0069620	0.0152314	0.2589332
15	0.0072077	0.0161802	0.2588830	0.0072077	0.0161802	0.2588830
16	0.0074861	0.0172557	0.2588357	0.0074861	0.0172557	0.2588357
17	0.0078043	0.0184851	0.2587915	0.0078043	0.0184851	0.2587915
18	0.0078130	0.0185190	0.2407470	0.0078130	0.0185190	0.2407470
19	0.0078147	0.0185265	0.2223178	0.0078147	0.0185265	0.2223178
20	0.0078168	0.0185361	0.2038971	0.0078168	0.0185361	0.2038971
21	0.0078192	0.0185487	0.1854873	0.0078192	0.0185487	0.1854873
22	0.0078222	0.0185658	0.1670922	0.0078222	0.0185658	0.1670922
23	0.0078260	0.0185896	0.1487170	0.0078260	0.0185896	0.1487170
24	0.0078308	0.0186243	0.1303702	0.0078308	0.0186243	0.1303702
25	0.0078372	0.0186777	0.1120659	0.0078372	0.0186777	0.1120659
26	0.0078462	0.0187658	0.0938288	0.0078462	0.0187658	0.0938288
27	0.0078597	0.0189269	0.0757077	0.0078597	0.0189269	0.0757077
28	0.0078822	0.0192705	0.0578114	0.0078822	0.0192705	0.0578114
29	0.0079210	0.0200701	0.0401401	0.0079210	0.0200701	0.0401401
30	0.0079220	0.0201082	0.0201082	0.0079220	0.0201082	0.0201082

2. 1996-2006 Real Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0032216	0.0087599	0.2627984	0.0032216	0.0087599	0.2627984
2	0.0032901	0.0090210	0.2616093	0.0032901	0.0090210	0.2616093
3	0.0033634	0.0093020	0.2604553	0.0033634	0.0093020	0.2604553
4	0.0034422	0.0096051	0.2593370	0.0034422	0.0096051	0.2593370
5	0.0035270	0.0099329	0.2582547	0.0035270	0.0099329	0.2582547
6	0.0036186	0.0102884	0.2572090	0.0036186	0.0102884	0.2572090
7	0.0037179	0.0106750	0.2562003	0.0037179	0.0106750	0.2562003
8	0.0038258	0.0110969	0.2552290	0.0038258	0.0110969	0.2552290
9	0.0039435	0.0115589	0.2542955	0.0039435	0.0115589	0.2542955
10	0.0040724	0.0120667	0.2534004	0.0040724	0.0120667	0.2534004
11	0.0042141	0.0126272	0.2525439	0.0042141	0.0126272	0.2525439
12	0.0043709	0.0132488	0.2517265	0.0043709	0.0132488	0.2517265
13	0.0045450	0.0139416	0.2509485	0.0045450	0.0139416	0.2509485
14	0.0047396	0.0147183	0.2502104	0.0047396	0.0147183	0.2502104
15	0.0049585	0.0155945	0.2495124	0.0049585	0.0155945	0.2495124
16	0.0052067	0.0165903	0.2488550	0.0052067	0.0165903	0.2488550
17	0.0054902	0.0177313	0.2482384	0.0054902	0.0177313	0.2482384
18	0.0058174	0.0190510	0.2476630	0.0058174	0.0190510	0.2476630
19	0.0061992	0.0205941	0.2471289	0.0061992	0.0205941	0.2471289
20	0.0062168	0.0206655	0.2273201	0.0062168	0.0206655	0.2273201
21	0.0062168	0.0206655	0.2066555	0.0062168	0.0206655	0.2066555
22	0.0062168	0.0206657	0.1859910	0.0062168	0.0206657	0.1859910
23	0.0062169	0.0206658	0.1653266	0.0062169	0.0206658	0.1653266
24	0.0062169	0.0206661	0.1446624	0.0062169	0.0206661	0.1446624
25	0.0062170	0.0206664	0.1239985	0.0062170	0.0206664	0.1239985
26	0.0062170	0.0206670	0.1033351	0.0062170	0.0206670	0.1033351
27	0.0062171	0.0206681	0.0826726	0.0062171	0.0206681	0.0826726
28	0.0062173	0.0206705	0.0620116	0.0062173	0.0206705	0.0620116
29	0.0062176	0.0206774	0.0413548	0.0062176	0.0206774	0.0413548
30	0.0062187	0.0207144	0.0207144	0.0062187	0.0207144	0.0207144

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Efficient Frontier						
Frontier Point	International bond			International stock and bond		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0034495	0.0092078	0.2762339	0.0034495	0.0092078	0.2762339
2	0.0035264	0.0094864	0.2751059	0.0035264	0.0094864	0.2751059
3	0.0036086	0.0097861	0.2740118	0.0036086	0.0097861	0.2740118
4	0.0036970	0.0101093	0.2729518	0.0036970	0.0101093	0.2729518
5	0.0037922	0.0104587	0.2719265	0.0037922	0.0104587	0.2719265
6	0.0038950	0.0108374	0.2709362	0.0038950	0.0108374	0.2709362
7	0.0040064	0.0112492	0.2699814	0.0040064	0.0112492	0.2699814
8	0.0041274	0.0116984	0.2690623	0.0041274	0.0116984	0.2690623
9	0.0042595	0.0121900	0.2681794	0.0042595	0.0121900	0.2681794
10	0.0044041	0.0127301	0.2673330	0.0044041	0.0127301	0.2673330
11	0.0045632	0.0133262	0.2665235	0.0045632	0.0133262	0.2665235
12	0.0047390	0.0139869	0.2657511	0.0047390	0.0139869	0.2657511
13	0.0049344	0.0147231	0.2650163	0.0049344	0.0147231	0.2650163
14	0.0051528	0.0155482	0.2643193	0.0051528	0.0155482	0.2643193
15	0.0053984	0.0164788	0.2636605	0.0053984	0.0164788	0.2636605
16	0.0056768	0.0175360	0.2630401	0.0056768	0.0175360	0.2630401
17	0.0059950	0.0187470	0.2624584	0.0059950	0.0187470	0.2624584
18	0.0061100	0.0191854	0.2494106	0.0061100	0.0191854	0.2494106
19	0.0061117	0.0191927	0.2303119	0.0061117	0.0191927	0.2303119
20	0.0061138	0.0192019	0.2112213	0.0061138	0.0192019	0.2112213
21	0.0061162	0.0192141	0.1921413	0.0061162	0.0192141	0.1921413
22	0.0061192	0.0192306	0.1730754	0.0061192	0.0192306	0.1730754
23	0.0061230	0.0192536	0.1540289	0.0061230	0.0192536	0.1540289
24	0.0061278	0.0192871	0.1350098	0.0061278	0.0192871	0.1350098
25	0.0061342	0.0193386	0.1160317	0.0061342	0.0193386	0.1160317
26	0.0061432	0.0194237	0.0971187	0.0061432	0.0194237	0.0971187
27	0.0061567	0.0195795	0.0783179	0.0061567	0.0195795	0.0783179
28	0.0061792	0.0199118	0.0597353	0.0061792	0.0199118	0.0597353
29	0.0062176	0.0206774	0.0413548	0.0062176	0.0206774	0.0413548
30	0.0062187	0.0207144	0.0207144	0.0062187	0.0207144	0.0207144

3. 1996-2000 Nominal Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0054367	0.0076773	0.2303185	0.0069076	0.0103263	0.3097901
2	0.0054972	0.0079400	0.2302599	0.0070175	0.0106811	0.3097516
3	0.0055620	0.0082215	0.2302032	0.0071352	0.0110612	0.3097144
4	0.0056317	0.0085240	0.2301485	0.0072617	0.0114696	0.3096785
5	0.0057066	0.0088498	0.2300958	0.0073979	0.0119094	0.3096439
6	0.0057876	0.0092018	0.2300451	0.0075449	0.0123844	0.3096106
7	0.0058753	0.0095832	0.2299964	0.0077043	0.0128991	0.3095785
8	0.0059707	0.0099978	0.2299496	0.0078775	0.0134586	0.3095478
9	0.0060747	0.0104502	0.2299048	0.0080664	0.0140690	0.3095184
10	0.0061886	0.0109458	0.2298620	0.0082734	0.0147376	0.3094903
11	0.0063140	0.0114911	0.2298212	0.0085010	0.0154732	0.3094635
12	0.0064525	0.0120938	0.2297823	0.0087526	0.0162862	0.3094381
13	0.0066064	0.0127636	0.2297455	0.0090322	0.0171897	0.3094139
14	0.0067784	0.0135124	0.2297106	0.0093446	0.0181995	0.3093910
15	0.0069719	0.0143549	0.2296778	0.0096961	0.0193356	0.3093694
16	0.0071912	0.0153098	0.2296469	0.0100944	0.0206233	0.3093492
17	0.0074418	0.0164013	0.2296180	0.0105497	0.0220950	0.3093302
18	0.0077310	0.0176609	0.2295911	0.0110629	0.0237541	0.3088031
19	0.0080684	0.0191305	0.2295661	0.0112417	0.0243498	0.2921976
20	0.0084672	0.0208676	0.2295432	0.0114530	0.0250945	0.2760397
21	0.0089457	0.0229522	0.2295223	0.0117066	0.0260413	0.2604127
22	0.0091177	0.0237059	0.2133531	0.0120166	0.0272687	0.2454180
23	0.0091609	0.0239199	0.1913590	0.0124040	0.0288974	0.2311788
24	0.0092163	0.0242286	0.1696001	0.0128564	0.0309165	0.2164152
25	0.0092903	0.0246967	0.1481800	0.0134004	0.0335291	0.2011748
26	0.0093939	0.0254540	0.1272700	0.0141619	0.0374626	0.1873130
27	0.0095493	0.0267923	0.1071690	0.0147857	0.0408656	0.1634626
28	0.0098083	0.0294769	0.0884306	0.0147857	0.0408656	0.1225969
29	0.0103262	0.0360622	0.0721245	0.0147857	0.0408656	0.0817313
30	0.0114771	0.0536440	0.0536440	0.0147857	0.0408656	0.0408656

(continued)

Efficient Frontier						
Frontier Point	International bond			International stock and bond		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0076382	0.0114437	0.3433099	0.0084863	0.0125916	0.3777479
2	0.0077732	0.0118370	0.3432729	0.0086499	0.0130247	0.3777155
3	0.0079179	0.0122585	0.3432372	0.0088252	0.0134887	0.3776842
4	0.0080733	0.0127112	0.3432026	0.0090134	0.0139872	0.3776540
5	0.0082406	0.0131988	0.3431694	0.0092161	0.0145240	0.3776249
6	0.0084214	0.0137255	0.3431373	0.0094351	0.0151039	0.3775969
7	0.0086172	0.0142961	0.3431066	0.0096723	0.0157321	0.3775700
8	0.0088300	0.0149164	0.3430771	0.0099301	0.0164150	0.3775441
9	0.0090621	0.0155931	0.3430488	0.0102114	0.0171600	0.3775194
10	0.0093164	0.0163344	0.3430218	0.0105194	0.0179760	0.3774958
11	0.0095961	0.0171498	0.3429961	0.0108583	0.0188737	0.3774732
12	0.0099052	0.0180511	0.3429716	0.0112328	0.0198659	0.3774518
13	0.0102487	0.0190527	0.3429483	0.0116490	0.0209684	0.3774315
14	0.0106326	0.0201721	0.3429263	0.0121141	0.0222007	0.3774122
15	0.0110645	0.0214316	0.3429056	0.0123315	0.0227830	0.3645276
16	0.0113081	0.0221459	0.3321883	0.0125092	0.0232812	0.3492182
17	0.0114479	0.0225776	0.3160857	0.0127067	0.0238593	0.3340306
18	0.0115599	0.0229416	0.2982413	0.0128793	0.0243895	0.3170640
19	0.0116150	0.0231292	0.2775499	0.0129554	0.0246385	0.2956623
20	0.0116151	0.0231294	0.2544232	0.0130454	0.0249548	0.2745029
21	0.0116151	0.0231297	0.2312969	0.0131535	0.0253647	0.2536466
22	0.0116152	0.0231301	0.2081709	0.0132516	0.0257651	0.2318856
23	0.0116153	0.0231307	0.1850453	0.0133007	0.0259892	0.2079140
24	0.0116155	0.0231315	0.1619205	0.0133639	0.0263128	0.1841896
25	0.0116157	0.0231328	0.1387967	0.0134481	0.0268037	0.1608221
26	0.0116159	0.0231349	0.1156745	0.0135661	0.0275985	0.1379927
27	0.0116163	0.0231388	0.0925552	0.0137430	0.0290049	0.1160196
28	0.0116170	0.0231473	0.0694418	0.0140378	0.0318319	0.0954957
29	0.0116183	0.0231714	0.0463427	0.0146275	0.0387899	0.0775798
30	0.0116224	0.0233011	0.0233011	0.0147857	0.0408656	0.0408656

4.1996-2000 Real Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0038593	0.0079850	0.2395488	0.0052898	0.0105552	0.3166545
2	0.0039198	0.0082379	0.2388981	0.0053997	0.0109025	0.3161713
3	0.0039846	0.0085096	0.2382678	0.0055174	0.0112751	0.3157038
4	0.0040542	0.0088021	0.2376580	0.0056439	0.0116760	0.3152521
5	0.0041292	0.0091180	0.2370689	0.0057801	0.0121083	0.3148162
6	0.0042102	0.0094600	0.2365007	0.0059272	0.0125758	0.3143961
7	0.0042979	0.0098314	0.2359534	0.0060865	0.0130830	0.3139920
8	0.0043933	0.0102360	0.2354273	0.0062597	0.0136350	0.3136039
9	0.0044973	0.0106783	0.2349225	0.0064487	0.0142378	0.3132318
10	0.0046112	0.0111638	0.2344391	0.0066556	0.0148989	0.3128759
11	0.0047365	0.0116989	0.2339772	0.0068832	0.0156268	0.3125362
12	0.0048750	0.0122914	0.2335371	0.0071348	0.0164322	0.3122127
13	0.0050289	0.0129510	0.2331187	0.0074144	0.0173281	0.3119054
14	0.0052010	0.0136895	0.2327223	0.0077268	0.0183303	0.3116145
15	0.0053945	0.0145217	0.2323478	0.0080783	0.0194587	0.3113400
16	0.0056138	0.0154664	0.2319956	0.0084767	0.0207388	0.3110819
17	0.0058644	0.0165475	0.2316655	0.0089319	0.0222029	0.3108402
18	0.0061536	0.0177968	0.2313579	0.0093947	0.0236925	0.3080022
19	0.0064910	0.0192560	0.2310726	0.0095735	0.0242897	0.2914764
20	0.0068898	0.0209827	0.2308098	0.0097848	0.0250362	0.2753982
21	0.0073683	0.0230570	0.2305697	0.0100384	0.0259851	0.2598508
22	0.0075041	0.0236513	0.2128617	0.0103484	0.0272150	0.2449351
23	0.0075473	0.0238658	0.1909261	0.0107358	0.0288467	0.2307738
24	0.0076028	0.0241752	0.1692261	0.0112023	0.0309310	0.2165170
25	0.0076768	0.0246443	0.1478656	0.0117463	0.0335425	0.2012553
26	0.0077803	0.0254032	0.1270158	0.0125079	0.0374746	0.1873731
27	0.0079357	0.0267440	0.1069759	0.0131586	0.0410266	0.1641064
28	0.0081947	0.0294330	0.0882989	0.0131586	0.0410266	0.1230798
29	0.0087126	0.0360264	0.0720527	0.0131586	0.0410266	0.0820532
30	0.0098500	0.0534001	0.0534001	0.0131586	0.0410266	0.0410266

(continued)

Efficient Frontier						
Frontier Point	International bond			International stock and bond		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0060240	0.0116310	0.3489310	0.0074943	0.0135004	0.4050125
2	0.0061591	0.0120182	0.3485288	0.0076782	0.0139546	0.4046820
3	0.0063037	0.0124336	0.3481398	0.0078751	0.0144415	0.4043624
4	0.0064591	0.0128802	0.3477641	0.0080694	0.0149221	0.4028954
5	0.0066265	0.0133616	0.3474016	0.0081007	0.0150010	0.3900269
6	0.0068072	0.0138821	0.3470524	0.0081345	0.0150892	0.3772299
7	0.0070030	0.0144465	0.3467166	0.0081644	0.0151699	0.3640769
8	0.0072158	0.0150606	0.3463943	0.0081914	0.0152453	0.3506419
9	0.0074480	0.0157312	0.3460853	0.0082208	0.0153308	0.3372775
10	0.0077022	0.0164662	0.3457898	0.0082530	0.0154282	0.3239924
11	0.0079819	0.0172754	0.3455079	0.0082884	0.0155398	0.3107969
12	0.0082911	0.0181705	0.3452394	0.0083275	0.0156686	0.2977027
13	0.0086346	0.0191658	0.3449846	0.0083710	0.0158180	0.2847238
14	0.0090185	0.0202790	0.3447433	0.0084196	0.0159928	0.2718769
15	0.0094504	0.0215322	0.3445157	0.0084743	0.0161988	0.2591815
16	0.0095952	0.0219604	0.3294060	0.0085363	0.0164441	0.2466610
17	0.0097350	0.0223956	0.3135390	0.0086071	0.0167388	0.2343435
18	0.0098963	0.0229237	0.2980077	0.0086888	0.0170971	0.2222627
19	0.0099870	0.0232323	0.2787876	0.0087842	0.0175383	0.2104593
20	0.0099870	0.0232325	0.2555579	0.0088969	0.0180893	0.1989828
21	0.0099871	0.0232328	0.2323283	0.0090321	0.0187893	0.1878931
22	0.0099872	0.0232332	0.2090991	0.0091973	0.0196959	0.1772627
23	0.0099873	0.0232338	0.1858704	0.0093067	0.0203283	0.1626268
24	0.0099874	0.0232346	0.1626424	0.0093743	0.0207689	0.1453826
25	0.0099876	0.0232359	0.1394154	0.0094570	0.0213736	0.1282417
26	0.0099879	0.0232380	0.1161901	0.0095427	0.0220963	0.1104813
27	0.0099883	0.0232419	0.0929677	0.0096712	0.0233682	0.0934729
28	0.0099890	0.0232503	0.0697510	0.0098854	0.0259039	0.0777118
29	0.0099903	0.0232743	0.0465486	0.0103137	0.0320622	0.0641244
30	0.0099943	0.0234035	0.0234035	0.0111772	0.0467069	0.0467069

5. 2001-2006 Nominal Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.004890	0.008990	0.269713	0.004890	0.008990	0.269713
2	0.004973	0.009299	0.269670	0.004973	0.009299	0.269670
3	0.005063	0.009630	0.269628	0.005063	0.009630	0.269628
4	0.005158	0.009985	0.269588	0.005158	0.009985	0.269588
5	0.005261	0.010367	0.269549	0.005261	0.010367	0.269549
6	0.005373	0.010780	0.269511	0.005373	0.010780	0.269511
7	0.005493	0.011228	0.269475	0.005493	0.011228	0.269475
8	0.005625	0.011715	0.269441	0.005625	0.011715	0.269441
9	0.005768	0.012246	0.269408	0.005768	0.012246	0.269408
10	0.005924	0.012827	0.269376	0.005924	0.012827	0.269376
11	0.006097	0.013467	0.269346	0.006097	0.013467	0.269346
12	0.006287	0.014175	0.269317	0.006287	0.014175	0.269317
13	0.006499	0.014961	0.269290	0.006499	0.014961	0.269290
14	0.006735	0.015839	0.269264	0.006735	0.015839	0.269264
15	0.006985	0.016767	0.268266	0.006985	0.016767	0.268266
16	0.006999	0.016819	0.252282	0.006999	0.016819	0.252282
17	0.007014	0.016882	0.236353	0.007014	0.016882	0.236353
18	0.007032	0.016961	0.220490	0.007032	0.016961	0.220490
19	0.007053	0.017059	0.204709	0.007053	0.017059	0.204709
20	0.007078	0.017185	0.189031	0.007078	0.017185	0.189031
21	0.007107	0.017348	0.173482	0.007107	0.017348	0.173482
22	0.007143	0.017567	0.158103	0.007143	0.017567	0.158103
23	0.007189	0.017868	0.142946	0.007189	0.017868	0.142946
24	0.007247	0.018299	0.128092	0.007247	0.018299	0.128092
25	0.007324	0.018943	0.113659	0.007324	0.018943	0.113659
26	0.007325	0.018946	0.094729	0.007325	0.018946	0.094729
27	0.007325	0.018946	0.075783	0.007325	0.018946	0.075783
28	0.007325	0.018946	0.056837	0.007325	0.018946	0.056837
29	0.007325	0.018946	0.037891	0.007325	0.018946	0.037891
30	0.007325	0.018946	0.018946	0.007325	0.018946	0.018946

(continued)

Efficient Frontier						
Frontier Point	International bond			International stock and bond		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0048902	0.0089904	0.2697133	0.0048902	0.0089904	0.2697133
2	0.0049734	0.0092990	0.2696700	0.0049734	0.0092990	0.2696700
3	0.0050626	0.0096296	0.2696281	0.0050626	0.0096296	0.2696281
4	0.0051583	0.0099847	0.2695878	0.0051583	0.0099847	0.2695878
5	0.0052615	0.0103673	0.2695488	0.0052615	0.0103673	0.2695488
6	0.0053728	0.0107805	0.2695114	0.0053728	0.0107805	0.2695114
7	0.0054935	0.0112281	0.2694754	0.0054935	0.0112281	0.2694754
8	0.0056246	0.0117148	0.2694409	0.0056246	0.0117148	0.2694409
9	0.0057677	0.0122458	0.2694078	0.0057677	0.0122458	0.2694078
10	0.0059244	0.0128274	0.2693762	0.0059244	0.0128274	0.2693762
11	0.0060967	0.0134673	0.2693461	0.0060967	0.0134673	0.2693461
12	0.0062872	0.0141746	0.2693174	0.0062872	0.0141746	0.2693174
13	0.0064989	0.0149606	0.2692902	0.0064989	0.0149606	0.2692902
14	0.0067354	0.0158391	0.2692645	0.0067354	0.0158391	0.2692645
15	0.0069852	0.0167667	0.2682665	0.0069852	0.0167667	0.2682665
16	0.0069988	0.0168188	0.2522824	0.0069988	0.0168188	0.2522824
17	0.0070143	0.0168824	0.2363530	0.0070143	0.0168824	0.2363530
18	0.0070322	0.0169608	0.2204901	0.0070322	0.0169608	0.2204901
19	0.0070530	0.0170591	0.2047091	0.0070530	0.0170591	0.2047091
20	0.0070777	0.0171846	0.1890306	0.0070777	0.0171846	0.1890306
21	0.0071073	0.0173482	0.1734823	0.0071073	0.0173482	0.1734823
22	0.0071435	0.0175670	0.1581026	0.0071435	0.0175670	0.1581026
23	0.0071887	0.0178683	0.1429461	0.0071887	0.0178683	0.1429461
24	0.0072468	0.0182989	0.1280920	0.0072468	0.0182989	0.1280920
25	0.0073243	0.0189431	0.1136588	0.0073243	0.0189431	0.1136588
26	0.0073246	0.0189457	0.0947286	0.0073246	0.0189457	0.0947286
27	0.0073246	0.0189457	0.0757829	0.0073246	0.0189457	0.0757829
28	0.0073246	0.0189457	0.0568372	0.0073246	0.0189457	0.0568372
29	0.0073246	0.0189457	0.0378915	0.0073246	0.0189457	0.0378915
30	0.0073246	0.0189457	0.0189457	0.0073246	0.0189457	0.0189457

6. 2001-2006 Real Return

Efficient Frontier						
Frontier Point	Canadian domestic portfolio			International stock		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0028389	0.0096870	0.2906109	0.0028389	0.0096870	0.2906109
2	0.0029221	0.0099740	0.2892468	0.0029221	0.0099740	0.2892468
3	0.0030113	0.0102830	0.2879229	0.0030113	0.0102830	0.2879229
4	0.0031070	0.0106163	0.2866395	0.0031070	0.0106163	0.2866395
5	0.0032101	0.0109768	0.2853974	0.0032101	0.0109768	0.2853974
6	0.0033215	0.0113679	0.2841970	0.0033215	0.0113679	0.2841970
7	0.0034422	0.0117933	0.2830389	0.0034422	0.0117933	0.2830389
8	0.0035733	0.0122575	0.2819236	0.0035733	0.0122575	0.2819236
9	0.0037164	0.0127660	0.2808517	0.0037164	0.0127660	0.2808517
10	0.0038731	0.0133249	0.2798235	0.0038731	0.0133249	0.2798235
11	0.0040454	0.0139420	0.2788396	0.0040454	0.0139420	0.2788396
12	0.0042359	0.0146263	0.2779005	0.0042359	0.0146263	0.2779005
13	0.0044476	0.0153893	0.2770066	0.0044476	0.0153893	0.2770066
14	0.0046841	0.0162446	0.2761583	0.0046841	0.0162446	0.2761583
15	0.0049503	0.0172098	0.2753561	0.0049503	0.0172098	0.2753561
16	0.0052237	0.0182042	0.2730629	0.0052237	0.0182042	0.2730629
17	0.0052392	0.0182629	0.2556807	0.0052392	0.0182629	0.2556807
18	0.0052571	0.0183354	0.2383605	0.0052571	0.0183354	0.2383605
19	0.0052780	0.0184264	0.2211168	0.0052780	0.0184264	0.2211168
20	0.0053027	0.0185427	0.2039692	0.0053027	0.0185427	0.2039692
21	0.0053323	0.0186944	0.1869440	0.0053323	0.0186944	0.1869440
22	0.0053684	0.0188976	0.1700780	0.0053684	0.0188976	0.1700780
23	0.0054137	0.0191780	0.1534238	0.0054137	0.0191780	0.1534238
24	0.0054718	0.0195798	0.1370585	0.0054718	0.0195798	0.1370585
25	0.0055493	0.0201832	0.1210993	0.0055493	0.0201832	0.1210993
26	0.0055565	0.0202431	0.1012153	0.0055565	0.0202431	0.1012153
27	0.0055565	0.0202431	0.0809722	0.0055565	0.0202431	0.0809722
28	0.0055565	0.0202431	0.0607292	0.0055565	0.0202431	0.0607292
29	0.0055565	0.0202431	0.0404861	0.0055565	0.0202431	0.0404861
30	0.0055565	0.0202431	0.0202431	0.0055565	0.0202431	0.0202431

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Efficient Frontier						
Frontier Point	International bond			International stock and bond		
	Expected Return	Standard Deviation	Sharpe Ratio	Expected Return	Standard Deviation	Sharpe Ratio
1	0.0028389	0.0096870	0.2906109	0.0028389	0.0096870	0.2906109
2	0.0029221	0.0099740	0.2892468	0.0029221	0.0099740	0.2892468
3	0.0030113	0.0102830	0.2879229	0.0030113	0.0102830	0.2879229
4	0.0031070	0.0106163	0.2866395	0.0031070	0.0106163	0.2866395
5	0.0032101	0.0109768	0.2853974	0.0032101	0.0109768	0.2853974
6	0.0033215	0.0113679	0.2841970	0.0033215	0.0113679	0.2841970
7	0.0034422	0.0117933	0.2830389	0.0034422	0.0117933	0.2830389
8	0.0035733	0.0122575	0.2819236	0.0035733	0.0122575	0.2819236
9	0.0037164	0.0127660	0.2808517	0.0037164	0.0127660	0.2808517
10	0.0038731	0.0133249	0.2798235	0.0038731	0.0133249	0.2798235
11	0.0040454	0.0139420	0.2788396	0.0040454	0.0139420	0.2788396
12	0.0042359	0.0146263	0.2779005	0.0042359	0.0146263	0.2779005
13	0.0044476	0.0153893	0.2770066	0.0044476	0.0153893	0.2770066
14	0.0046841	0.0162446	0.2761583	0.0046841	0.0162446	0.2761583
15	0.0049503	0.0172098	0.2753561	0.0049503	0.0172098	0.2753561
16	0.0052237	0.0182042	0.2730629	0.0052237	0.0182042	0.2730629
17	0.0052392	0.0182629	0.2556807	0.0052392	0.0182629	0.2556807
18	0.0052571	0.0183354	0.2383605	0.0052571	0.0183354	0.2383605
19	0.0052780	0.0184264	0.2211168	0.0052780	0.0184264	0.2211168
20	0.0053027	0.0185427	0.2039692	0.0053027	0.0185427	0.2039692
21	0.0053323	0.0186944	0.1869440	0.0053323	0.0186944	0.1869440
22	0.0053684	0.0188976	0.1700780	0.0053684	0.0188976	0.1700780
23	0.0054137	0.0191780	0.1534238	0.0054137	0.0191780	0.1534238
24	0.0054718	0.0195798	0.1370585	0.0054718	0.0195798	0.1370585
25	0.0055493	0.0201832	0.1210993	0.0055493	0.0201832	0.1210993
26	0.0055565	0.0202431	0.1012153	0.0055565	0.0202431	0.1012153
27	0.0055565	0.0202431	0.0809722	0.0055565	0.0202431	0.0809722
28	0.0055565	0.0202431	0.0607292	0.0055565	0.0202431	0.0607292
29	0.0055565	0.0202431	0.0404861	0.0055565	0.0202431	0.0404861
30	0.0055565	0.0202431	0.0202431	0.0055565	0.0202431	0.0202431

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