ESTIMATION OF THE TAMRP

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EXECUTIVE SUMMARY

This paper has updated an earlier (2019) estimate of the TAMRP, for application to four and five year periods. The same set of approaches that were used earlier have been used here, and warrant an estimate of 7.0% for both four and five-year terms rounded to the nearest 0.5%. By comparison with the 2019 estimates, the median estimate has declined from 7.5% to 7.0% because the DGM and Siegel version 2 estimates have substantially declined, partly offset by increases in the survey-based estimates.

1. Introduction

This paper updates the estimates for the TAMRP provided in Lally (2019), using the same set of approaches and for application to four and five year periods.

2. Background

For estimating the cost of equity capital, the Commerce Commission uses a simplified version of the Brennan-Lally CAPM (Lally, 1992; Cliffe and Marsden, 1992), which assumes (since the introduction of dividend imputation in 1988) that all dividends are fully imputed, shareholders can fully utilise the credits, the average tax rate on dividends and interest is equal to the corporate tax rate, and capital gains are tax free. Under these assumptions, since 1988, the TAMRP is as follows:

$$TAMRP = E(R_m) - R_f(1 - T_c) \qquad (1)$$

where $E(R_m)$ is the expected market return exclusive of imputation credits, R_f is the risk-free rate, and T_c is the corporate tax rate.

3. Historical Averaging of Excess Returns

I start with historical averaging of excess returns for New Zealand (the "Ibbotson" approach). Using this approach with data from 1931-2002, Lally and Marsden (2004a, Table 2) estimate the TAMRP in the general version of the Brennan-Lally model at 7.2%. Correcting for the taxation assumptions underlying the simplified version of the model that apply from 1988, by applying equation (1) from 1988, the result is slightly higher at 7.3%. I apply the same approach to the years 2003-2022. For each such year t, the ex-post counterpart to the TAMRP in equation (1) is

$$TA\hat{M}RP_t = R_{mt} - R_{ft}(1 - T_c) \qquad (2)$$

Consistent with Lally and Marsden (2004a), R_{ft} is the ten-year government bond rate averaged over the year with the rates taken from Reserve Bank data.[1] In respect of R_{mt}, Lally and

[1] Table B2 on the Reserve Bank website (www.rbnz.govt.nz).

Marsden (2004a, Appendix A) deduced this from the NZX50 Gross Index return GR_{mt} (which includes the imputation credits) because there was no gross index at that time that excluded the credits. However, in 2005, a gross index was introduced without the imputation credits (NZX50G), with backdating to 2000, and the rate of change in this index is R_{mt}. The values for these parameters and the resulting values for $TA\hat{M}RP$ are shown in Table 1 below.[2]

Table 1: Ibbotson Estimates of the TAMRP for NZ 2003-2022

Year	R_m	T_c	R_f	$TA\hat{M}RP$
2003	.235	.33	.059	.196
2004	.227	.33	.061	.187
2005	.082	.33	.059	.042
2006	.203	.33	.058	.164
2007	-.003	.33	.063	-.045
2008	-.328	.30	.061	-.370
2009	.189	.30	.055	.151
2010	.024	.30	.056	-.015
2011	-.010	.28	.050	-.046
2012	.242	.28	.037	.215
2013	.165	.28	.041	.135
2014	.175	.28	.043	.144
2015	.136	.28	.034	.111
2016	.088	.28	.028	.068
2017	.220	.28	.030	.199
2018	.049	.28	.027	.029
2019	.304	.28	.017	.292
2020	.139	.28	.09	.132
2021	-.004	.28	.018	-.018
2022	-.120	.28	.036	-.146
Average				.071

[2] All data in the table for the years 2003-2018 is taken from Lally (2019, Table 1).

As shown in the table, the average of these ex-post values for the TAMRP is .071. This average over 20 years is combined with the estimate of .0727 for 1931-2002 referred to above (72 years), to yield the updated estimate of the TAMRP for 1931-2022 of .073 as follows:

$$\widehat{TAMRP} = .073\left(\frac{72}{92}\right) + .071\left(\frac{20}{92}\right) = .073$$

In using a historical average to estimate the current or future population mean, it is implicit that the historical data are drawn from a population whose mean is constant over time. The Appendix tests this hypothesis using this 1931-2022 data and concludes that it cannot be rejected.

This estimate of the TAMRP is defined relative to the ten-year risk-free rate, and is therefore applicable to a ten-year period. By contrast, the estimates sought here are for four and five year periods, and therefore requires use of the four and five year risk-free rates. In respect of the five-year risk-free rate, data is only available in New Zealand from March 1985. Nevertheless, data is available on both five and ten-year rates in the US from April 1953. This allows an estimate as follows. Firstly, the average differential for the New Zealand five and ten year rates from 1985-2022 inclusive has been 0.14%.[3] In addition, the average differential for the US five and ten year rates over the period 1953-1985 has been 0.08%.[4] I extrapolate the latter differential to New Zealand for the same period and also to the earlier period 1931-1953. The time-weighted average differential over the entire period 1931-2022 is then 0.10%. In addition the average tax rate on interest over the period since 1931 has been 0.29.[5] So, following equation (1), the Ibbotson type estimate for the TAMRP over the 1931-2022 period using five-year risk free rates is the estimate of .073 based on ten-year rates, corrected for the rate differential (after tax) to yield .074 as follows:

[3] Data from Table B2 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz). The ten and five year rates average 6.81% and 6.67% respectively.

[4] The rates are reported at http://research.stlouisfed.org/fred2/categories/115, and average 6.42% for the five-year constant-maturity bonds (GS5) and 6.50% for the ten-year constant-maturity bonds (GS10).

[5] This comprises an average of 0.29 over the period 1931-2018 (Lally, 2019, footnote 5) and values of 0.28 for each of the years 2019-2022 (corresponding to the corporate tax rate in accordance with the assumptions underlying the simplified Brennan-Lally version of the CAPM used by the Commission), yielding a time-weighted average of 0.29.

$$\widehat{TAMRP} = .073 + .0010(1 - .29) = .074 \quad (3)$$

In respect of the four-year TAMRP, the average differential for ten over four year risk-free rates in New Zealand over the 1985-2022 period was 0.13% whilst the average differential for the US over the 1953-1985 period was also 0.13%.[6] Extrapolating the latter differential to New Zealand for the same period and also to the earlier period 1931-1953, the time-weighted average differential over the entire period 1931-2022 is then 0.13%. Substituted into equation (3) instead of the figure of 0.10%, the resulting estimate of the TAMRP is also .074.

In respect of other markets, tax regimes typically differ across markets, and differences would be reflected in the definition of the TAMRP. However, when defined to reflect the tax regime in each market, the values for TAMRP would differ across markets only in so far as risk or risk aversion differed. Accordingly, the conceptually best approach would be to replicate the analysis in Lally and Marsden (2004a) for each foreign market, taking account of the tax regime in each market and at each point at which data was used, and then average over the results. This would involve starting with the general version of equation (1), as shown in Lally (1992, page 32), which allows for differing personal tax rates on interest (T), dividends (T_d), and capital gains (T_g). Letting D_m denote the market dividend yield, this general form is as follows:

$$TAMRP = E(R_m) - D_m\left(\frac{T_d - T_g}{1 - T_g}\right) - R_f\left[1 - \left(\frac{T - T_g}{1 - T_g}\right)\right] \quad (4)$$

For each foreign market, it would be necessary to determine the tax regime operating in each year for which historical data is collected, then the appropriate form for equation (4) for each such year, then the ex-post counterpart for each such year, followed by collection of the relevant data and then averaging over time for each market. This requires data that is not readily available. However, it is possible to estimate the result for a typical foreign tax regime,

[6] NZ data is from Table B2 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz). The ten and five year rates are reported for all months, averaging 6.81% and 6.67% respectively, and the two-year rates for some months. The average differential for five over two year rates is -0.03% for the months for which data is available, implying an average differential for five over four year rates of -0.01%, implying an average four year rate of 6.68%, which implies an average differential of ten over four year rates of 0.13%. US data is from http://research.stlouisfed.org/fred2/categories/115, and averages 6.31%, 6.42% and 6.50% for the three, five and ten-year constant maturity bonds (GS3, GS5 and GS10) respectively. The implied average rate for four-year bonds is then 6.37% and the differential for ten over four year bonds is then 0.13%.

over both markets and time. Doing so involves recognising three typical features of the taxation of dividends and capital gains relative to interest. Firstly, in general, capital gains are levied on realisation rather than as they arise, and the resulting opportunity to defer payment of the tax reduces the effective tax rate by approximately 50% (Protopapadakis, 1983)[7]. Secondly, capital gains are or have been taxed at lower rates in many cases. For example, they are currently taxed at significantly lower rates in Australia, are currently exempt in Switzerland, and were exempt in Austria before 2010 and in Australia before 1985.[8] Thirdly, dividends are or have been less heavily taxed than interest in many cases. For example, they have been largely tax-free in Australia since the introduction of imputation in 1987, they were largely tax free due to the use of imputation in the UK in the 1973-1999 period, they were exempt until 1954 in the US, and have been taxed in the US at only 15% since 2003.[9] This suggests that the average effective capital gains tax rate since 1900 has been about 25% of that on interest (a 50% reduction due to deferral and a further 50% due to lower rates) whilst that on dividends has been about 50% of that on interest. Coupling these assumptions with equation (4) gives the TAMRP in each year of approximately:

$$TAMRP = E(R_m) - D_m 0.25T - R_f(1 - 0.75T) \tag{5}$$

The TAMRP estimate for year *t* would then be as follows:

$$\widehat{TAMRP}_t = (R_{mt} - R_{ft}) + R_{ft}(0.75T_t) - D_{mt}(0.25T_t) \tag{6}$$

Averaging over time and then markets then produces the required estimate. In respect of (R_{mt} – R_{ft}), Dimson et al (2023) presents estimates of the standard market risk premium in 20 foreign markets (using the ten-year risk-free rate), using data from 1900-2022.[10] With the exception

[7] The deferral lowers the effective tax rate not only because of the time value of money but also, as Hamson and Ziegler (1990, p. 49) note, because gains can be realised when the investor's tax rate is lower, such as in retirement.

[8] See https://en.wikipedia.org/wiki/Capital_gains_tax and http://taxsummaries.pwc.com/ID/Austria-Individual-Income-determination.

[9] See https://en.wikipedia.org/wiki/Dividend_imputation and https://www.dividend.com/taxes/a-brief-history-of-dividend-tax-rates/.

[10] The results presented by them use geometric differencing rather than arithmetic differencing of annual stock and bond returns. However, geometric differencing is not consistent with the definition of the market risk premium. The result from arithmetic differencing was obtained by subtracting their average bond return from their average stock return, for each market.

of South Africa, they can all be regarded as 'developed' economies and therefore suitable comparators for New Zealand. The mean of these 19 point estimates is .062 (see Table 3 below). To convert to an estimate relative to the five-year risk-free rate, I use the average differential between five and ten year US rates over the period 1953-2022 to proxy for the average differential in these markets over the longer period 1900-2022. The average US differential is 0.30% (data source as per footnote 4), and therefore the median MRP estimate for these foreign markets based upon the five-year risk-free rate is .065.

In respect of the remaining terms in equation (6), historical data on the parameters R_{ft}, D_{mt} and T_t for every one of these foreign markets is not readily available. So, I invoke New Zealand data. Over the period 1931-2002, the average (ten-year) R_{ft} for New Zealand was .067 (Lally and Marsden, 2004a, Table 2), and the average for 2003-2022 was .042[11], yielding a 1931-2022 time-weighted average of .062. This involves ten-year risk-free rates and the average differential for ten versus five year rates over the same period is estimated at 0.10% (see above), yielding an average five-year risk-free rate over the 1931-2022 period of .061. In addition, the average D_m for New Zealand for 1931-2002 was .050 (Lally and Marsden, 2004a), whilst that for 2003-2022 was .047[12], yielding an average for 1931-2022 of .049. In respect of T, the average tax rate on interest in New Zealand over the period since 1931 has been 0.29 (see footnote 5). Substitution of these estimates into equation (6) yields an estimate for the TAMRP of a typical foreign market of .075 as follows:

$$\widehat{TAMRP} = .065 + .061(.22) - .049(.07) = .075 \qquad (7)$$

In respect of the four-year risk-free rate, the average differential between four and ten year US rates over the period 1953-2022 is used to estimate the average differential in these foreign markets over the longer period 1900-2022. This differential is 0.42% (data source as per footnote 4), and therefore the mean MRP estimate for these foreign markets based upon the four-year risk-free rate is .062 + .0042 = .0662. In addition, over the period 1931-2022, the average (ten-year) risk-free rate for New Zealand was .062 (as noted in the previous paragraph), the average differential for ten versus four-year rates over the same period is estimated at 0.13%

[11] Data from Table B2 on on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz).

[12] These annual dividend yields are each calculated from the return on the NZ50G index (capital plus cash dividends) less the return on the NZ50 Index (capital only).

(see above), yielding an average four-year risk-free rate over the 1931-2022 period of .0607. Substitution of these figures of .0662 and .0607 into equation (7) in substitution for the figures of .065 and .061 respectively yields an estimate of the TAMRP of .076.

4. Siegel Estimates

Siegel (1992) analyses real bond and equity returns in the US over the sub-periods 1802-1870, 1871-1925 and 1926-1990. He shows that the Ibbotson-type estimate of the standard MRP (involving historical averaging of R_m - R_f) is unusually high using data from 1926-1990, due to the very low realised real returns on conventional government bonds in that period. He further argues (plausibly) that the latter is attributable to pronounced unanticipated inflation in that period. Consequently the Ibbotson-type estimate of the standard MRP is biased up when using data from 1926-1990. Thus, if the data used is primarily from that period, then this suggests alternatively estimating the standard MRP by correcting the Ibbotson-type estimate through adding back the historical average long-term realised real risk free rate and then deducting an improved estimate of the historical average expected real risk free rate. The same approach can be adopted to estimating the TAMRP, subject to correction for taxes. Applying this approach to New Zealand data, Lally and Marsden (2004b) obtain an estimate for the TAMRP of .055-.062, using data from 1931-2002, with the range in values reflecting estimates of the expected real risk-free rate (averaged over 1931-2002) of .03-.04. The latter estimate was consistent with the average yield on inflation-protected New Zealand government bonds from their inception in 1995 to 2002, of .036.[13] Correcting these numbers, for consistency with the tax assumptions underlying the simplified version of the Brennan-Lally model used by the Commission, the result is .056-.063. I invoke the midpoint of this range, of .059.

This estimate of .059 requires augmentation by data from 2003-2022. Letting R_{ft}^{r} denote the realised real yield on conventional ten-year government bonds in year t, and $E(R_5)$ the long-term expected real risk-free rate for five years ahead for New Zealand, the estimate of the Siegel-type estimate of the TAMRP for year t is then as follows:

$$T\widehat{AMR}P(S)_t = T\widehat{AMR}P_t + R_{ft}^{r}(1-T_c) - E(R_5)(1-T_c) \tag{8}$$

[13] Data from Table B2 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz).

In respect of $E(R_5)$, the best estimate is the average yield on inflation-protected New Zealand government bonds from their inception in 1995 till 2022, for a five-year term to maturity. This suggests use of the following inflation-protected New Zealand government bonds to create the best proxy for a "five-year constant maturity" series:

(a) From November 1995 till October 2012, the yield on the Feb 2016 bonds is used, because these are the only inflation-protected bonds on issue during this period.

(b) From November 2012 till February 2016, the yields on the Feb 2016 and Sept 2025 bonds are used, as the desired five-year term to maturity lies between the terms to maturity on these two bonds. In particular, at the midpoint of this period (June 2014), the terms to maturity on these two bonds are 1.7 and 11.3 years, implying weights of 66% and 34% on the yields of these two bonds during this period.

(c) From March 2016 till Sept 2020, the only bonds available have maturity dates of Sept 2025 and later, and therefore the yield on the Sept 2025 bonds is used in this period because its term to maturity corresponds most closely to the desired term of five years.

(d) From October 2020 till December 2022, the yields on the Sept 2025 and Sept 2030 bonds are used, as the desired five-year term to maturity lies between the terms to maturity on these two bonds. In particular, at this midpoint of this period (Nov 2021), the terms to maturity on these two bonds are 3.8 and 8.8 years, implying weights of 76% and 24% on the yields of these two bonds during this period.

The average yield on this "five-year constant maturity" series over 1995-2022 is .028.

In respect of the other terms in equation (8), the values for $TA\hat{M}RP$ for 2003-2022 are shown in Table 1 along with the ten-year nominal risk-free rates for those years, and are reproduced in Table 2 below. Table 2 also shows CPI inflation rates for these years[14], and these are used to convert the ten-year nominal risk-free rates for these years to real rates. Substitution of these values into equation (8) then yields the Siegel-type estimate of the TAMRP for each year, as shown in Table 2 below. As shown in the table, the average of these Siegel-type estimates for the TAMRP over the 2003-2022 period is .063. This average of .063 over 2003-2022 (20 years) is combined with the average of .059 for 1931-2002 (72 years), to yield the updated Siegel-type estimate of the TAMRP of .060 as follows:

[14] Data from Table M1 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz).

$$\widehat{TAMRP}(S) = .059\left(\frac{72}{92}\right) + .063\left(\frac{20}{92}\right) = .060 \qquad (9)$$

This Siegel-type estimate of the TAMRP uses ten-year risk-free rates at two points in the calculation, firstly in equation (2) and then in (8), and these offset. The fact that it is defined for a five-year term is reflected in the use of E(R_5) in equation (8). For a four-year term, E(R_5) must be replaced by E(R_4), i.e., the long-term expected real risk-free rate for four years ahead for New Zealand. This is estimated from the average yield on inflation-protected government bonds from their inception in 1995 till 2022, for a four-year term to maturity. This requires a "four-year constant maturity" series, which is proxied in the same way as the "five-year constant maturity" series, and produces the same average yield of .028. So, the Siegel estimate for a four-year term is also .060.

Table 2: Siegel-Type Estimates of the TAMRP for NZ 2003-2022

Year	R_f	Inf	R_f^r	$\widehat{TAMRP}$	$\widehat{TAMRP}(S)$
2003	.059	.016	.042	.196	.204
2004	.061	.027	.033	.187	.189
2005	.059	.032	.026	.042	.040
2006	.058	.026	.031	.165	.166
2007	.063	.032	.030	-.045	-.045
2008	.061	.034	.026	-.370	-.373
2009	.055	.020	.034	.151	.154
2010	.056	.040	.015	-.015	-.024
2011	.050	.018	.031	-.046	-.045
2012	.037	.009	.028	.216	.214
2013	.041	.016	.025	.135	.132
2014	.043	.008	.035	.144	.149
2015	.034	.001	.033	.111	.114
2016	.028	.013	.014	.068	.058
2017	.030	.016	.014	.199	.188
2018	.027	.019	.008	.029	.015
2019	.017	.019	-.002	.292	.270

2020	.009	.014	-.005	.132	.108
2021	.018	.060	-.039	-.018	-.067
2022	.036	.072	-.033	-.146	-.191
Average					.063

In respect of other markets, as with the Ibbotson approach, the conceptually appropriate approach would be to replicate the analysis in Lally and Marsden (2004b) for each foreign market, and then average over the results. This would involve starting with the Ibbotson estimate for each market, and then replacing the historical average real risk-free rate within that estimate by the long-run expected real risk-free rate for five years for that market. However, Ibbotson-type estimates of the TAMRP are not readily available for foreign markets. So, I start with the case for the typical foreign market shown in equation (6), yielding an average outcome of .075 across 19 foreign markets as shown in equation (7), and replace the historical average real risk-free rate for each market $(\overline{\boldsymbol{R_f^r}})$ by an estimate of the long-run expected real risk-free rate for five years for that market of E(R_5). Following equation (6), this implies an estimator for the TAMRP of that market as follows:

$$\widehat{TAMRP} = .075 + [\overline{R_f^r} - E(R_5)](1 - .75T) \qquad (10)$$

Across the 19 markets for which data is used to generate the Ibbotson estimate in equation (7), the average real risk-free rate is .020 as shown in Table 3. In respect of *T*, I use the average historical value for New Zealand of 0.29, as noted above. In respect of E(R_5), I also use the estimate for New Zealand, which is .035 for 1931-2002 and .028 for 2003-2022, implying a time-weighted average of .033. Substitution into equation (10) yields an average Siegel-type estimate for the TAMRP across these 19 foreign markets of .065 as follows:

$$\widehat{TAMRP} = .075 + (.020 - .033)(1 - .22) = .065$$

This estimate is for a term of five years, and commences with the value of .075 from equation (7). For a term of four years, this rises to .076 as shown immediately following equation (7). In addition, E(R_5) is replaced by E(R_4), as with the Siegel type estimate for New Zealand, but these are identical. So, with substitution of .076 for .075 in the last equation, the Siegel-type estimate for the 19 foreign markets averages .066 for a term of four years.

Table 3: Historical Average Returns for Foreign Markets 1900-2021

Country	$M\hat{R}P$	$\overline{R}_f^r$	$\overline{R}_m^r$
Australia	.060	.024	.082
Austria	.102	.042	.050
Belgium	.046	.013	.053
Canada	.048	.024	.070
Denmark	.053	.027	.075
Finland	.093	.011	.092
France	.058	.009	.058
Germany	.078	.015	.078
Ireland	.046	.023	.067
Italy	.067	.004	.059
Japan	.078	.015	.086
Netherlands	.055	.019	.070
Norway	.053	.022	.072
Portugal	.097	.000	.084
Spain	.034	.024	.055
Sweden	.053	.032	.080
Switzerland	.039	.024	.063
UK	.051	.023	.071
US	.063	.022	.083
Average	.062	.020	.071

An alternative approach to the inflation-shock issue raised by Siegel (1992, 1999) arises from Siegel's observation that the average real market return was similar across the three subperiods examined by him, leading him to conclude that the expected real market return was stable over time.[15] Accordingly, to estimate the current TAMRP for New Zealand for five years, one could estimate the current expected real market return from the historical average, convert to its current nominal counterpart using a current inflation forecast for five years, and then deduct the current five-year risk-free rate (net of tax) in accordance with equation (1). Like the previous Siegel methodology, this too eliminates reliance upon the historical average real risk-free rate. Using data from 1900-2022, the average real market return for New Zealand was .078 (Dimson et al, 2023, Table 58). In respect of inflation forecasts over the next five years, Table 4 shows forecasts from the Reserve Bank (2023, Table 7.1), The Treasury (2022, Table 1), Westpac (2023), and the BNZ (2023, page 9).[16]

Table 4: CPI Forecasts for New Zealand (%)

	2023	2024	2025	2026	2027
Reserve Bank	5.3	2.4	2.0		
The Treasury	4.9	2.9	2.2	2.0	
Westpac	5.1	2.9	2.0	2.0	1.8
BNZ	5.1	2.5			
Average	5.1	2.7	2.1	2.0	1.8

Using the average forecast for each year, as shown in the last row of the table, the geometric mean for the next five years is .0273.[17] So, for the next five years, the nominal expected market return for New Zealand is 1.078*1.0273 – 1 = .1074. In addition the current New Zealand five-year risk-free rate is .0425 (February 2023 average)[18]. Substitution of these figures into

[15] The Appendix tests the hypothesis that the population mean real R_m for New Zealand is constant over time and cannot reject this hypothesis.

[16] Forecasts were also sought from the ANZ. The ANZ's (2023, Figure 1.1) forecasts are only shown graphically, and the graph is insufficiently clear to translate into values for calendar years. The Treasury's (2022, Table 1) forecasts are 6.4%, 3.5%, 2.5%, 2%, and 2% for the years 2023-2027. These are outliers relative to the other forecasts, and I am advised by staff of The Treasury that they are for years ended 30 June. In response to a request, the quarterly forecasts were supplied, enabling me to present the calendar year forecasts in Table 4 above.

[17] In respect of the averaging method used across the annual forecasts, the focus of concern is the entire five-year period, the result for the entire five years arises by compounding, and the annual counterpart to this compounding is the geometric mean. So, the geometric mean is used.

[18] Data from Table B2 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz).

equation (1), along with the current corporate tax rate of 0.28, yields a Siegel (version 2) estimate for the TAMRP of .077 as follows:

$$\widehat{TAMRP} = .1074 - .0425(1 - 0.28) = .077 \tag{11}$$

In respect of the next four years (2023-2026), the geometric mean of the average inflation forecasts in Table 4 is .0297. So, for the next four years, the nominal expected market return for New Zealand is 1.078*1.0297 – 1 = .1100. In addition, the current New Zealand four-year risk-free rate is .0438 (February 2023 average).[19] Substitution of these last two figures into equation (1), along with the current corporate tax rate of 0.28, yields a four-year estimate of the TAMRP of .078.

In respect of foreign markets, and consistent with the Ibbotson approach, a typical case is considered, corresponding to equation (5). Across the 19 foreign markets considered above, the average real market return for 1900-2022 is .071 as shown in Table 3. Converting this to the current nominal expected market return using expected inflation over five years yields the estimate for $E(R_m)$ over the next five years, whilst current values are required for the remaining terms in equation (5). Table 5 provides results from the other four Anglo-Saxon markets. For Australia, the current (February 2023 average) four and five-year risk-free rates are taken from Table F2 on the website of the Reserve Bank of Australia (with the four-year rate interpolated from the three and five-year rates). In addition, the inflation forecasts for 2023 and 2024 are taken from the Reserve Bank of Australia (2023, Table 5.1), with linear convergence to the midpoint of the Bank's Inflation Target Band (2.5%) over the remaining three years because the preceding years' figures are consistent with that extrapolation. For the US, the current (February 2023 average) four and five-year risk-free rates are taken from the DGS3 and DGS5 daily series, with the four-year rate by interpolation from the three and five-year rates (see footnote 4 for the source). In addition, the inflation forecasts for 2023-2027 are taken from the Federal Reserve Board (2022, Table 1). For the UK, the current (February 2023 average) four and five-year risk-free rates are taken from the Daily Government Liability Curve.[20] In

[19] Table B2 on the website of the Reserve Bank (www.rbnz.govt.nz) reports the two and five year rates as 4.65% and 4.25% respectively, and interpolation implies a four-year rate of 4.38%.

[20] See https://www.bankofengland.co.uk/statistics/yield-curves. This figure of 3.35% is a spot rate rather than a yield to maturity for five years but the spot rates for shorter terms are sufficiently similar that the yield to maturity would still be 3.35% for any reasonable choice of the coupon rate on the bond. For example, with a coupon of

addition, the inflation forecasts for 2023-2027 are taken from the Office for Budget Responsibility (2022).[21] For Canada, the current (February 2023 average) four and five-year risk-free rates are taken from the website of the Bank of Canada, with the four-year rate by interpolation from the three and five-year rates.[22] In addition, the inflation forecasts for 2023-2027 are taken from the Bank of Canada (2023, Table 3) for 2023 and 2024, with extrapolation of the latter figure (2%) to the remaining three years because it corresponds to their Inflation Target. Table 5 shows these risk-free rates for four and five years, inflation forecasts for 2023-2027, and the geometric average inflation forecasts for four and five years. The corporate tax rate T is also shown for each country.[23] The last row of the table shows the cross-country averages.

Table 5: Current Parameter Values for Foreign Markets (%)

Country	R_{f4}	R_{f5}	2023	2024	2025	2026	2027	GM_4	GM_5	T
Australia	3.44	3.48	4.75	3.25	3.0	2.75	2.5	3.43	3.25	30
US	4.09	3.94	3.1	2.5	2.1	2.0	2.0	2.42	2.34	21
UK	3.35	3.35	7.4	.60	-.80	.20	1.7	1.80	1.79	25
Canada	3.55	3.33	2.6	2.0	2.0	2.0	2.0	2.20	2.12	26.5
Average	3.61	3.52						2.46	2.38	26

5%, and using the reported spot rates for 1, 2, 3, 4 and 5 years, the value of a five-year bond paying a 5% coupon annually is $1.0746 per $1 of face value. The yield to maturity on such a bond is 3.354%.

[21] The Bank of England (2023, Chart A, page 93) only provides forecasts for the next three years, and these do not show a consistent trend towards the Inflation Target, and hence the resort to this alternative source. The figures from this source are provided quarterly, in annualized form (in a CSV file). So, each quarter's figure is first stripped of the annualizing adjustment, and these raw figures are then compounded up for each year.

[22] See https://www.bankofcanada.ca/rates/interest-rates/canadian-bonds/.

[23] These figures are drawn from various sites. For Australia, see https://business.gov.au/finance/taxation/income-tax-for-business#:~:text=The%20full%20company%20tax%20rate,25%20million%20for%202017%20%E2%80%932018. For the US, see https://en.wikipedia.org/wiki/Corporate_tax_in_the_United_States#:~:text=Hence%2C%20P.L.%20(115%2D97,under%20federal%20or%20state%20law. For the UK, see https://www.gov.uk/government/publications/rates-and-allowances-corporation-tax/rates-and-allowances-corporation-tax. For Canada, see https://www.orbitax.com/taxhub/corporatetaxrates/CA/Canada#:~:text=The%20general%20federal%20rate%20of,federal%20rate%20down%20to%2028%25.

In respect of a five-year term, the expected inflation of .0238 per year (see Table 5) is coupled with the average real market return of .071 to yield the nominal expected market return of 1.071*1.0238 – 1 = .0965. In addition the current five-year risk-free rate is .0352 and the current value for *T* is .26 (see Table 5 for both). In respect of the current dividend yield, and in view of its trivial impact on the result from equation (5), I use the current New Zealand value of .025 (see footnote 12) rather than an average for foreign markets. Substituting these parameter values into equation (5), the resulting estimate of the TAMRP for a typical foreign market for a five-year term is .067 as follows:

$$\widehat{TAMRP} = .0965 - .025(.07) - .0352(1 - 0.20) = .067$$

In respect of a four-year term, the expected inflation of .0246 per year (see Table 5) is coupled with the average real market return of .071 to yield the nominal expected market return of 1.071*1.0246 – 1 = .0973. In addition the current four-year risk-free rate is .0361 (see Table 5). Substituting these values for their counterparts in the last equation, the resulting estimate of the TAMRP for a typical foreign market for a four-year term is .067.

Both of these versions of the Siegel approach were motivated by the late 20th century inflation shock, and accordingly remove the effect of the historical average real risk-free rate on the estimate of the TAMRP. They might then be considered to be alternatives rather than complementary. However, the second version has merit independent of any historical inflation shock because it assumes that the expected real market return is constant over time and this may be a better assumption than that underlying the historical averaging of excess returns (that the TAMRP is constant over time). As shown in the Appendix, neither hypothesis can be rejected. Furthermore, the estimated standard deviations in the annual returns for each time series are very similar (21% and 22%), suggesting that any fluctuations in the true values over time are similar. Accordingly, the results from both of these versions of the Siegel approach are considered.

5. The Dividend Growth Model

A Dividend Growth Model (DGM) is a model in which the expected market return is chosen such that it discounts future dividends on existing shares to the current market value of those shares. One version of this model (the three-stage model) involves estimates of expected dividends for the first three years, followed by linear convergence over eight years from the expected growth rate in the third year to the long-run expected growth rate (applicable from year 11). Letting S_0 denote the current value of the market index, S_{11} the expected value in three years, D_t the expected dividends in year t, g the long-run expected growth rate in dividends per share (DPS) from the end of year 11, and k the market cost of equity, it follows that the current value of equities is as follows:

$$S_0 = \frac{D_1}{1+k} + \frac{D_2}{(1+k)^2} + \frac{D_3}{(1+k)^3} + ... + \frac{D_{11}}{(1+k)^{11}} + \frac{S_{11}}{(1+k)^{11}}$$

$$= \frac{D_1}{1+k} + \frac{D_2}{(1+k)^2} + \frac{D_3}{(1+k)^3} + ... + \frac{D_{11}}{(1+k)^{11}} + \frac{\left[\frac{D_{11}(1+g)}{k-g}\right]}{(1+k)^{11}} \qquad (12)$$

Solving (numerically) for k, and then deducting the prevailing risk free rate (net of tax) in accordance with equation (1), yields the estimate of the TAMRP for New Zealand.

Equation (12) assumes that the dividends for year t are received at the end of year t. However, the dividends in year t would be received in a continuous stream throughout the year, with an average term till receipt of six months. Thus, following Pratt and Grabowski (2010, equation (4.14)), the term of discounting is reduced by six months in respect of each year and equation (12) becomes:

$$S_0 = \frac{D_1}{(1+k)^{0.5}} + \frac{D_2}{(1+k)^{1.5}} + \frac{D_3}{(1+k)^{2.5}} + ... + \frac{D_{11}}{(1+k)^{10.5}} + \frac{\left[\frac{D_{11}(1+g)}{k-g}\right]}{(1+k)^{10.5}} \qquad (13)$$

Finally, estimates of expected dividends are generally performed for calendar years and therefore equation (13) assumes that the current point in time is the beginning of a calendar year. If the analysis is done part way through the calendar year, with proportion y of the year remaining, then following Pratt and Grabowski (2010, equation (4.18)), equation (13) becomes:[24]

[24] Pratt and Grabowski (2010, equation (4.18)) mistakenly contains the term n instead of n-1. The test is thus: if y = 1, Pratt and Grabowski's equation (4.18) must collapse to their equation (4.14), which does not occur unless n-1 substitutes for n.

$$S_0 = \frac{D_1 y}{(1+k)^{y/2}} + \frac{D_2}{(1+k)^{0.5+y}} + \frac{D_3}{(1+k)^{1.5+y}} + ... + \frac{D_{11}}{(1+k)^{9.5+y}} + \frac{\left[\frac{D_{11}(1+g)}{k-g}\right]}{(1+k)^{9.5+y}} \quad (14)$$

The expected dividends in year *t* constitute the cash dividends, consistent with the simplified version of the Brennan-Lally model that is used by the Commission. Following Cornell (1999, Ch. 4), an appropriate estimate for the long-run expected growth rate in Dividends Per Share (DPS) would equal the expected long-run real growth in GDP (g_e) less a deduction (d) for the net creation of new shares from new companies and new share issues (net of buybacks) from existing companies, converted to a nominal rate using expected inflation of i, i.e.,

$$g = [1 + (g_e - d)](1 + i) - 1 \quad (15)$$

In respect of g_e, New Zealand's real GDP growth rate over the period 1900-2013 averaged 3%, with 3% also from 1945 (CEG, 2014, page 73). For 2014-2022, the average has been 3.2%.[25] So, the 1900-2022 average has been 3%. In addition, Bernstein and Arnott (2003, Table 1) provide average real GDP growth rates over 16 other developed countries over the period 1900-2000, and these average 2.8% rising to 3.0% with exclusion of those countries that suffered devastation during wars. This suggests $g_e = .03$ for New Zealand, and CEG (ibid, in a report for Chorus) concur with this. In respect of d, Lally (2013, sections 7 and 8) examines this issue and concludes that an appropriate deduction would be 0.5 - 1.5% for these developed markets. This suggests using $d = .01$, and CEG (ibid) concurs with this. In respect of i, and consistent with the definition of g in equation (15), this is the long-run expected rate, i.e., beyond the next few years. Table 4 above suggests a figure of 2%, which also matches the midpoint of the Reserve Bank's inflation target. Substitution of these parameter values into equation (15) yields $g = .04$. The same estimate was used by Lally (2019, section 5).

As at 13 March 2023, Bloomberg's expected dividends for the NZX50 index for the financial years ending in 2023, 2024 and 2025 expressed as a proportion of the index value on 13 March 2023 were .033, .036 and .039 respectively.[26] This implies $y = 0.30$ and an expected growth

[25] Data from Table M5 on the Reserve Bank's website (www.rbnz.govt.nz).

[26] The dividends are forecast for each company, and are for each of their financial years. So, for the typical case of a financial year ending on June 30, the first's forecast is for dividends in the year ending 30 June 2023. Thus, at the forecast date of 13 March 2023, only 30% of the year remains and therefore 70% of the 'forecasted'

rate in the last forecast year of .083. Substitution of these parameter values into equation (14), along with $g = .04$, yields $k = .0835$. Deduction of the prevailing five-year risk free rate of .0425 (February 2023 average[27]) net of the tax adjustment in accordance with equation (1) then yields an estimate of the TAMRP of .053 as follows

$$\widehat{TAMRP} = .0835 - .0425(1 - .28) = .0529 \qquad (16)$$

In respect of the current New Zealand four-year risk-free rate, this is .0438 (February 2023 average). Substitution into equation (16) in substitution for the figure of .0425 yields a four-year estimate of the TAMRP of .052.

In respect of other markets, the same approach is applied to Australia. As at 13 March 2023, Bloomberg's expected dividends for the ASX200 index for the calendar years 2023, 2024 and 2025 expressed as a proportion of the index value on 13 March 2023 were .041, .043 and .045 respectively. This implies $y = 0.30$ and an expected growth rate in the last forecast year of .0465. In respect of equation (15), and matching the approach for New Zealand, an appropriate estimate for long-run expected inflation is the midpoint of the Reserve Bank of Australia's target range (.025). In addition, Australia's real GDP growth rate has averaged 3.2% for 1900-2022[28], whilst average real GDP growth rates over 16 developed countries over the period 1900-2000 averaged 2.8% rising to 3.0% with exclusion of those countries that suffered devastation during wars (Bernstein and Arnott (2003, Table 1)). This suggests $g_e = .03$ for Australia. In addition, d is estimated at .01 as discussed above. Substitution into equation (15) yields $g = .046$ as follows:

$$g = [1 + (.03 - .01)][1.025] - 1 = .046$$

Substitution of these parameter values into equation (14) yields $k = .0904$. Unlike New Zealand, this estimate cannot be substituted into equation (1) because this equation does not

dividends for the year ended 30 June 2023 are assumed to have already been paid. Since companies pay dividends semi-annually, a better estimate would be 50% but this does not materially affect the result.

[27] Data from Table B2 on the website of the Reserve Bank of New Zealand (www.rbnz.govt.nz).

[28] This comprises 3.3% for 1900-2011 (see Lally, 2013, page 17) and 2.5% for 2012-2018 (RBA website Table HI: www.rba.gov.au/statistics/tables).

reflect the current Australian tax regime, due to the taxation of capital gains (whilst cash dividends are like New Zealand essentially tax-free due to the imputation system). As discussed in section 3, the taxation of capital gains upon realisation reduces the effective rate by about 50%, and the use of lower statutory rates than on interest reduces it by a further 50%, to yield an effective tax rate on capital gains of about 25% of that on interest. Following equation (4), the TAMRP for Australia should then be as follows:

$$TAMRP = E(R_m) + D_m(.25T) - R_f(1 - .75T) \qquad (17)$$

In addition, the prevailing Australian five-year risk-free rate is .0348 (February 2023 average[29]), the prevailing dividend yield is .041 (as above), and T is estimated at the current Australian corporate tax rate of .30. Substitution of these parameter values into equation (17) then yields an estimate of the TAMRP for Australia of .067 as follows:

$$\widehat{TAMRP} = .0904 + .041(.075) - .0348(1 - .225) = .0665 \qquad (18)$$

In respect of the current Australian four-year risk-free rate, this is .0344 (February 2023 average, interpolated from the figures for three and five-year bonds). Substitution into equation (18) in substitution for the figure of .0348 yields a four-year estimate of the TAMRP of .067.

This DGM approach assumes convergence to the long-run expected growth rate in DPS over an 11 year period, and such a convergence period is at the low end of the plausible distribution. However, longer convergence periods would lead to a higher estimate of the TAMRP for NZ and no difference for Australia. Furthermore, as discussed in Lally (2013), such estimates are likely to be too high because they couple a prevailing estimate of the expected market return that is constant out to infinity with a prevailing risk-free rate for only the next ten years. This may or may not outweigh the impact of using a short period for convergence in the expected growth rate in DPS to the long-run rate. So the point estimates in equations (16) and (18) are merely indicative.

6. Surveys

[29] Data from Table F2 on the website of the Reserve Bank of Australia (www.rba.gov.au).

The most important characteristics of survey results are that they are recent, that the responses are the product of very careful consideration, that they are regularly updated (to ensure comparability in the surveys used at the different times that the TAMRP estimates are required), and that they contain results for other markets. No available survey satisfies all four requirements but the Fernandez et al (2023) survey (which is conducted annually) clearly satisfies all but the second requirement. The survey provides estimates of the standard MRP in 80 markets including New Zealand (ibid, Table 2). This table provides both means and medians, and therefore a choice must be made. The MRP is a mathematical expectation corresponding to the mean of a distribution of returns, and therefore the mean of any sample of returns must be used to estimate it rather than the median. However, the survey respondents' estimates of the MRP are subjective estimates of it rather than returns data, and therefore there is no requirement to use the mean response. Furthermore, one could reasonably suspect that some of the responses to this survey are frivolous or calculated to affect the result in a particular direction because they are aware of the use of the survey results by regulators. For example, at least one Australian respondent to the 2015 survey has provided an estimate of 19% (Fernandez, 2015, Table 2), which is implausibly high. Even more implausible is the 25% response offered by at least one Australian respondent in 2013 (Fernandez et al, 2013, Table 2), and this one response raised the mean Australian response from 5.7% to 6.8%. In light of this problem, I switched in 2014 to use of the median response (Lally, 2014, section 3) and adopt the same policy here.

The median of the estimates of the MRP for New Zealand is .059 (from 10 responses), and the survey was conducted in March 2023. Adjusted in accordance with equation (1) and the contemporaneous five-year risk-free rate of 0.0438 (March 2023 average)[30], the resulting estimate of the TAMRP is .071 as follows:

$$\widehat{TAMRP} = .059 + .0438(0.28) = .071$$

In respect of the contemporaneous New Zealand four-year risk-free rate, this was 0.0450 (March 2023 average, interpolating from the two and five-year rates). Substitution into the last

[30] Data from Table B2 on the website of the Reserve Bank (www.rbnz.govt.nz).

equation in substitution for the figure of .0438 yields a four-year estimate of the TAMRP of .072.

Turning to the remaining 79 markets surveyed by Fernandez et al (2023, Table 2), these can be partitioned into 26 'developed' countries or equivalents (high income but not oil dominated, comprising those in Western Europe, US, Canada, Australia, Japan, South Korea, Singapore, Taiwan, and Hong Kong), and 53 others (which are middle income or oil dominated).[31] For each of these two groups, the cross-country means of the within country medians is .064 for the 26 'developed' countries and .120 for the others, the difference is statistically very significant ($p < .001$), and there is minimal overlap in the two groups.[32] The relevant comparator for New Zealand is the first group, and I therefore invoke the cross-country mean for that group, of .064. As with the Ibbotson and Siegel estimates for foreign markets, equation (5) is invoked to reflect the tax regime in a typical foreign market, i.e.,

$$TAMRP = E(R_m) - R_f - D_m(0.25T) + R_f(.75T) \tag{19}$$

The average survey result of .064 provides an estimate of $E(R_m) - R_f$. In respect of the other parameters, the parameter values should also be current. In view of the difficulties in collecting data on 26 markets, New Zealand values are used; these are .0438 for the contemporaneous five-year R_f (see above), .025 for the contemporaneous D_m[33], and 0.28 for T (the current corporate tax rate). Substitution into equation (19) yields an estimate of the TAMRP for a typical foreign market of .071 as follows:

$$\widehat{TAMRP} = .064 - .025(.07) + .0438(.21) = .071$$

[31] The 26 markets comprise the 19 used in Table 3 (for the foreign Ibbotson and Siegel estimates) and a further seven that would have been used in Table 3 but Dimson et al (2022) do not provide data on them back to 1900.

[32] Using .0705 as the dividing line, only 4/26 of the first group of countries have a median MRP estimate that exceeds that figure and only 7/53 of the second group have a median MRP estimate that is less than that figure.

[33] This is the return on the NZ50G index (capital plus cash dividends) for 2022 less the return on the NZ50 Index (capital only) for 2022.

In respect of the contemporaneous New Zealand four-year risk-free rate, this is 0.0450 (see above). Substitution into the last equation in substitution for the figure of .0438 yields a four-year estimate of the TAMRP of .072.

7. Overall Results

The estimates determined above are summarised in Table 6 below. I favour use of the median results because doing so reduces the impact on the estimate from an extreme outcome arising from one of the methods. Using only New Zealand data, the median estimate is .072 for four years and .071 for five years. Using foreign data, the median estimate is .067 for both terms. Lally and Randal (2015) examine estimators of the MRP and show that the optimal estimator for a country should place high weight on foreign data because estimates using only local data are very noisy and the true MRPs do not vary greatly across countries. However, this conclusion presumes that the data underlying these MRP estimates is foreign, whereas the 'foreign' estimates in Table 6 have in some cases used some New Zealand data, thereby reducing the value of these 'foreign' estimates. All of this suggests that, when rounded to the nearest 0.5%, an appropriate estimate of the TAMRP at the present time is .070, for both four and five year terms. Averaging over the five estimates in each column (rather than using the median) would not change the result when rounded to the nearest 0.5%.

Table 6: Estimates of the TAMRP with Four and Five Year Risk-Free Rates

	New Zealand		Other Markets	
Ibbotson estimate	.074	.074	.076	.075
Siegel estimate: version 1	.060	.060	.066	.065
Siegel estimate: version 2	.078	.077	.067	.067
DGM estimate	.052	.053	.067	.067
Surveys	.072	.071	.072	.071
Median	.072	.071	.067	.067

By comparison with the estimates in Lally (2019), the estimates for both the Siegel version 2 and DGM have substantially declined, the survey-based estimates have substantially increased, and results from the other methods have not changed materially. The net effect is to reduce the median estimate from .075 in 2019 to .070 now, rounded in both cases to the nearest 0.5%.

8. Conclusions

This paper has updated an earlier (2019) estimate of the TAMRP, for application to four and five year periods. The same set of approaches that were used earlier has been used here, and warrants an estimate of 7.0% for both four and five-year terms rounded to the nearest 0.5%. By comparison with the 2019 estimates, the median estimate has declined from 7.5% to 7.0% because the DGM and Siegel version 2 estimates have substantially declined, partly offset by increases in the survey-based estimates.

APPENDIX: Mean Stationarity of Return Distributions

This Appendix investigates whether the historical time series of values for the realised values for the TAMRP, and the real R_m values, are drawn from populations whose means are constant over time, i.e., mean stationarity holds. Data from 1931-2022 is used for both series.

I start with the realised values for the TAMRP. Tests for mean stationarity should reflect the possible types of departures from stationarity. One such possibility is a gradual drift upwards or downwards in the population mean for the realised TAMRP values (possibly because investors have become more diversified and the cost of forming a well-diversified portfolio has fallen). The natural test for this involves regressing the realised values for the TAMRP on time. The result is a coefficient on time of 0.014% and this is not statistically significant (p = 0.87). So, the hypothesis of no time trend can't be rejected. However, unlike most economic and financial time series, returns reflect not only events that have occurred in the period in question but revised expectations about the future. So, if the true TAMRP declines, the asset price simultaneously rises, thereby raising the realised value. Thus, as the true TAMRP falls over time, the realized values tend to be drawn from above the population mean, and this latter effect reduces the downward drift in the realised TAMRP values, thereby making it harder to detect the downward drift in the true TAMRP from the regression test.

A second possible source of non-stationarity is that the population mean (the true TAMRP) experiences occasional changes (regime shifts). The natural test for this is to partition the data into subsets and test for the statistical significance of the differences in sample means across the subsets. Wahab and Lashgari (1993, pp. 244-245) use two subsets in testing for stationarity in means for stock returns. Pagan and Schwert (1990, page 167), and Loretan and Phillips (1994, page 218), do likewise in testing for stationarity in variances for stock returns. Generalising this, I split the New Zealand data into two equal sized subsets (first and second halves of the data), and then into three equal sized subsets (first, second and third parts of the data), and the resulting sample means are shown in the second column of Table 7. The standard test for differences in the true means is the ANOVA test (Mood et al, 1974, pp. 435-438), involving a test statistic that has the F distribution if the null hypothesis (that the true means are equal) is true.[34] The observed F values are shown in the third column of Table 1, whilst the fourth column shows the critical values (at the 90% level, beyond which an observed value leads to rejection of the hypothesis of equal means). In both cases, the differences in the sample means are not statistically significant at even the 10% significance level. So, the hypothesis that the true mean has not changed over time cannot be rejected at even a significance level of 10%.

Table 7: ANOVA Tests on Sample Mean Realised TAMRP Values

Partition	Sample Means	Observed F	Critical F (90%)	p Value
Halves	.056, .089	0.50	2.75	> 0.10
Triples	.063, .092, .062	0.18	2.35	> 0.10

Turning now to the real values for R_m, these are also regressed on time, yielding a coefficient on time of 0.015% and this is not statistically significant ($p = 0.85$). So, the hypothesis of no time trend can't be rejected. In respect of possible regime shifts, the ANOVA test results are shown in Table 8. Again, the hypothesis that the true mean has not changed over time cannot be rejected at even a significance level of 10%.

Table 8: ANOVA Tests on Sample Mean Real R_m Values

Partition	Sample Means	Observed F	Critical F (90%)	p Value
Halves	.050, .088	0.75	2.75	> 0.10
Triples	.066, .066, .075	0.02	2.35	> 0.10

[34] The test statistic is the product of the number of observations in a subperiod and the squared difference between the subperiod mean and the overall mean, summed over subperiods, and divided by the sum over subperiods of the sum of squares for each subperiod. So, if the true mean shifts over time, the numerator of this ratio will tend to increase, thereby increasing the chance of it exceeding the critical F value.

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