STRUCTURAL BREAKS AND THE ESTIMATION OF THE MARKET RISK PREMIUM IN AUSTRALIA

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1. Introduction

Estimation of the market risk premium in Australia, for the Officer (1994) version of the Capital Asset Pricing Model, can be undertaken in a number of ways. A number of Australian regulatory bodies consider that the value has declined in recent years, based inter alia upon a reduction in its ex-post outcome (ACCC, 2001, ORG, 2001), i.e., a structural break has occurred. By contrast, Gray (2001) argues that the observed decline in the ex-post outcomes in recent years is not statistically significant, that alternative estimation methods point to a value of at least 6%, and that the historical averaging methodology is the best. Accordingly, he favours an estimate of 6-7%.

This paper seeks to examine Gray's three propositions, and therefore the conclusion that he extracts from them. Section 2 examines Gray's argument that the decline in the ex-post outcome is not statistically significant. Section 3 examines Gray's argument that alternative approaches point to an estimate of at least 6%. Section 4 examines Gray's argument that the historical averaging methodology is the best. Section 5 concludes.

2. Statistical Significance

The market risk premium in the Officer version of the Capital Asset Pricing Model is defined as follows

$$\hat{k}_m - R_f = k_m + U\frac{IC_m}{S_m} - R_f$$

where $\hat{k}_m$ is the expected return on the market portfolio inclusive of the imputation credits to the extent of being usable, k_m is the expected return exclusive of the credits, U is the utilisation rate on the credits, IC_m/S_m is the credits as a proportion of the value of the market portfolio, and R_f is the risk free rate (Officer, 1994). The most widely employed estimation methodology (Ibbotson, 2004) consists of determining the ex-post outcome for each of a number of years and then averaging over these outcomes. If the market risk premium has not changed over time, the resulting estimate will be unbiased. However, if the market risk premium has declined over the estimation period, then the estimate will be biased up relative to the true value, with the degree of bias depending upon the reduction in the premium along with the time since the reduction occurred as a proportion of the total estimation period. For example, if the estimation period is the last 100 years and the premium declined by 2% 20 years ago, then 80% of the data used in the estimation process will be drawn from a distribution whose population mean is higher than the present time by 2%. Accordingly, the upward bias in the estimate will be 1.6%. By contrast, if the decline occurred 50 years ago, then the upward bias will be only 1%.

Gray (2001) observes that the Ibbotson estimate of the market risk premium is 7.3% when using the longest available time series (1883-2000). He notes that estimates based on recent data are lower than this, but the differences are not statistically significant. For example, he considers the average for 1883-1970 (8.2%) along with that for 1970-2000 (4.8%). Performing a conventional *t* test on the difference, he finds the *p*-value is .175, and therefore one cannot reject the hypothesis that the premium has not changed. Consideration of a range of other possible "breakpoints" does not change this conclusion. He also considers the hypothesis that the true value is at least 6%, and cannot reject this on the basis of recent data.

Gray's conclusions based upon this test are correct. Furthermore, as he notes, choosing the "breakpoint" only after inspection of the data biases the test in favour of rejecting the hypothesis that there is no break. Despite this bias, he still cannot the reject the hypothesis that there is no break. Nevertheless, this test suffers from the crucial limitation that it is virtually powerless to detect even quite substantial shifts in the premium. To demonstrate this point, Gray's own example could be used. Suppose the market risk premium is 8.2% from 1883-1970, then drops to 4.8% and remains at that level for the period 1970-2000. In addition, the average ex-post outcomes for these two periods correspond exactly to the premiums. Applying the test invoked by Gray, the reduction in the premium (of 3.4%) would be dismissed as statistically insignificant. In fact, with average outcomes exactly matching the premiums in the two periods, the premium would have to fall from 8.2% to 1.2% before it could be detected as statistically significant! Thus, Gray's test is virtually powerless to identity even substantial shifts in the market risk premium. Accordingly the fact that this test cannot reject the hypothesis of no break is unremarkable. In the same way, if a virtually blind person were asked to report when the sun set, and delivered no such report, the absence of the report would be unremarkable and should not lead us to conclude that the sun is still shining.

Since this test is so weak, one might ask whether there are statistical tests for regime shifts that are much more powerful. Unfortunately this does not seem to be the case, for two reasons. First, the noise in returns data is very large relative to the size of possible shifts in the premium. Secondly, some of the underlying causes of regime shifts are subject to continuous evolution through time rather than discrete shifts (such as market volatility). This implies the same behaviour in the market risk premium and thereby undercuts the entire concept of a regime within which the premium is stable. So, instead of invoking purely statistical approaches to this issue, the more promising approach is to invoke methodologies for estimating the premium that admit time variation in the premium. These are considered in the following section.

3. Estimates Implied By Alternative Approaches

3.1 Dividend Growth Model

Gray (2001) considers a number of alternative methodologies to that of Ibbotson, and he argues that they are consistent with a premium of at least 6%. The principal methodologies examined by him, and offered in support of his conclusion, are the Dividend Growth Model and survey evidence. In respect of the Dividend Growth Model, he considers the simplest version of this model, involving a constant expected growth rate in dividends over future years (ibid, pp. 5-9). This implies a market risk premium in the Officer model of

$$\hat{k}_m - R_f = \hat{D}_m + g_r + g_p - R_f \tag{1}$$

where $\hat{D}_m$ is the expected gross dividend yield over the next year on the market portfolio (i.e., inclusive of imputation credits to the extent of being usable), g_r is the expected real growth rate in GDP and g_p is the expected rate of inflation. Gray then injects the average realised values for these variables over the period 1990-2000 into this equation, with the exception of the risk free rate for which he uses the "current" 10 year rate. The result is

$$\hat{k}_m - R_f = \hat{D}_m + g_r + g_p - R_f = .0486 + .0337 + .0261 - .0521 = .0563 \qquad (2)$$

This estimate is subject to a number of difficulties. First, Gray implicitly treats the average realised gross dividend yield over the ten year period as a good estimate of the expected yield one year into the future. A better approach would be to use the observed dividend yield at the "current" time, on the grounds that there is little estimation error here, i.e., the current yield is a good estimate for the expected yield over the next year.

Secondly, Gray implicitly treats the average realised values for the growth rates and inflation as good estimates of the expected growth rates and expected inflation at the "current" time. A better approach would be to use forecasts at that time for the two growth rates. These forecasts would reflect recent history but would also incorporate other information. Importantly, the forecast for inflation would be consistent with the ten year risk free rate at that time. The point in time to which Gray's choice of R_f relates is not clear, and therefore it cannot be related to a contemporaneous forecast for inflation. However, Lally (2002) invokes a value for R_f of .062 in early 2002 along with a contemporaneous inflation forecast of .025. If these (compatible) figures were substituted into equation (2), the resulting estimate for the premium would be .0453 rather than .0563. So, the effect of using compatible figures in this area would seem to be to lower the estimate of the premium by about .01.

Thirdly, Gray's approach assumes that dividends are expected to grow at the same rate in all future years, and this growth rate is that for GDP. However, the expected growth rate in the next few years may diverge from this. Cornell (1999) addresses this problem by using analysts' five-year forecasts for earnings per share as the short term growth rate, and imposes convergence upon the expected growth rate in GDP over some period such as 20 years.

Fourthly, the long-run expected growth rate required here is that for dividends per share in respect of existing companies, whereas the long-run expected growth rate in GDP is at least as great as this, due to share issues by existing companies and the creation of new companies. So, the market risk premium estimated through this method is an upper bound rather than a point estimate[1]. Lally (2002) applies the Cornell approach to Australia, and generates upper bound estimates of .045 - .057, assuming a convergence period of 5 – 20 years, an expected real growth rate in GDP of .035 and an expected inflation rate of .025.

In view of all of these difficulties, Gray's point estimate for the premium of .0563 should be rejected. A more supportable conclusion from the Dividend Growth Model is that the upper bound on the premium is .045 - .057. This does not support Gray's conclusion that the premium is at least .06.

3.2 Survey Evidence

Gray cites three surveys on the issue of the market risk premium. The first is Welch (2000), relating to the US, and Gray attributes a consensus forecast of .07 to this survey. The second is Welch (2001), again relating to the US, and Gray attributes a mean forecast of .055 to this survey. Gray argues for ignoring the responses of "amateurs" and that doing so would raise the estimate by .003-.015, thereby yielding a forecast in excess of .06. The third is Jardine Fleming Capital Partners (2001), relating to Australia, and Gray attributes a figure of .0587 to this. Gray summarises this evidence as pointing to a figure of at least .06.

There are a number of difficulties in his reasoning. Firstly, whilst Gray refers to the results of Welch (2000) and Welch (2001), the latter displaces the former on account of being more recent. Secondly, in respect of Welch (2001), the median is a more suitable figure than the mean (because it is insensitive to extreme responses arising from error or malice), and this median was .05 rather than .055. Thirdly, these figures are defined relative to short-term bonds, and this is inconsistent with the use of ten-year bonds in the earlier Ibbotson results. At the time of the survey (August 2001),

[1] Bernstein and Arnott (2003, Table 1) argue for deducting 2% from the expected real growth rate in GDP on account of this point.

US ten year bonds were offering about .015 more than short-term bonds[2]. So, measured relative to US ten year bonds, Welch's median of .05 implies a figure of about .035. Fourthly, deletion of the "amateurs" raises the median estimate by no more than .004 (Welch, 2001, Table 5). So, even with deletion of the results for the alleged "amateurs", the median outcome is still .039. Finally, the Welch figures relates to the US rather than Australia[3]. However, if one is going to cite recent US results, one should mention Graham and Harvey (2001, Figure 3), who survey US CFOs and report a median estimate of .040 defined relative to ten year bond yields[4].

Turning now to the result in Jardine Fleming Capital Partners (2001), the figure of .0587 is in fact a mean perception concerning the historic premium and the mean forecast is reported to be about .01 lower. So the relevant estimate would be about .05. In addition, the question posed is not disclosed. Consequently one cannot know whether the premium is defined against ten year bonds or not and whether the forecast value relates to the Officer or the standard CAPM. In so far as the premium is defined against shorter term bonds, and shorter term bonds had lower yields (which is typical), a further reduction would be warranted.

In summary, the relevant evidence here comprises a forecast US market risk premium defined against ten year bonds of .035 from one survey (or about .039 if the "amateurs" are deleted), a forecast US market risk premium defined against ten year bonds of .040 from a second survey, and a forecast Australian market risk premium of about .050 (with certain critical information lacking). This evidence does *not* support the suggestion that the future Australian market risk premium is at least .06.

3.5 Additional Evidence

Of the three estimation methodologies reviewed above, both the Ibbotson and Cornell methodologies are worthy of significant weight (the survey evidence being

[2] This data is drawn from the website of the Federal Reserve.

[3] It also relates to the standard version of the CAPM (Sharpe, 1964: Lintner, 1965; Mossin, 1966) rather than to the Officer version. However, given that the difference in the models relates only to Dividend Imputation, and this is absent from the US, these two effects should offset.

[4] Their Figure 3 reports results for a series of surveys over time, with median estimates ranging from .032 to .045. The median of this set is .040.

problematic for the reasons just noted). In respect of the Ibbotson methodology, Gray (2001) reports an estimate of .073 using data from 1883-2000 and ten year government yields. This is similar to the estimate of .075 reported by Lally (2004) over the same period and also using ten year bond yields. For consistency with the Siegel estimate to be considered shortly, Lally's estimate of .075 is preferred. In respect of the Cornell methodology, as noted earlier, Lally (2002) applies this to Australia and estimates the upper bound on the premium at .045 - .057. By contrast, the survey evidence noted above warrants much lesser weight because the surveys relate to the US market or, in the single case relating to Australia, fail to disclose significant information concerning the questions posed. Results from other methodologies are also available, and are now considered.

Siegel (1992) argues that Ibbotson estimates drawing upon data from the post WWII period overestimate the premium because of unanticipated inflation in that period, which raised nominal stock returns more than bond yields. He favours correcting the Ibbotson estimate by replacing the realised real bond yield embedded in it by an estimate of the long-run expected real bond yield. Applying this methodology to the Australian market, and starting with an Ibbotson estimate of .075, Lally (2004, section 6.1) generates an estimate for the premium of .054. This is markedly below the estimate using the Ibbotson methodology.

The possibility that the market risk premium has changed over time has given rise to estimation processes that attempt to model this. The first of these processes is presented by Merton (1980), who conjectures that the premium is proportional to market volatility. Accordingly he estimates the coefficient of proportionality from long time-series data, and then couples it with a current estimate of market volatility to yield a current estimate of the market risk premium. Lally (2004) applies this methodology to the Australian market, and generates a current estimate for the premium of about .070. This estimator is subject to estimation error in respect of both the coefficient in the model and the market variance. Accordingly, the standard deviation on the estimate is likely to be higher than for any other estimator.

In addition to these approaches, for which Australian estimates are available, there are a number of other methodologies that have been applied to other markets and which generally yield low estimates relative to the Ibbotson methodology. This *suggests* that application of them to the Australian market would do likewise. For example, Fama and French (2002) express the market risk premium in the standard version of the CAPM as

$$k_m - R_f = D_m + g - R_f$$

where D_m is the expected dividend yield on the market portfolio and g is the expected rate of capital gain. They estimate the expected dividend yield from the historic average yield and estimate the expected rate of capital gain from the historical average growth rates in both dividends and profits. Applied to the US market, the result is estimates ranging from .026 to .043. Jagannathan et al (2000) undertake a similar analysis, except that they estimate the expected rate of capital gain from the average growth rate in GDP. Again applied to the US market, the resulting estimate is .013. In addition, Claus and Thomas (2001) inject accounting variables into the Dividend Growth Model. Applying their methodology to a wide range of markets, they generate estimates for the market risk premiums in these markets of around .03. Pastor and Stambaugh (2001) extend Merton's (1980) methodology to incorporate the possibility of regime shifts in Merton's coefficient, and estimate the current US premium at .048.

In summary then, the alternative evidence that is available is not uniformly consistent with the evidence from the Ibbotson methodology. In particular, much of it points to a lower estimate. This could be because the Australian market risk premium has declined over the estimation period or because the estimate arising from the Ibbotson methodology simply overestimates the premium.

4. Choosing the Best Methodology

Gray (2001) argues that the Ibbotson methodology is better than the Dividend Growth Model, in the sense of lesser standard deviation on the estimate, and therefore should be preferred. In respect of the point estimate from the Ibbotson methodology (.073), he notes that the standard deviation is .0156. In respect of the point estimate for the Dividend Growth Model, appearing in equation (2), he estimates the standard deviation by using the estimated standard deviations and correlation coefficients for the underlying parameters from the 1990-2000 data. This yields a standard deviation on the point estimate for the market risk premium of .0312, i.e., double that for the Ibbotson estimate. Gray concedes that the appropriate parameter values are forecasts and these are less volatile than average realisations over ten years. However he asserts that recognition of this point is unlikely to reduce the standard deviation on this estimate (.0312) below that of the Ibbotson estimate (.0156).

This argument suffers from four principal difficulties. Firstly, the process by which he obtains a point estimate of the market risk premium under the Dividend Growth Model is quite unsatisfactory as discussed in section 3.1. His estimate for the standard deviation must then be irrelevant. Secondly, and in respect of the uncertainty surrounding the expected growth rates in GDP, Gray draws upon the statistical uncertainty surrounding the average realisation over ten years. Gray rightly acknowledges that forecasts are less volatile than average outcomes and therefore acknowledges that his estimated standard deviation of .0312 is too high. However he offers no evidence in support of his claim that the appropriate value is still in excess of .0156. To illustrate the distinction between volatility in forecasts relative to average outcomes, suppose that the market risk premium has not changed over time and the standard deviation of annual outcomes is .20. In this case, the standard deviation on the average outcome over 10 years would be .063. Since the premium is assumed to be stable then forecasts may be likewise, with forecasters understanding that the standard deviation on the average outcome is simply a reflection of noise rather than shifts over time in the premium. So, the volatility in the forecasts may be zero whilst the standard deviation on the average outcome is .063. Thus, having estimated the standard deviation on the average outcome at .063, the most one could say is that the volatility on the forecast should be less than this and possibly zero. One could not say that the volatility on the forecast was at least .0315.

Thirdly, Gray implicitly argues that one should select the methodology with the lowest standard deviation on the estimate. Although it is true that a low standard deviation is a desirable property of an estimator, the lowest standard deviation would arise from placing some weight on each of a series of individual estimators. By analogy, in considering a set of risky assets, the lowest risk portfolio will be some combination of assets rather than simply the asset with the lowest risk. To demonstrate this point, two unbiased estimation methods are considered (1 and 2). Their estimators X_1 and X_2 can be expressed as

$$X_1 = T + e_1, \quad X_2 = T + e_2$$

where T is the true value for the premium and e_1 and e_2 are each mean zero residuals. Purely to simplify the analysis, we assume that these two estimators are independent (this would in fact be the case if the two estimators were the Ibbotson estimator and that arising from the Dividend Growth Model). Define w as the weight placed upon the first estimator, with the balance of the weight placed upon the second estimator. We then choose w so as to minimise the variance of this weighted estimator, i.e., to minimise

$$\begin{aligned} E[wX_1 + (1-w)X_2 - T]^2 &= E[w(T+e_1) + (1-w)(T+e_2) - T]^2 \\ &= E[w(e_1) + (1-w)e_2]^2 \\ &= w^2 Var(X_1) + (1-w)^2 Var(X_2) \end{aligned}$$

Application of elementary differentiation demonstrates that

$$w = \frac{Var(X_2)}{Var(X_1) + Var(X_2)}$$

Suppose the standard deviations on the two estimators are equal, at .0156 each. In that case, equal weight will be applied to them and the resulting standard deviation on this equally weighted estimator will be 30% less than either estimator.

Even if the standard deviations of the two estimators are .0156 and .025, 28% of the weight should still be placed on the second estimator and the resulting standard deviation on this 72/28 weighted estimator will still be 15% less than that of the first estimator. Even more pronounced reductions in standard deviation are possible when more than two estimators are employed.

Finally, Gray assumes that the estimators are unbiased. If at least one of the estimators is biased then the appropriate criterion for placing weights upon the estimators is minimisation of mean square error rather than variance, and this leads to lower weight upon any biased estimator. To demonstrate this, consider the previous example except that the first estimator is biased upwards by the amount *B*. So, the estimators are then

$$X_1 + T + B + e_1, \quad X_2 = T + e_2$$

As before, define *w* as the weight placed upon the first estimator, with the balance of the weight placed upon the second estimator. We then choose *w* so as to minimise the mean squared error, i.e., to minimise

$$\begin{aligned} E[wX_1 + (1-w)X_2 - T]^2 &= E[w(T + B + e_1) + (1-w)(T + e_2) - T]^2 \\ &= E[w(B + e_1) + (1-w)e_2]^2 \\ &= w^2 B^2 + w^2 Var(X_1) + (1-w)^2 Var(X_2) \end{aligned}$$

Application of elementary differentiation demonstrates that

$$w = \frac{Var(X_2)}{B^2 + Var(X_1) + Var(X_2)}$$

So, if the two estimators have the same standard deviation (of .0156) and the bias is zero, they should be equally weighted. However, if the bias in the first estimator is .015, the weight on the first estimator falls to .34. The same result obtains if the bias in the first estimator is negative rather than positive.

This point is only significant if there are grounds to suppose that at least one of the estimators is biased. The leading candidate for such a judgement is the Ibbotson methodology, notwithstanding the fact that Gray's test cannot reject the hypothesis of no change[5]. One possible source of bias is unanticipated inflation in the estimation

[5] This is because Gray's test is weak and also because bias does not necessarily imply that the true value has shifted over time.

period (Siegel, 1992), and the lower estimate arising from Siegel's approach discussed earlier is consistent with this argument. A second possibility is survivorship bias, i.e., the fact that the Australian market has "survived" implies that the average outcome will exceed the expectation. Brown et al (1995) suggest that this effect may be substantial. However, Li and Xu (2002) argue that the modelling in Brown et al overstates the significance of the issue and the history of markets also suggests that this bias will be modest[6]. A third possible source of bias lies in changes in the premium over time, and this embraces a number of possibilities. For example, Siegel (1999) argues that the costs of acquiring a well-diversified portfolio (via a mutual fund) have fallen considerably in the past 20 years, and suggests that the resulting reduction in the US premium is .015. Booth (1999) argues that, if the investor horizon implicit in the CAPM differs from the term of the bonds used to estimate the market risk premium and the term structure of interest rates shifts over time, then the market risk premium defined relative to the bonds used to measure it will shift over time. In respect of the US, Booth argues that this leads to upward bias at the present time[7]. In general these arguments suggest that the Ibbotson methodology embodies upward bias. However, as discussed in the previous paragraph, the (net) direction of bias is immaterial. Whether upward or downward, the appropriate response to bias in an estimator is to reduce the weighting on this estimator.

In summary then, the best estimator is not the individual estimator with the lowest standard deviation but instead involves some weight on a number of alternative estimators. In my view, some weight should be placed upon the Ibbotson, Siegel, Cornell and Merton methodologies. They generate estimates for Australia of .075, .054, an upper bound of .045 - .057, and .070 respectively. Using the midpoint of the Cornell estimate, and equally weighting the four estimates, the result is .063 (mean). Alternatively, use of the median yields an estimate of .062. Recognising that the estimates from Cornell's methodology are upper bounds would not change this

[6] These first two instances of possible bias do not involve a shift over time in the premium.

[7] Another possible source of bias suggested by the results from foreign markets is a decline in the premium over time induced by a decline in the volatility of market returns. However, by contrast with most markets, there does not seem to have been any decline in the volatility of Australian market returns. For example, over the period 1883-1985, the standard deviation is 17% whilst that for 1986-2003 is 18.4%. The data used here was annual, derived from Officer (1989) and the Queensland Competition Authority.

median but would lower the mean. In addition, recognition of the fact that the Ibbotson methodology is more likely to be biased than the alternatives would lead to a reduction in its weighting, and therefore a reduction in the overall estimate. Finally, recognition of the fact that the Merton methodology is likely to suffer from the highest standard deviation would lead to a reduction in its weighting, and therefore a reduction in the overall estimate. All of this points to an estimate of .06 *at most*. Since the premium cannot be estimated to any greater degree of precision than the second decimal point, an estimate of .06 would seem to be appropriate.

5. Conclusion

Gray (2001) argues that the observed decline in the ex-post outcome for the Australian market risk premium in recent years is not statistically significant, that alternative estimation methods point to a value of at least .06, and that the historical averaging methodology is the best. Accordingly, he favours an estimate of .06 - .07. Gray's conclusion concerning statistical significance is correct. However, the test is virtually powerless to detect even very substantial shifts in the premium, and therefore its failure to characterise the recent decline as statistically significant is unremarkable. Much more powerful tests do not seem to be available. In respect of his claim that alternative methods point to a value of at least .06, he presents evidence from only two methodologies. In fact, the evidence from these methodologies points to a lower value than .06, and consideration of additional methodologies yields mixed results. Finally, in respect of his claim that historical averaging is the best methodology, the best methodology will in general draw upon estimates from a range of approaches. There are no apparent grounds for attaching an unduly high weight to the historical averaging estimate, whilst concerns about biases in this method point to a reduction in the weight that should be granted to it.

Estimates for the Australian market risk premium in the Officer model that invoke Australian data are available from the Ibbotson, Siegel, Cornell and Merton methodologies. They generate estimates of .075, .054, an upper bound of .045 - .057, and .070 respectively. Using the midpoint of the Cornell estimate, and equally weighting the four estimates, the result is .063 (mean). Alternatively, use of the median yields an estimate of .062. Recognising that the estimates from Cornell's methodology are upper bounds would not change this median but would lower the mean. In addition, recognition of the fact that the Ibbotson methodology is more likely to be biased than the alternatives would lead to a reduction in its weighting, and therefore a reduction in the overall estimate. Finally, recognition of the fact that the Merton methodology is likely to suffer from the highest standard deviation would lead to a reduction in its weighting, and therefore a reduction in the overall estimate. All of this points to an estimate of .06 *at most.* Mindful that the premium cannot be estimated to any greater precision than the second decimal point, the evidence from these methodologies points to an estimate of .06.

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