Measuring the potential effect of taxes and weight constraints on the home bias in New Zealand PIEs[☆]

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Abstract

This paper measures the potential effect of taxes and allocation weight constraints on the efficiency of an equity home bias for New Zealand investors indirectly invested in equities held in a portfolio investment entity (PIE). Historical monthly index data for 34 markets denominated in New Zealand dollars from 1993 to 2014 is used with an in-sample data-based mean-variance optimization approach to measure the benefits of international diversification. Naive diversification into the untaxed global market capitalization weighted (1/M) portfolio is shown to provide marginal return-to-risk (RR) benefits versus the New Zealand market portfolio during the 1993-2014 investment period. Relaxing the weight constraints on the markets held in the 1/M portfolio increases the potential benefits from diversification. Taxes are reported to reduce these benefits and increase the size of the home bias. Both weight constraints on overseas market allocations and taxes are shown to reduce the RR gains from diversification to statistically insignificant levels compared to the domestic market portfolio.

Keywords: International financial markets; Portfolio choice

JEL: G15; G11

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1. Introduction

For New Zealand tax residents there exist unequal tax frictions between dividends and capital gains earned in New Zealand versus those realized overseas. A New Zealand investor receives dividend imputation credits for New Zealand company dividends which effectively makes these dividends tax free. Capital gains on New Zealand shares held by a New Zealand investor are not taxed. Dividends paid by shares held overseas are often taxed by foreign governments. Additional New Zealand taxes are also applied to foreign investment fund (FIF)[1] assets exceeding $50,000 each income tax year. The unequal taxation of dividends and capital gains earned overseas can reduce the realized after-tax returns on international investment and can be expected to increase the efficiency of an equity home bias. This paper investigates the effect of taxes on the potential benefits from international diversification on investments held indirectly in a portfolio investment entity (PIE).

Investigating the effect of taxes on the potential benefits from international diversification is of practical value to investors in New Zealand. The recent introduction of the New Zealand KiwiSaver savings initiative, designed to encourage New Zealanders to save for retirement, has increased the breadth of investors in the country that are concerned with optimizing their equity investment portfolio. The KiwiSaver program began in 2007 and these accounts incur taxes. PIEs are commonly used as an investment vehicle in the Kiwisaver retirement accounts. As of June, 2015, New Zealand has a resident population of roughly 4.5 million and there are 2,530,919 active KiwiSaver accounts[2]. As of March, 2015, there are roughly $28 billion in total assets under management in KiwiSaver accounts[3]. Over $8.8 billion is held in New Zealand equities and units in trusts[4]. Nearly $9.1 billion is held in overseas equities and units in trusts[5]. The market capitalization of the New Zealand stock exchange main board of equities is approximately $100 billion.

[1] Foreign companies and foreign unit trusts are FIFs.
[2] source: http://www.rbnz.govt.nz/statistics/tables/t43/ (accessed December 5, 2015).
[3] Ibid.
[4] Ibid.
[5] Ibid.

The New Zealand market represents less than .20 of one percent of the global market capitalization in US dollars. Assets under management in KiwiSaver accounts are predicted to exceed $70 billion by the year 2020 (Heuser et al., 2015). Research measuring the effects of tax on optimal portfolio performance can be of value to retail investors selecting an indirect equity investment, managers of investment funds who are agents for investors, and pension funds interested in the aggregate portfolio performance of their clients.

This is the only study that this author is aware of that investigates the potential effect of taxes on the benefits of international diversification for New Zealand investors holding indirect equity investments in PIEs. This study uses historical monthly equity index data for 34 markets denominated in New Zealand dollars from 1993 to 2014 with an in-sample data-based mean-variance optimization approach to measure the benefits of international diversification. Portfolios are optimized with various levels of weight constraints on overseas market allocations and with the different tax rates that can be applied to PIE unit holders. The significance of the benefits achieved by the optimized portfolios versus the New Zealand market portfolio are measured using the Ledoit and Wolf (2008) bootstrap testing methods. These tests are designed to address the non-normality of returns and fat-tail events that occur with historical financial data. Using a bootstrap technique, regressions are performed on paired data points of a given block size between the monthly returns of two portfolios to provide a p-value measuring the significance of the hypothesis that the difference between the two portfolios is zero.

The results find that static portfolios optimized without weight constraints, no short sales and no taxes provide potential gains from diversification for New Zealand investors using historical data from the 1993 to 2014 investment period. Weight constraints reduce the size of allocations that can be made to small markets that provide diversification benefits. Taxes reduce the returns achieved by overseas markets. Both taxation and allocation constraints on overseas investments held in a PIE reduce the size and the statistical significance of the potential diversification benefits and increase the size and

efficiency of an equity home bias.

This paper is divided into four more sections. Section 2 reviews the literature related to New Zealand KiwiSaver investments and the documented effect of taxes on the equity home bias. Section 3 outlines the dividend and capital gains tax regime for equity investments held in PIEs and used in this study. Section 4 describes the data and methods used in this paper to investigate the benefits of international diversification. Section 5 reports the results of this investigation. Section 6 concludes with a summary of the main findings and suggestions for future study.

2. Literature Review

KiwiSaver is a recently introduced retirement scheme and the literature investigating fund performance is limited. Frijns and Tourani-Rad (2015) report that the risk-adjusted performance of KiwiSaver funds concentrated in domestic or international equity markets generally under-perform their benchmarks from September 2007 to April 2013. Heuser et al. (2015) present similar results, with under-performance more pronounced and prevalent amongst international funds. Bauer et al. (2006) reports that 143 New Zealand non-KiwiSaver domestic and international equity mutual funds from 1990 to 2003 generally under-perform their benchmarks. Funds that have positive alpha are not found to be statistically different from zero.

MacDonald et al. (2014) employ stochastic simulations to examine asset allocations that can improve the probabilities of adequate retirement balances for KiwiSaver investors. The results suggest that the legislated default funds are overly conservative and that investors may achieve better results with heavier allocations to equities. The paper reports that hypothetical funds heavily weighted in global equities have the strongest performance results. Taxes on KiwiSaver earnings and transaction fees are ignored in the study.

Taxes reduce investment returns and this affects portfolio optimization solutions and performance. In many countries, such as the United States, capital gains are taxed when

assets are sold. Investors have an incentive to realize capital losses and defer capital gains (Constatinides, 1984) in order to minimize these taxes. As a result, capital gains taxes can create a capitalization effect that reduces demand and a lock-in effect that can reduce supply (Dai et al., 2008). Trading and holding investments for purely tax reasons can be sub-optimal over time if an investor is seeking benefits associated with diversification. As a result of such taxes, optimal portfolio allocations can be different between investors because of the different trade frictions incurred by investors. In the case of New Zealand investors, the annual taxation of international gains and the inability to carry forward losses would likely eliminate these trading incentives.

Taxes are reported to influence portfolio selection amongst asset managers. Chan et al. (2005) examines how mutual funds in 26 different countries allocate assets locally and internationally. The paper finds that a domestic bias is influenced by market development and familiarity variables. The foreign bias is effected by economic development, capital controls and withholding tax variables. The paper reports that the New Zealand funds used in the study in aggregate allocate 74.93% of assets to New Zealand during 1999 to 2000. The New Zealand market was .07% of world market capitalization at the time. The paper notes that New Zealand funds have a foreign bias towards its nearest geographical neighbour Australia and allocate 14.4% of equity assets in that country. The Australian market represents 1.2% of the world market in the paper. Australian superannuation funds have a home bias that may be partially explained by factors such as anchoring formed from legacy investment, industry peers (Warren, 2010) and overseas taxes (Mishra and Ratti, 2013). And Christoffersen et al. (2005) report that Canadian fund managers consider the tax preferences of investors when setting investment policy.

This paper addresses gaps in the literature concerning the effect of taxes on the potential benefits from international diversification for New Zealand investors indirectly holding equity portfolios in PIEs. The taxation of overseas equity investments is reported to reduce the statistical significance of the diversification benefits derived from international investment and increases the efficiency of heavier allocations to New Zealand equities.

The findings contribute to previous literature that has identified tax as an explanatory factor in the documented home bias that exists with international investment funds in New Zealand (Chan et al., 2005). The results presented here find that the tax effect is more pronounced when optimizing a portfolio to maximize the RR performance than when minimizing portfolio variance. Furthermore, the empirical results do not support the conclusion presented in MacDonald et al. (2014) that heavier allocations to international equities is likely to improve KiwiSaver investor retirement outcomes. Rather, this paper reports that the combination of allocation weight constraints on overseas markets and the unequal taxation rates applied to international equity investment returns makes it unlikely that internationally diversified KiwiSaver portfolios can provide statistically significant positive return-to-risk improvements versus the untaxed domestic New Zealand market portfolio.

3. Tax

This section provides a brief overview of the taxes considered in this study that are applied to equities held in a portfolio investment entity (PIE). PIEs can be managed funds such as unit trusts[6]. Taxes to be paid by PIE unit holders are calculated by the PIE for each investor based on the taxable income for the investment period and the prescribed investor rate (PIR) for each investor. The four prescribed investor rates of 0%, 10.5%, 17.5% and 28% are used to measure the potential effect of taxes on the equity home bias in this study.

3.1. Foreign investment fund (FIF)

FIF rules were introduced from April 1, 2007. A FIF includes foreign companies and unit trusts. Australian shares listed on an approved index such as the ASX All Ordinaries

[6]Unit trusts are open-ended collective investments constituted under a trust deed and are similar to mutual funds.

are exempt from being an attributing interest in a FIF[7]. A New Zealand investor that holds less than 10% of a FIF is considered to have a portfolio position. Positions greater than $50,000 held at the beginning of each tax year must be declared.

PIEs use the fair dividend rate (FDR) method to determine the income to be taxed from the FIF[8]. The FDR of 5% is multiplied by the value of assets held at the beginning of the tax year. This amount is treated as income to be taxed. Dividends received overseas are considered to be part of this amount. Taxes paid on overseas dividends are given credit to reduce the income tax on the FDR. If there is no New Zealand income tax payable on the FIF investment, the credits for foreign tax paid can not be claimed. Unused credits can't be used to reduce tax payable on other income such as Australian dividend income[9]. The FDR method ignores positions bought and sold in the tax period. These are treated separately as quick sale adjustments which are then added to the FDR amounts[10].

PIEs are generally held by many different unit holders and units in the PIE can be purchased and sold by different investors each day. For this reason PIEs generally calculate a daily closing value for existing units. The FDR is pro-rated by the number of trading days in the period being measured compared to the number of days in the tax year. The value of the PIE at the beginning of the day is multiplied by the pro-rated FDR, and this amount is taxed at the client's PIR to determine the tax owed for the

[7]This study uses MSCI market indices to measure portfolio performance. For the purposes of this study Australian equities are treated as exempt from being an attributing interest in a FIF and only the dividends are treated as income to be taxed.

[8]New Zealand Income Tax Act 2007, section EX 53.

[9]Tax credits can be used to offset the tax payable on the FDR income associated with that attributing interest. As explained in IR 461 (Inland Revenue (2016). A guide to foreign investment funds and the fair dividend rate.): "Such foreign tax credits can only be used to reduce the income tax payable on your FIF income. If there is no New Zealand income tax payable on your FIF investment, no claim can be made for the foreign tax paid on any dividends received from the FIF. You can't use foreign tax credits to get a refund or reduce tax payable on other income. This includes other foreign income with a different nature or source, eg, dividends from companies with the Australian exemption and credits attached to United Kingdom dividends." (p.25)

[10]This study uses static portfolios. Portfolio asset weights are adjusted each month because of differences in asset returns. Quick sale adjustments are not considered in this study because all portfolio adjustments would occur on the first trading day of each month. As explained in Elliffe (2015), section 3.2.10(2): "If a fund does daily valuations, then no quick sale adjustment is required as all changes in the value of the portfolio will be picked up in the FDR formula."

trading day[11].

3.2. Imputation credits

Dividends paid by New Zealand companies to New Zealand tax residents receive imputation credits that effectively reduce the income tax owed on the dividends to zero[12]. The regime was introduced April 1, 1988. It is designed to avoid the double taxation of company profits. Because companies pay taxes on profits, imputation credits protect dividends paid to shareholders from being taxed again as income.

3.3. Taxation of foreign dividends

Dividends paid from shares held overseas generally incur non-resident withholding taxes in the source country. These dividends may also incur taxes to be paid in New Zealand. Double Taxation Agreements (DTA) provide relief from double taxation. These agreements outline the rate at which sources of income from investments are taxed in the country they are paid, and whether the country the shareholder is resident can also tax them. Thirty of the thirty-four countries studied in this paper have DTAs with New Zealand. These DTA countries tax dividends at a 15% rate. Argentina, Brazil, Greece and Portugal do not have DTAs and dividends are taxed at different rates. Table 1 identifies the countries that have DTAs with New Zealand and reports the tax rates applied to dividends paid in the 34 countries.

3.4. Portfolio investment entity (PIE)

From October 2007 unit trusts that meet the definition of a PIE are able to elect into tax rules under which they are not taxable on capital gains on shares in New Zealand and Australian companies listed on an approved index. Funds that do not meet the definition of a PIE are taxed on all earnings[13]. Portfolio investment entities pay tax on

[11] For a more detailed explanation refer to Appendix A or section 3.2.10 in Elliffe (2015).

[12] In practice not all dividends receive full imputation credits. For the purposes of this study all New Zealand dividends are treated as fully imputed and are not taxed.

[13] All KiwiSaver default schemes are PIEs.

investment income for each investor based on that investor's PIR of 0%, 10.5%, 17.5% or 28%. Only certain trustees are able to choose a rate. All other investors have only one rate that they qualify for based on their income and tax residency status. Income in the PIE can be taxed at a lower PIR than the investor's marginal tax rate. For example, the 28% PIR is lower than the 33% marginal tax rate of investors with income in excess of $70,000. The 17.5% PIR is for investors with income between $48,000 and $70,000 who have a marginal income tax rate of 30%.

Capital gains from New Zealand shares are not taxed. Dividends from New Zealand listed companies generally receive dividend imputation credits for distributions from taxed earnings paid by the firm which effectively make dividends tax free. Capital gains from Australian shares that meet listing requirements are not taxed. Withholding taxes are not deducted in Australia on dividends paid by these firms to a PIE[14]. The dividends are treated as income by the PIE and taxes are deducted based on the client's PIR. For equity held in other countries, the PIE determines the tax paid following the FDR rules.

The PIE rules address earlier differences in tax treatment between investors invested directly in New Zealand shares and those invested in shares via a New Zealand collective investment vehicles (CIV). An investor holding New Zealand shares directly was not typically taxed on capital gains. Under the old rules, an equivalent investment in a CIV was taxed on any realised New Zealand share gains. This was done because a CIV was considered a business trading in shares in order to make an income. The new PIE tax rules make indirect investments held in a PIE taxable in a similar way as directly held investments.

[14] As explained in Elliffe (2015), section 2.6.5(c): "Most Australian companies pay their dividends and attach Australian franking credits. When a fully franked dividend is paid, the Australian company does not have to deduct Australian NRWT [non-resident withholding tax]. These Australian franking credits are not creditable under the New Zealand provisions." This study treats all dividends paid in Australia as fully franked.

4. Data and Methods

The monthly MSCI price and total return data for 34 international markets priced in New Zealand dollars is used to investigate the effect of taxes on dividends and capital gains on the potential benefits of international diversification for New Zealand investors. The price data represents the capital gains realized by the markets. The difference between the price and the total return monthly returns represent the dividend portion of gains paid by these markets. The sample period covers December 31, 1992 to December 31, 2014. The data is collected from Datastream.

Annual market capitalization data in U.S. dollars for 1993 to 2012 is from two sources: the World Bank and the World Federation of Exchanges. The World Bank data is available for 33 of the 34 markets from 1993 to 2012. The 1993 and 1994 data is incomplete for Ireland. This incomplete data is calculated using changes to the MSCI total return data to backward fill the missing capitalization values from the first available market capitalization data point. The Taiwanese market capitalization data is retrieved from the World Federation of Exchanges.

Table 1 reports market characteristics. The second column presents the market capitalization of each market used in this study in U.S. dollars as a percent of all 34 markets combined at the end of 1993. The columns that follow report the geometric annual returns, the standard deviation of returns and the return-to-risk (RR) ratios of these markets as measured in the domestic currency and the New Zealand dollar for the 1993 to 2014 holding period. The gains derived from capital gains and dividends in New Zealand dollars are also presented. Also, which countries have double taxation agreements with New Zealand and the rate of withholding taxes on dividends paid in those countries are presented.

A comparison of the market returns realized in each local currency and the returns realized in the New Zealand currency presented in table 1 finds that the New Zealand dollar has appreciated against all of the foreign currencies over the period studied. As a result, the RR ratios of these markets are lower in the New Zealand currency versus the

Table 1: Market characteristics from 1993 to 2014.

	1993	Local Currency			New Zealand Dollar							
Country(i)	w_i	r	sd	RR	r	sd	RR	cap. gain	div.	div./total	DTA	Rate
Panel A: Developed Markets												
Australia	1.51	0.0977	0.132	0.74	0.0856	0.157	0.54	0.0438	0.0418	0.49	yes	0.15
Austria	0.21	0.0269	0.227	0.12	0.0076	0.214	0.04	-0.0145	0.0221	2.90	yes	0.15
Belgium	0.58	0.0827	0.192	0.43	0.0621	0.189	0.33	0.0263	0.0358	0.58	yes	0.15
Canada	2.41	0.1000	0.155	0.65	0.0840	0.178	0.47	0.0601	0.0239	0.28	yes	0.15
Denmark	0.31	0.1316	0.185	0.71	0.1112	0.187	0.59	0.0929	0.0183	0.16	yes	0.15
Finland	0.17	0.1422	0.311	0.46	0.1240	0.304	0.41	0.0922	0.0318	0.26	yes	0.15
France	3.37	0.0751	0.184	0.41	0.0558	0.174	0.32	0.0289	0.0269	0.48	yes	0.15
Germany	3.43	0.0880	0.212	0.41	0.0676	0.202	0.33	0.0423	0.0253	0.37	yes	0.15
H.K.	2.85	0.0929	0.257	0.36	0.0723	0.230	0.31	0.0381	0.0342	0.47	yes	0.15
Ireland	0.14	0.0451	0.215	0.21	0.0228	0.208	0.11	-0.0012	0.0240	1.05	yes	0.15
Italy	1.01	0.0637	0.217	0.29	0.0398	0.223	0.18	0.0065	0.0332	0.84	yes	0.15
Japan	22.18	0.0185	0.186	0.10	0.0011	0.176	0.01	-0.0118	0.0129	11.33	yes	0.15
Netherlands	1.34	0.0929	0.186	0.50	0.0725	0.178	0.41	0.0405	0.0321	0.44	yes	0.15
N.Z.	0.19	0.0743	0.163	0.46	0.0743	0.163	0.46	0.0205	0.0538	0.72	yes	0.15
Norway	0.20	0.1030	0.224	0.46	0.0783	0.232	0.34	0.0452	0.0330	0.42	yes	0.15
Singapore	0.98	0.0639	0.227	0.28	0.0540	0.217	0.25	0.0272	0.0268	0.50	yes	0.15
Spain	0.88	0.1179	0.215	0.55	0.0879	0.215	0.41	0.0491	0.0388	0.44	yes	0.15
Sweden	0.79	0.1358	0.223	0.61	0.1092	0.229	0.48	0.0815	0.0277	0.25	yes	0.15
Switzerland	2.01	0.0932	0.155	0.60	0.0916	0.145	0.63	0.0698	0.0218	0.24	yes	0.15
U.K.	8.52	0.0734	0.138	0.53	0.0546	0.138	0.40	0.0201	0.0345	0.63	yes	0.15

U.S.	37.98	0.0952	0.149	0.64	0.0746	0.147	0.51	0.0537	0.0209	0.28	yes	0.15
Panel B: Emerging Markets												
Argentina	0.33	0.1335	0.388	0.34	0.0096	0.390	0.02	-0.0149	0.0244	2.56	no	0.00
Brazil	0.74	0.5165	0.408	1.27	0.1139	0.356	0.32	0.0726	0.0413	0.36	no	0.00
Chile	0.33	0.1038	0.193	0.54	0.0605	0.222	0.27	0.0317	0.0288	0.48	yes	0.15
Greece	0.09	0.0321	0.318	0.10	0.0003	0.311	0.00	-0.0276	0.0279	97.66	no	0.10
Indonesia	0.24	0.1614	0.334	0.48	0.0507	0.406	0.12	0.0240	0.0267	0.53	yes	0.15
Korea	1.03	0.0895	0.293	0.31	0.0529	0.330	0.16	0.0363	0.0167	0.31	yes	0.15
Malaysia	1.63	0.0747	0.256	0.29	0.0407	0.291	0.14	0.0161	0.0247	0.61	yes	0.00
Mexico	1.49	0.1711	0.230	0.74	0.0711	0.279	0.25	0.0520	0.0190	0.27	yes	0.15
Philipines	0.30	0.0809	0.268	0.30	0.0303	0.283	0.11	0.0099	0.0204	0.67	yes	0.15
Portugal	0.09	0.0488	0.203	0.24	0.0235	0.208	0.11	-0.0109	0.0344	1.47	no	0.20
Taiwan	1.43	0.0686	0.270	0.25	0.0381	0.270	0.14	0.0141	0.0241	0.63	yes	0.15
Thailand	0.97	0.0521	0.352	0.15	0.0201	0.346	0.06	-0.0088	0.0289	1.44	yes	0.15
Turkey	0.28	0.4460	0.454	0.98	0.1007	0.498	0.20	0.0721	0.0285	0.28	yes	0.15

This table reports the percentage of market capitalization for each market as the percent of market capitalization of all 34 markets combined in U.S. dollars at the end of the year 1993. The geometric annual returns (r), standard deviation of returns (sd), and the return-to-risk ratios (RR) of each market in the local currency and in New Zealand dollars is also presented. The annual capital gains (cap. gain), dividends (div.) and the percentage of gains from dividends as a percent of the total gains of these markets in New Zealand dollars (div./total) is reported. Whether a country has a double taxation agreement (DTA) with New Zealand is reported. The withholding tax rate applied to dividends paid to non-residents of each country is also reported.

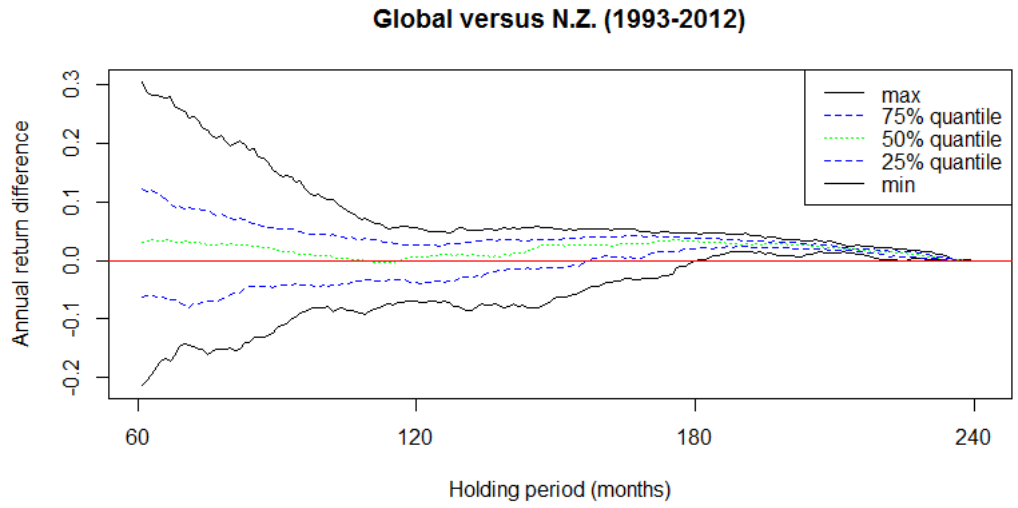

Figure 1: *This figure shows the difference in untaxed annual returns between the naive global portfolio in New Zealand dollars and the domestic New Zealand market portfolio in New Zealand dollars for all possible holding periods between January 1993 to December 2012.*

local currency. A comparison of the RR values shows that only the six markets of Australia, Canada, Denmark, Sweden, Switzerland, and the United States provide a higher RR ratio than New Zealand in New Zealand dollar terms for the 1993-2014 period.

Figure 1 presents the distribution of the difference in annual returns between the untaxed naive global portfolio and the local New Zealand market portfolio for all possible monthly holding periods from January 1993 to December 2012. The annual return of the domestic market portfolio is subtracted from the annual return of the untaxed naive global portfolio for each holding period. The returns from the naive global portfolio are calculated using the market capitalization weights for each year against the returns the markets provided each month. From each month, starting at January 1993, the returns for the domestic market portfolio and the naive global portfolio are calculated for each possible monthly holding period to the end of 2012. Starting from January 1993 there are 240 measurable one month holding periods and a single measurable 240 month holding period. The maximum and minimum difference in outcomes, along with the 75%, 50%

and 25% quantiles, are shown in figure 1. The graph starts from the 60 month holding period to reduce the scale of the graph that occurs using shorter holding periods.

Figure 1 shows that the naive global portfolio does not always outperform the local market portfolio. For almost all holding periods presented the naive global portfolio more often outperforms the domestic portfolio. The naive global portfolio always outperformed the local portfolio for investment periods exceeding 15 years. These results suggest that for the sample period used, diversification into the untaxed naive global portfolio can provide potential excess returns beyond the local portfolio, but that the size of these gains are not consistent across time.

4.1. International diversification

Investors can choose to maximize the return of their portfolio while seeking the same volatility obtained in the local market. Similarly, they can choose to minimize the volatility of their portfolio. They can choose to allocate funds in international markets where the investment opportunities of those markets can be stated as a vector of multivariate Gaussian stochastic returns of N assets, $R^T = [r_1, r_2, ..., r_n]$. The estimated mean of asset returns for these markets can be expressed as a vector μ. The variance-covariance of asset returns can be expressed as a positive definite matrix V. Let S be the set of all real vectors w that define the weights such that $w^T 1 = w_1 + w_2 + ... + w_n = 1$, where 1 is an N vector of ones. Using the methods developed by Markowitz (1952), the efficient frontier of global investments can be formed when the objective function and restrictions are combined in order to find the efficient portfolio that minimizes volatility at every level of expected return:

$$\min_{\{w,\phi,\eta\}} \Xi = \frac{1}{2} w^T V w + \phi(\mu_p - w^T \mu) + \eta(1 - w^T 1) \tag{1}$$

where μ_p is the expected return of the portfolio, and the shadow prices ϕ and η are two positive constants. The quadratic programming solution of assets in a portfolio spanning w_p can be obtained by the first-order conditions of equation (1).

For the purposes of this study, an investor may choose to diversify out of the domestic market and into the maximum return-to-risk portfolio (MRRP). When there are no weight restrictions, the MRRP can be determined using the estimated mean of asset returns and the estimated variance-covariance of asset returns to find the vector w of weights that define the estimated maximum return-to-risk (MRR) achieved by the MRRP such that:

$$MRR = \max_{\{w_p\}} \left\{ \frac{w_p^T \mu}{(w_p^T V w_p)^{1/2}} \middle| w_p^T \in S \right\} \tag{2}$$

where w_p is the vector of weights of the assets held in the MRRP. The estimated MRR measures the estimated return achieved by the MRRP compared to the estimated standard deviation of the MRRP.

Similarly, an investor may choose to diversify out of the domestic market and into the minimum volatility portfolio (MVP). When there are no weight restrictions, the MVP can be determined using the estimated variance-covariance of asset returns to find the vector w of weights that define the estimated minimum volatility (MV) achieved by the MVP such that:

$$MV = \min_{\{w_p\}} \left\{ (w_p^T V w_p)^{1/2} \middle| w_p^T \in S \right\} \tag{3}$$

where w_p is the vector of weights of the assets held in the MVP.

When an investor has constraints on the weights that can be assigned to assets held in the optimized portfolio and does not allow short sales, equations (2) and (3) can be solved such that $w_p^T \in S_c$ where $S_c = \{w_p \in S : 0 \leq w_i \leq \eta w(Cap)_i \leq 1, i = 1, 2, ..., N\}$, where η is the weight constraint multiplier greater than or equal to one, and $w(Cap)_i$ is the weight of the market value of each country i in the set of markets. This paper analyses the changes to the benefits of diversification when constraints are relaxed and overweighting of international markets can occur with η set to 1, 2, 5 and 10. The optimized portfolio that constrains all markets by η set to 1 is referred to in this paper as the naive 1/M portfolio. For the purposes of this study, the domestic New Zealand

market allocation is not constrained by the the market capitalization weight in order to measure the potential effect of taxes on the home bias in the optimal portfolios. The optimized portfolio that constrains all markets except New Zealand by η set to 1 is referred to as the $1/M^*$ portfolio. Similarly, for the purposes of measuring the home bias as the weight constraints are relaxed, the New Zealand market is not weight constrained in any of the optimized portfolios with relaxed weight constraints. As unit trusts are likely to restrict short sales, this paper does not consider short sales in the optimization solutions.

4.1.1. Estimated returns

This study uses the historical monthly returns of 34 markets denominated in New Zealand dollars from January 1993 to December 2014 to assess the potential effect of taxes on the benefits of international diversification for equity investments held in a PIE. The estimated optimal MVPs and MRRPs held in a PIE with different tax rates are determined using a vector μ of estimated mean after-tax asset returns for these markets. The estimated monthly after-tax market returns are calculated by deducting the appropriate overseas dividend withholding taxes and New Zealand taxes to be paid each month for each individual market.

New Zealand dividends and capital gains are not taxed. Australian equities are treated as exempt from being an attributing interest in a FIF. Capital gains on Australian shares are not taxed. This study treats all Australian dividends as fully franked and no withholding taxes are held. The dividends are taxed as income using the PIR. For all other markets, taxes withheld on overseas dividends are given credit to reduce the New Zealand FDR taxes. The New Zealand taxes to be paid are equal to the monthly pro-rated FDR multiplied by the PIR. The after-tax monthly returns for each market are used to calculate the estimated geometric annual market returns used in the optimization solution. The monthly after-tax returns are also converted to logarithmic monthly returns which are used to build the variance-covariance matrix used in the optimization solution.

4.1.2. Portfolio returns

The monthly after-tax returns achieved by the estimated MRRP and the MVP are used to measure the benefits from diversification. Using the same historical data used in the optimization stage, the after-tax monthly returns achieved by the static portfolios are calculated. A portfolio's monthly after-tax returns are used to calculate the geometric annual return and the standard deviation of returns for the portfolio. These are used to determine the RR ratio of the MRRP (RR_{MRRP}) and the variance of returns of the MVP (V_{MVP}) which are then used to measure the benefits from diversification.

4.1.3. Measuring the potential benefits of international diversification

For the New Zealand investor, adjusting their portfolio out of the domestic market and into the internationally diversified portfolio that maximizes the return-to-risk ratio, the greatest increment of unit-risk performance is measured as:

$$\delta = \frac{RR_{MRRP}}{RR_{nz}} - 1 \tag{4}$$

where δ (delta) represents the percentage improvement over the New Zealand market portfolio return-to-risk ratio (RR_{nz}) the investor achieves when moving into the internationally diversified portfolio that maximizes the return-to-risk performance (RR_{MRRP}).

This paper measures the reduction in volatility, ε (epsilon), that can result from diversification out of the domestic market and into the MVP as

$$\varepsilon = 1 - \left[\frac{V_{MVP}}{V_{nz}}\right]^{1/2} \tag{5}$$

where V_{nz} is the variance of the domestic New Zealand market portfolio and V_{MVP} is the variance of the MVP. A positive value represents the percentage reduction in portfolio volatility when diversifying out of the domestic portfolio and into the optimal internationally diversified MVP. A result approaching zero represents diminishing benefits from diversification.

5. Results

This section reports the results of examining the potential effect of taxes and weight constraints on the equity home bias for indirect equity investments held in a PIE using the data and methods presented in section 4. First, the domestic New Zealand market weight assigned to the MRRPs and MVPs with different weight constraints and tax levels optimized for the 1993 to 2014 investment period are presented. Next, the geometric annual returns, standard deviation of returns and RR ratios of these portfolios are reported. Then the delta and epsilon results for these optimized static portfolios are presented. The results are tested for statistical significance using the Ledoit and Wolf (2008) bootstrap testing methods designed to test whether the difference between two portfolio strategies is significantly different from zero. The results show that while the RR ratio improvement achieved with the unconstrained MRRP with no taxes approaches a statistically significant level, none of the taxed portfolios provide return-to-risk (RR) gains versus the New Zealand market portfolio that are statistically significant. Weight constrained MVPs can provide volatility reducing benefits that are statistically significant. Taxes on these MVPs reduce the significance of the RR ratios versus the domestic New Zealand market portfolio. The results report that taxes and allocation weight constraints on overseas markets increase the efficiency of a home bias for equity investments held in a PIE.

Table 2 reports the domestic New Zealand market allocations for each of the MRRPs and MVPs with no shorts and overseas market weights constrained by the 1993 market capitalization weights at various weight constraint limits: one times (wx1), two times (wx2), five times (wx5), ten times (wx10) and no weight constraints (nw). The New Zealand market is the only market unconstrained by weight constraints in the optimization solutions. For this study, it is assumed that an investor starting with a 100% weighting in the domestic New Zealand market portfolio might choose to diversify internationally into an optimized portfolio where the New Zealand market weight is unconstrained but the international markets are constrained by the market capitalization

weight of each market at the beginning of the investment period. In this paper a portfolio with only the overseas markets constrained to a maximum of one times the country's market capitalization weight (wx1) is referred to as the $1/M^*$ portfolio. The portfolios are optimized with no taxes (No Tax), or with withholding taxes on overseas dividends and the local New Zealand FDR taxes calculated with the PIR set to 0%, 10%, 17.5% or 28%.

In the case of the $1/M^*$ portfolio with no taxes, the New Zealand allocation is 44.07%. When overseas dividend taxes are considered and a PIR of 0% is used, the New Zealand allocation increases to 48.02%. When a PIR of 10% is used, the New Zealand allocation increases to 49.37%. At the 0% PIR level, credit for withholding taxes on overseas dividends can not be used as there is no New Zealand tax owed. As the PIR is increased, these credits can be used against the New Zealand tax owed. This partially explains why the marginal change in the home bias between the 0% and 10% PIR levels is smaller than between the no tax level and the 0% PIR level. The $1/M^*$ portfolio with a PIR of 28% has the highest New Zealand allocation of the MRRPs reported at 53.05%.

When no taxes are considered, weakening the weight constraints to two times the market capitalization weight reduces the allocation to the New Zealand market to 38.34%. As the weight constraints are relaxed further, allocations to small beneficial markets can increase and the domestic allocation falls. The smallest allocation to the New Zealand market of 16.67% occurs in the unconstrained MRRP with no taxes. At each weight constraint level, because the expected returns from the overseas equity markets are reduced by higher tax rates, a home bias becomes more efficient and the New Zealand market allocations increase as the PIR is increased.

In the case of the MVP, taxes at each weight constraint level has little effect on the domestic allocation. The home bias is reduced as the weight constraints are relaxed. The largest New Zealand allocation of 32.98% is with the $1/M^*$ portfolio taxed at a 28% PIR. The New Zealand allocation in the unconstrained MVP with no taxes is 24.50%.

Chan et al. (2005) reports that in the 1999 to 2000 period, New Zealand unit-trusts

Table 2: Domestic market allocations.

	MRRP domestic market weight					MVP domestic market weight				
Case	wx1	wx2	wx5	wx10	nw	wx1	wx2	wx5	wx10	nw
No Tax	0.4407	0.3834	0.3338	0.2863	0.1667	0.3289	0.3001	0.2637	0.2467	0.2450
0% PIR	0.4802	0.3996	0.3564	0.3039	0.1740	0.3291	0.3001	0.2638	0.2468	0.2448
10% PIR	0.4937	0.4151	0.3717	0.3154	0.2041	0.3293	0.3004	0.2641	0.2471	0.2453
17.5% PIR	0.5181	0.4405	0.3958	0.3385	0.2305	0.3295	0.3005	0.2644	0.2473	0.2455
28% PIR	0.5305	0.4788	0.4333	0.3723	0.2713	0.3298	0.3008	0.2647	0.2477	0.2460

This table reports the domestic New Zealand market allocation held in each MRRP and MVP optimized with different tax levels and allocation weight constraints. The portfolios do not implement short sales and the domestic New Zealand market weight is unconstrained in the optimization solutions. Each overseas market weight is constrained by the country's 1993 market capitalization weight at the one times (wx1), two times (wx2), five times (wx5), ten times (wx10) and no weight constraint (nw) level. The portfolios are optimized with no taxes (No Tax), or with withholding taxes on overseas dividends and the local New Zealand FDR taxes calculated with the PIR set to 0%, 10%, 17.5% or 28%.

Table 3: Annual returns, standard deviation of returns and RR ratios.

Tax	MRRP overseas markets constrained by ...						MVP overseas markets constrained by ...					
Rate	1/M	wx1	wx2	wx5	wx10	nw	1/M	wx1	wx2	wx5	wx10	nw
Panel A: Annual Returns												
No Tax	0.063	0.080	0.083	0.087	0.088	0.098	0.063	0.065	0.065	0.067	0.070	0.071
0% PIR	0.060	0.080	0.082	0.084	0.087	0.096	0.060	0.063	0.063	0.064	0.068	0.068
10% PIR	0.058	0.078	0.080	0.082	0.084	0.093	0.057	0.061	0.061	0.063	0.066	0.067
17.5% PIR	0.054	0.077	0.078	0.080	0.082	0.090	0.054	0.059	0.058	0.060	0.063	0.064
28% PIR	0.048	0.075	0.076	0.077	0.079	0.086	0.048	0.055	0.055	0.056	0.059	0.060
NZ	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Panel B: Standard Deviation of Returns												
No Tax	0.130	0.121	0.122	0.121	0.118	0.122	0.130	0.115	0.113	0.112	0.111	0.111
0% PIR	0.130	0.123	0.123	0.121	0.117	0.122	0.130	0.115	0.113	0.112	0.111	0.111
10% PIR	0.130	0.123	0.123	0.121	0.117	0.122	0.130	0.115	0.113	0.112	0.111	0.111
17.5% PIR	0.130	0.124	0.123	0.121	0.118	0.122	0.130	0.115	0.113	0.112	0.111	0.111
28% PIR	0.130	0.125	0.124	0.122	0.118	0.122	0.130	0.115	0.113	0.112	0.111	0.111
NZ	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
Panel C: Return-to-Risk												
No Tax	0.483	0.663	0.681	0.714	0.752	0.798	0.483	0.565	0.573	0.596	0.632	0.636
0% PIR	0.458	0.647	0.669	0.697	0.737	0.784	0.458	0.547	0.553	0.574	0.612	0.615
10% PIR	0.441	0.638	0.656	0.683	0.718	0.760	0.441	0.533	0.540	0.560	0.595	0.598
17.5% PIR	0.412	0.621	0.637	0.664	0.700	0.738	0.412	0.511	0.516	0.536	0.570	0.574
28% PIR	0.370	0.600	0.612	0.637	0.670	0.707	0.370	0.479	0.482	0.500	0.534	0.537

NZ	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459

This table reports the realized geometric annual returns, the standard deviation of returns and the RR ratios for each portfolio optimized at different tax levels and allocation weight constraints. The untaxed domestic New Zealand (NZ) market characteristics are also presented. The 1/M portfolio is the portfolio with all market weights, including the New Zealand market, set by the 1993 market capitalization weights. The MRRPs and the MVPs are optimized with no shorts and the international markets constrained by the 1993 market capitalization weights at the one times (wx1), two times (wx2), five times (wx5), ten times (wx10) and no weight constraint (nw) level. The domestic New Zealand market weight is unconstrained in the MRRP and MVP optimization solutions. The portfolios are optimized with no taxes (No Tax), or with withholding taxes on overseas dividends and the local New Zealand FDR taxes calculated with the PIR set to 0%, 10%, 17.5% or 28%.

Table 4: The measured benefits.

Tax		Overseas market weights constrained by ...					benefit gained			
Rate	1/M	wx1	wx2	wx5	wx10	nw	1/M	wx1	wx2	wx5	wx10
Panel A: MRRP delta											
No Tax	0.0513 (0.982)	0.4446 (0.278)	0.4839 (0.268)	0.5547 (0.218)	0.6384 (0.140)	0.7369 (0.114)	0.07	0.60	0.66	0.75	0.87
0% PIR	-0.0023 (0.948)	0.4084 (0.286)	0.4557 (0.274)	0.5179 (0.236)	0.6051 (0.148)	0.7065 (0.128)	0.00	0.58	0.64	0.73	0.86
10% PIR	-0.0394 (0.896)	0.3883 (0.296)	0.4277 (0.302)	0.4881 (0.252)	0.5676 (0.166)	0.6560 (0.148)	-0.06	0.59	0.65	0.74	0.87
17.5% PIR	-0.1028 (0.802)	0.3513 (0.322)	0.3869 (0.336)	0.4460 (0.278)	0.5228 (0.186)	0.6079 (0.172)	-0.17	0.58	0.64	0.73	0.86
28% PIR	-0.1946 (0.680)	0.3040 (0.376)	0.3320 (0.370)	0.3872 (0.318)	0.4584 (0.216)	0.5405 (0.228)	-0.36	0.56	0.61	0.72	0.85
Panel B: MVP epsilon											
No Tax	0.1989 (0.012)	0.2906 (0.002)	0.3026 (0.002)	0.3116 (0.002)	0.3150 (0.002)	0.3151 (0.002)	0.63	0.92	0.96	0.99	1.00
0% PIR	0.1989 (0.012)	0.2906 (0.002)	0.3026 (0.002)	0.3116 (0.002)	0.3152 (0.002)	0.3152 (0.002)	0.63	0.92	0.96	0.99	1.00
10% PIR	0.1986 (0.012)	0.2904 (0.002)	0.3024 (0.002)	0.3115 (0.002)	0.3150 (0.002)	0.3150 (0.002)	0.63	0.92	0.96	0.99	1.00
17.5% PIR	0.1983 (0.012)	0.2903 (0.002)	0.3023 (0.002)	0.3112 (0.002)	0.3147 (0.002)	0.3147 (0.002)	0.63	0.92	0.96	0.99	1.00
28% PIR	0.1980 (0.012)	0.2900 (0.002)	0.3021 (0.002)	0.3110 (0.002)	0.3144 (0.002)	0.3144 (0.002)	0.63	0.92	0.96	0.99	1.00
Panel C: MVP delta											
No Tax	0.0513 (0.982)	0.2300 (0.654)	0.2478 (0.688)	0.2970 (0.550)	0.3770 (0.418)	0.3839 (0.426)	0.13	0.60	0.65	0.77	0.98
0% PIR	-0.0023 (0.948)	0.1917 (0.724)	0.2047 (0.738)	0.2499 (0.610)	0.3317 (0.496)	0.3401 (0.490)	-0.01	0.56	0.60	0.73	0.98
10% PIR	-0.0394 (0.896)	0.1616 (0.772)	0.1752 (0.780)	0.2191 (0.654)	0.2955 (0.560)	0.3029 (0.552)	-0.13	0.53	0.58	0.72	0.98
17.5% PIR	-0.1028 (0.802)	0.1132 (0.876)	0.1242 (0.868)	0.1661 (0.756)	0.2420 (0.648)	0.2491 (0.630)	-0.41	0.45	0.50	0.67	0.97
28% PIR	-0.1946 (0.680)	0.0434 (0.998)	0.0506 (1.000)	0.0881 (0.920)	0.1620 (0.784)	0.1687 (0.784)	-1.15	0.26	0.30	0.52	0.96

This table reports the delta and epsilon benefits from diversification out of the New Zealand domestic market and into the MRRPs and the MVPs optimized with no shorts and the international markets constrained by the 1993 market capitalization weights at the one times (wx1), two times (wx2), five times (wx5), ten times (wx10) and no weight constraint (nw) level. The results for the 1/M portfolio, which is the portfolio optimized with no shorts and all market weights, including the New Zealand market, constrained by the 1993 market capitalization weights, are also presented. The portfolios are optimized with no taxes (No Tax), or with withholding taxes on overseas dividends and the local New Zealand FDR taxes calculated with the PIR set to 0%, 10%, 17.5% or 28%. The p-value results from the Ledoit and Wolf (2008) Sharpe ratio and volatility tests using a block size of 5 and 499 iterations are presented in parentheses. The last five columns report the percent of the unconstrained portfolio benefits that are captured by each weight constrained portfolio.

in aggregate held 74.93% of equity assets in New Zealand. While the tax polices for that period are different than considered in this study, the results presented here suggest that taxes on overseas equity investments and weight constraints imposed on overseas allocations held in a unit-trust are factors that can contribute towards a home bias. The tax effect is more pronounced when optimizing a portfolio to maximize the RR performance than when minimizing variance.

Table 3 reports the realized after-tax geometric annual returns, standard deviation of returns and RR ratios for the MRRPs and MVPs optimized with different weight constraints and tax levels. The 1/M portfolio results are also presented. The 1/M portfolio is the naive market capitalization weighted (1/M) portfolio that the international CAPM suggests investors will hold in order to capture the naive diversification benefits from sharing risk. The New Zealand market allocation in this portfolio is .19%. Panel A reports the annual returns for each optimized portfolio with different tax rates and the annual returns of the domestic New Zealand (NZ) market which is not taxed. The untaxed 1/M portfolio achieves annual returns of 6.29% versus the New Zealand market portfolio return of 7.46%. Relaxing the weight constraints on the 1/M portfolio increases the returns realized by the MRRP and the MVP. At each constraint level, taxes reduce these returns.

Panel B of table 3 reports that the standard deviation of returns for the MRRPs and MVPS are lower than the New Zealand market for all weight constraint and tax levels. Panel C reports the RR ratios for the various portfolios. The taxed 1/M portfolios do not achieve RR ratios that are larger than the New Zealand market. The MRRPs and MVPs with relaxed weight constraints and taxes have RR ratios that are greater than the New Zealand market.

Table 4 reports the delta and epsilon results for the MRRPs and MVPs with various weight constraints and tax rates. Panel A reports the percentage increase in the RR ratio when moving from the domestic New Zealand market portfolio to the MRRP. The results from the Ledoit and Wolf (2008) Sharpe ratio tests are presented in parentheses.

The p-values report the significance of the hypothesis that the difference between the RR ratio of the monthly returns of the domestic portfolio and the optimized portfolio is zero. A 10% result is treated as statistically significant[15]. The last five columns in the table report the percent of the unconstrained portfolio gains that are captured by the constrained portfolio at each tax level. At each level of weight constraint, taxes reduce the diversification benefits. Taxes negate the benefits from diversifying into the naive 1/M portfolio. The $1/M^*$ portfolio with no taxes provides a positive delta benefit of 44.46%. The $1/M^*$ portfolio captures the majority of potential gains available with the unconstrained portfolio at each tax level. For example, 56% of the benefits available from the unconstrained MRRP taxed with a 28% PIR can be captured by the $1/M^*$ portfolio. As the weight constraints are relaxed the potential benefits from diversification increase. Taxes reduce the benefits from diversification which remain positive at the highest PIR of 28%. Only the unconstrained MRRP with no taxes approaches a statistically significant benefit level with a p-value of 0.114.

Panel B of table 4 reports the percentage reduction in portfolio volatility when moving from the New Zealand domestic market portfolio to the optimized MVPs. The results from the Ledoit and Wolf (2008) volatility tests are presented in parentheses. The p-values report the significance of the hypothesis that the difference between the standard deviation of the monthly returns of the domestic portfolio and the optimized portfolio is zero. A 10% result is treated as statistically significant. At each tax level, the 1/M portfolio captures 63% of the potential volatility reducing benefits available from the unconstrained MVP. The $1/M^*$ portfolio can capture as much as 92% of the maximum unconstrained potential gains at each tax level. All the portfolios provide reductions in volatility that are statistically significant.

Panel C of table 4 reports the delta results for the various weight constrained and taxed MVPs. The results from the Ledoit and Wolf (2008) Sharpe ratio tests are presented in parentheses. As with the MRRP, taxes reduce realized returns which results

[15] A 10% significance level is used in Behr et al. (2013). DeMiguel et al. (2009) uses a 5% significance level.

in lower potential RR improvements from diversification. With no taxes, none of the optimized MVPs have positive RR improvements that are statistically significant. The unconstrained portfolio with no taxes offers the greatest potential RR improvement of 38.39% over the domestic market. The p-value for this portfolio is .426. This is greater than the .10 significance level. In the case of a PIE with a 28% PIR, taxes on the unconstrained portfolio reduce the delta gains to 16.87%. The statistical significance of the results weakens to 0.784. Strengthening the weight constraints on the MVPs reduces the delta results. Taxes at each level of weight constraint reduces the potential RR gains. While MVPs with weight constraints and taxes offer potential volatility reducing benefits that are statistically significant, the resulting RR ratios are not significantly larger than the domestic market. An investor choosing to reduce portfolio volatility may find maintaining a home bias and diversifying into a risk free asset may achieve a similar level of volatility offered by an internationally diversified MVP which does not offer statistically different RR performance.

These results do not support the suggestion by MacDonald et al. (2014) that KiwiSaver funds are likely to improve long term performance by increasing allocations to global equities. Rather, based on historical data, static optimized portfolios of international markets held in a PIE are unlikely to achieve statistically significant RR efficiency gains beyond the domestic New Zealand market portfolio when taxes are considered. Furthermore, a PIE optimizing a portfolio with imperfect market return and covariance estimates is unlikely to achieve the ex-post optimized results presented in this study. Weight constraints on assets may be used to reduce ex-ante estimation error in the optimization solution (Jagannathan and Ma, 2003; DeMiguel et al., 2009) which will further reduce the potential benefits from diversification and increase the efficiency of a home bias.

These results suggest that an optimized MRRP or MVP with no taxes and no weight constraints held during the 1993 to 2014 investment period is unlikely to provide positive RR improvement beyond the domestic market portfolio that can be reported to be

statistically different. As the PIR is increased on equity investments held in a PIE, the potential RR gains from an unconstrained portfolio falls and the efficiency of a home bias increases. Increasing the weight constraints on the optimized portfolios further reduces the potential gains of diversification and increases the home bias.

6. Conclusion

This paper investigates the potential effect of taxes on the benefits from international diversification and the efficiency of an equity home bias for New Zealand investors with indirect equity investments held in a PIE. Weight constraints on overseas market allocations and taxes reduce the potential benefits of international diversification. Relaxing the weight constraints on overseas market allocations reduces the equity home bias. Taxes increase the equity home bias. While relaxing weight constraints on the optimization solution and reducing taxes does increase the potential benefits from international diversification for both the MRRP and the MVP, the RR gains from these portfolios are not statistically different than the domestic New Zealand market portfolio.

The findings presented in this paper contribute to the literature investigating the benefits of international diversification for New Zealand investors. First, the results provide evidence of the importance of taxes in reducing the benefits from international diversification for KiwiSaver investors which previous literature has not considered in their conclusions. MacDonald et al. (2014) suggests that heavier KiwiSaver allocations to international equities may improve investor retirement outcomes. This paper reports that the combination of allocation weight constraints on overseas markets and the unequal taxation rates applied to international equity investment returns makes it unlikely that internationally diversified KiwiSaver portfolios can provide statistically significant positive return-to-risk improvements versus the untaxed domestic New Zealand market portfolio. Second, the empirical results contribute to previous literature that has identified tax as an explanatory factor in the documented home bias that exists with international investment funds in New Zealand (e.g., Chan et al., 2005). The results

presented here find that the tax effect is more pronounced when optimizing a portfolio to maximize the RR performance than when minimizing portfolio variance.

The results presented in this paper reflect the historical benefits from diversification. The New Zealand currency strengthened against all other currencies over the sample period. It is unclear whether this currency appreciation will continue and what effect the currency will have on the potential benefits from diversification that may be available in the future. Furthermore, this study does not consider the effect of the forecast increase in ownership of the New Zealand market by KiwiSaver funds (e.g., Heuser et al., 2015) on future New Zealand market performance. Research that addresses these points may extend the results presented in this chapter.

Appendix A. Calculating the FDR for a PIE

The New Zealand Income Tax Act 2007 sets out the rules governing tax obligations in New Zealand. Section EX 53 defines the rules used by a unit-valuing fund, such as a unit trust, to calculate tax owed by unit holders using the FDR method. The unit trust assigns each investor an interest (the unit) in a proportion of the net returns from the investments[16] and determines the value of the investors' units for each of a number of periods making up the income year[17]. The FDR amount is pro-rated by the number of trading days in the period being measured compared to the number of days in the tax year. The value of the PIE unit at the beginning of the period is multiplied by the pro-rated FDR, and this amount is treated as income to be taxed at the clients' PIR to determine the tax owed.

PIEs generally calculate a daily closing value for existing units. The pro-rated annual FDR of 5% for a single trading day is 1/365 of the FDR. If the unit price at the end of the previous closing is $10.00, and a client has a PIR of 28% and holds 1,000 units, the unit-trust can calculate the tax owed by the client at the end of the trading day as

[16] EX53, 1(b)(ii)
[17] EX53, 1(b)(iii)

follows:

$$1/365 \times 0.05 \times 1,000 \times \$10.00 \times 0.28 = \$0.383562 \tag{A.1}$$

For this study, the monthly after-tax portfolio returns are determined using a monthly pro-rated FDR equal to $1/12 \times .05$.

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