REPORT TO THE AER

REVIEW OF NERA REPORT ON THE BLACK CAPM

MICHAEL MCKENZIE

AND

GRAHAM PARTINGTON

ON BEHALF OF

THE SECURITIES INDUSTRY RESEARCH CENTRE OF ASIA-PACIFIC (SIRCA) LIMITED

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Expert Witness Compliance Declaration

We have read the Guidelines for Expert Witnesses in proceedings in the Federal Court of Australia and this report has been prepared in accordance with those guidelines. As required by the guidelines we have made all the inquiries that we believe are desirable and appropriate and that no matters of significance that we regard as relevant have, to our knowledge, been withheld from the Court.

Signed

Michael McKenzie

Graham Partington

Preamble

The AER has sought a review of the NERA report titled 'The Black CAPM', dated March 2012 (the NERA Black CAPM March 2012 report). Drawing on material in the background documents and any other relevant material as required, we have been asked to provide advice in the following areas:

1. Critically evaluate NERA's conclusion that the Black CAPM better estimates the cross section of mean returns than the Sharpe-Linter CAPM.
2. Examine and report on the veracity of NERA's critiques of the Davis 16 January 2011 report and the Handley 18 January 2011 peer review.
3. Critically evaluate whether NERA's findings in relation to survey evidence on the use of the CAPM by companies and institutions are sufficient to conclude that the Black CAPM is a well accepted financial model.
4. Assess whether the methods to calculate the zero-beta excess returns outlined in the NERA Black CAPM March 2012 report are robust, and in your view, whether these zero-beta returns are commensurate with prevailing market conditions.

In addressing these issues, we have engaged with the background documents listed below and we have consulted relevant research literature.

- NERA, *The Black CAPM*, March 2012

Documents from Envestra SA access arrangement review:

- Professor Bruce Grundy, *The calculation of the cost of capital: A report for Envestra*, September 2010.
- CEG, *Estimating the cost of capital under the NGR*, September 2010.
- Professor Kevin Davis, *Cost of equity issues: A report for the AER*, January 2011.
- Associate Professor John Handley, *Peer review of draft report by Davis on the cost of equity*, January 2011.
- Professor Kevin Davis, *Cost of equity issues: A further report for the AER*, May 2011.
- CEG, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula*, September 2008
- Lajbcygier, P. and S. M. Wheatley, *An evaluation of some alternative models for pricing Australian stocks*, Monash University, March 2012

Summary

In essence, the NERA (2012) report empirically estimates that the return on equity is a constant, which they take to be equal to the rate of return for a zero beta portfolio. In our opinion it is not plausible that the return across shares and through time is a constant, or that the return on the zero beta portfolio in the Black CAPM is the market return. Reductio ab absurdum the implication of the result is that each individual share is a zero beta portfolio. This cannot be described as a well accepted approach, or commensurate with prevailing market conditions.

With regard to the robustness of the estimated zero beta return we take this to mean robustness in the sense that there is little or no variation of the estimated parameter in response to sensible alternative approaches to estimation.[1] We conclude that, with respect to the magnitude of the zero beta return, the estimate is not robust. The NERA (2012) report, for example, shows estimates ranging from 6.985 percent to 10.309 percent. However, we make a more general and more important point that "the empirical zero beta portfolio" is not unique. Consequently, there are many different zero beta returns that might be estimated and very large differences in the value of that return could be obtained.

The results in the NERA report are robust in the sense that many studies undertaking a similar regression analysis have found a positive intercept term. However, what this means and whether this result is really statistically significant has been the subject of an ongoing debate.[2]

[1] Traditionally, robustness tests include re-estimating the model on different samples and might include alternative estimation procedures.

[2] See particularly, Roll (1977), Roll (1980), Roll and Ross (1994), and Beaulieu, Dufour, Khalaf (2012).

Taken at face value, the empirical NERA (2012) result, that equity returns are a constant, would lead to rejection of both the standard CAPM and the Black CAPM as theoretical models and "empirical models" of security returns. However, in our opinion the empirical work undertaken is not appropriate as a test of either the standard theoretical CAPM, or the theoretical Black CAPM. Neither, in our opinion, is it a particularly good test of appropriate empirical application of these models and we are not convinced that it can reliably distinguish between them.[3] As our report will show, there are many potential sources of error and bias in the estimation of zero beta returns and consequently such estimates should be viewed with great caution. Even if the foregoing problems were set aside, there are also question marks over the standard errors of the zero beta return estimates. This is an important unresolved issue given that the magnitude of the standard error is the basis for concluding whether estimated zero beta returns differ from zero.

Despite advocating the benefits of their empirical model, the NERA (2012) report does not adopt this model to estimate the cost of equity. The result from the empirical model is that the return on equity is a constant, but the NERA estimate of the return on equity for a regulated entity is higher than that constant. This is due to the use of a market risk premium that is inconsistent with their model. The risk premium from NERA's empirical model is negative, although not substantively or significantly different from zero. Whereas, the risk premium they use to estimate the return on equity for a regulated entity is positive and very substantial.

The NERA (2012) report argues that the Black CAPM is a well accepted financial model. In our opinion, it is rather unlikely that the Black CAPM is used in practice, but it cannot be ruled out in every case. We find the NERA report arguments on the implied use of the Black

[3] We also note that if it is accepted that the evidence suggests rejecting both models, then arguing about which is better is a somewhat fruitless debate.

CAPM unconvincing and the possibility that the Black CAPM *might* be used in some cases is not a demonstration that it is actually used, let alone well accepted.

In NERA's (2012) criticism of Davis (2011) and Handley (2011), there is merit on both sides of the debate. Most of the points of debate are due to differences in framing the context of the discussion, interpretation of the issues being addressed, and interpretation of the wording used. These differences in framing and interpretation mainly arise from pitting the empirical perspective (NERA) against the theoretical perspective (Davis and Handley). In our opinion, this is not a particularly fruitful debate as the theory and empirics cannot be completely divorced. Without some link to the theory it makes no sense to talk of "an empirical version of the CAPM". Without some theory all we have is a regression. That regression boils down to being a constant and that constant is simply an estimate of the average return on the market.

Introduction

In the discussion that follows, we focus on the benchmark return for measuring the risk premium/excess returns and the estimation of the zero beta return for this purpose (item 4 in the terms of reference.) There are two reasons for this. First, we take determination of the benchmark return for asset pricing to be the key issue. Second, most of the issues discussed jointly apply to items 1 and 4 since it is the properties of the estimated zero beta excess return (item 4) that determine whether the Black CAPM or the standard CAPM is the better model (item 1). The discussion in relation to item 4 also makes redundant a separate discussion of the differences between Davis (2011) and Handley (2011) on the one hand and NERA (2012) on the other. If items 1, 3 and 4 were dealt with separately the report would be excessively repetitive.

We should also be clear that what NERA (2012) refers to as “empirical versions of the CAPM” are empirical applications that attempt either to estimate the parameters for the theoretical CAPM, or to empirically test the theoretical CAPM, or that attempt to apply the CAPM to estimation of the required return on equity. Therefore, it should be clearly understood that “empirical versions of the CAPM” is shorthand for different types of attempts to empirically apply the theoretical model. While dealing with terminology, we note that we use the term standard CAPM for the Sharpe-Lintner CAPM, because this is the standard approach that is advocated in textbooks and is also the approach extensively used in practice for estimating the cost of capital.

The Choice of Benchmark

At issue here is the benchmark for measuring risk premiums/excess returns and the method of estimation for that benchmark. Should the benchmark be the risk free rate, for which the usual proxy is the return on a government security? Alternatively, should the benchmark be the rate of return on the zero beta portfolio in the Black CAPM, for which the proxy is an estimate of the rate of return on a zero beta portfolio?

The near universal practice in measuring the risk premium/excess returns is to benchmark using the risk free rate as proxied by the yield on a government security. The widespread nature of this approach suggests that there are good reasons to prefer the risk free rate as the benchmark. As we subsequently demonstrate there are indeed good reasons to prefer the risk free rate.

Using the yield on a government security as a proxy for the risk free rate is generally accepted. The measurement of the yield is relatively simple and transparent. The input variables can be readily observed and error in the measurement of the resulting yield is little or nothing.

In contrast, there is no generally accepted empirical measurement of the zero beta return in the Black CAPM. This is because the empirical measurement of the zero beta return is neither simple, nor transparent. There are many possible zero beta portfolios that might be used and the return on these portfolios is not directly observed, but has to be estimated. In the estimation process for the zero beta return, there are also inputs that cannot be observed and they too have to be estimated. The resulting estimate of the zero beta return is sensitive to the choices made in regard to the input variables and methods of estimation. As a result the measurement error can be large and the result ambiguous, as is illustrated below.

To put it another way, if a group of independent experts were asked to each provide the current yield on ten year government bonds, there would be little if any difference in their answers and the accuracy of the estimates could easily be assessed. If the same group of experts was each asked to provide the current zero beta return it is likely that they would provide different answers and the accuracy of these estimates would be difficult to assess, if they could be assessed at all. This can be seen in Table 3.1 of the NERA (2012) report. Despite some commonality in the experts supplying the estimates of excess zero beta returns these estimates vary and range from 6.985 percent to 10.309 percent.[4]

The foregoing estimates seem extraordinarily high relative to the limits imposed by the underlying theoretical model,[5] but since the exact value of the theoretical zero beta return is not observed, it is impossible to determine exactly how far from the theoretical value these estimates lie. NERA's (2012) argument is that their estimates are a purely empirical matter and thus there is no correspondence between the theoretical value and the value that they

[4] Due to commonality in the experts providing these estimates, we would expect to see less variation in Table 3.1 than if these estimates had each been provided by a different expert.
[5] The theory tells us that the equilibrium zero beta return in the Black CAPM must lie between the lending and borrowing rates.

estimate. This puts us in a more difficult position with regard to the assessment of accuracy. We no longer have the well defined limits of the theory and the empirical zero beta return is not observable. Therefore, we cannot measure the error in the estimate and consequently attempts to test the "forecasting" ability of the model tell us very little.

The Consequences of Roll's Critique

Roll's (1997) critique of tests of the CAPM, has had coverage in both Davis (2011) and Handley (2011). The NERA (2012) report seems to implicitly accept Roll's argument that the only test of the CAPM is whether the true market portfolio is efficient. Given this and the prior coverage of the material, we will not revisit the issue of testing the theoretical CAPM. Instead we use Roll's work to illustrate some of the properties of zero beta portfolios. This is necessary in order to understand the problems that can arise in empirically estimating the return on such portfolios.

The starting point for our analysis in Roll's (1977, p.130) own words is:

> *"In any sample of observations on individual returns, regardless of the generating process, there will always be an infinite number of ex-post mean variance efficient portfolios. For each one, the sample 'betas' calculated between it and individual assets will be exactly linearly related to the individual sample mean returns. … On the other hand, the chosen proxy may turn out to be inefficient; but obviously, this alone implies nothing about the true market portfolio's efficiency. Furthermore, most reasonable proxies will be very highly correlated with each other and with the true market whether or not they are mean-variance efficient. This high correlation will make it seem that the exact composition is unimportant, whereas it can cause quite different inferences."*

The consequences of this are now quite widely understood and accepted by finance academics, but may be less familiar to readers of this document. Therefore, we will provide some simple numerical analyses below to illustrate what the consequences are for the estimation of the return on the zero beta portfolio. We will begin with efficient portfolios and then move on to inefficient portfolios. Efficient portfolios are the portfolios that give the maximum return for a given risk, where risk is measure by the variance of returns.

An empirical analogue of the Black CAPM may be written as:

$$r_i = r_{zp} + \beta_{ip}\left(r_p - r_{zp}\right) \tag{1}$$

Where r_i is the return on asset *i*, r_p is the return on an efficient portfolio *p*, r_{zp} is the return on the zero beta portfolio that is the counterpart to portfolio *p*, β_{ip} is the beta coefficient for portfolio *i*.

Roll's (1977) work shows that Equation (1) will hold exactly for each of an infinite set of efficient portfolios and their zero beta counterparts. Each efficient portfolio has a set of zero beta portfolios associated with it, but they all have the same return. Thus, there is a unique zero beta return for each portfolio in the efficient set of portfolios. Which zero beta return we get depends upon which efficient portfolio we happen to pick. We will get the correct value of the zero beta return for the Black CAPM only if we pick the true market portfolio and that portfolio is efficient. If we pick an inefficient portfolio, there is no longer a unique zero beta return. It will be a matter of chance (since we now have many zero beta returns to choose from) whether we also pick the correct value for the zero beta portfolio, even assuming that the Black CAPM is true.

In empirical work we have to use actual (ex-post) returns as opposed to expected (ex-ante) returns. If we pick an ex-post efficient portfolio the estimate of the zero beta return will depend only on the ex-post efficient portfolio that we have chosen. If we pick an ex-post inefficient portfolio there is no unique zero beta return. There can be zero beta portfolios at all levels of return, notably one of these returns may be $E(R_z) = E(R_m)$ (see Roll 1980).

Numerical Examples

We now turn to numerical examples in order to illustrate the effect of choosing different reference portfolios as proxies for the market portfolio. In constructing our numerical example we use data for the means and standard deviations of three securities (A, B and C) and the correlations between the returns on these securities. We use three securities to facilitate a parsimonious presentation, more securities would just mean bigger tables and more computation, but the lessons of the analysis would remain unchanged. We also emphasise that the lessons we draw from our analysis do not depend upon the specific values we have chosen for the data.

Table 1 gives the correlation matrix for the securities in columns two to four and the standard deviations and expected returns are given in columns four and five. Since we know exactly what the values of these input variables are we can undertake a precise analysis. We do not face the additional problems found in empirical analysis of having to estimate the unobservable values for the inputs to the analysis and having to deal with the distinction between ex-ante and ex-post returns.

Table 1
Security Returns Data and Correlation Matrix

Security	A	B	C	Standard Deviation %	Expected Return %
A	1.00	0.31	0.60	20.18	18
B		1.00	0.14	17.54	12
C			1.00	28.47	16

Zero Beta Returns for Efficient Portfolios

Using the data from Table 1 and Equations (2) and (3) we can generate the returns and standard deviations for any given set of proportions (weights) of the different securities in the portfolio. The return on the portfolio is given by:

$$r_p = \sum_{i=1}^{n} x_i r_i \qquad (2)$$

where r_p is the expected return on the portfolio, x_i is the proportion of the portfolio invested in security i, r_i is the return on security i, n is the number of securities in the portfolio.

The variance of the portfolio is given by:

$$\text{Portfolio variance} = \sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} \qquad (3)$$

where σ_{ij} is the covariance of returns between share i and j.

Consider the data for portfolios 1 and 2 in Table 2. The weights of the securities in these portfolios have been chosen so that both portfolios are exactly on the efficient set. Using the data from Tables 1 and 2 it is possible to compute the exact beta of each security with respect to each portfolio. These betas are given in column 3 for portfolio 1 and column 7 for portfolio 2. The betas for each security are plotted against the returns for the security in Figure 1 for Portfolio 1 and in Figure 2 for Portfolio 2. The result is a perfect linear relation between beta and return, exactly as given by Equation (1).

Table 2
Data for Two Efficient Portfolio

Portfolio 1	Security Weight %	Security Beta	Security Return %	Portfolio 2	Security Weight %	Security Beta	Security Return %
A	36.4312	1.054122	18	A	53.7251	1.160003	18
B	55.4540	0.961112	12	B	41.8625	0.790765	12
C	8.1149	1.022770	16	C	4.4124	1.036924	16
Portfolio return %	14.5105			Portfolio return %	15.4000		
Portfolio Standard Deviation	15.0001			Portfolio Standard Deviation	15.5534		

Figure 1
Beta Return Relation for Portfolio 1

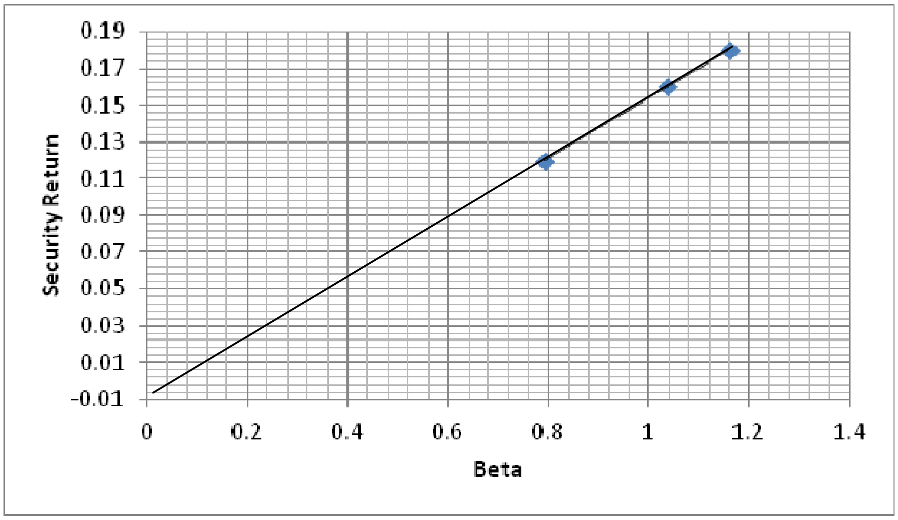
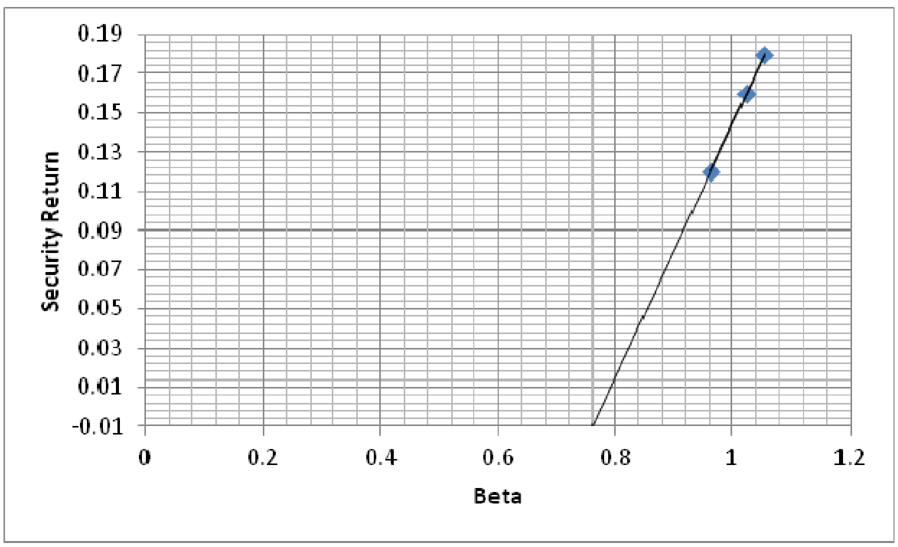


Figure 2
Beta Return Relation for Portfolio 2



The return on the zero beta portfolio is given by the intersection of the plotted line with the vertical axis (intercept). No intercept is visible in Figure 2 because it has a large negative value beyond the scale of the plot. Comparing Figures 1 and 2 suggests that despite the modest difference (less that 1 percent) in the returns and standard deviations of portfolios 1 and 2, there are dramatic differences in the returns on the zero beta portfolios. For portfolio 1 the return on the zero beta portfolio is minus 0.85 percent and for portfolio 2 it is minus 50 percent.

The return on the zero beta portfolio for the Black CAPM should lie between the lending and borrowing rates, which are unlikely have negative values. In our numerical illustrations, the returns on the zero beta portfolios are negative. If this were real data we would conclude either that there was something wrong with our estimation procedure, or that our reference portfolios were not the market portfolio, or that the Black model did not hold.[6] The same conclusions would apply if we estimated a zero beta return above the borrowing rate. Unfortunately, with real data it is not clear how to determine which conclusion is true and indeed all three conclusions could be simultaneously be true.

The lessons of the foregoing illustration are not specific to the examples used, but rather apply in general. The estimate of the return on the zero beta portfolio is sensitive to the choice of the proxy for the market portfolio. If the portfolio used is not the market portfolio you may get estimates of the zero beta return that are very different to the true value.

Zero Beta Returns for Inefficient Portfolios

We now move on to considering the effect of using an inefficient portfolio as a proxy for the market. The betas and returns for two inefficient portfolios, portfolios 3 and 4, are given in Table 3. The plots of the relation between beta and return are given in Figures 3 and 4 respectively. These two portfolios were selected to have the same return (15.4 percent) as portfolio 2, but being inefficient portfolios they have higher standard deviations. Efficient

[6] If the Black CAPM did not hold, this would in turn imply that the standard CAPM did not hold. This is because the standard CAPM can be viewed as a special case of the Black CAPM with the zero beta asset being the risk free rate.

portfolio 2 and inefficient portfolio 3 not only have the same return but they also have almost the same standard deviations. The standard deviation of portfolio 3 is higher by just under six hundredths of one percent (6 basis points). Despite this close similarity between the two portfolios, the relation between beta and return is very different as is evident from comparing Figure 2 and Figure 3.

It is clear that in moving from Figure 2 to Figure3 that the intercept has switched from being negative fifty percent to a positive value. Turning to Figure 4 (for inefficient portfolio 4), it is evident that the relation between beta and return is rather flat and hence the intercept will be substantially higher than for portfolios 1 to 3. It is also evident in Figures 3 and 4 that the points representing each security no longer lie along a straight line, so the intercept can no longer be precisely determined.

Table 3
Data for Two Inefficient Portfolios

Portfolio3	Security Weight %	Security Beta	Security Return %	Portfolio 4	Security Weight %	Security Beta	Security Return %
A	50.0000	1.15996	18	A	10.0000	0.62575	18
B	40.0000	0.76067	12	B	20.0000	0.24999	12
C	10.0000	1.15748	16	C	70.0000	1.26775	16
Portfolio return %	15.4000			Portfolio return %	15.4000		
Portfolio Standard Deviation	15.5914			Portfolio Standard Deviation	22.0401		

Figure 3
Beta Return Relation for Portfolio 3

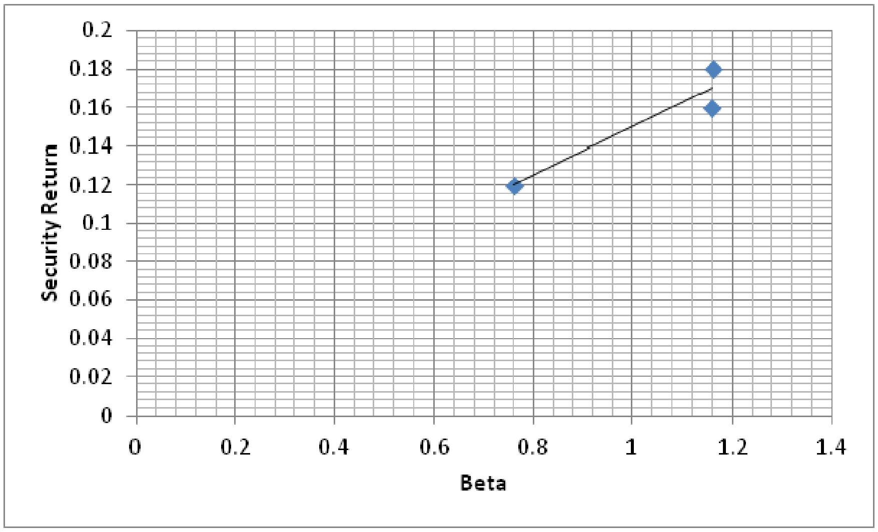
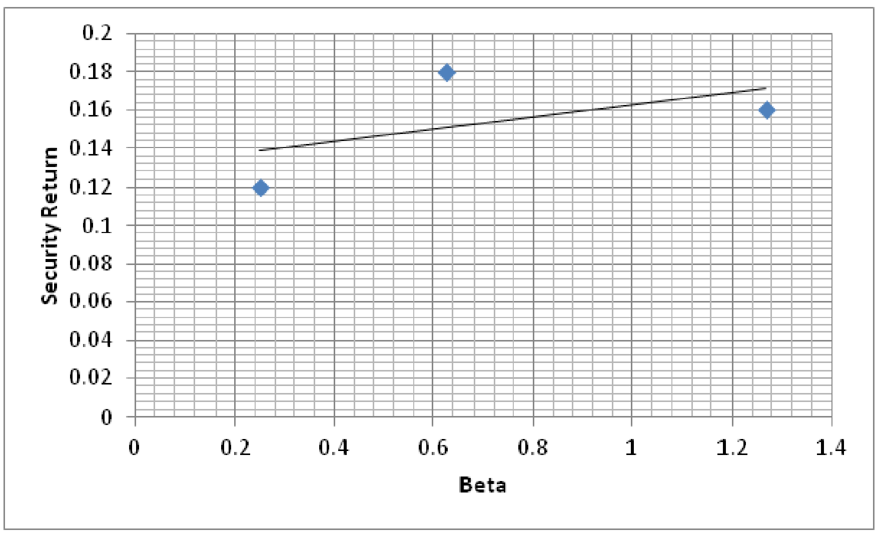


Figure 4
Beta Return Relation for Portfolio 4



So far, we have been somewhat vague in relation the returns on the zero beta portfolios that are the counterparts to portfolios 3 and 4. There are good reasons for this. Multiple zero beta portfolios may be associated with a single inefficient portfolio, so there are many values of zero beta return that are possible for any given inefficient portfolio. We can estimate a zero beta return for one of the zero beta portfolios by regression and conceptually there is a unique zero beta return for that regression. The corollary is that the zero beta return you get will depend on which regression you choose to run.[7] There will be some error in the regression estimate of the intercept and, as we discuss below, the estimate may be unreliable.

The analysis above illustrates two general lessons. First, in moving from efficient to inefficient portfolios, it is no longer possible to precisely determine the return on zero beta portfolios. Second, even for portfolios with closely similar risks and returns the estimates of zero beta returns may be quite different. Thus, even if you pick a reference portfolio that is very close to the true market portfolio you can still get a very misleading estimate of the zero beta return.

Regression Estimates for the Inefficient Portfolios

In order to estimate a zero beta return in relation the portfolios 3 and 4, we regress the returns of the stocks against the stock betas and this gives estimates of 2.42 percent for portfolio 3 and 13.07 percent for portfolio 4. The regression lines are plotted in Figures 3 and 4 and this reveals another problem. The regression line is plotted in the regions where we have data, but we have no data in the region of the intercept. Even basic statistics textbooks caution against placing reliance on the extrapolation of regressions to regions where there is no data, particularly with respect to the intercept.

Given that very low[8] and negative beta equity securities are rare, if they exist at all,[9] a shortage of data to correctly fix the position of the zero beta intercept is likely to be a

[7] The choice of data points for your regression will determine the zero beta return that you estimate and will implicitly define your market portfolio.
[8] Very low beta portfolios could be created by combining equities with government bonds and this would tend would tend to push the intercept towards the risk free rate.
[9] In estimating betas, particularly with daily data, negative beta estimates do arise, but this is generally a sign of problems with the estimation process. It is possible to get negative betas, by an assumed short position, but this gives assumed returns not real ones. For example, a short position is assumed feasible, which is not the case for

pervasive problem. If so, regression estimates of the zero beta return and the estimate of its standard error should be taken with a pinch of salt. It might be argued that the underlying theoretical relation is a straight line and thus extrapolation of the regression line is warranted. The counterpoint is that more data in the region of the intercept might well change the position of the fitted regression line.

Subtracting the zero beta returns corresponding to portfolios 2, 3 and 4, from the portfolio returns, the risk premiums on the market are estimated at minus 65.4 percent, 12.98 percent and 2.33 percent respectively. The risk premium is remarkably variable, particularly so given that the returns on portfolios 2, 3 and 4 are identical at 15.4 percent, and that portfolios 2 and 3 are so close in terms of risk and return as to be almost indistinguishable.

The problems revealed by the illustrations above do not arise when using the risk free rate as the benchmark for measuring the risk premium. For example, suppose that the government bond rate was 7 percent and the true market portfolio was efficient portfolio 2. It would not matter whether you choose portfolios 2, 3 or 4 to estimate the market risk premium. They would all give an estimate of the market risk premium of 8.4 percent. This illustrates an important point. In order to get a reasonable estimate of the market risk premium using the risk free rate as the benchmark, the proxy portfolio does not need to be a close proxy for the market. The proxy portfolio just needs to have a return reasonably close to the market return.

Empirical Issues

In our opinion the analysis above provides plenty of reasons for great caution in the use of zero beta estimates of return. However, once we move to estimates using real data another layer of problems arise. The Black CAPM is a model of expected asset returns with known

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all stocks, or at all times. Neither do the returns reflect the additional costs of the short positions. These are costs that vary across stocks and through time.

asset betas. In empirical estimation we must use some measure of actual returns and an estimated beta. The choices made in this regard and in relation to other aspects of the empirical analysis, for example, the period chosen for study, can have a substantial effect on the results obtained.

Beta and Thin Trading

In order to illustrate the sort of empirical problems that can arise let us consider just one of the problems in the estimation of beta. Thin trading is a feature of the equity markets and it is common in the Australian market. Thin trading creates problems in estimating beta. It is well understood that the result of thin trading is upward biased estimates of beta for frequently traded stocks and downward biased estimates of beta for less frequently traded stocks. The more frequently traded stocks tend to be the large stocks and the less frequently traded stocks tend to be the small stocks. It is also well known that large stocks tend to have smaller returns than small stocks. So the larger stocks will tend to have upward biased betas and also tend to have smaller returns, while the small stocks will tend to have downward biased betas and also tend to have higher returns. This will tend to flatten the empirically estimated relation between beta and returns, raising the intercept and reducing the slope.

We are not asserting that the bias created by thin trading is the explanation for the relatively flat relation between beta and returns in the NERA (2012) report. The impact of thin trading on the results presented is an open question. What is illustrated is a further source of potential difficulty in relying on the empirical estimate of the zero beta return. This is not the only possible empirical issue. However, rather than nit-pick we will confine ourselves to two important issues, the choice of the sample period for analysis and the standard error of the intercept estimate.

Changing the Sample Period

The estimated relation between beta and returns changes with the sample period. The sensitivity of the estimated relation to differing sample periods can be illustrated using the US market results from Black (1993) with updated results as presented in Brealey Myers and Allen (2011).[10] Black shows that over the period 1931 to 1965 the estimated relation between beta and return is positively sloped. However, over the period 1966 to 1991, the estimated relation, like the NERA (2012) result, is essentially a flat line. However, it is evident from Brealey Myers and Allen that updating the 1966 to 1991 data to 2008, restores a positive slope. Unfortunately, there is no objective basis for determining what the sample period should be.

The lesson is that the empirical results are sensitive to the sample period over which you choose to estimate the relation between beta and return. In the Australian context this is very clearly illustrated by Wood, Faff and Hillier (2001) who find that the estimated zero beta return is positive and significant before the introduction of the imputation tax system and is negative and significant afterwards.

Standard Errors

Testing whether an estimated zero beta return really is statistically significant depends on using the correct standard error. Unfortunately, once we leave the cosy world of independent, identically and normally distributed regression errors, and enter the real world of empirical asset pricing the waters become rather murky. In this context, an important problem in the

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[10] The data is taken from the US market. The advantage of US data is good quality data available over a longer period than in Australia. We note that the report by NERA (2012) expresses a preference for the estimate of the zero beta return "based on the longest time series" (p. iii) which they have available.

two-pass regressions approach of Fama and MacBeth is the errors in variables problem. This problem is well described in the following quote from the NERA (2012, pp.8-9) report:

> *"To test hypotheses about the mean over time of the excess return to a zero-beta portfolio, one can compare the sample mean of the time series of estimates of the excess return to its standard error computed in the usual way, that is, under the assumption that the series of estimates is independently and identically distributed over time. There are, however, two problems with doing so. The first problem is that since the least squares estimate of a stock's beta measures the beta with error, the second-pass estimator of the excess return to a zero beta portfolio will be biased. There are two ways of addressing this problem. The first way is to place stocks into portfolios, like Fama and MacBeth (1973), so as to diversify away much of the measurement error but to do so in such a manner as to retain as much of the cross-sectional variation in the second-pass regressors as possible. This is the method that CEG (2008) choose. The second way is to modify the second-pass estimator, as Litzenberger and Ramaswamy (1979) and Shanken (1992) do, to take into account the errors in-variables problem. This is the method that Lajbcygier and Wheatley (2012) choose. …*
>
> *The second problem with the two-pass procedure is that the Fama-MacBeth method of computing standard errors does not properly take into account the measurement error associated with the beta estimates and so can misstate the precision with which the mean overtime of the excess return to a zero-beta portfolio is estimated. Shanken (1992) shows that if, conditional on the factors, returns are homoscedastic, Fama-MacBeth standard errors will overstate the precision with which the mean is estimated. He notes, though, that for models in which the factors are portfolio returns the extent to which the standard errors overstate the precision are likely to be small. So, like Kalay and Michaely (2000), in their empirical work, CEG (2008) and Lajbcygier and Wheatley (2012) use Fama-MacBeth standard errors and do not adjust the standard errors for the measurement error associated with the beta estimates."*

It is unclear, to what extent this creates a problem in the NERA (2012) results, but we do note that the estimates of the betas for individual stocks are likely to have some very substantial measurement errors, the more so when the thin trading problems discussed above are added to the mix. So although it is unclear to what extent there is a problem, it is clear that there is a question mark over the results.

Beaulieu, Dufour, Khalaf (2012) carefully examine the multivariate regression framework that has been used as an alternative to the Fama MacBeth two pass regression approach. They particularly focus on the confidence interval for the estimated zero beta return and allow for non-normality in the regression error. Key elements of their conclusions are:

> *"We also derive exact confidence sets for the zero-beta rate γ. While available Wald-type intervals are unreliable and lead to substantially different inference concerning γ, our confidence sets are valid in finite samples …We also examine efficiency of the market portfolio for monthly returns on NYSE CRSP portfolios. We find that efficiency is less rejected with non-normal assumptions. Exact confidence sets for γ differ importantly from asymptotic ones, and likelihood-ratio-based confidence sets are tighter than their Wald counterparts. All confidence sets nevertheless suggest that γ is not stable over time."*
> Beaulieu, Dufour, Khalaf (2012, p.26)

While the content of this quote is technical, the conclusion to be drawn is clear - when it comes to estimates of the zero beta return and its standard error, caveat emptor.

The NERA Estimates

NERA (2012) present several different estimates of the zero beta excess return, but their preferred estimate is 6.99 percent. Adding the 3.99 percent for the risk free rate used by the AER in it *Aurora Draft Decision*, gives an estimated zero beta return of 10.98 percent. Given that the zero beta return in the Black CAPM should lie between the lending and borrowing rates, an estimate of 10.98 percent for the zero beta return is not credible. The estimated zero beta return looks more like the return to an equity security with a beta of the order of one. The excess zero beta return should be no more than the credit spread, but at 6.99 percent it is more like a high side estimate for the market risk premium.

Clearly an estimate of 10.98 percent indicates that there was something wrong with the estimation procedure, or that the reference portfolio was not the market portfolio, or that the Black CAPM did not hold, or possibly all three of these problems were present. NERA (2102) focuses on problems with the reference portfolio, which they point out is not the market portfolio and which they show to be inefficient. This immediately rules out getting the correct result for the zero beta return, but it does not rule out the possibility that the other two problems are also present.

As we illustrated earlier, the use of a portfolio which is not the market portfolio, and which is inefficient, leads to all sorts of problems when estimating the zero beta return. In this case, the result is a parameter estimate that is clearly incorrect, lying well outside the bounds prescribed by the underlying theoretical model. This hardly seems a solid basis on which to establish a cost of capital for regulatory purposes. However, NERA (2012) take the rather interesting approach of arguing that since they use an imperfect proxy portfolio an incorrect result should be expected, and by implication is therefore acceptable. They state:

> *"The Black CAPM states that the risk of an asset should be measured relative to the market portfolio of all risky assets whereas empirical versions of the model measure the risk of an asset relative to a portfolio of stocks alone. It follows that one should not expect the zero-beta rate in an empirical version of the model to lie between the risk-free borrowing and lending rates. This is because the Black CAPM does not impose the restriction that the mean return to a portfolio that has a zero beta relative to the market portfolio of stocks must lie between the risk-free borrowing and*

NERA (2012) justify their use of a portfolio of stocks on the basis that the empirical applications of the standard CAPM, underpinning the work of the AER, also use a portfolio of stocks. However, there are some important differences between the empirical use of the standard CAPM by the AER and the use of the Black CAPM in the empirical model estimated by NERA (2012). For empirical use of the standard CAPM, the choice of market proxy does not affect the estimate of the risk free rate[11] and in estimating the risk premium on the market it is not critical that the market proxy exactly matches the true market portfolio.

[11] We note the exception that in determining the risks free rate it does matter whether you use an international or domestic version of the CAPM. For example, if you use a domestic version of the CAPM then consistency dictates that you use a domestic risk free rate and a domestic market portfolio.

The exact identification of the market portfolio is critical to the correct estimation of the zero beta return for the Black CAPM, a portfolio close to the market portfolio is not sufficient. Whereas, the estimation of the risk free rate for use in the standard CAPM does not depend on the market portfolio. In the NERA approach, the estimate of the zero beta return will vary with the choice of the proxy for the market portfolio and the proxy chosen in this case results in a poor estimate of the Black CAPM zero beta return. In the AER approach, the estimate of the risk free rate is determined from the return on government securities, which are widely regarded as an acceptable proxy for the risk free rate.

As we demonstrated earlier the exact identification of the market portfolio is not critical to the estimation of the market risk premium for the standard CAPM. To estimate the market risk premium empirically an average of the realised excess returns on a poxy portfolio can be used. For this purpose the only characteristic of the proxy portfolio that has to match the market portfolio is the return. Thus, a proxy portfolio with a return that approximates the market portfolio will suffice. Whether the equity market portfolio suffices for this approximation is an open question. However, it does have the recommendation of extensive practical use for this purpose. In contrast, measuring the market risk premium is problematic in the case of the zero beta model unless the empirical portfolio chosen to estimate the zero beta return is exactly the market portfolio.

The Use of NERA's Results

There are two ways in which NERA might have used the estimates from their empirical Black CAPM to estimate the market risk premium. They might have followed the approach above and taken the mean difference over time between the return on the equity index and the estimated value for the zero beta return. It would have been more convenient, however, to have used the slope coefficient of their regression, which is an estimate of the market risk premium for the empirical Black CAPM. However, neither of these estimates was used.[12] Perhaps this is because these estimates were implausibly, and from the perspective of regulated entities undesirably, negative. This is the case for the slope coefficient estimate of the market risk premium (see Lajbcygier. and Wheatley (2012), Table 5).

While the slope coefficient was negative, it was not statistically significant. The interpretation of the estimated model, therefore, is that the return on equity is a constant across stocks. That constant is the return on a zero beta portfolio. It is difficult to give much weight to the proposition that the return for all stocks is a constant. However, this is the proposition that the NERA (2012) empirical results support and this is what underpins the NERA report.

Having established the above proposition empirically, the NERA (2012) report selectively sets it aside in estimating the required equity return for a regulated entity. The required return on equity is not estimated as a constant, instead a risk premium is added to the constant. In other words, the estimate of the zero beta return is accepted in the NERA report, but the absence of a risk premium is not. This implies that the intercept term is measured reliably, but the slope coefficient is not. This is difficult to accept. More acceptable propositions are that both the slope coefficient and the intercept are reliably estimated, or that neither the slope coefficient nor the intercept are reliably estimated. You might hope for the former, but in our opinion it is safer to assume the latter.

Survey Evidence Commercial and Regulatory use of the CAPM

The NERA (2012) report begins the discussion of this topic with the following statement:

> *"…Black CAPM became the most widely accepted pricing model among academics for much of the 1970s and 1980s. It is less clear, on the other*

[12] Instead the market risk premiums used to calculate the required return on equity were derived from a regime switching model and from a dividend growth model.

> *hand, that the model has ever gained widespread explicit acceptance among practitioners. We will argue, though, that one cannot rule out a widespread implicit acceptance of the model by practitioners*". NERA (2012, p.20)

It is true that the Black CAPM was widely accepted as an alternative theoretical asset pricing model among academics in the latter part of the last century and remains a continuing topic of research.[13] However, this does not mean that academics accepted the Black CAPM as a useful practical tool for determining the cost of capital. If they had done so we would have expected that its use for this purpose would be advocated in corporate finance textbooks. In our experience, the coverage of the Black CAPM in such textbooks is negligible.

With respect to practitioners the evidence is clear that the Black CAPM is not explicitly accepted and we think it unlikely that it is used implicitly, although we cannot entirely rule it out. However, the argument that implicit use of the Black CAPM cannot be ruled out is a considerable distance from demonstrating that the Black CAPM really has implicit use and is a long, long way from demonstrating that it is widely accepted. In our opinion, the arguments that the NERA (2012) report make to support the case for implicit use are weak.

The NERA (2012) report begins its arguments for implicit use of the Black CAPM by pointing to flexibility in the choice of parameters for use in the standard CAPM. The argument then proceeds to the use of Blume adjusted estimates of beta.

There is considerable flexibility in the selection of parameters for the standard CAPM and practitioners make a range of different choices. To that extent we agree with the NERA report. We do not agree with NERA's conclusion that as result of these flexible choices :

> *"... one can rule out the idea that companies choose the parameters of the model to produce conservative estimates of the cost of equity – that is, estimates that are neither too low nor too high*." NERA (2012, p.21-22).

[13] Whether it was the "most widely accepted " is not really known.

In our opinion practitioners make different choices simply because there is no uniform prescription accepted by all for the measurement of the parameters of the standard CAPM. Some practitioners will be seeking the right cost of capital, neither too high nor too low, others will be seeking high or low estimates. For example, regulated entities will, for the purpose of price setting, rationally seek parameters that maximise the estimated cost of capital.

With regard to the use of Blume adjusted betas, this is likely to be because practitioners recognise that changes in firm's investments through time tend to shift risks towards the mean, or because they believe regression to the mean is a statistical artefact of the process used to estimate beta. The adjustment has no necessary connection to the use of the Back CAPM.

The NERA (2012, p. 22) report opens its discussion of the Blume adjustment with the following statement[14]

> *"We will show that because practitioners often use Blume-adjusted estimates of beta without a clear rationale for doing so that they are in effect using a combination of the SL CAPM and Black CAPM."*

And almost immediately following this the NERA report says:

> *"There are two rationales for using Blume-adjusted estimates of beta: the true betas of firms tend to regress towards the mean of all betas of one over time as the risks of the activities undertaken by firms change; and adjusted estimates of betas can be more precise than unadjusted least squares estimates because they take into account prior beliefs about the cross-sectional distribution of betas."*

This rather seems to undercut the preceding NERA statement about practitioners having no clear rationale for the use of Blume adjusted betas. Consequently there seems very little point

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[14] We note that some practioners may use the Blume adjustments, but we see no substantive evidence that "practioners *often* use Blume adjusted estimates of beta".

in the ensuing discussion in NERA (2012), the more so since part of the argument relies on the fundamentally implausible empirical result that the return on equities is a constant.

With respect to NERA's analysis of survey evidence we confirm that surveys such as Truong, Partington and Peat (2008) contain no report of explicit use of the Black CAPM. Understandably, such surveys do not report on the use of implicit estimation of the cost of capital. However, it is important to distinguish between implicit use and unconscious use. Most surveys include the opportunity for respondents to make open ended comments to clarify their responses and add other information that explains what they do. In the USA, Graham and Harvey (2001) is one of a series of regular questionnaire surveys that Graham and Harvey have undertaken and they have supplemented their questionnaire work by interviews with managers. In Australia, Coleman, Maheswaran and Pinder (2010) conduct both a questionnaire survey and interviews with managers. An important objective of such interviews is to elicit clarifying information that might otherwise have slipped through the net. Given the opportunity for managers to make open ended responses to questionnaires and to participate in interviews, we would have expected that if the implicit use of the Black CAPM was conscious and widespread, then some hint that it was used would have surfaced by now. We agree that if the use of the Black CAPM is implicit and unconscious, its use is unlikely to be have been detected.

Having reviewed the arguments supporting the NERA (2012) conclusion that the Black CAPM is a well accepted financial model, we conclude that the NERA report is not so much drawing a long bow, but rather more ambitiously it is trying to wind a Greek ballista. The argument will not make the distance that has to be traversed.

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