ESQUANT
Statistical Consulting

Review of ERA Cross-Validation Approach

A REPORT PREPARED FOR DBP

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ESQUANT STATISTICAL CONSULTING

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1 Summary

In its Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 -2020, dated 22 December 2015 (Draft Decision), the ERA rejected the "Model Adequacy Test" proposed by DBP for estimating the return on equity in its Access Arrangement Proposal dated 31 December 2014, including DBP's Submission 12 on Rate of Return. The ERA suggested the use of cross-validation.

The cross-validation code supplied by the ERA appears to be unfinished, and does not undertake the form of cross-validation suggested by the ERA in its draft decision. Instead it calculates the generalised cross-validation statistic, but only for the SL CAPM.

Cross-validation for time series models is conventionally undertaken using a rolling forecast origin, where the models are fitted to a period of data and predictions to the model are compared to actuals forward in time. DBP have effectively undertaken such an analysis for five models using a loss function corresponding to bias but not prediction variance. Some recent literature suggests that conventional K-fold cross validation may, in some restricted circumstances, also be a valid method for cross-validation of time series models.

For one month ahead forecasts, conventional K-Fold cross validation and leave one out cross-validation may be valid, although there is an issue of using future data to predict the past. Accordingly, time series cross-validation, 10-fold cross validation, and leave one out cross-validation was used for each of the five models considered by DBP: The Sharpe-Lintner capital asset pricing model (SL-CAPM), the SL-CAPM with the estimate of beta replaced by the upper bound of the 95% confidence interval of beta, the Black CAPM, CAPM based on a modified beta called betastar by DBP, and the Fama-French model (FFM). The results show that for month ahead forecasts there are no real differences in prediction variance but differences in bias, as found by DBP.

For averaging monthly forecasts over a longer period, conventional K-Fold cross validation and leave one out cross-validation is not valid using "overlapping" returns, that is using blocks of data that overlap. With time series cross-validation, both overlapping and non-overlapping returns can be used. The appropriate methods of cross-validation were repeated using 12-month ahead forecasts. The average prediction variance of the mean monthly return over the twelve months was reduced but the bias remained at the same levels. Again there were no differences in prediction variance between the five models but the differences between prediction bias found using the month ahead results remain.

It is recommended that both prediction variance and prediction bias be calculated in future cross-validation exercises. The results show that the bias of some of the methods found by DBP using their model adequacy test are maintained when focusing on longer term forecasts.

2 Terms of Reference

In its Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 -2020, dated 22 December 2015 (Draft Decision), the ERA rejected the "Model Adequacy Test" proposed by DBP for estimating the return on equity in its Access Arrangement Proposal dated 31 December 2014, including DBP's Submission 12 on Rate of Return. In doing so, the ERA notes at the bottom of page 46, and in more detail in Appendix 4B(i), of the Draft Decision that, were one to adopt some form of model adequacy test, one ought to use cross-validation rather than the t, Wald and Mincer-Zarnowitz tests used by DBP in its Model Adequacy Test. Although the ERA's statement is reasonably specific about the form the cross-validation which ought to be undertaken, it has not undertaken such tests itself. DBP seeks an expert report concerning issues related to cross-validation assessment of prediction errors, including the undertaking of that cross-validation assessment in accordance with "best practice", as follows:

1. In appendix 4B(i) (pages 232 to 235 of Appendix 4 to the Draft Decision), the ERA describes the way in which it believes a cross-validation test ought to be undertaken. DBP requires

an empirical application of this test, using the 2015 version of the SPPR data DBP used in its original Access Arrangement proposal of 31 December 2014 (including DBP's Submission 12, Rate of Return, 31 December 2014) and the same portfolio returns DBP used in its own tests. Model prediction will be under the Method A and Method B described in DBP's original Access Arrangement proposal (see DBP's Submission 12, section 5, page 60 and following), as well as a foreshadowed "Method C", which DBP intends to prepare in response to the ERA's new treatment of the market risk premium in its Draft Decision. All of the relevant data will be provided to the consultant as part of a formal brief.

2. In an email dated the 24th of December 2015, the ERA provided to DBP regression code which appears to calculate a cross-validation model using daily, weekly and monthly returns using Bloomberg data. DBP requests the consultant to run the regression code using a Bloomberg terminal and to set out in its report the results derived from that process.

3. Subsequent to running each of the models referred to at 1 and 2, DBP seeks an expert opinion as to whether the ERA's proposed approaches are appropriate in all of the circumstances. If the consultant believes improvements can and ought to be made in order to achieve a "best practice" cross validation approach, please re-run the modelling work with any improvements considered appropriate, and present the results of this analysis.

4. Having regard to each of the matters raised at 1 to 3, and further to each of those matters, DBP seeks an expert opinion concerning the conclusion reached by the ERA, that cross-validation is a more appropriate method than the Model Adequacy Test adopted by DBP, particularly having regard to the nature of the particular cross validation tests which the ERA has proposed and the time series nature of the data (see page 46 and appendix 4B(i) to the Draft Decision). In particular, we seek your opinion on whether cross-validation is materially preferable to the empirical DBP approach adopted by DBP and whether DBP's approach should be rejected in favour of cross-validation.

In preparing an expert report which covers the above matters, the consultant is required to have regard to the requirements of the National Gas Rules, including rule 87 concerning the calculating rate of return, particularly the allowed rate of return objective set out in rule 87(3).

Please provide a short written, fixed fee, quotation responding to the points above by the 8th of January. Given the tight time frames required for a response to the regulator, it is anticipated that all work will be completed to a Draft Report stage by February 5th, with comments back from DBP by February 12th and a Final Report by February 19th. Also having regard to those time frames, this request for quotation, including the particular questions raised above, is provided to you as a draft in the first instance. We anticipate working closely with consultants during the project to address any additional issues as they arise. If, having regard to additional issues that arise, it becomes necessary to seek your opinion on additional or different matters, we will seek to agree that additional or revised scope with you. Accordingly, please also provide an hourly rate for relevant consultants to allow for an expansion of scope where this becomes necessary.

Since it is possible that your expert report may be relied on in future proceedings before the Australian Competition Tribunal, we require that the work be undertaken in accordance with the Federal Court Guidelines for Expert Witnesses (attached). Further, your report should contain a declaration that you have been given and have read, understood and complied with Practice Note CM7 issued by the Federal Court of Australia concerning guidelines for expert witnesses. It should also contain a declaration that you have made all the inquiries that you believe are desirable and appropriate and that no matters of significance that you regard as relevant have, to your knowledge, been withheld.

3 Declaration

This report has been prepared by Neil Diamond of ESQUANT Statistical Consulting. The contact details for ESQUANT Statistical Consulting are:

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The author of this report has read, understood and complied with the Expert Witness Guidelines as given by the Federal Court of Australia's Practice Note CM 7, entitled "Expert Witnesses in Proceedings in the Federal Court of Australia". I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from this report.

4 ERA Regression Code

The following code is in lines 699 to 815 of the ERA's code (`support_functions_r`).

```
### cross-validation
# window size
# test on last 365 days; predict on data of 1:10 years + 1 day.
# compare with a rolling window model.

# require lubridate::month
calcCVError<- function(model=AGLHenry,equityReturn=gasReturns,marketReturn=marketReturns[,1],
  trainingPeriod=12,predstart=as.Date(max(dateIndex)-365),predEnd=max(dateIndex),
  rolling=FALSE,offsetReturn=NULL) {

⋮

 if(class(model)[1]=="lm"){

⋮

   if(rolling==FALSE) {

⋮

predCV<-sum(apply(response,2, function(y) sum(((y-HMat%*%y)[predRange]/(1-sDiag))^2)/length(y))
    return(predCV)
   }else{
   CVPred<-0
     for(i in 1:length(predRange)){

⋮

     CVPred<-CVPred +   sum(((response[testDay,]-yPred)/(1-sDiag))^2)
     }
     CVPred<-CVPred/length(predRange)
```

```
    }
  }else{

  # non lm models - the good old way

  }
  return(CVPred)
⋮

}
```

4.1 Comments on the ERA Code

- The code, as supplied to me, is apparently "work in progress".
- All the models evaluated by DBP are linear models, so do not require the completion of the code for non-linear models.
- The code distinguishes between a rolling window and a non-rolling window.
  - As explained by Hastie, Tibshirani, and Friedman (2009, pp. 232 and 244), for a linear model
    $$\hat{y} = Sy$$
    where S is $N \times N$ matrix depending on the input factors x_i but not on the y_i. For many linear fitting methods
    $$\frac{1}{N}\sum_{i=1}^{N}[y_i - \hat{f}^{-i}(x_i)]^2 = \frac{1}{N}\left[\frac{y_i - \hat{f}(x_i)}{1 - S_{ii}}\right]^2$$
    where S_{ii} is the ith diagonal element of S. The Generalised cross-validation approximation is
    $$GCV(\hat{f}) = \frac{1}{N}\sum_{i=1}^{n}\left[\frac{y_i - \hat{f}(x_i)}{1 - \text{trace}(S)/N}\right]^2,$$
    where the trace of a matrix is the sum of the diagonal elements.
  - For a non-rolling window, the ERA calculates the generalised cross-validation approximation above using the fixed matrix S.
  - For a rolling window, the ERA recalculates the S matrix for each observation over the testing period and accumulates the cross-validation approximation.

5 The models considered by DBP

5.1 SL-CAPM

In Appendix D of their supporting submission 12, DBP (2014), describe the Sharpe-Lintner Capital Asset Pricing Model (SL-CAPM). They say:

"The SL-CAPM implies that:

$$E_{t-1}(z_{jt}) = \beta_{jt}E_{t-1}(z_{mt})$$

where $E_{t-1}(\dot{})$ denotes an expectation formed on all that is known at time $t-1$, z_{mt} is the return to the market portfolio from time $t-1$ to t in excess of the risk free rate, quoted at time $t-1$ and to be earned from time $t-1$ to t,

$$\beta_{jt} = \frac{E_{t-1}\left[(z_{jt} - E_{t-1}(Z_{jt}))(z_{mt} - E_{t-1}(Z_{mt}))\right]}{E_{t-1}\left[(z_{mt} - E_{t-1}(z_{mt}))^2\right]}$$

and z_{jt} is the excess return to the portfolio j from time $t-1$ to t."

5.2 SL-CAPM using percentile of beta

DBP (paragraph 5.65 of submission 12, page 51) explain, following the way that the ERA have implemented the SL-CAPM, that they have also tested the model where the 95th percentile of the beta estimate is used, rather than the ordinary least squares estimate of beta. Examining the code used by DBP, it appears the value is the upper bound of the two-sided 95% confidence interval for beta, and hence the upper 90th percentile of the beta estimate. These estimates are labelled SL-CAPM95 in this report.

5.3 Black CAPM

Again in appendix D, DBP say:

> "The Black CAPM implies that:
>
> $$E_{t-1}(z_{jt}) = (1 - \beta_{jt})E_{t-1}(z_{0t}) + \beta_{jt}E_{t-1}(Z_{mt})."$$

where, presumably, z_{0t} is the zero beta premium to be earned from time $t-1$ to t. They go onto say

> "A regulator using the Black CAPM explicitly would set the cost of equity for a firm equal to:
>
> $$(1 - \hat{\beta}_{jt})\hat{z}_{0t} + \hat{\beta}_{jt}\hat{z}_{mt},$$
>
> where $\hat{z}_{0t}$ denotes the regulator's assessment of the zero-beta premium to be earned from $(t-1)$ to t and $\hat{z}_{mt}$ is the regulator's assessment of the market risk premium. The regulator might set $\hat{z}_{mt}$ and $\hat{z}_{0t}$ equal to the means of all past excess returns to the market portfolio and all past estimates of the zero-beta premium but may choose other information."

5.4 FFM

Fama and French modified the SL CAPM by introducing two additional risk factors. The modified model, using referred to as FFM, is given by

$$E_{t-1}(z_{jt}) = \beta^1_{jt}E_{t-1}(z_{mt}) + \beta^2_{jt}\text{SML}_t + \beta^2_{jt}\text{HML}_t$$

where (see, for example, Ruppert pages 455-456) small minus large (SML) is the difference in returns on a portfolio of small stocks (in terms of market value) and a portfolio of large stocks; and high minus low (HML) is the difference in returns on a portfolio of high book-to-market value stocks and portfolio of low book-to-market values stocks.

5.5 Betastar

DBP (Appendix D, Equation 11) introduce "betastar" as

$$\beta^*_{jt} = \left(1 - \frac{\hat{z}_{0t}}{\hat{z}_{mt}}\right)\hat{\beta}_{jt} + \left(\frac{\hat{z}_{0t}}{\hat{z}_{mt}}\right)$$

where the prediction for the Black CAPM can be written as

$$(1 - \hat{\beta}_{jt})\hat{z}_{0t} + \hat{\beta}_{jt}\hat{z}_{mt} = \beta^*_{jt}\hat{z}_{mt}$$

6 Methods A, B, and C

For each of the models described in Section 3, DBP estimates the betas for each portfolio using the excess returns to each portfolio and the excess return to the market.

For prediction, however, DBP used what they called Method A and Method B, and have indicated that they will consider using a Method C. These three methods are described below:

Method A uses estimates of the historical market risk premium.

Method B uses the actual excess return to the market.

Method C uses the so called "Wright" approach for estimating the market risk premium. The steps involved are summarised by SFG (paragraph 84):

> "The Wright approach involves the following steps:
>
> a) Estimate the real return on the market portfolio each year for some historical period using the Fisher relation:
>
> $$r_{m,t}^{\text{real}} = \frac{1 + r_{m,t}^{\text{nominal}}}{1 + \text{inflation}} - 1$$
>
> b) Take the average real market return over the relevant historical period.
>
> c) Use the Fisher relation, and a contemporaneous estimate of expected (forward-looking) inflation to obtain an estimate of the nominal return on the market:
>
> $$r_m^{\text{nominal}} = \left(1 + \overline{r_m^{\text{real}}}\right)(1 + E[\text{inflation}]) - 1$$

SFG also give an example (paragraph 94):

> "The average real return on the market portfolio (including imputation credits with theta set to 0.35) is 8.8%. If expected inflation is set to 2.5% (the mid-point of the RBA target band), an 8.8% real return is consistent with a nominal return of 11.6% (using the standard Fisher relation). That is, if the current real return is expected to be the same as the long-run historical average, the current nominal required return is 11.6%. If the current risk-free rate us estimated on the basis of the current 10-year government bond yield of 3.97% (as we recommend), the implied MRP is 7.6%."

7 Cross-Validation

7.1 Cross-Validation for time series models

Hyndman and Athanasopoulos (2014) give a careful explanation of how a time series model should be validated. They say (page 50):

> "It is important to evaluate forecast accuracy using genuine forecasts. That is, it is invalid to look at how well a model fits the historical data; the accuracy of forecasts can only be determined by considering how well a model performs on new data that were not used when fitting the model."

They further go on to explain the steps of cross-validation for time series models as follows (page 52):

> "Suppose k observations are required to produce a reliable forecast. Then the process works as follows.
>
> 1. Select the observations at time $k + i$ for the test set, and use the observations at times $1, 2, \ldots, k + i - 1$ to estimate the forecasting model. Compute the error on the forecast for time $k + i$.

2. Repeat the above steps for $i = 1, 2, \ldots, T - k$ where T is the total number of observations.
3. Compute the forecast accuracy measures based on the errors obtained.

This procedure is sometimes known as a "rolling forecasting origin" because the "origin" $(k + i - 1)$ at which the forecast is based rolls forward in time."

When one-step ahead forecasts are not the primary focus, Hyndman and Athanasopoulos (2014, page 52) modify the procedure as follows:

"Suppose we are interested in models that produce good $h-$step ahead forecasts.

1. Select the observations at time $k + h + i - 1$ for the test set, and use the observations at times $1, 2, \ldots, k + i - 1$ to estimate the forecasting model. Compute the $h-$step ahead error on the forecast for time $k + h + i - 1$.
2. Repeat the above steps for $i = 1, 2, \ldots, T - k - h + 1$ where T is the total number of observations.
3. Compute the forecast accuracy measures based on the errors obtained.

When $h = 1$, this gives the same procedure as outlined above."

Note that DBP have set $k = 60$. I have used the same value in this report and additionally have examined the average of the one-step, two-step, ..., 12-step forecast errors.

7.2 K-fold Cross Validation

A common method of estimating prediction error is K-fold cross validation (see, for example, Hastie, Tibshirani, and Friedman, 2009, pages 241-249). The data is split up into K roughly equal sized parts. For the kth part, $k = 1, 2, \ldots, K$, the model is fitted on the other $K - 1$ parts of the data and calculate the prediction error of the fitted model when predicting the kth part of the data.

Hastie, Tibshirani, and Friedman (2009, page 242) define the method.

Let $\kappa : \{1, \ldots, N\} \mapsto \{1, \ldots, K\}$ be an indexing function that indicates the partition to which observation i is allocated by the randomization. Denote by $\hat{f}^{-k}(x)$ the fitted function, computed with the kth part of the data removed. Then the cross-validation estimate of the prediction error is

$$\text{CV}(\hat{f}) = \frac{1}{N} \sum_{i=1}^{N} L(y_i, \hat{f}^{\kappa(i)}(x_i))$$

Typical choices are 5 or 10. The case $K = N$ is known as *leave-one-out* cross-validation (LOOCV). In this case $\kappa(i) = i$ and for the ith observation the fit is computed using all the data except the ith."

In the above the cross-validation error is a function of a loss function L for measuring errors between the target variable Y and a prediction model $\hat{f}(X)$, which Hastie, Tibshirani, and Friedman (20009, page 219) define typical choices as

$$L(Y, \hat{f}(X)) = \begin{cases} (Y - \hat{f}(X))^2 & \text{squared error} \\ |Y - \hat{f}(X)| & \text{absolute error} \end{cases}$$

The ERA suggest that the squared error loss function is the one that should be used i.e.

$$L(Y, \hat{f}(X)) = (Y - \hat{f}(X))^2.$$

In this report I have used this loss function as well as the loss function (corresponding to bias) used by DBP:

$$L(Y, \hat{f}(X)) = (Y - \hat{f}(X)).$$

Note that DBP actually use

$$L(Y, \hat{f}(X))_{\text{DBP}} = (\hat{f}(X) - Y),$$

a choice which is unusual but has its advantages (see, for example, Nash, 2014, p.124).

8 Use of K-Fold Cross-Validation and LOOCV for time series models

The ERA have said (Paragraph 1047):

> "A month-ahead, moving window forecast is a form of cross-validation, as applied in the DBP model adequacy test. Such a cross-validation scheme is not considered as efficient as K-fold schemes, in terms of the number of predictions they generate for the same sample of data. Step-ahead forecasting is designed to reduce the impact of non-stationary effects on estimates of the out-of-sample prediction error. However, *there is little evidence* (emphasis added) that K-fold schemes perform less well for non-stationary time series than step-ahead forecasting."

To justify their assertion, the ERA cite a paper by Bergmeir and Benítez (2010), who undertook an empirical study using simulated and real world time series and found that K-fold and LOOCV techniques led to more robust conclusions than those found using the classical time series cross-validation as outlined by Hyndman and Athanasopoulos (2014). Bergmeir, Hyndman, and Koo (2016) proved that for an autoregressive process of order p, i.e. one that can be written as

$$y_t = \phi_0 + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} + \varepsilon_t$$

with the ϕ's parameters to be estimated, and ε_t are independent and identically distributed (see, for example, Box, Jenkins, and Reinsel, 1994, p.52), that the estimates of the prediction error using K-fold or LOOCV are asymptotically correct, and hence these methods are asymptotically valid.

Note that the proof is specifically restricted for an autoregressive process of order p, which is a stationary process. It appears that, contrary to the ERA's statement, there is *no* evidence that K-fold schemes perform as well for non-stationary time series than step-ahead forecasting. Bergmeir, Hyndman, and Koo (2016) also make the point that to use K-fold and LOOCV for time series models that the models considered must fit well. As Hyndman and Athanasopoulos (2014, p. 52) say:

> " A residual in forecasting is the difference between an observed value and its forecast based on other observations: $e_i = y_i - \hat{y}_i$. For time series forecasting, a residual is based on one-step forecast; that is $\hat{y}_t$ is the forecast of y_t based on observations $y_1, \ldots, y_{t-1}$."

They go on to say (p. 53):

> "A good forecasting method will yield residuals with the following properties:
>
> - The residuals are uncorrelated. If there are correlations between residuals, then there is information left in the residuals which should be used in computing forecasts.
> - The residuals have zero mean. If the residuals have a mean other than zero, then the forecasts are biased."

Though, there is little evidence, that the residuals are correlated for the models considers by DBP, there is substantial evidence that some of the models are biased, and hence cannot be considered "good forecasting models".

The models considered by DBP have explanatory variables (the market returns and, in the case of the FFM model, the SMB and HML factors), but no lagged variables. Bergmeir, Hyndman, and Koo's proof could perhaps carry over to these cases, so for one month ahead step ahead errors both K-fold and LOOCV may be valid methods, assuming the betas are effectively constant over time. One serious further complication is that when predicting, forecasts of the explanatory variables are required. In addition, the predictions are based in part on future observations, since the estimated betas are calculated based on both future and past values.

The applicability of K-Fold and LOOCV will be different for returns over a longer time period (for example, annual returns) where the continuously compounded annual return is the sum of the continuously compounded monthly returns. If we analysed non-overlapping returns the size of the data set would be approximately 35 for $K = 12$, which may be considered too few to get a reasonable comparison between the methods. On the other hand, if we use overlapping returns (i.e January to December, February to January, March to February, ...) we have to take into account the correlations induced by the aggregating process. As explained by Zivot (2006), if R_t is the monthly continuously compounded return, and the annual return $R_t(12)$ is given by

$$R_t(12) = \sum_{j=0}^{11} R_{t-j},$$

then if $R_t \sim WN(\mu, \sigma^2)$, that is a white noise process with mean μ and variance σ^2, then $R_t(12)$ is *not* a white noise process. In fact

$$\begin{aligned} E[R_t(12) &= 12\mu \\ \gamma_0 &= 12\sigma^2 \\ \gamma_j &= (12-j)\sigma^2,\ j < 12 \\ \gamma_0 &= 0,\ j \geq 12 \end{aligned}$$

and $R_t(12)$ behaves like the MA(11) process, see for example (Box, Jenkins, and Reinsel, 1994, p.52),

$$\begin{aligned} R_t(12) &= 12\mu + \varepsilon_t + \theta_{1t-1} + \cdots + \theta_{11}\varepsilon_{t-11} \\ \varepsilon_t &\sim WN(0, \sigma^2) \end{aligned}$$

which can be approximated by an AR(1) process, see for example (Box, Jenkins, and Reinsel, 1994, p.58),

$$R_t(12) \approx 12\mu + a_t$$

where

$$\begin{aligned} a_t &= \phi a_{t-1} + \eta_t \\ \eta_t &\sim WN(0, \sigma_1^2). \end{aligned}$$

with

$$\sigma_a^2 = \frac{\sigma_1^2}{1-\phi^2}.$$

For overlapping returns then the SL-CAPM model is

$$R_t(12) = \beta M_t(12) + a_t$$

where the a_t follow an autoregressive model, and $M_t(12)$ is the annual return to the market. We do not have an autoregressive model in the overlapping returns, for which Bergmeir, Hyndman, and Koo's proof would apply, but an autoregressive model in the error terms, for which Bergmeir, Hyndman, and Koo's proof does *not* apply.

In summary:

- For one month ahead predictions, K-Fold and LOOCV cross-validation may in some circumstances be applied as too can the usual time series cross-validation.
- For averaging 12 month prediction, for example, K-Fold and LOOCV cross-validation are invalid with overlapping returns. The only valid way to cross-validate is to use the usual time series cross-validation methods.

9 Empirical Testing

9.1 Month ahead forecasts

10-Fold cross-validation, leave one out cross-validation, and time series cross-validation was applied for month ahead forecasts using Methods A, B, and C. Monthly data from 1976 to 2014 was used.

In addition, time series cross-validation was used. Testing was applied from 1980 onwards, with data from 1975 to 1979 used for training but not testing.

Note that with 10-Fold cross-validation and leave-one-out cross validation, future data is used in the estimation of the betas. Also required are forecast of the explanatory variables in the models. I made the choice of basing these forecasts only on past data. However, the results were little changed when past and future data were used to forecast the explanatory variables.

9.2 12 month ahead forecasts

Only time series forecasting was used with overlapping data for 12 month ahead testing, since 10-Fold and Leave one out cross validation approaches are invalid in these cases. 10-Fold cross-validation, leave one out cross-validation, and time series cross-validation used non-overlapping data. In all cases the models were fitted using the returns to the market as the explanatory variable (together with HML and SMB in case of the Fama-French Model).

As an example, for data collected up to June 2015 with prediction for March 2016 (i.e. 9 months ahead), the predictions errors are calculated as follow:

The prediction error is the excess return to the portfolio (March 2016) minus (beta (using data up to and including June 2015) times the historical MRP (up to December 2014)), since the MRP's are only updated at the end of each year.

The prediction error is the excess return to the portfolio (March 2016) minus (beta (using data up to and including June 2015) times the excess return to the market (March 2016)).

Similar to Method A, the prediction error is the excess return to the portfolio (March 2016) minus (beta (using data up to and including June 2015) times the Wright version of the MRP up to May 2015).

Note that with non-overlapping data, the usual t-tests and paired t-tests can be applied on the assumption that returns are uncorrelated. However, using overlapping data more care needs to be taken as predictions, and thus errors, are autocorrelated. See Appendix A for the variance of a mean of overlapping observations. This analysis shows, however, that essentially there is no great statistical advantage in using overlapping returns in this case.

10 Results for Month ahead Forecasts

The one month ahead prediction error and bias was calculated using ten-fold cross-validation, leave one out cross-validation, and time series cross-validation. Results are presented as

$$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}$$

and

$$\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)$$

respectively, i.e. average square root of the prediction error and average bias. These quantities are on the same scale and hence can be easily compared.

Figures 1 to 9 give graphical summaries for each portfolio, while Tables 1 to 3 give numerical results for portfolio 1, with the results for the other portfolios in Appendix B.

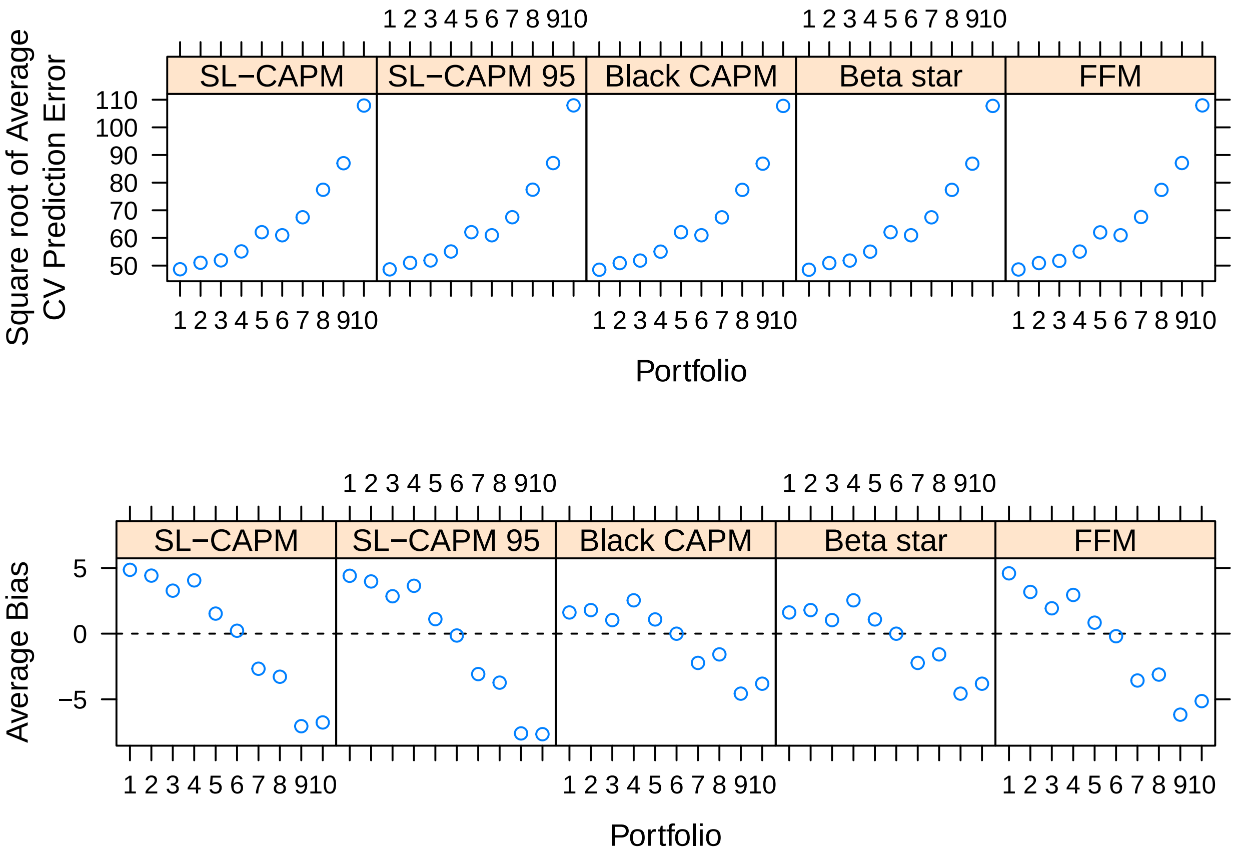
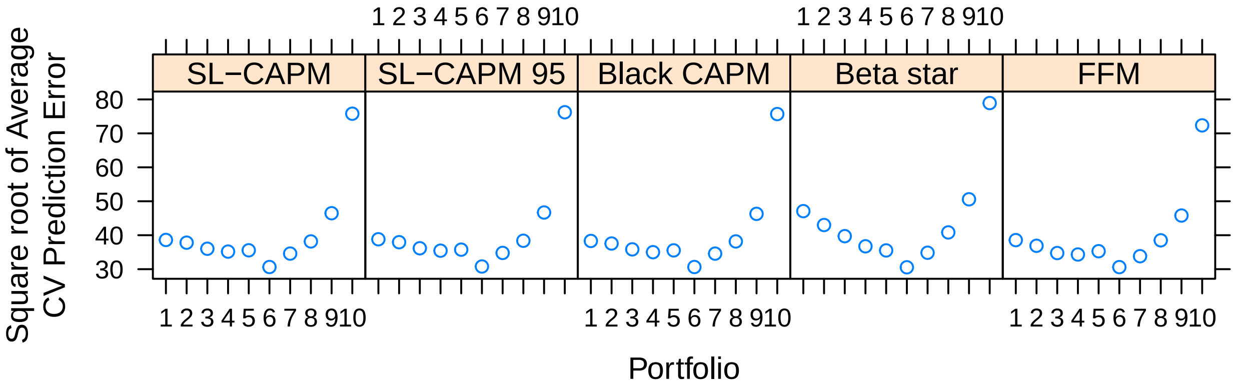


Figure 1: Comparison of time series cross-validation results for Method A. In this and subsquent figures, the monthly errors have been scaled to an annual percentage.



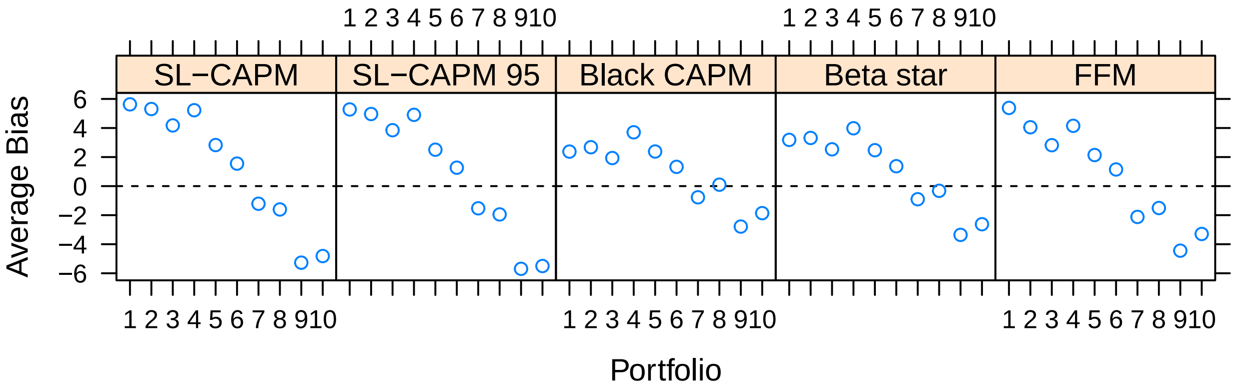


Figure 2: Comparison of ten fold cross-validation results (annualised) for Method B.

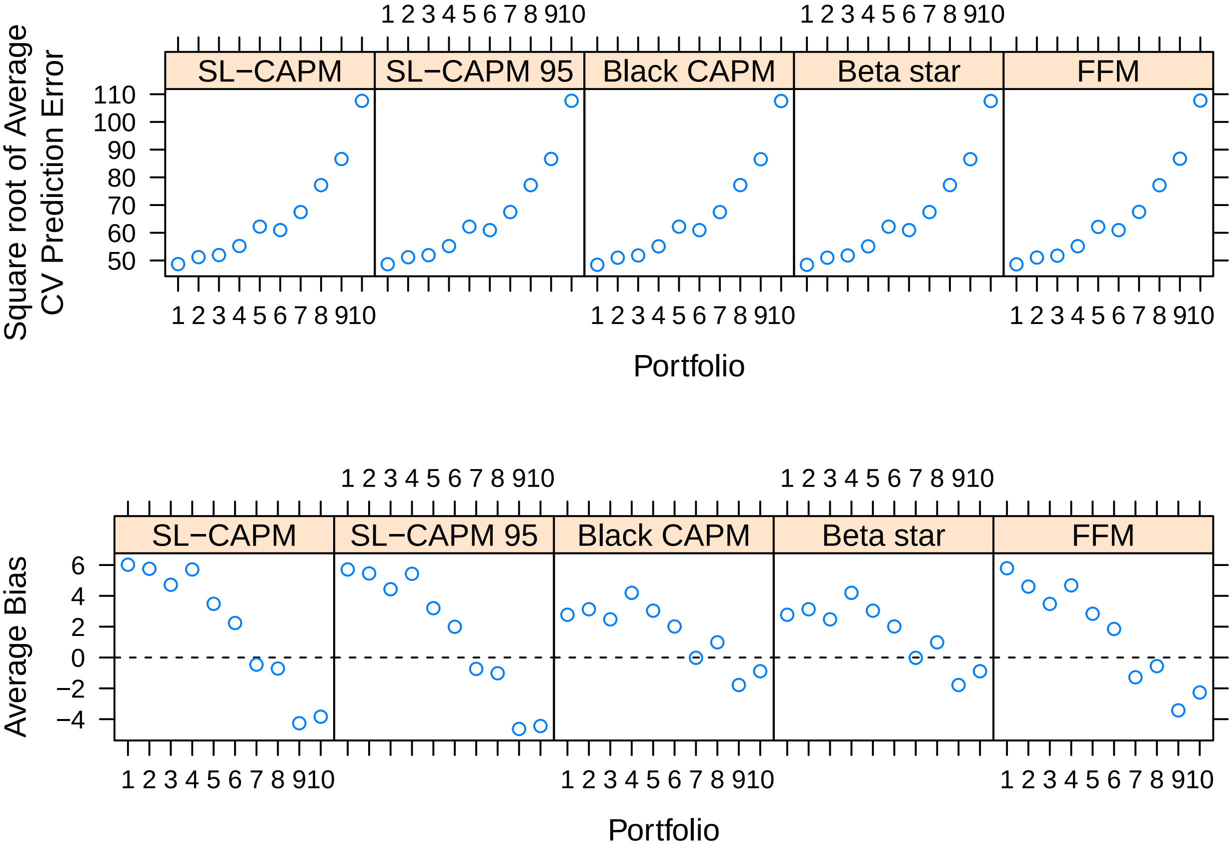


Figure 3: Comparison of ten fold cross-validation results (annualised) for Method C.

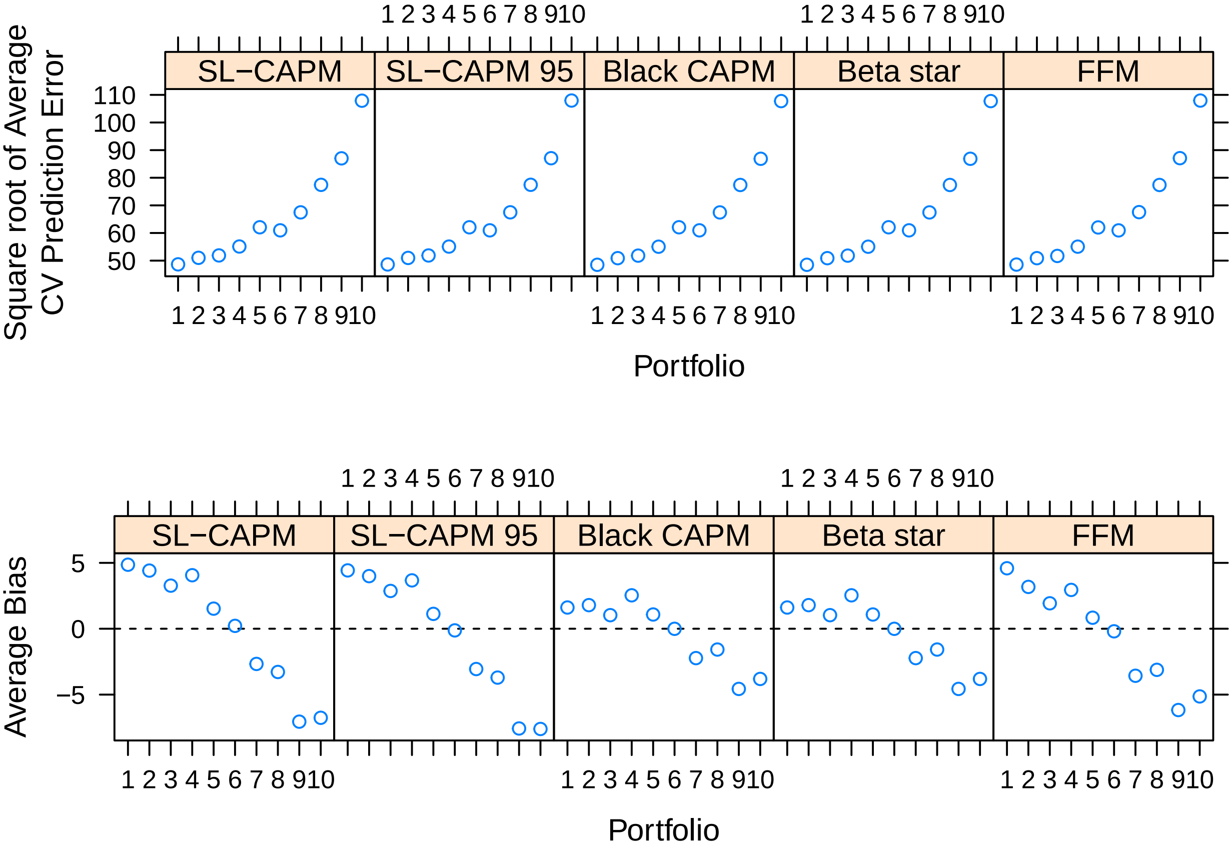


Figure 4: Comparison of leave-one-out cross-validation results (annualised) for Method A.

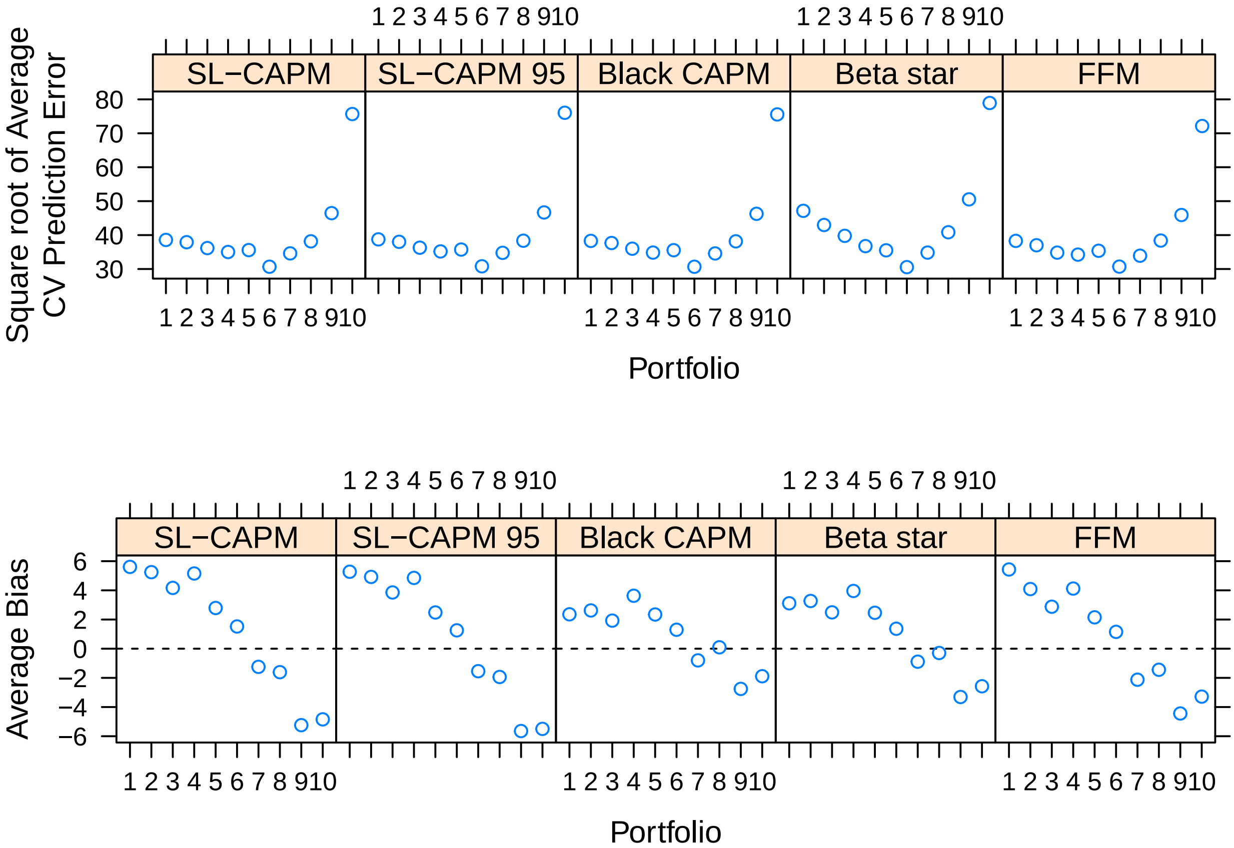
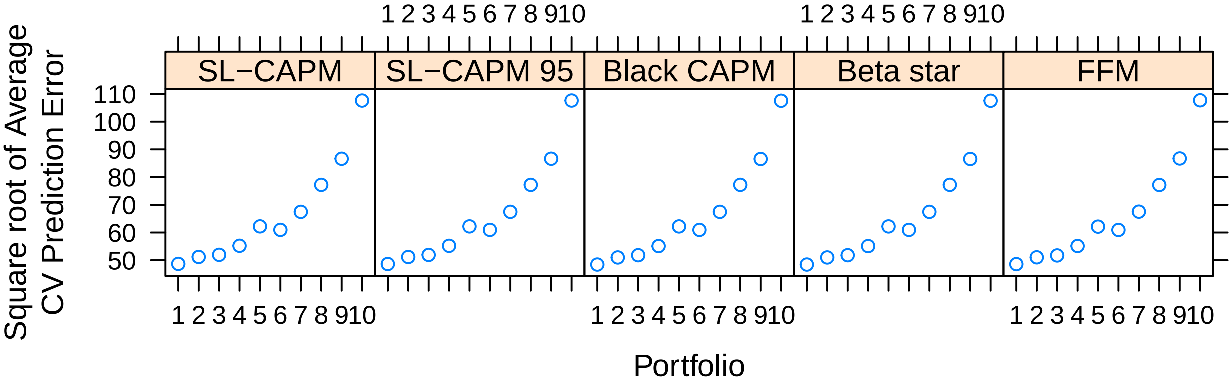


Figure 5: Comparison of leave-one-out cross-validation results (annualised) for Method B.



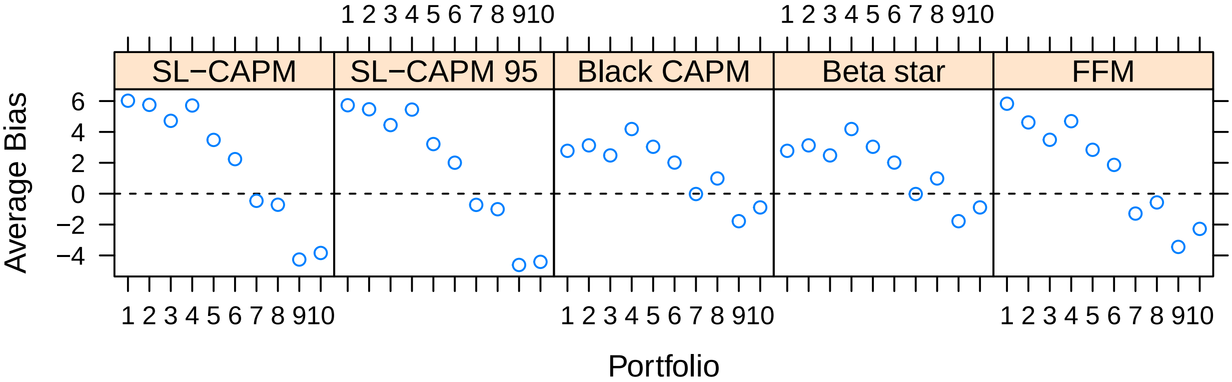


Figure 6: Comparison of leave-one-out cross-validation results (annualised) for Method C.

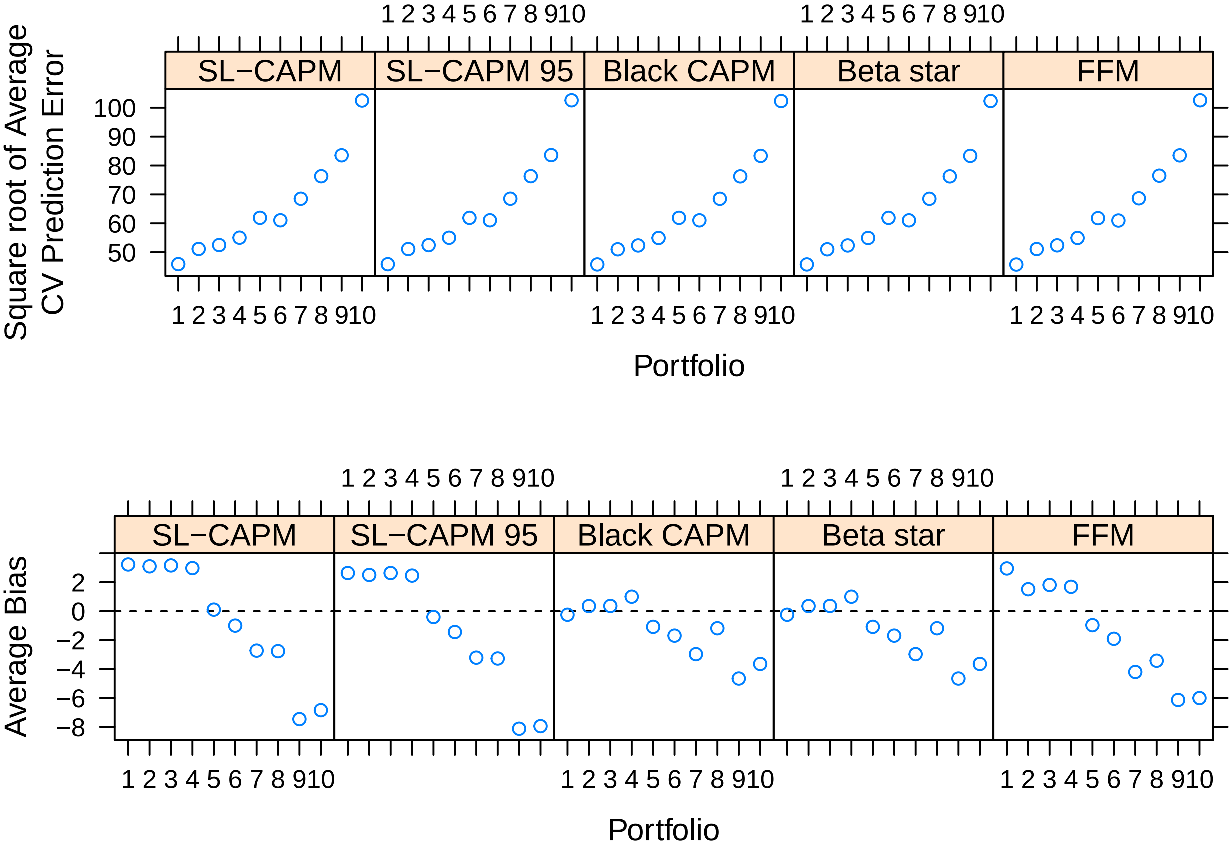


Figure 7: Comparison of time series cross-validation results (annualised) for Method A.

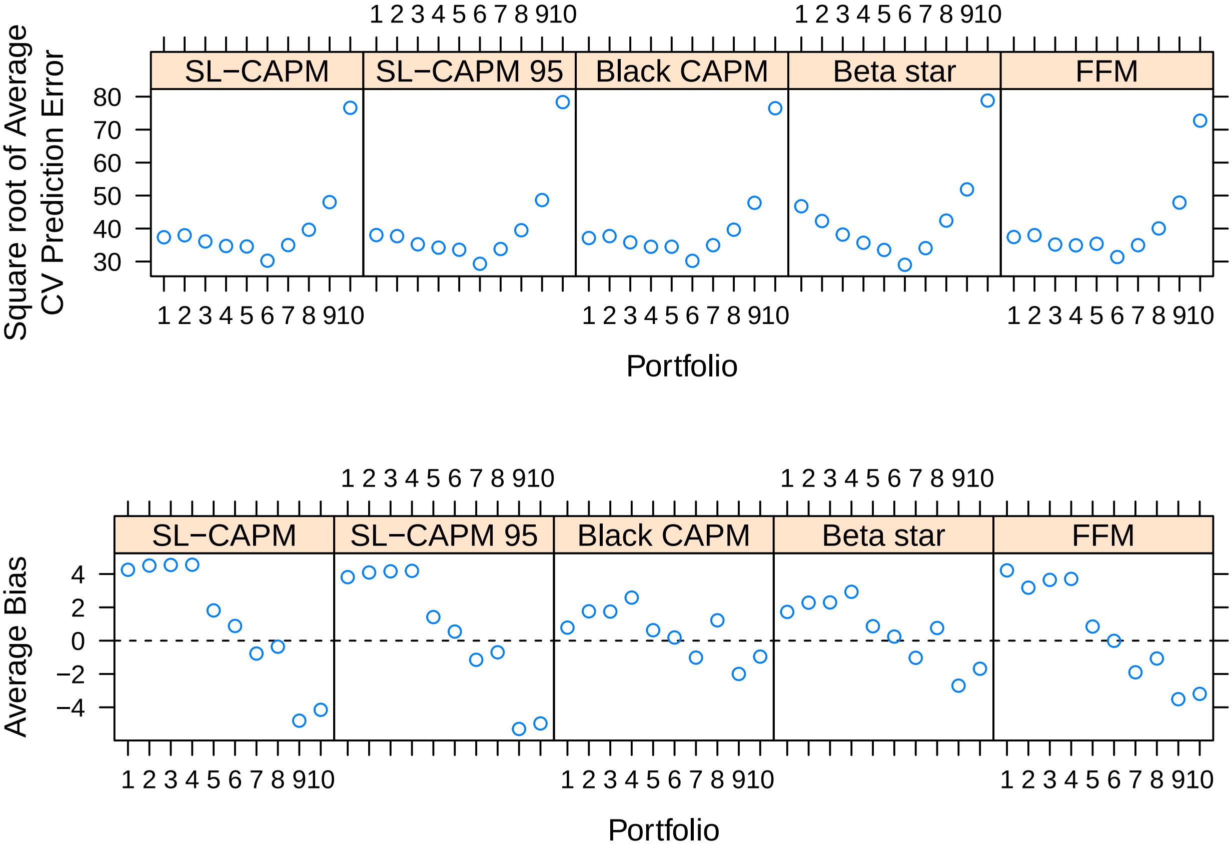


Figure 8: Comparison of time series cross-validation results (annualised) for Method B.

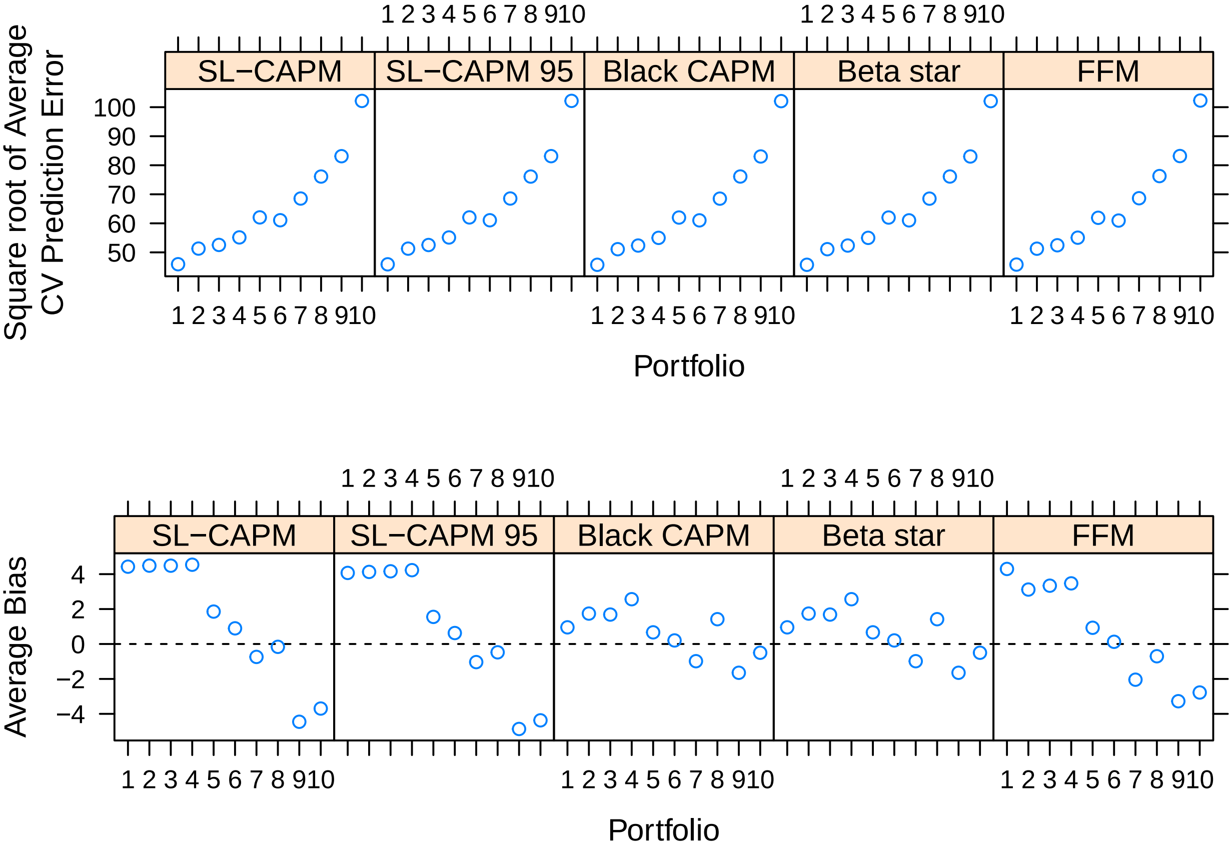


Figure 9: Comparison of time series cross-validation results (annualised) for Method C.

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	45.586	48.657	45.892
SL-CAPM95	45.549	48.619	45.859
Black CAPM	45.431	48.497	45.784
Betastar	45.431	48.497	45.784
FFM	45.514	48.569	45.748
Bias			
SL-CAPM	4.860	4.859	3.227
SL-CAPM95	4.404	4.428	2.636
Black CAPM	1.612	1.612	−0.246
Betastar	1.612	1.612	−0.246
FFM	4.591	4.627	2.951
t-tests for Bias			
SL-CAPM	1.895	2.079	1.354
SL-CAPM95	1.715	1.894	1.106
Black CAPM	0.632	0.689	−0.103
Betastar	0.632	0.689	−0.103
FFM	1.799	1.982	1.242

Table 1: Cross-Validation results (annualised) for Portfolio 1, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	38.159	38.571	37.363
SL-CAPM95	36.357	38.736	38.028
Black CAPM	35.885	38.284	37.136
Betastar	44.115	47.148	46.769
FFM	36.119	38.289	37.439
Bias			
SL-CAPM	5.628	5.609	4.256
SL-CAPM95	5.278	5.276	3.814
Black CAPM	2.376	2.357	0.784
Betastar	2.381	3.113	1.725
FFM	5.382	5.431	4.219
t-tests for Bias			
SL-CAPM	2.482	3.044	2.202
SL-CAPM95	2.326	2.847	1.936
Black CAPM	1.057	1.278	0.406
Betastar	1.059	1.370	0.709
FFM	2.291	2.968	2.179

Table 2: Cross-Validation results (annualised) for Portfolio 1, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	45.614	48.689	45.912
SL-CAPM95	45.573	48.646	45.876
Black CAPM	45.387	48.451	45.717
Betastar	45.387	48.451	45.717
FFM	45.540	48.600	45.787
Bias			
SL-CAPM	6.021	6.022	4.427
SL-CAPM95	5.712	5.729	4.070
Black CAPM	2.773	2.775	0.954
Betastar	2.773	2.775	0.954
FFM	5.791	5.828	4.297
t-tests for Bias			
SL-CAPM	2.374	2.582	1.861
SL-CAPM95	2.253	2.457	1.711
Black CAPM	1.100	1.188	0.401
Betastar	1.100	1.188	0.401
FFM	2.295	2.502	1.811

Table 3: Cross-Validation results (annualised) for Portfolio 1, Method C

Some comments on the results are given below:

- For methods A and C, the results for the Black CAPM and Beta star models are identical, as expected. However, the results are not exactly the same for method B.
- For methods A and C, the average square root of the prediction error is lower for the low beta portfolios than for the high beta portfolios. For method B, portfolio 6 gives the lowest prediction error while portfolio 10 gives the highest.
- For each of the methods the bias is positive (i.e. predicted returns are lower than observed returns) for low beta portfolios and negative (i.e. predicted returns are higher than observed returns) for high beta portfolios.
- The bias is less pronounced for the Black CAPM.
- The average square root of the prediction error is much higher than the bias for all methods and models.

11 Results for forecasts over 12 months

Non-overlapping 10 fold cross-validation and non-overlapping leave one out cross-validation, as well as time series cross-validation using both non-overlapping and overlapping data were applied using all models and methods.

In this case, leave one out cross-validation means to leave one year out. For predicting the results in 1975, for example, the models are fitted using data from 1976 to 2014, i.e. future data is used in calculating the betas. Similarly, for 10-fold cross-validation, four years are left out in each fold. Table 4 give the ten folds used in the cross-validation. For each of the folds, future data is involved in estimating the betas. Fold 9 is particularly notable-it consists of only data up to 1989, but the betas are estimated with data up to 2014.

On the other hand, times series cross-validation only uses past data for estimating betas and making predictions.

Fold	Years			
1	1980	1991	1994	2002
2	1975	2001	2007	2013
3	1987	1993	2003	2008
4	1996	2000	2012	2014
5	1976	2004	2010	2011
6	1988	1999	2005	2009
7	1981	1985	1986	1995
8	1990	1992	1997	1997
9	1978	1979	1982	1989
10	1977	1983	1984	2006

Table 4: The ten folds used in the 10-fold cross-validation

The average monthly prediction error and average monthly bias were calculated and annnualised. The results are given in Figures 10 to 18 for all portfolios and Tables 5 to 7 for portfolio 1, and Appendix C for portfolios 2 to 10.

Most of the same comments as before apply:

- For methods A and C, the results for the Black CAPM and Beta star models are identical, as expected. However, the results are not the same for method B.
- For methods A and C, the average square root of the prediction error is lower for the low beta portfolios than for the high beta portfolios. For method B, portfolio 6 gives the lowest prediction error while portfolio 10 gives the highest.
- For each of the methods the bias is positive (i.e. predicted returns are lower than observed returns) for low beta portfolios and negative (i.e. predicted returns are higher than observed returns) for high beta portfolios.
- The bias is less pronounced for the Black CAPM.

However, when comparing the results, it is clear that the average square root of the prediction error is much less than before, while the bias is of a similar level and now approximately half the square root of the prediction error under method B, and more than a third of the square root of the prediction error under the other two methods.

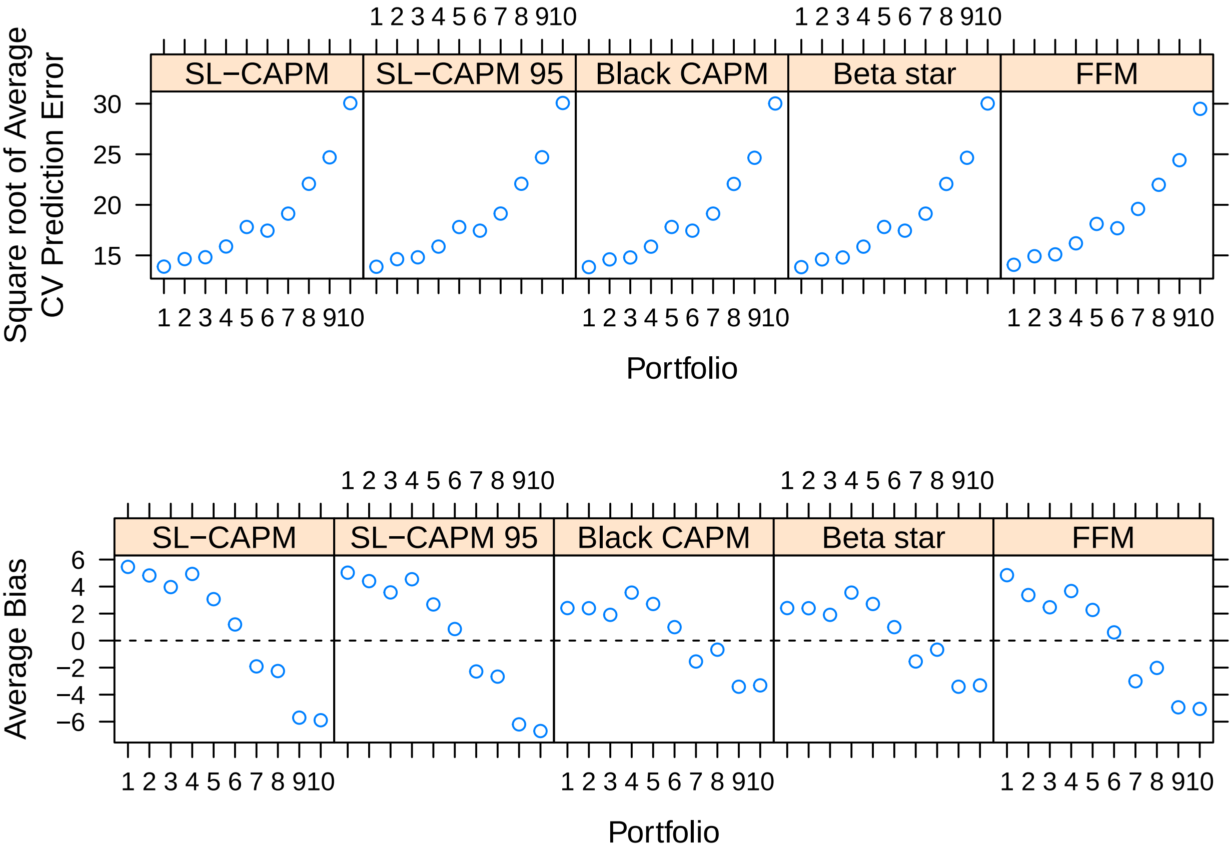
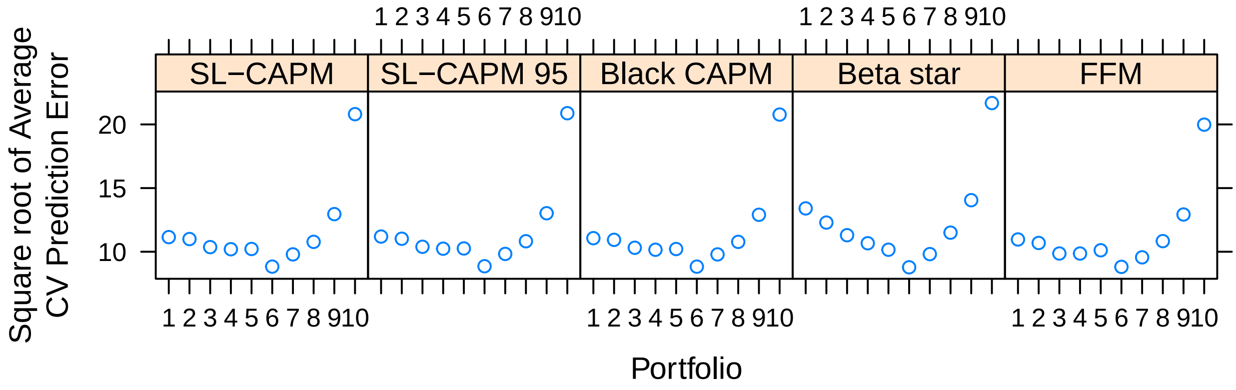


Figure 10: Comparison of ten fold cross-validation results for Method A, Average over 12 months



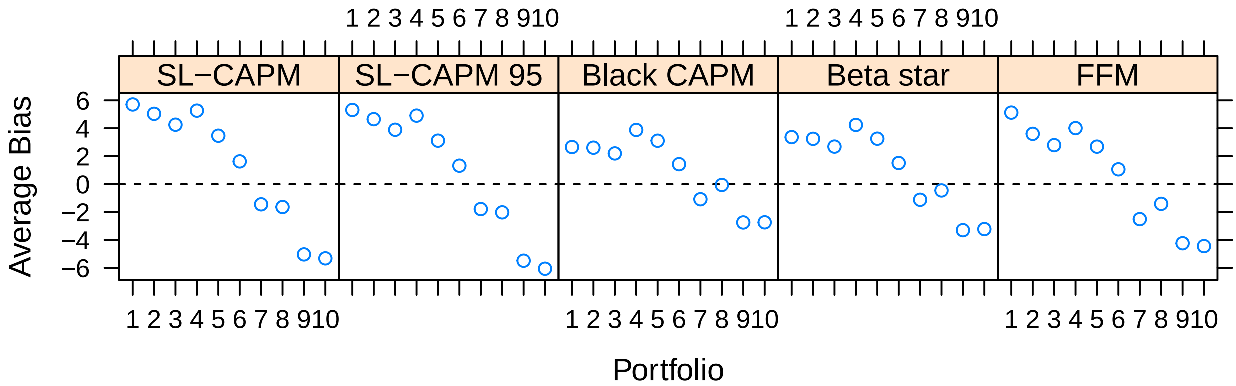


Figure 11: Comparison of ten fold cross-validation results for Method B, Average over 12 months

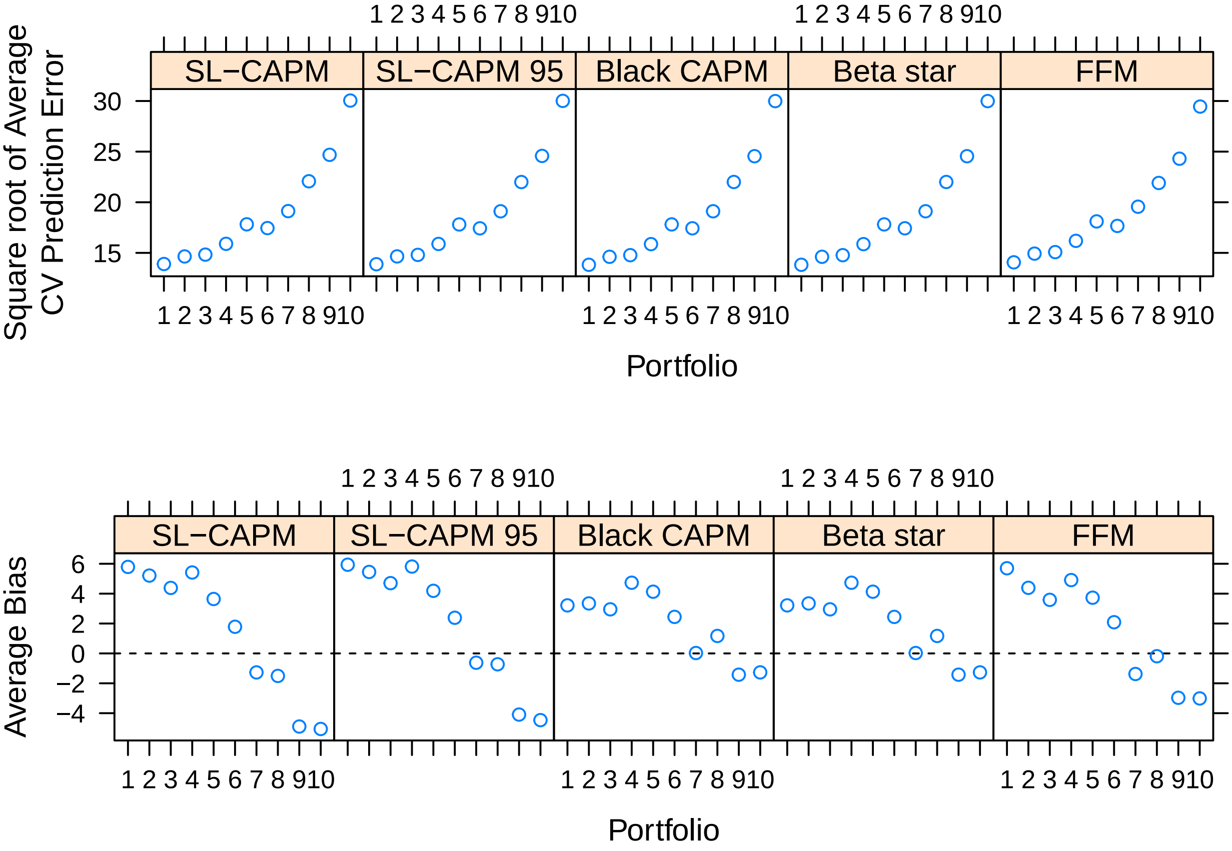


Figure 12: Comparison of ten fold cross-validation results for Method C, Average over 12 months

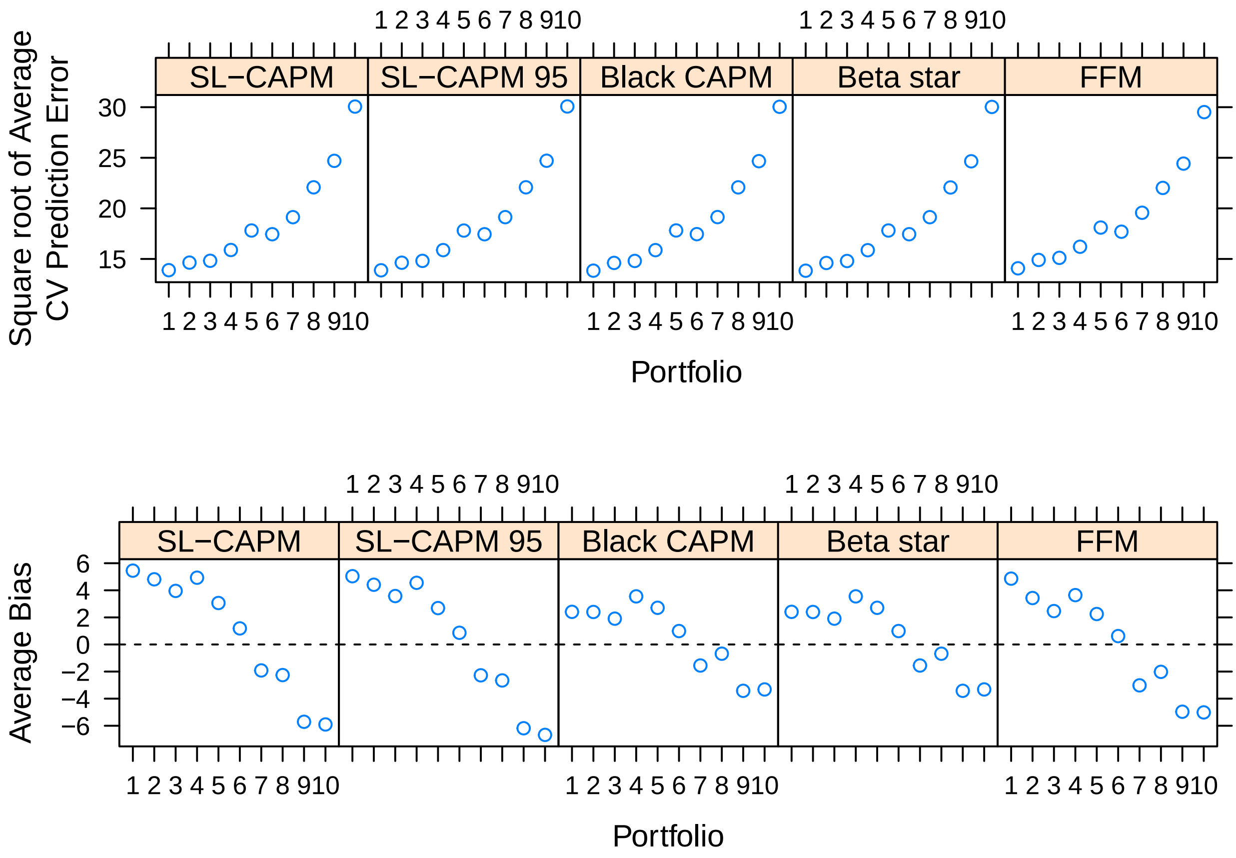


Figure 13: Comparison of leave one out cross-validation results for Method A, Average over 12 months

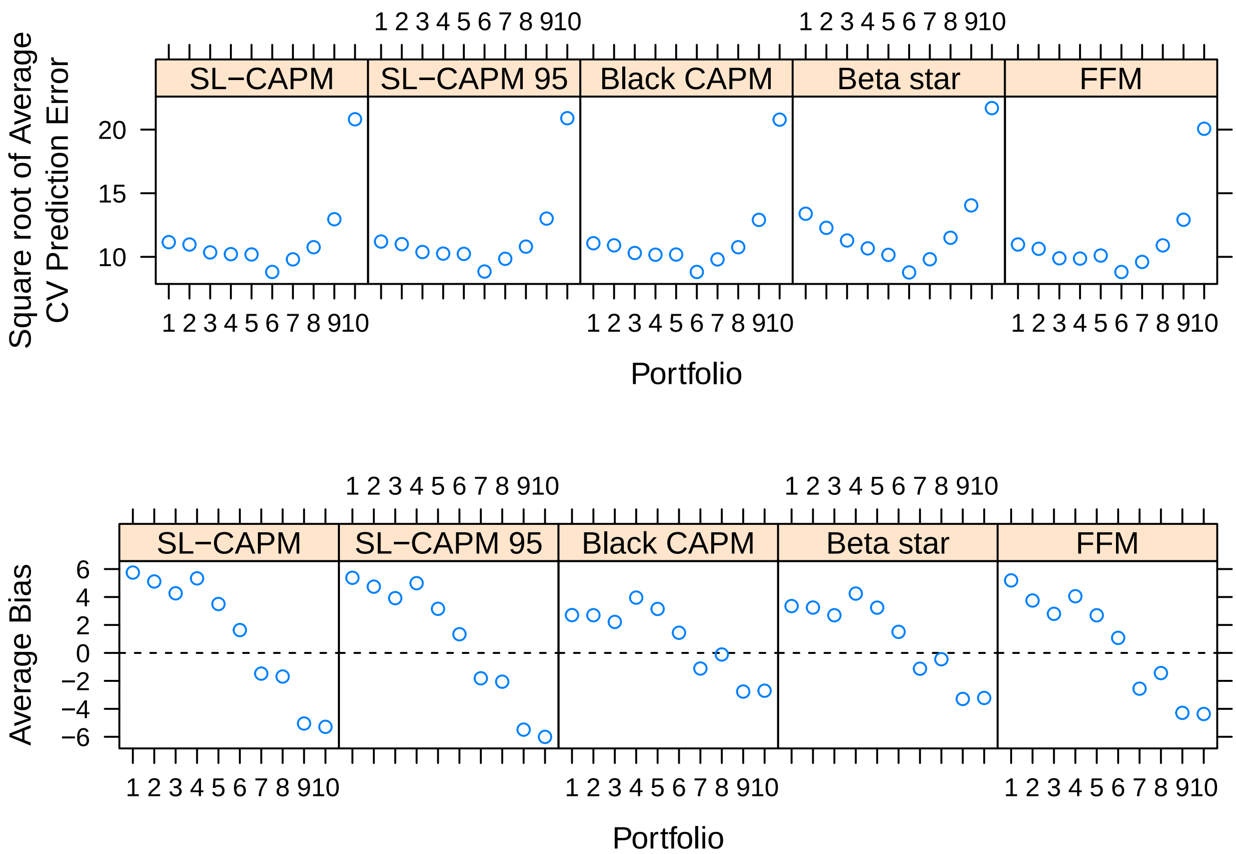


Figure 14: Comparison of leave one out cross-validation results for Method B, Average over 12 months

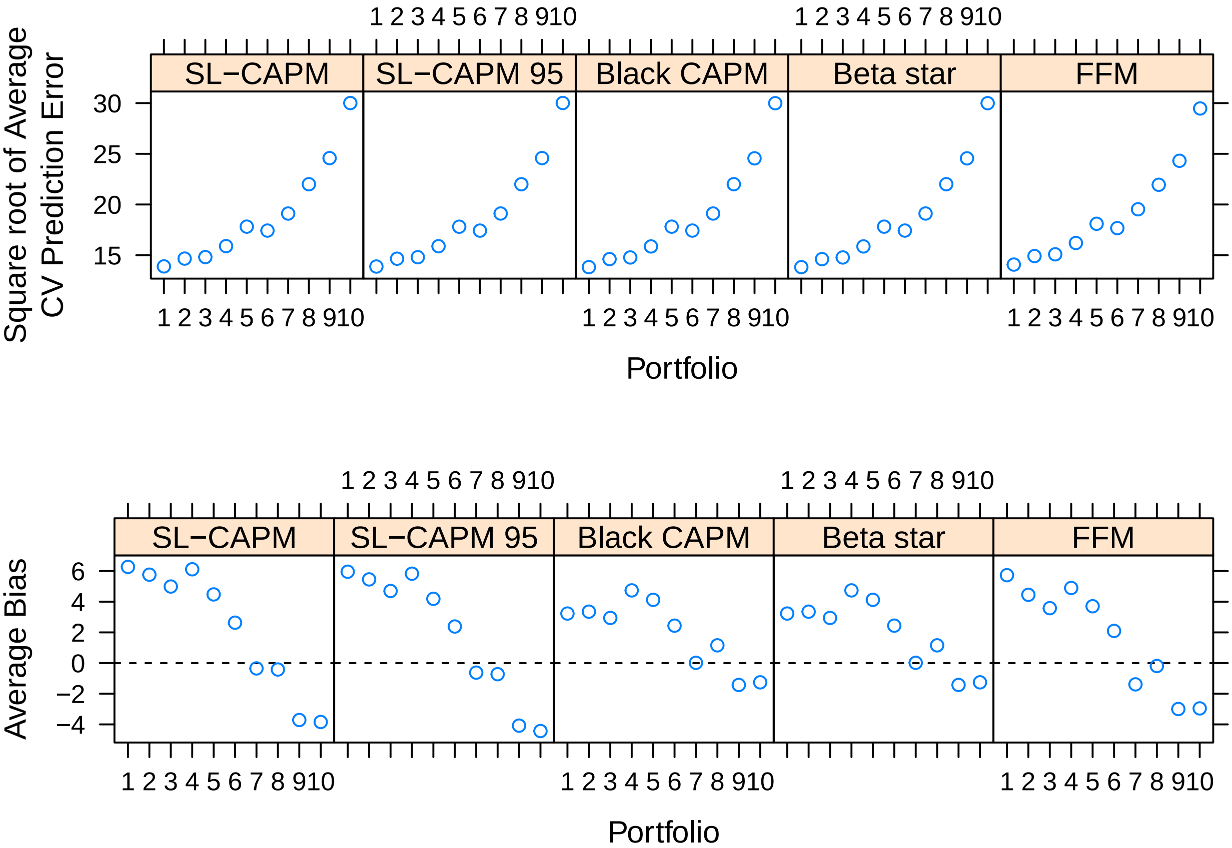


Figure 15: Comparison of leave one out cross-validation results for Method C, Average over 12 months

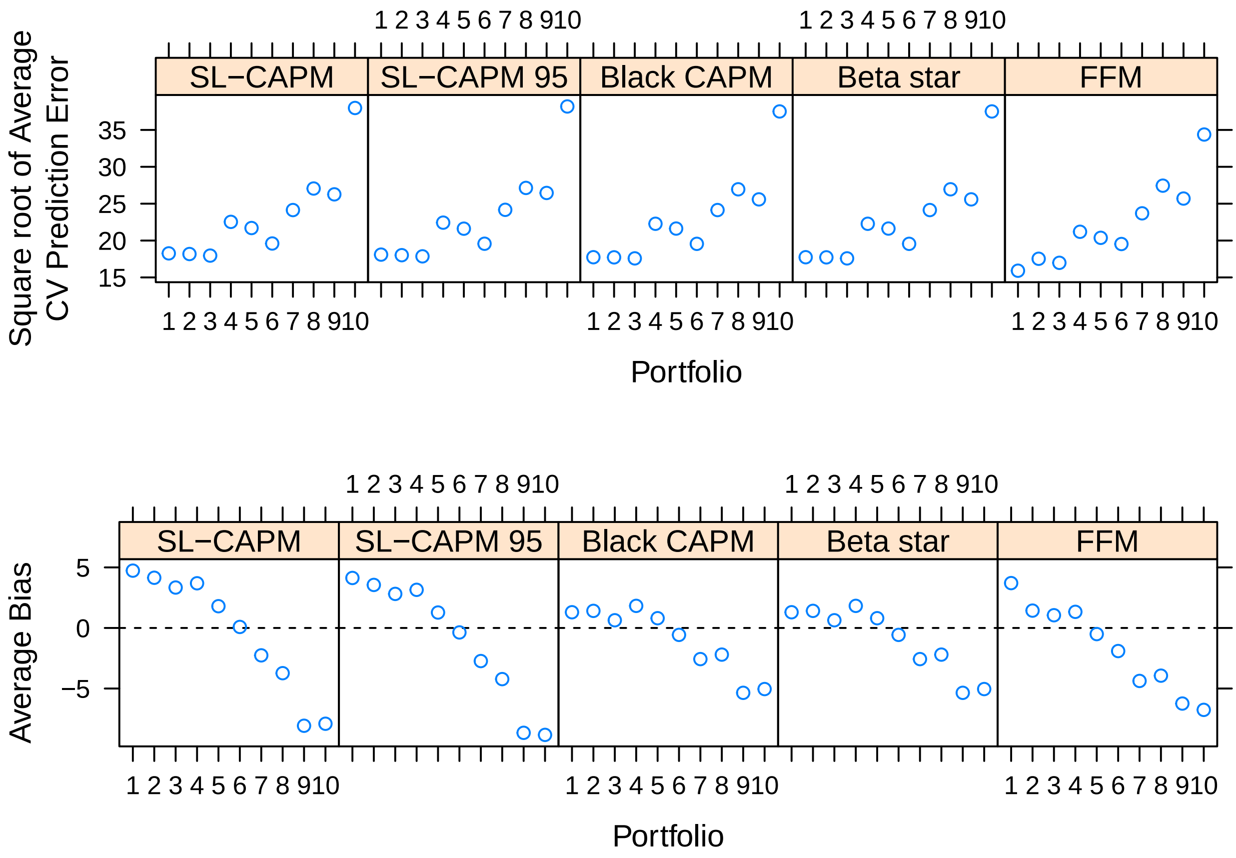


Figure 16: Comparison of time series cross-validation results for Method A, Average over 12 months, non-overlapping data.

12 Concluding remarks

DBP's model adequacy test is a form of cross-validation with bias as the loss-function. DBP have been careful in using the appropriate time-series approach to cross-validation. With this test, DBP find that the SL-CAPM is biased whereas the Black CAPM is not.

The ERA have suggested that cross-validation would be better than DBP's model adequacy test, with a focus on prediction error. For one-month ahead forecasts, recent research has shown that K-Fold and leave one out cross-validation may be used in some circumstances. While I have reservations of the use of K-fold cross-validation and LOOCV, all forms of cross-validation show that the square root of the month ahead prediction error is much larger than the average bias.

However, one month ahead forecasts are less relevant than forecasts over longer time periods, for example over the next year, or the next two years, or the next five years. For these longer term forecasts, K-Fold and leave one out cross-validation can only be used with non-overlapping data, much reducing the data available. On the other hand, times series cross-validation can be used with overlapping data. Applying these methods, the square root of the mean monthly prediction error was similar for all models, but much reduced, while the bias remained at a similar level .

The implication of this result is that DBP's empirical finding of a bias between the SL-CAPM relative to the Black CAPM becomes increasingly important as the projection window increases. Given that the regulatory period is 5 years, it is important not to ignore the finding of the bias. While the square root of the prediction error is much the same with each of the models, the differences in bias remain, irrespective of the length of the prediction window. It would be a mistake to focus on one month ahead prediction error alone and ignore the bias, based on its relative size, when the main focus should be on longer term predictions.

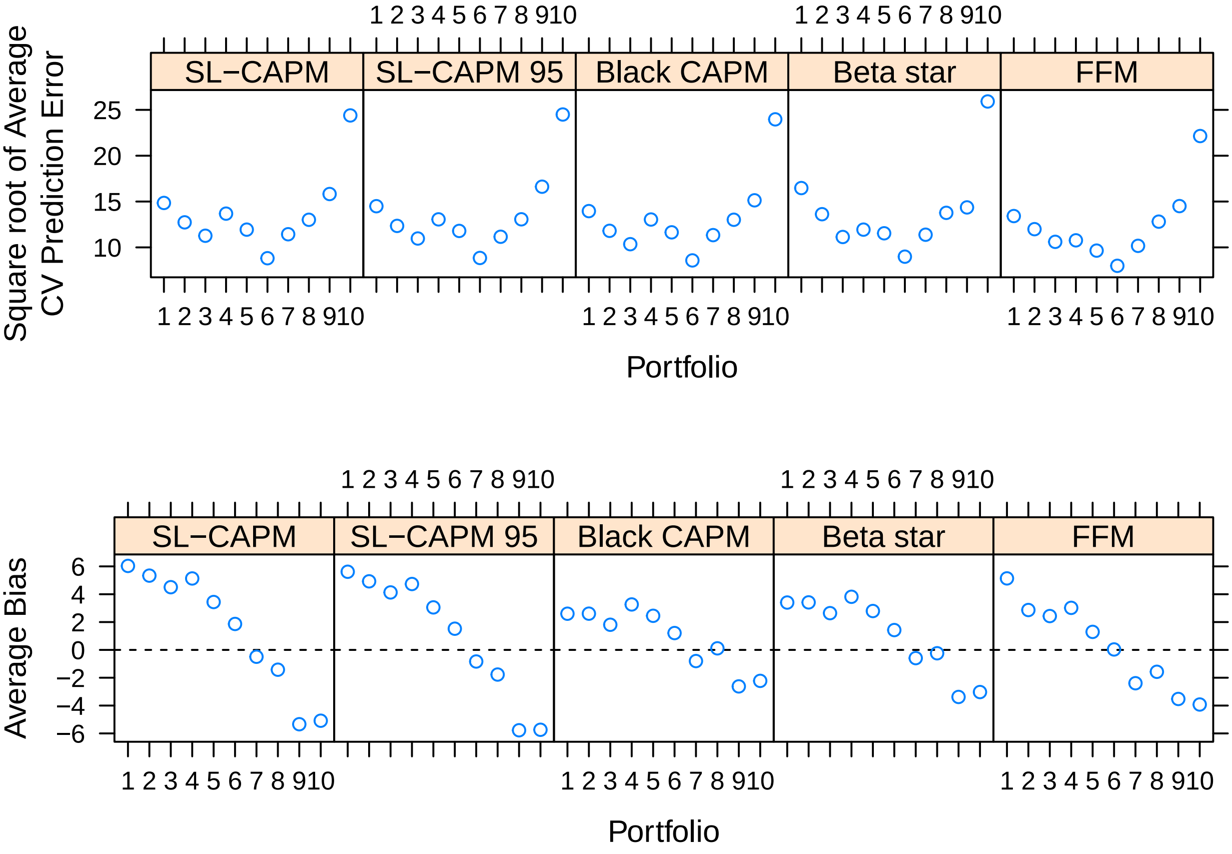


Figure 17: Comparison of time series cross-validation results for Method B, Average over 12 months, non-overlapping data

MethodA12	**Non-overlapping data**			**Overlapping data**
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	13.889	13.891	14.165	14.137
SL-CAPM95	13.876	13.878	14.147	14.121
Black CAPM	13.840	13.843	14.111	14.085
Betastar	13.840	13.839	14.111	14.085
FFM	14.070	14.075	14.935	14.906
Bias				
SL-CAPM	5.457	5.452	4.733	4.863
SL-CAPM95	5.029	5.041	4.127	4.310
Black CAPM	2.408	2.409	1.298	1.233
Betastar	2.408	2.409	1.298	1.233
FFM	4.844	4.862	3.705	3.681
t-tests for Bias				
SL-CAPM	2.188	2.007	1.565	1.533
SL-CAPM95	2.016	1.855	1.366	1.359
Black CAPM	0.949	0.877	0.428	0.386
Betastar	0.949	0.877	0.428	0.386
FFM	2.091	1.905	1.396	1.298

Table 5: Cross-Validation results for Portfolio 1, Method A, Average over 12 months

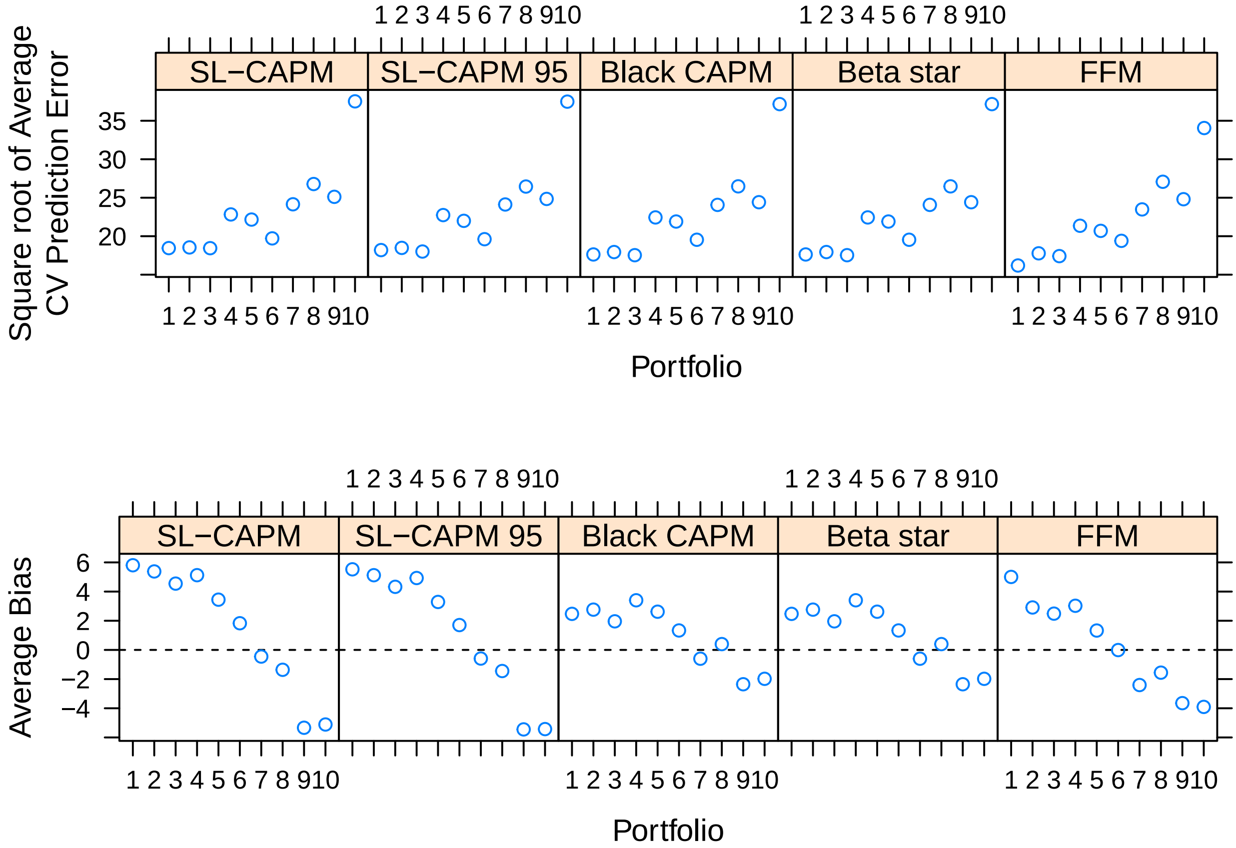


Figure 18: Comparison of time series cross-validation results for Method C, Average over 12 months, non-overlapping data

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	11.149	11.156	11.324	11.263
SL-CAPM95	11.194	11.204	11.380	11.234
Black CAPM	11.067	11.072	11.230	11.173
Betastar	13.403	13.389	13.704	13.752
FFM	10.964	10.973	11.407	11.341
Bias				
SL-CAPM	5.704	5.750	6.035	5.732
SL-CAPM95	5.313	5.374	5.616	5.268
Black CAPM	2.656	2.707	2.600	2.102
Betastar	3.364	3.352	3.403	2.850
FFM	5.121	5.187	5.139	4.629
t-tests for Bias				
SL-CAPM	2.633	2.749	2.594	2.376
SL-CAPM95	2.436	2.568	2.451	2.238
Black CAPM	1.215	1.282	1.106	0.863
Betastar	1.396	1.344	1.231	1.076
FFM	2.411	2.545	2.418	2.236

Table 6: Cross-Validation results for Portfolio 1, Method B, Average over 12 months

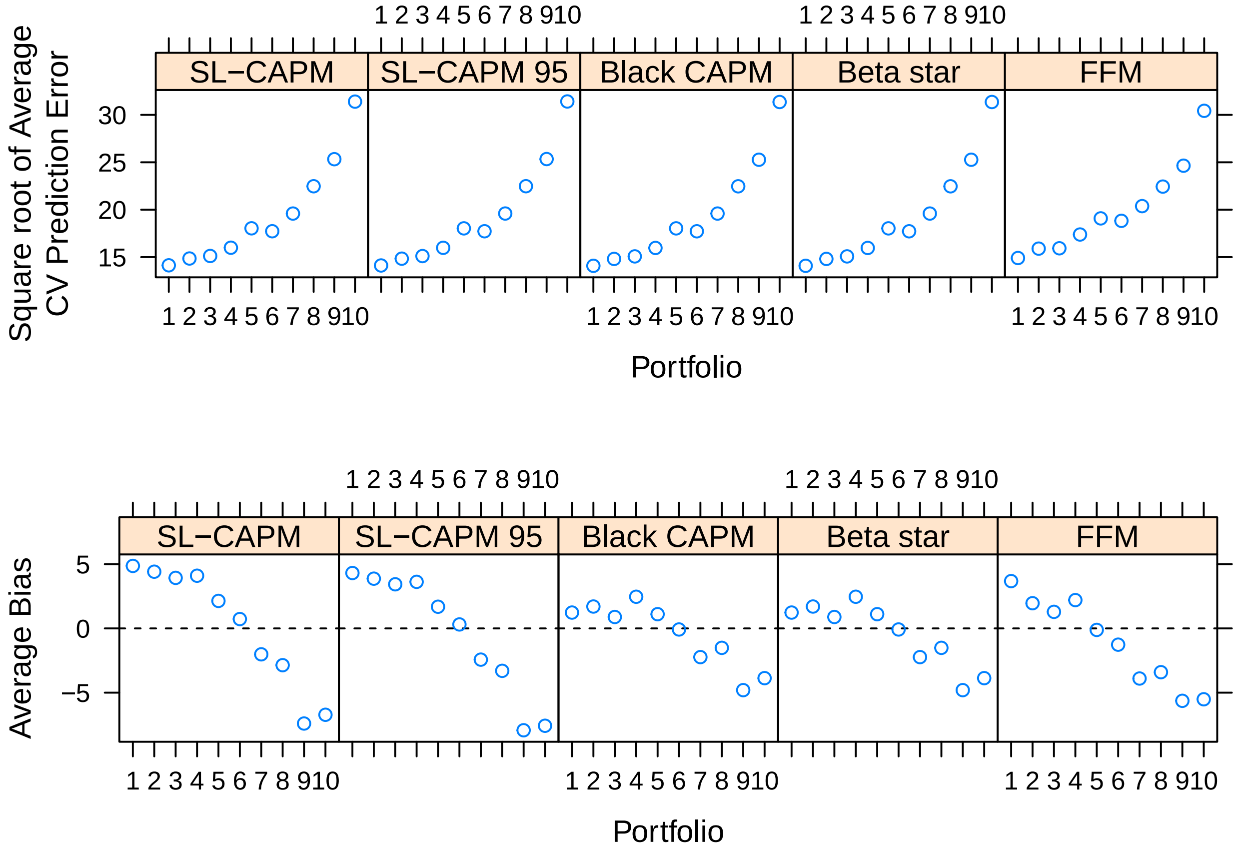


Figure 19: Comparison of time series cross-validation results for Method A, Average over 12 months, overlapping data.

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	13.900	13.895	14.185	14.142
SL-CAPM95	13.880	13.881	14.151	14.125
Black CAPM	13.824	13.824	14.094	14.067
Betastar	13.824	13.824	14.094	14.067
FFM	14.069	14.075	14.960	14.903
Bias				
SL-CAPM	5.788	6.270	5.805	5.950
SL-CAPM95	5.936	5.955	5.525	5.594
Black CAPM	3.216	3.227	2.472	2.320
Betastar	3.216	3.227	2.472	2.320
FFM	5.699	5.727	5.004	5.103
t-tests for Bias				
SL-CAPM	2.322	2.335	1.933	1.893
SL-CAPM95	2.369	2.219	1.858	1.783
Black CAPM	1.267	1.192	0.826	0.734
Betastar	1.267	1.192	0.826	0.734
FFM	2.463	2.278	1.895	1.826

Table 7: Cross-Validation results for Portfolio 1, Method C, Average over 12 months

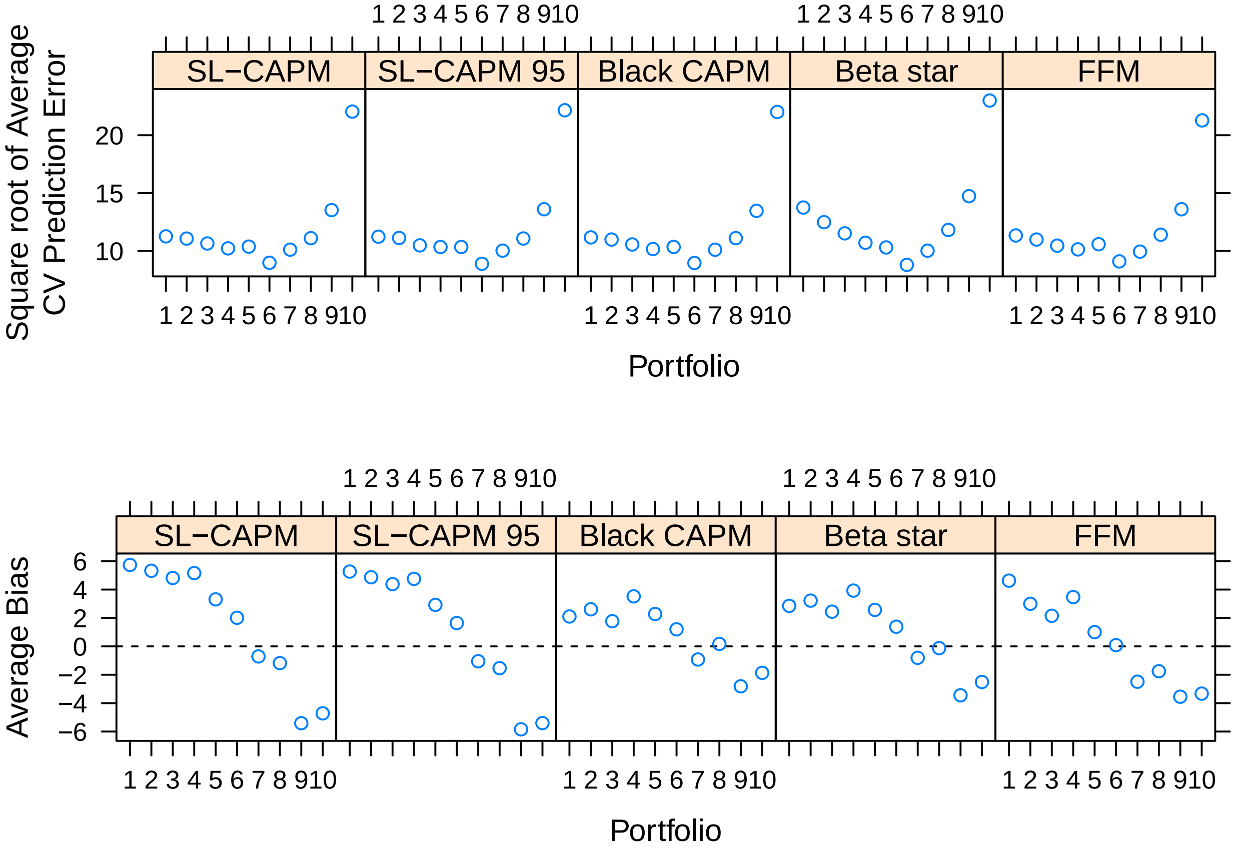


Figure 20: Comparison of time series cross-validation results for Method B, Average over 12 months, overlapping data.

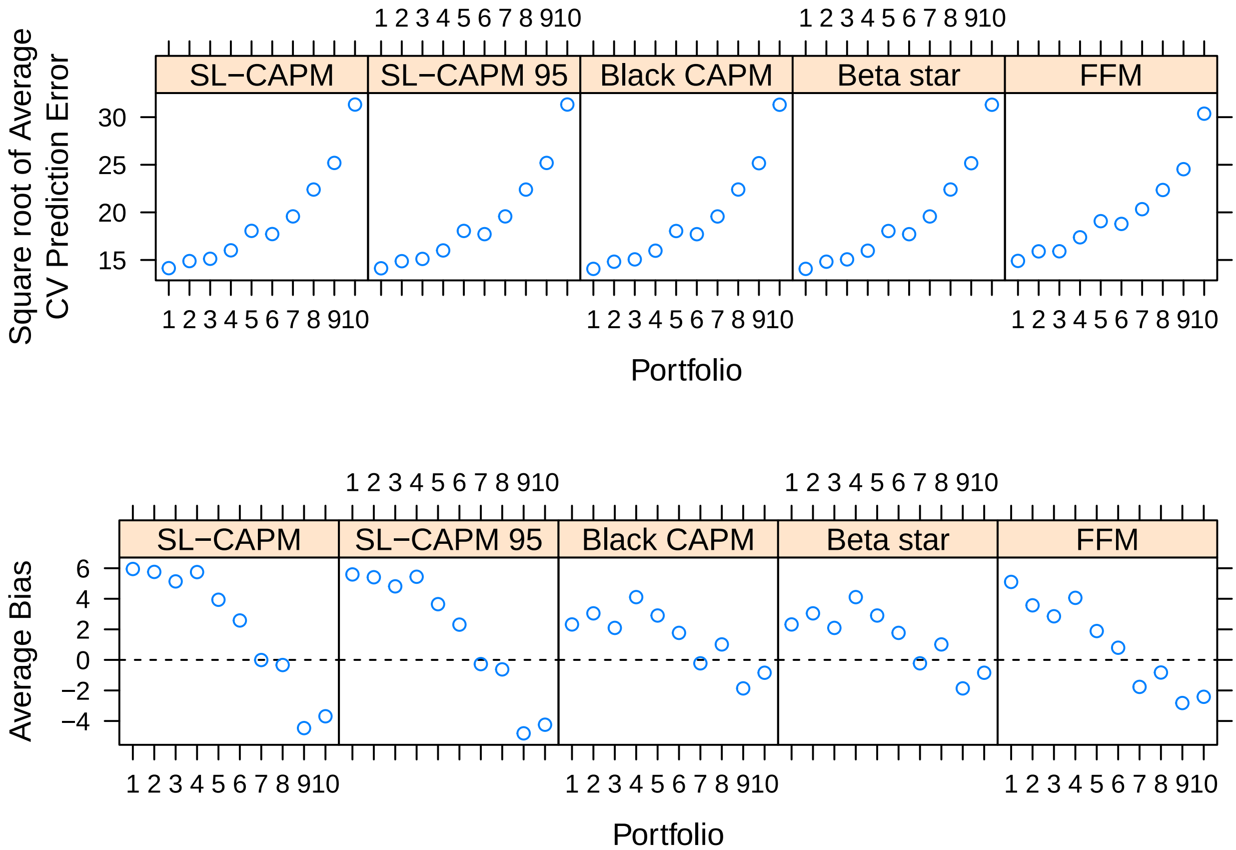


Figure 21: Comparison of time series cross-validation results for Method C, Average over 12 months, overlapping data

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A Variance of a Mean of Overlapping Observations

As shown by Hayashi (2000, p.401) the variance of a mean of n autocorrelated observations is given by

$$\mathrm{Var}(\overline{y}) = \frac{\gamma_0}{n} + \frac{2}{n}\sum_{j-1}^{n-1}\left(1-\frac{j}{n}\right)\gamma_j.$$

This can be re-written as

$$\begin{aligned}\mathrm{Var}(\overline{y}) &= \frac{\gamma_0}{n} + \frac{2\gamma_0}{n}\sum_{j-1}^{n-1}\left(1-\frac{j}{n}\right)\rho_j \\ &= \frac{\gamma_0}{n}\left[1+2\sum_{j=1}^{n-1}\left(1-\frac{j}{n}\right)\rho_j\right]\end{aligned}$$

where γ_0 is the variance of y, γ_j is the jth-order autocovariance, and ρ_j is the jth-order autocorrelation.

Assuming

$$\rho_j = \begin{cases}\dfrac{12-j}{12} & j=0,\ldots,11 \\ 0 & j>12\end{cases}$$

$$\begin{aligned}\mathrm{Var}(\overline{y}) &= \frac{\gamma_0}{n}\left[1+2\left\{(1-\frac{1}{n})\frac{11}{12}+\ldots+(1-\frac{11}{n})\frac{1}{12}\right\}\right] \\ &= \frac{\gamma_0}{n}\left[1+\frac{2}{12}\{11+\ldots+1\}-\frac{2}{12n}\{11+\ldots+1\}\right]\end{aligned}$$

which leads to

$$\begin{aligned}&= \frac{\gamma_0}{n}\left[1+\frac{2}{12}\times 66-\frac{2}{12n}\times 66\right] \\ &= \frac{\gamma_0}{n}\left[1+11\left\{1-\frac{1}{n}\right\}\right]\end{aligned}$$

B Month ahead forecasts

B.1 Portfolio 2

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	47.795	51.012	51.145
SL-CAPM95	47.762	50.979	51.105
Black CAPM	47.677	50.895	51.018
Betastar	47.677	50.895	51.018
FFM	47.680	50.890	51.106
Bias			
SL-CAPM	4.419	4.415	3.096
SL-CAPM95	3.974	3.993	2.502
Black CAPM	1.793	1.791	0.351
Betastar	1.793	1.791	0.351
FFM	4.591	3.187	1.516
t-tests for Bias			
SL-CAPM	1.902	1.799	1.165
SL-CAPM95	1.708	1.627	0.942
Black CAPM	0.775	0.730	0.132
Betastar	0.775	0.730	0.132
FFM	1.410	1.300	0.570

Table 8: Cross-Validation results (annualised) for Portfolio 2, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	37.372	37.902	37.967
SL-CAPM95	35.545	38.013	37.706
Black CAPM	35.181	37.662	37.715
Betastar	40.283	42.975	42.285
FFM	34.557	37.005	38.008
Bias			
SL-CAPM	5.307	5.249	4.507
SL-CAPM95	4.963	4.921	4.093
Black CAPM	2.677	2.622	1.762
Betastar	2.681	3.270	2.281
FFM	4.051	4.088	3.180
t-tests for Bias			
SL-CAPM	3.510	2.896	2.297
SL-CAPM95	3.389	2.704	2.098
Black CAPM	1.788	1.445	0.899
Betastar	1.789	1.581	1.038
FFM	2.700	2.302	1.613

Table 9: Cross-Validation results (annualised) for Portfolio 2, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	47.965	51.195	51.291
SL-CAPM95	47.942	51.172	51.273
Black CAPM	47.782	51.010	51.092
Betastar	47.782	51.010	51.092
FFM	47.832	51.055	51.259
Bias			
SL-CAPM	5.756	5.753	4.486
SL-CAPM95	5.454	5.467	4.126
Black CAPM	3.130	3.130	1.741
Betastar	3.130	3.130	1.741
FFM	4.602	4.616	3.117
t-tests for Bias			
SL-CAPM	2.513	2.342	1.686
SL-CAPM95	2.383	2.226	1.551
Black CAPM	1.372	1.273	0.655
Betastar	1.372	1.273	0.655
FFM	2.075	1.880	1.170

Table 10: Cross-Validation results (annualised) for Portfolio 2, Method C

B.2 Portfolio 3

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	48.603	51.884	52.491
SL-CAPM95	48.581	51.862	52.457
Black CAPM	48.534	51.809	52.351
Betastar	48.534	51.809	52.351
FFM	48.424	51.695	52.381
Bias			
SL-CAPM	3.274	3.271	3.160
SL-CAPM95	2.849	2.868	2.635
Black CAPM	1.032	1.031	0.361
Betastar	1.032	1.031	0.361
FFM	1.931	1.938	1.809
t-tests for Bias			
SL-CAPM	1.450	1.308	1.158
SL-CAPM95	1.260	1.147	0.966
Black CAPM	0.453	0.412	0.132
Betastar	0.453	0.412	0.132
FFM	0.869	0.777	0.664

Table 11: Cross-Validation results (annualised) for Portfolio 3, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	35.598	36.170	36.101
SL-CAPM95	33.869	36.284	35.222
Black CAPM	33.564	35.987	35.818
Betastar	37.208	39.772	38.178
FFM	32.549	34.835	35.156
Bias			
SL-CAPM	4.177	4.167	4.545
SL-CAPM95	3.848	3.855	4.162
Black CAPM	1.932	1.924	1.747
Betastar	1.935	2.492	2.296
FFM	2.817	2.878	3.648
t-tests for Bias			
SL-CAPM	3.093	2.402	2.438
SL-CAPM95	2.959	2.213	2.286
Black CAPM	1.422	1.109	0.938
Betastar	1.425	1.300	1.157
FFM	2.256	1.717	2.004

Table 12: Cross-Validation results (annualised) for Portfolio 3, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	48.669	51.954	52.554
SL-CAPM95	48.645	51.930	52.526
Black CAPM	48.543	51.817	52.341
Betastar	48.543	51.817	52.341
FFM	48.464	51.736	52.436
Bias			
SL-CAPM	4.718	4.718	4.483
SL-CAPM95	4.430	4.445	4.162
Black CAPM	2.476	2.479	1.684
Betastar	2.476	2.479	1.684
FFM	3.479	3.491	3.338
t-tests for Bias			
SL-CAPM	2.138	1.889	1.645
SL-CAPM95	2.010	1.779	1.527
Black CAPM	1.113	0.992	0.618
Betastar	1.113	0.992	0.618
FFM	1.601	1.401	1.225

Table 13: Cross-Validation results (annualised) for Portfolio 3, Method C

B.3 Portfolio 4

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	51.637	55.114	55.043
SL-CAPM95	51.611	55.088	55.012
Black CAPM	51.561	55.041	54.944
Betastar	51.561	55.041	54.944
FFM	51.585	55.061	54.955
Bias			
SL-CAPM	4.055	4.061	2.975
SL-CAPM95	3.642	3.670	2.459
Black CAPM	2.539	2.537	1.001
Betastar	2.539	2.537	1.001
FFM	2.947	2.966	1.684
t-tests for Bias			
SL-CAPM	1.811	1.530	1.040
SL-CAPM95	1.624	1.383	0.859
Black CAPM	1.147	0.956	0.350
Betastar	1.147	0.956	0.350
FFM	1.344	1.117	0.589

Table 14: Cross-Validation results (annualised) for Portfolio 4, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	34.775	35.015	34.716
SL-CAPM95	33.203	35.183	34.221
Black CAPM	32.790	34.842	34.492
Betastar	34.412	36.745	35.694
FFM	32.150	34.241	34.920
Bias			
SL-CAPM	5.224	5.156	4.559
SL-CAPM95	4.906	4.853	4.189
Black CAPM	3.705	3.629	2.585
Betastar	3.707	3.959	2.933
FFM	4.151	4.122	3.707
t-tests for Bias			
SL-CAPM	3.138	3.083	2.545
SL-CAPM95	2.925	2.884	2.369
Black CAPM	2.229	2.169	1.444
Betastar	2.230	2.244	1.584
FFM	2.281	2.511	2.051

Table 15: Cross-Validation results (annualised) for Portfolio 4, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	51.734	55.225	55.145
SL-CAPM95	51.709	55.200	55.121
Black CAPM	51.617	55.107	54.987
Betastar	51.617	55.107	54.987
FFM	51.660	55.146	55.052
Bias			
SL-CAPM	5.712	5.712	4.539
SL-CAPM95	5.432	5.446	4.227
Black CAPM	4.195	4.187	2.564
Betastar	4.195	4.187	2.564
FFM	4.682	4.696	3.471
t-tests for Bias			
SL-CAPM	2.583	2.154	1.587
SL-CAPM95	2.455	2.054	1.477
Black CAPM	1.919	1.578	0.897
Betastar	1.919	1.578	0.897
FFM	2.160	1.770	1.213

Table 16: Cross-Validation results (annualised) for Portfolio 4, Method C

B.4 Portfolio 5

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	58.157	62.078	61.912
SL-CAPM95	58.150	62.071	61.902
Black CAPM	58.152	62.076	61.900
Betastar	58.152	62.076	61.900
FFM	58.091	62.011	61.795
Bias			
SL-CAPM	1.526	1.526	0.106
SL-CAPM95	1.107	1.128	−0.405
Black CAPM	1.081	1.081	−1.082
Betastar	1.081	1.081	−1.082
FFM	0.836	0.838	−0.968
t-tests for Bias			
SL-CAPM	0.737	0.509	0.033
SL-CAPM95	0.533	0.376	−0.126
Black CAPM	0.525	0.361	−0.336
Betastar	0.525	0.361	−0.336
FFM	0.408	0.280	−0.301

Table 17: Cross-Validation results (annualised) for Portfolio 5, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	35.153	35.574	34.566
SL-CAPM95	33.487	35.737	33.575
Black CAPM	33.286	35.548	34.500
Betastar	33.274	35.506	33.511
FFM	33.059	35.377	35.391
Bias			
SL-CAPM	2.827	2.791	1.816
SL-CAPM95	2.507	2.483	1.417
Black CAPM	2.381	2.345	0.628
Betastar	2.382	2.462	0.866
FFM	2.138	2.150	0.848
t-tests for Bias			
SL-CAPM	3.533	1.630	1.011
SL-CAPM95	3.121	1.442	0.811
Black CAPM	2.999	1.369	0.350
Betastar	2.999	1.439	0.497
FFM	2.354	1.261	0.460

Table 18: Cross-Validation results (annualised) for Portfolio 5, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	58.284	62.215	62.036
SL-CAPM95	58.277	62.208	62.033
Black CAPM	58.266	62.199	61.983
Betastar	58.266	62.199	61.983
FFM	58.201	62.130	61.902
Bias			
SL-CAPM	3.484	3.483	1.856
SL-CAPM95	3.199	3.213	1.552
Black CAPM	3.039	3.038	0.667
Betastar	3.039	3.038	0.667
FFM	2.840	2.842	0.929
t-tests for Bias			
SL-CAPM	1.736	1.161	0.575
SL-CAPM95	1.595	1.071	0.481
Black CAPM	1.522	1.013	0.207
Betastar	1.522	1.013	0.207
FFM	1.432	0.948	0.288

Table 19: Cross-Validation results (annualised) for Portfolio 5, Method C

B.5 Portfolio 6

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	57.111	60.964	61.052
SL-CAPM95	57.112	60.964	61.054
Black CAPM	57.113	60.967	61.039
Betastar	57.113	60.967	61.039
FFM	57.107	60.947	60.970
Bias			
SL-CAPM	0.220	0.219	−0.998
SL-CAPM95	−0.142	−0.125	−1.440
Black CAPM	−0.004	−0.005	−1.691
Betastar	−0.004	−0.005	−1.691
FFM	−0.196	−0.185	−1.908
t-tests for Bias			
SL-CAPM	0.119	0.074	−0.314
SL-CAPM95	−0.077	−0.042	−0.453
Black CAPM	−0.002	−0.002	−0.532
Betastar	−0.002	−0.002	−0.532
FFM	−0.107	−0.063	−0.601

Table 20: Cross-Validation results (annualised) for Portfolio 6, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	30.290	30.677	30.252
SL-CAPM95	28.840	30.799	29.322
Black CAPM	28.696	30.668	30.210
Betastar	28.623	30.558	29.017
FFM	28.671	30.712	31.371
Bias			
SL-CAPM	1.550	1.524	0.882
SL-CAPM95	1.268	1.258	0.546
Black CAPM	1.325	1.300	0.190
Betastar	1.326	1.368	0.245
FFM	1.145	1.153	−0.011
t-tests for Bias			
SL-CAPM	0.917	1.030	0.560
SL-CAPM95	0.726	0.847	0.358
Black CAPM	0.783	0.878	0.121
Betastar	0.783	0.928	0.162
FFM	0.646	0.778	−0.007

Table 21: Cross-Validation results (annualised) for Portfolio 6, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	57.106	60.960	61.059
SL-CAPM95	57.099	60.953	61.056
Black CAPM	57.101	60.956	61.016
Betastar	57.101	60.956	61.016
FFM	57.090	60.931	60.950
Bias			
SL-CAPM	2.239	2.238	0.897
SL-CAPM95	1.993	2.005	0.628
Black CAPM	2.014	2.014	0.204
Betastar	2.014	2.014	0.204
FFM	1.852	1.863	0.125
t-tests for Bias			
SL-CAPM	1.256	0.761	0.282
SL-CAPM95	1.120	0.682	0.198
Black CAPM	1.131	0.685	0.064
Betastar	1.131	0.685	0.064
FFM	1.043	0.634	0.039

Table 22: Cross-Validation results (annualised) for Portfolio 6, Method C

B.6 Portfolio 7

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	63.207	67.472	68.507
SL-CAPM95	63.224	67.489	68.521
Black CAPM	63.191	67.456	68.490
Betastar	63.191	67.456	68.490
FFM	63.292	67.559	68.656
Bias			
SL-CAPM	−2.672	−2.671	−2.724
SL-CAPM95	−3.080	−3.058	−3.212
Black CAPM	−2.230	−2.230	−2.970
Betastar	−2.230	−2.230	−2.970
FFM	−3.570	−3.574	−4.201
t-tests for Bias			
SL-CAPM	−1.227	−0.821	−0.765
SL-CAPM95	−1.413	−0.939	−0.901
Black CAPM	−1.023	−0.685	−0.834
Betastar	−1.023	−0.685	−0.834
FFM	−1.668	−1.097	−1.178

Table 23: Cross-Validation results (annualised) for Portfolio 7, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	34.189	34.602	34.987
SL-CAPM95	32.581	34.774	33.797
Black CAPM	32.391	34.590	34.956
Betastar	32.633	34.842	34.062
FFM	31.681	33.920	34.957
Bias			
SL-CAPM	−1.214	−1.243	−0.772
SL-CAPM95	−1.529	−1.543	−1.148
Black CAPM	−0.770	−0.801	−1.017
Betastar	−0.771	−0.890	−1.030
FFM	−2.121	−2.127	−1.899
t-tests for Bias			
SL-CAPM	−1.176	−0.745	−0.424
SL-CAPM95	−1.448	−0.920	−0.653
Black CAPM	−0.732	−0.480	−0.559
Betastar	−0.732	−0.529	−0.581
FFM	−1.913	−1.301	−1.045

Table 24: Cross-Validation results (annualised) for Portfolio 7, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	63.201	67.464	68.536
SL-CAPM95	63.209	67.473	68.542
Black CAPM	63.199	67.463	68.501
Betastar	63.199	67.463	68.501
FFM	63.264	67.528	68.643
Bias			
SL-CAPM	−0.463	−0.463	−0.740
SL-CAPM95	−0.739	−0.726	−1.037
Black CAPM	−0.020	−0.022	−0.985
Betastar	−0.020	−0.022	−0.985
FFM	−1.283	−1.288	−2.043
t-tests for Bias			
SL-CAPM	−0.221	−0.142	−0.207
SL-CAPM95	−0.354	−0.223	−0.291
Black CAPM	−0.009	−0.007	−0.276
Betastar	−0.009	−0.007	−0.276
FFM	−0.625	−0.395	−0.572

Table 25: Cross-Validation results (annualised) for Portfolio 7, Method C

B.7 Portfolio 8

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	72.532	77.428	76.287
SL-CAPM95	72.552	77.449	76.309
Black CAPM	72.491	77.382	76.248
Betastar	72.491	77.382	76.248
FFM	72.486	77.383	76.485
Bias			
SL-CAPM	−3.282	−3.282	−2.763
SL-CAPM95	−3.733	−3.709	−3.271
Black CAPM	−1.581	−1.580	−1.180
Betastar	−1.581	−1.580	−1.180
FFM	−3.119	−3.126	−3.424
t-tests for Bias			
SL-CAPM	−1.186	−0.879	−0.696
SL-CAPM95	−1.348	−0.993	−0.824
Black CAPM	−0.573	−0.423	−0.297
Betastar	−0.573	−0.423	−0.297
FFM	−1.135	−0.838	−0.861

Table 26: Cross-Validation results (annualised) for Portfolio 8, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	37.736	38.157	39.633
SL-CAPM95	35.946	38.341	39.491
Black CAPM	35.761	38.156	39.658
Betastar	38.237	40.834	42.412
FFM	36.060	38.390	40.037
Bias			
SL-CAPM	−1.607	−1.609	−0.361
SL-CAPM95	−1.951	−1.939	−0.699
Black CAPM	0.097	0.096	1.221
Betastar	0.095	−0.295	0.760
FFM	−1.509	−1.446	−1.070
t-tests for Bias			
SL-CAPM	−0.933	−0.874	−0.175
SL-CAPM95	−1.117	−1.049	−0.340
Black CAPM	0.057	0.052	0.592
Betastar	0.055	−0.150	0.344
FFM	−0.914	−0.781	−0.513

Table 27: Cross-Validation results (annualised) for Portfolio 8, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	72.318	77.199	76.107
SL-CAPM95	72.316	77.198	76.103
Black CAPM	72.329	77.209	76.119
Betastar	72.329	77.209	76.119
FFM	72.278	77.160	76.268
Bias			
SL-CAPM	−0.716	−0.717	−0.162
SL-CAPM95	−1.021	−1.006	−0.477
Black CAPM	0.985	0.986	1.421
Betastar	0.985	0.986	1.421
FFM	−0.559	−0.566	−0.701
t-tests for Bias			
SL-CAPM	−0.266	−0.192	−0.041
SL-CAPM95	−0.380	−0.270	−0.120
Black CAPM	0.367	0.264	0.359
Betastar	0.367	0.264	0.359
FFM	−0.209	−0.152	−0.177

Table 28: Cross-Validation results (annualised) for Portfolio 8, Method C

B.8 Portfolio 9

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	81.523	87.028	83.538
SL-CAPM95	81.568	87.073	83.602
Black CAPM	81.374	86.865	83.339
Betastar	81.374	86.865	83.339
FFM	81.584	87.089	83.504
Bias			
SL-CAPM	−7.048	−7.051	−7.460
SL-CAPM95	−7.597	−7.571	−8.122
Black CAPM	−4.569	−4.568	−4.655
Betastar	−4.569	−4.568	−4.655
FFM	−6.170	−6.191	−6.137
t-tests for Bias			
SL-CAPM	−1.993	−1.684	−1.722
SL-CAPM95	−2.146	−1.808	−1.875
Black CAPM	−1.292	−1.091	−1.075
Betastar	−1.292	−1.091	−1.075
FFM	−1.732	−1.476	−1.415

Table 29: Cross-Validation results (annualised) for Portfolio 9, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	45.952	46.467	48.018
SL-CAPM95	43.737	46.669	48.640
Black CAPM	43.361	46.270	47.804
Betastar	47.380	50.532	51.870
FFM	42.898	45.914	47.878
Bias			
SL-CAPM	−5.268	−5.243	−4.803
SL-CAPM95	−5.693	−5.645	−5.300
Black CAPM	−2.785	−2.757	−1.998
Betastar	−2.789	−3.312	−2.702
FFM	−4.445	−4.442	−3.512
t-tests for Bias			
SL-CAPM	−2.310	−2.352	−1.931
SL-CAPM95	−2.494	−2.524	−2.106
Black CAPM	−1.227	−1.236	−0.803
Betastar	−1.229	−1.360	−1.002
FFM	−2.056	−2.013	−1.413

Table 30: Cross-Validation results (annualised) for Portfolio 9, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	81.148	86.624	83.118
SL-CAPM95	81.158	86.634	83.132
Black CAPM	81.073	86.540	83.021
Betastar	81.073	86.540	83.021
FFM	81.244	86.720	83.169
Bias			
SL-CAPM	−4.264	−4.264	−4.453
SL-CAPM95	−4.635	−4.617	−4.864
Black CAPM	−1.784	−1.781	−1.647
Betastar	−1.784	−1.781	−1.647
FFM	−3.429	−3.448	−3.276
t-tests for Bias			
SL-CAPM	−1.248	−1.021	−1.031
SL-CAPM95	−1.360	−1.105	−1.126
Black CAPM	−0.522	−0.426	−0.381
Betastar	−0.522	−0.426	−0.381
FFM	−0.996	−0.824	−0.757

Table 31: Cross-Validation results (annualised) for Portfolio 9, Method C

B.9 Portfolio 10

MethodA	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	101.068	107.889	102.477
SL-CAPM95	101.127	107.949	102.565
Black CAPM	100.938	107.750	102.313
Betastar	100.938	107.750	102.313
FFM	101.125	107.933	102.559
Bias			
SL-CAPM	−6.762	−6.760	−6.841
SL-CAPM95	−7.656	−7.607	−7.946
Black CAPM	−3.812	−3.810	−3.646
Betastar	−3.812	−3.810	−3.646
FFM	−5.138	−5.146	−6.005
t-tests for Bias			
SL-CAPM	−2.562	−1.300	−1.285
SL-CAPM95	−2.896	−1.463	−1.493
Black CAPM	−1.455	−0.733	−0.685
Betastar	−1.455	−0.733	−0.685
FFM	−1.895	−0.989	−1.127

Table 32: Cross-Validation results (annualised) for Portfolio 10, Method A.

MethodB	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	74.924	75.668	76.619
SL-CAPM95	71.396	76.043	78.347
Black CAPM	70.899	75.558	76.490
Betastar	73.939	78.930	78.821
FFM	67.772	72.139	72.723
Bias			
SL-CAPM	−4.816	−4.844	−4.151
SL-CAPM95	−5.503	−5.499	−4.968
Black CAPM	−1.861	−1.889	−0.957
Betastar	−1.866	−2.575	−1.685
FFM	−3.294	−3.286	−3.193
t-tests for Bias			
SL-CAPM	−2.481	−1.329	−1.042
SL-CAPM95	−2.659	−1.502	−1.221
Black CAPM	−0.956	−0.518	−0.240
Betastar	−0.958	−0.676	−0.411
FFM	−1.769	−0.945	−0.844

Table 33: Cross-Validation results (annualised) for Portfolio 10, Method B

MethodC	10-Fold	LOOCV	TSCV
Square root of Cross-Validation Error			
SL-CAPM	100.802	107.610	102.154
SL-CAPM95	100.819	107.627	102.170
Black CAPM	100.746	107.550	102.093
Betastar	100.746	107.550	102.093
FFM	100.910	107.711	102.288
Bias			
SL-CAPM	−3.840	−3.841	−3.695
SL-CAPM95	−4.446	−4.415	−4.370
Black CAPM	−0.890	−0.890	−0.501
Betastar	−0.890	−0.890	−0.501
FFM	−2.270	−2.280	−2.776
t-tests for Bias			
SL-CAPM	−1.494	−0.740	−0.695
SL-CAPM95	−1.731	−0.850	−0.822
Black CAPM	−0.349	−0.171	−0.094
Betastar	−0.349	−0.171	−0.094
FFM	−0.857	−0.439	−0.522

Table 34: Cross-Validation results (annualised) for Portfolio 10, Method C

C Average over 12 months

C.1 Portfolio 2

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	14.637	14.638	14.830	14.854
SL-CAPM95	14.626	14.627	14.814	14.839
Black CAPM	14.604	14.608	14.788	14.809
Betastar	14.604	14.604	14.788	14.809
FFM	14.917	14.900	15.793	15.895
Bias				
SL-CAPM	4.822	4.811	4.144	4.413
SL-CAPM95	4.404	4.409	3.553	3.869
Black CAPM	2.395	2.399	1.412	1.701
Betastar	2.395	2.399	1.412	1.701
FFM	3.372	3.429	1.433	1.962
t-tests for Bias				
SL-CAPM	1.911	1.733	1.366	1.447
SL-CAPM95	1.745	1.588	1.173	1.271
Black CAPM	0.930	0.858	0.466	0.559
Betastar	0.930	0.858	0.466	0.559
FFM	1.441	1.267	0.478	0.626

Table 35: Cross-Validation results for Portfolio 2, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	10.997	10.969	11.151	11.071
SL-CAPM95	11.021	11.000	11.209	11.123
Black CAPM	10.934	10.904	11.069	10.989
Betastar	12.291	12.282	12.486	12.487
FFM	10.688	10.635	11.063	10.991
Bias				
SL-CAPM	5.035	5.110	5.337	5.321
SL-CAPM95	4.651	4.741	4.928	4.868
Black CAPM	2.609	2.698	2.604	2.609
Betastar	3.245	3.246	3.415	3.221
FFM	3.601	3.751	2.866	2.999
t-tests for Bias				
SL-CAPM	2.389	2.823	2.693	2.482
SL-CAPM95	2.190	2.629	2.539	2.276
Black CAPM	1.229	1.482	1.319	1.222
Betastar	1.341	1.562	1.510	1.344
FFM	1.788	2.198	1.436	1.481

Table 36: Cross-Validation results for Portfolio 2, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	14.648	14.664	14.868	14.886
SL-CAPM95	14.652	14.655	14.852	14.873
Black CAPM	14.612	14.612	14.802	14.821
Betastar	14.612	14.612	14.802	14.821
FFM	14.928	14.914	15.815	15.905
Bias				
SL-CAPM	5.210	5.762	5.380	5.759
SL-CAPM95	5.452	5.454	5.123	5.409
Black CAPM	3.346	3.350	2.762	3.046
Betastar	3.346	3.350	2.762	3.046
FFM	4.389	4.450	2.910	3.571
t-tests for Bias				
SL-CAPM	2.064	2.070	1.768	1.878
SL-CAPM95	2.140	1.958	1.682	1.763
Black CAPM	1.292	1.197	0.909	0.995
Betastar	1.292	1.197	0.909	0.995
FFM	1.889	1.645	0.968	1.135

Table 37: Cross-Validation results for Portfolio 2, Method C, Average over 12 months

C.2 Portfolio 3

MethodA12	**Non-overlapping data**			**Overlapping data**
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	14.818	14.817	15.068	15.120
SL-CAPM95	14.809	14.809	15.059	15.109
Black CAPM	14.796	14.801	15.035	15.077
Betastar	14.796	14.796	15.035	15.077
FFM	15.100	15.107	15.873	15.930
Bias				
SL-CAPM	3.963	3.955	3.337	3.932
SL-CAPM95	3.568	3.576	2.812	3.432
Black CAPM	1.906	1.907	0.637	0.889
Betastar	1.906	1.907	0.637	0.889
FFM	2.467	2.467	1.051	1.289
t-tests for Bias				
SL-CAPM	1.336	1.402	1.103	1.330
SL-CAPM95	1.202	1.267	0.930	1.162
Black CAPM	0.645	0.672	0.211	0.302
Betastar	0.645	0.672	0.211	0.302
FFM	0.902	0.904	0.361	0.432

Table 38: Cross-Validation results for Portfolio 3, Method A, Average over 12 months

MethodB12	**Non-overlapping data**			**Overlapping data**
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	10.362	10.352	10.596	10.648
SL-CAPM95	10.390	10.383	10.570	10.485
Black CAPM	10.312	10.304	10.521	10.563
Betastar	11.298	11.288	11.502	11.523
FFM	9.860	9.890	10.400	10.460
Bias				
SL-CAPM	4.254	4.266	4.507	4.815
SL-CAPM95	3.893	3.918	4.130	4.380
Black CAPM	2.197	2.218	1.807	1.772
Betastar	2.687	2.696	2.640	2.443
FFM	2.791	2.798	2.432	2.152
t-tests for Bias				
SL-CAPM	1.890	2.644	2.544	2.595
SL-CAPM95	1.738	2.450	2.370	2.416
Black CAPM	0.997	1.371	1.034	0.966
Betastar	1.223	1.543	1.424	1.255
FFM	1.332	1.832	1.374	1.151

Table 39: Cross-Validation results for Portfolio 3, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	14.827	14.812	15.117	15.125
SL-CAPM95	14.801	14.802	15.064	15.112
Black CAPM	14.774	14.775	15.022	15.061
Betastar	14.774	14.775	15.022	15.061
FFM	15.077	15.086	15.912	15.911
Bias				
SL-CAPM	4.384	4.989	4.547	5.136
SL-CAPM95	4.703	4.699	4.326	4.813
Black CAPM	2.949	2.941	1.959	2.093
Betastar	2.949	2.941	1.959	2.093
FFM	3.585	3.578	2.488	2.854
t-tests for Bias				
SL-CAPM	1.478	1.791	1.483	1.747
SL-CAPM95	1.587	1.687	1.443	1.638
Black CAPM	1.000	1.052	0.656	0.716
Betastar	1.000	1.052	0.656	0.716
FFM	1.331	1.337	0.842	0.966

Table 40: Cross-Validation results for Portfolio 3, Method C, Average over 12 months

C.3 Portfolio 4

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	15.881	15.884	15.962	15.992
SL-CAPM95	15.871	15.875	15.950	15.980
Black CAPM	15.865	15.871	15.935	15.967
Betastar	15.865	15.864	15.935	15.967
FFM	16.193	16.206	17.159	17.385
Bias				
SL-CAPM	4.934	4.929	3.689	4.099
SL-CAPM95	4.542	4.553	3.149	3.624
Black CAPM	3.552	3.552	1.823	2.462
Betastar	3.552	3.552	1.823	2.462
FFM	3.669	3.645	1.331	2.204
t-tests for Bias				
SL-CAPM	1.349	1.382	0.968	1.257
SL-CAPM95	1.241	1.277	0.827	1.112
Black CAPM	0.962	0.993	0.479	0.754
Betastar	0.962	0.993	0.479	0.754
FFM	1.089	1.049	0.367	0.645

Table 41: Cross-Validation results for Portfolio 4, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	10.198	10.214	10.228	10.226
SL-CAPM95	10.240	10.256	10.301	10.340
Black CAPM	10.156	10.169	10.160	10.168
Betastar	10.667	10.665	10.663	10.712
FFM	9.859	9.866	10.084	10.138
Bias				
SL-CAPM	5.262	5.334	5.133	5.159
SL-CAPM95	4.906	4.988	4.734	4.752
Black CAPM	3.880	3.956	3.267	3.522
Betastar	4.238	4.246	3.817	3.926
FFM	4.009	4.057	3.021	3.471
t-tests for Bias				
SL-CAPM	2.400	2.731	2.360	2.741
SL-CAPM95	2.325	2.623	2.269	2.518
Black CAPM	1.750	2.016	1.509	1.874
Betastar	2.226	2.297	1.968	2.024
FFM	2.312	2.336	1.704	2.010

Table 42: Cross-Validation results for Portfolio 4, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	15.894	15.894	15.997	16.013
SL-CAPM95	15.882	15.885	15.977	16.000
Black CAPM	15.864	15.863	15.945	15.973
Betastar	15.864	15.863	15.945	15.973
FFM	16.188	16.202	17.176	17.379
Bias				
SL-CAPM	5.416	6.113	5.125	5.746
SL-CAPM95	5.813	5.825	4.930	5.441
Black CAPM	4.731	4.736	3.404	4.109
Betastar	4.731	4.736	3.404	4.109
FFM	4.909	4.895	3.028	4.061
t-tests for Bias				
SL-CAPM	1.480	1.725	1.344	1.767
SL-CAPM95	1.602	1.644	1.295	1.674
Black CAPM	1.292	1.333	0.895	1.263
Betastar	1.292	1.333	0.895	1.263
FFM	1.485	1.422	0.835	1.199

Table 43: Cross-Validation results for Portfolio 4, Method C, Average over 12 months

C.4 Portfolio 5

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	17.810	17.811	18.020	18.037
SL-CAPM95	17.805	17.806	18.011	18.030
Black CAPM	17.812	17.817	18.014	18.030
Betastar	17.812	17.811	18.014	18.030
FFM	18.114	18.104	19.012	19.083
Bias				
SL-CAPM	3.068	3.062	1.796	2.140
SL-CAPM95	2.676	2.686	1.275	1.685
Black CAPM	2.711	2.708	0.806	1.108
Betastar	2.711	2.708	0.806	1.108
FFM	2.268	2.249	−0.505	−0.116
t-tests for Bias				
SL-CAPM	0.995	0.911	0.484	0.589
SL-CAPM95	0.867	0.799	0.345	0.465
Black CAPM	0.870	0.804	0.217	0.305
Betastar	0.870	0.804	0.217	0.305
FFM	0.767	0.677	−0.145	−0.032

Table 44: Cross-Validation results for Portfolio 5, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	10.217	10.189	10.354	10.377
SL-CAPM95	10.258	10.237	10.374	10.347
Black CAPM	10.213	10.184	10.326	10.351
Betastar	10.159	10.157	10.261	10.305
FFM	10.116	10.104	10.484	10.582
Bias				
SL-CAPM	3.466	3.500	3.440	3.310
SL-CAPM95	3.112	3.155	3.055	2.922
Black CAPM	3.109	3.146	2.450	2.278
Betastar	3.253	3.242	2.793	2.567
FFM	2.683	2.693	1.296	1.001
t-tests for Bias				
SL-CAPM	2.021	1.948	1.755	1.561
SL-CAPM95	1.831	1.747	1.564	1.364
Black CAPM	1.789	1.744	1.255	1.078
Betastar	1.927	1.816	1.455	1.205
FFM	1.733	1.576	0.790	0.536

Table 45: Cross-Validation results for Portfolio 5, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	17.819	17.815	18.067	18.059
SL-CAPM95	17.808	17.810	18.036	18.052
Black CAPM	17.813	17.813	18.029	18.043
Betastar	17.813	17.813	18.029	18.043
FFM	18.107	18.098	19.042	19.078
Bias				
SL-CAPM	3.642	4.475	3.446	3.937
SL-CAPM95	4.189	4.188	3.289	3.648
Black CAPM	4.131	4.121	2.621	2.905
Betastar	4.131	4.121	2.621	2.905
FFM	3.728	3.704	1.329	1.888
t-tests for Bias				
SL-CAPM	1.180	1.336	0.918	1.073
SL-CAPM95	1.363	1.250	0.882	0.995
Black CAPM	1.332	1.228	0.703	0.793
Betastar	1.332	1.228	0.703	0.793
FFM	1.279	1.121	0.375	0.522

Table 46: Cross-Validation results for Portfolio 5, Method C, Average over 12 months

C.5 Portfolio 6

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	17.444	17.444	17.733	17.729
SL-CAPM95	17.443	17.443	17.730	17.726
Black CAPM	17.446	17.453	17.730	17.725
Betastar	17.446	17.446	17.730	17.725
FFM	17.687	17.692	18.822	18.826
Bias				
SL-CAPM	1.194	1.187	0.085	0.729
SL-CAPM95	0.856	0.863	−0.368	0.309
Black CAPM	0.995	0.993	−0.570	−0.083
Betastar	0.995	0.993	−0.570	−0.083
FFM	0.610	0.619	−1.907	−1.265
t-tests for Bias				
SL-CAPM	0.358	0.374	0.025	0.234
SL-CAPM95	0.256	0.272	−0.110	0.100
Black CAPM	0.297	0.312	−0.170	−0.027
Betastar	0.297	0.312	−0.170	−0.027
FFM	0.188	0.198	−0.572	−0.381

Table 47: Cross-Validation results for Portfolio 6, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	8.832	8.816	8.876	8.983
SL-CAPM95	8.863	8.849	8.819	8.893
Black CAPM	8.831	8.815	8.857	8.963
Betastar	8.780	8.777	8.718	8.799
FFM	8.811	8.813	9.071	9.100
Bias				
SL-CAPM	1.626	1.638	1.865	2.011
SL-CAPM95	1.319	1.338	1.522	1.641
Black CAPM	1.427	1.443	1.209	1.199
Betastar	1.512	1.507	1.425	1.382
FFM	1.057	1.077	0.033	0.087
t-tests for Bias				
SL-CAPM	1.018	1.081	1.262	1.225
SL-CAPM95	0.851	0.870	1.019	0.974
Black CAPM	0.892	0.951	0.830	0.739
Betastar	0.964	0.992	0.937	0.793
FFM	0.735	0.736	0.024	0.055

Table 48: Cross-Validation results for Portfolio 6, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	17.448	17.428	17.743	17.721
SL-CAPM95	17.424	17.425	17.723	17.714
Black CAPM	17.428	17.428	17.718	17.708
Betastar	17.428	17.428	17.718	17.708
FFM	17.662	17.668	18.811	18.789
Bias				
SL-CAPM	1.783	2.632	1.828	2.580
SL-CAPM95	2.385	2.383	1.704	2.309
Black CAPM	2.444	2.438	1.335	1.768
Betastar	2.444	2.438	1.335	1.768
FFM	2.089	2.095	−0.010	0.797
t-tests for Bias				
SL-CAPM	0.534	0.837	0.543	0.833
SL-CAPM95	0.705	0.758	0.509	0.746
Black CAPM	0.721	0.774	0.399	0.573
Betastar	0.721	0.774	0.399	0.573
FFM	0.641	0.677	−0.003	0.242

Table 49: Cross-Validation results for Portfolio 6, Method C, Average over 12 months

C.6 Portfolio 7

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	19.131	19.130	19.590	19.593
SL-CAPM95	19.134	19.133	19.593	19.596
Black CAPM	19.129	19.137	19.591	19.592
Betastar	19.129	19.129	19.591	19.592
FFM	19.595	19.565	20.320	20.376
Bias				
SL-CAPM	−1.910	−1.918	−2.261	−2.017
SL-CAPM95	−2.285	−2.277	−2.732	−2.429
Black CAPM	−1.548	−1.553	−2.570	−2.233
Betastar	−1.548	−1.553	−2.570	−2.233
FFM	−3.010	−3.018	−4.374	−3.899
t-tests for Bias				
SL-CAPM	−0.507	−0.514	−0.549	−0.536
SL-CAPM95	−0.606	−0.610	−0.663	−0.645
Black CAPM	−0.408	−0.416	−0.624	−0.594
Betastar	−0.408	−0.416	−0.624	−0.594
FFM	−0.872	−0.848	−1.095	−1.009

Table 50: Cross-Validation results for Portfolio 7, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	9.791	9.804	10.140	10.114
SL-CAPM95	9.828	9.850	10.007	10.030
Black CAPM	9.791	9.803	10.132	10.106
Betastar	9.814	9.813	9.977	10.025
FFM	9.560	9.603	9.950	9.944
Bias				
SL-CAPM	−1.448	−1.480	−0.492	−0.711
SL-CAPM95	−1.790	−1.815	−0.834	−1.047
Black CAPM	−1.086	−1.115	−0.802	−0.926
Betastar	−1.122	−1.129	−0.591	−0.807
FFM	−2.510	−2.556	−2.394	−2.491
t-tests for Bias				
SL-CAPM	−0.671	−0.811	−0.251	−0.349
SL-CAPM95	−0.842	−0.994	−0.437	−0.511
Black CAPM	−0.497	−0.610	−0.413	−0.460
Betastar	−0.502	−0.618	−0.303	−0.396
FFM	−1.420	−1.573	−1.412	−1.328

Table 51: Cross-Validation results for Portfolio 7, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	19.126	19.108	19.591	19.577
SL-CAPM95	19.110	19.109	19.579	19.575
Black CAPM	19.111	19.110	19.576	19.572
Betastar	19.111	19.110	19.576	19.572
FFM	19.561	19.531	20.300	20.334
Bias				
SL-CAPM	−1.271	−0.350	−0.456	−0.009
SL-CAPM95	−0.623	−0.625	−0.593	−0.276
Black CAPM	0.026	0.015	−0.603	−0.225
Betastar	0.026	0.015	−0.603	−0.225
FFM	−1.376	−1.390	−2.408	−1.767
t-tests for Bias				
SL-CAPM	−0.337	−0.094	−0.110	−0.002
SL-CAPM95	−0.164	−0.168	−0.143	−0.073
Black CAPM	0.007	0.004	−0.146	−0.060
Betastar	0.007	0.004	−0.146	−0.060
FFM	−0.398	−0.392	−0.601	−0.457

Table 52: Cross-Validation results for Portfolio 7, Method C, Average over 12 months

C.7 Portfolio 8

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	22.080	22.078	22.418	22.472
SL-CAPM95	22.083	22.082	22.427	22.478
Black CAPM	22.066	22.076	22.408	22.465
Betastar	22.066	22.067	22.408	22.465
FFM	21.981	22.019	22.458	22.435
Bias				
SL-CAPM	−2.254	−2.259	−3.733	−2.861
SL-CAPM95	−2.667	−2.656	−4.222	−3.300
Black CAPM	−0.674	−0.682	−2.199	−1.512
Betastar	−0.674	−0.682	−2.199	−1.512
FFM	−2.021	−2.021	−3.937	−3.404
t-tests for Bias				
SL-CAPM	−0.495	−0.534	−0.812	−0.684
SL-CAPM95	−0.586	−0.628	−0.918	−0.789
Black CAPM	−0.149	−0.161	−0.477	−0.361
Betastar	−0.149	−0.161	−0.477	−0.361
FFM	−0.444	−0.479	−0.845	−0.805

Table 53: Cross-Validation results for Portfolio 8, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	10.776	10.759	11.125	11.106
SL-CAPM95	10.825	10.805	11.169	11.080
Black CAPM	10.775	10.758	11.127	11.111
Betastar	11.500	11.501	11.864	11.816
FFM	10.834	10.903	11.312	11.406
Bias				
SL-CAPM	−1.641	−1.688	−1.422	−1.177
SL-CAPM95	−2.024	−2.057	−1.771	−1.536
Black CAPM	−0.061	−0.111	0.112	0.172
Betastar	−0.455	−0.448	−0.242	−0.124
FFM	−1.414	−1.441	−1.572	−1.751
t-tests for Bias				
SL-CAPM	−0.679	−0.864	−0.641	−0.550
SL-CAPM95	−0.856	−1.047	−0.798	−0.708
Black CAPM	−0.025	−0.056	0.050	0.080
Betastar	−0.173	−0.214	−0.103	−0.057
FFM	−0.582	−0.722	−0.721	−0.796

Table 54: Cross-Validation results for Portfolio 8, Method B, Average over 12 months

MethodC12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	22.074	21.999	22.391	22.396
SL-CAPM95	21.998	21.997	22.348	22.394
Black CAPM	22.001	22.002	22.351	22.401
Betastar	22.001	22.002	22.351	22.401
FFM	21.905	21.943	22.421	22.351
Bias				
SL-CAPM	−1.506	−0.422	−1.362	−0.336
SL-CAPM95	−0.728	−0.727	−1.447	−0.622
Black CAPM	1.169	1.155	0.400	1.013
Betastar	1.169	1.155	0.400	1.013
FFM	−0.188	−0.195	−1.559	−0.827
t-tests for Bias				
SL-CAPM	−0.331	−0.102	−0.297	−0.082
SL-CAPM95	−0.173	−0.176	−0.320	−0.152
Black CAPM	0.277	0.279	0.088	0.247
Betastar	0.277	0.279	0.088	0.247
FFM	−0.044	−0.047	−0.336	−0.200

Table 55: Cross-Validation results for Portfolio 8, Method C, Average over 12 months

C.8 Portfolio 9

write.csv(MethodA12, ”METHODA12.csv”)

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	24.698	24.697	25.153	25.324
SL-CAPM95	24.708	24.706	25.169	25.338
Black CAPM	24.652	24.665	25.093	25.269
Betastar	24.652	24.653	25.093	25.269
FFM	24.416	24.424	24.540	24.640
Bias				
SL-CAPM	−5.704	−5.707	−8.073	−7.402
SL-CAPM95	−6.203	−6.186	−8.658	−7.924
Black CAPM	−3.415	−3.421	−5.355	−4.802
Betastar	−3.415	−3.421	−5.355	−4.802
FFM	−4.939	−4.964	−6.240	−5.633
t-tests for Bias				
SL-CAPM	−1.524	−1.425	−1.884	−1.599
SL-CAPM95	−1.657	−1.544	−2.019	−1.712
Black CAPM	−0.923	−0.857	−1.248	−1.039
Betastar	−0.923	−0.857	−1.248	−1.039
FFM	−1.362	−1.291	−1.460	−1.265

Table 56: Cross-Validation results for Portfolio 9, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	12.956	12.958	13.535	13.533
SL-CAPM95	13.025	13.008	13.673	13.607
Black CAPM	12.904	12.907	13.471	13.469
Betastar	14.050	14.043	14.714	14.736
FFM	12.926	12.917	13.633	13.603
Bias				
SL-CAPM	−5.037	−5.050	−5.341	−5.412
SL-CAPM95	−5.487	−5.488	−5.774	−5.843
Black CAPM	−2.748	−2.763	−2.622	−2.813
Betastar	−3.300	−3.291	−3.381	−3.446
FFM	−4.237	−4.287	−3.525	−3.548
t-tests for Bias				
SL-CAPM	−2.038	−2.238	−2.091	−1.900
SL-CAPM95	−2.180	−2.350	−2.160	−2.009
Black CAPM	−1.112	−1.219	−1.026	−0.987
Betastar	−1.381	−1.531	−1.413	−1.228
FFM	−1.851	−1.951	−1.461	−1.320

Table 57: Cross-Validation results for Portfolio 9, Method B, Average over 12 months

MethodC12	**Non-overlapping data**			**Overlapping data**
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	24.683	24.575	25.055	25.193
SL-CAPM95	24.577	24.576	25.029	25.195
Black CAPM	24.550	24.551	24.993	25.163
Betastar	24.550	24.551	24.993	25.163
FFM	24.303	24.311	24.463	24.536
Bias				
SL-CAPM	−4.892	−3.715	−5.336	−4.464
SL-CAPM95	−4.094	−4.081	−5.449	−4.806
Black CAPM	−1.423	−1.428	−2.354	−1.865
Betastar	−1.423	−1.428	−2.354	−1.865
FFM	−2.970	−2.999	−3.650	−2.824
t-tests for Bias				
SL-CAPM	−1.307	−0.967	−1.268	−0.995
SL-CAPM95	−1.239	−1.065	−1.311	−1.073
Black CAPM	−0.433	−0.373	−0.565	−0.416
Betastar	−0.433	−0.373	−0.565	−0.416
FFM	−0.922	−0.814	−0.867	−0.653

Table 58: Cross-Validation results for Portfolio 9, Method C, Average over 12 months

C.9 Portfolio 10

MethodA12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	30.059	30.059	31.347	31.395
SL-CAPM95	30.073	30.072	31.368	31.412
Black CAPM	30.025	30.038	31.300	31.353
Betastar	30.025	30.025		31.353
FFM	29.494	29.512	30.376	30.426
Bias				
SL-CAPM	−5.894	−5.906	−7.908	−6.720
SL-CAPM95	−6.694	−6.674	−8.827	−7.576
Black CAPM	−3.315	−3.320	−5.044	−3.870
Betastar	−3.315	−3.320	−5.044	−3.870
FFM	−5.056	−5.014	−6.761	−5.514
t-tests for Bias				
SL-CAPM	−1.522	−1.033	−1.241	−1.021
SL-CAPM95	−1.730	−1.167	−1.385	−1.151
Black CAPM	−0.857	−0.581	−0.791	−0.588
Betastar	−0.857	−0.581	−0.791	−0.588
FFM	−1.566	−0.968	−1.170	−0.929

Table 59: Cross-Validation results for Portfolio 10, Method A, Average over 12 months

MethodB12	Non-overlapping data			Overlapping data
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	20.806	20.812	22.106	22.044
SL-CAPM95	20.880	20.897	22.234	22.157
Black CAPM	20.774	20.783	22.070	22.010
Betastar	21.680	21.690		22.998
FFM	19.982	20.067	21.284	21.282
Bias				
SL-CAPM	−5.319	−5.288	−5.089	−4.718
SL-CAPM95	−6.061	−6.007	−5.739	−5.403
Black CAPM	−2.739	−2.703	−2.225	−1.867
Betastar	−3.223	−3.221	−3.028	−2.508
FFM	−4.441	−4.369	−3.925	−3.328
t-tests for Bias				
SL-CAPM	−1.863	−1.479	−1.244	−1.055
SL-CAPM95	−2.053	−1.686	−1.405	−1.216
Black CAPM	−0.957	−0.753	−0.544	−0.418
Betastar	−1.145	−0.826	−0.686	−0.527
FFM	−1.875	−1.325	−1.050	−0.825

Table 60: Cross-Validation results for Portfolio 10, Method B, Average over 12 months

MethodC12	**Non-overlapping data**			**Overlapping data**
	10-Fold	LOOCV	TSCV	TSCV
Square root of Cross-Validation Error				
SL-CAPM	30.047	30.006	31.302	31.323
SL-CAPM95	30.014	30.012	31.292	31.327
Black CAPM	29.991	29.991	31.261	31.304
Betastar	29.991	29.991		31.304
FFM	29.453	29.471	30.346	30.366
Bias				
SL-CAPM	−5.056	−3.843	−5.114	−3.691
SL-CAPM95	−4.464	−4.433	−5.427	−4.243
Black CAPM	−1.269	−1.258	−1.980	−0.841
Betastar	−1.269	−1.258	−1.980	−0.841
FFM	−3.013	−2.958	−3.907	−2.416
t-tests for Bias				
SL-CAPM	−1.305	−0.676	−0.802	−0.564
SL-CAPM95	−1.217	−0.780	−0.853	−0.649
Black CAPM	−0.345	−0.221	−0.311	−0.129
Betastar	−0.345	−0.221	−0.311	−0.129
FFM	−0.990	−0.574	−0.673	−0.410

Table 61: Cross-Validation results for Portfolio 10, Method C, Average over 12 months

D Federal Court of Australia's Practice Note CM 7: Expert Witness Guidelines

FEDERAL COURT OF AUSTRALIA

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Practice Note CM 7 issued on 1 August 2011 is revoked with effect from midnight on 3 June 2013 and the following Practice Note is substituted.

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[1], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

<u>Guidelines</u>

1. General Duty to the Court[2]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

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[1] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].
[2] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

2. The Form of the Expert's Report[3]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[4]; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[5].

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[6].

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[3] Rule 23.13.
[4] See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.
[5] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565
[6] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP
Chief Justice
4 June 2013

E Author

Neil Diamond CV

January 2016

Academic Qualifications:	B.Sc (Hons) (Monash), Ph.D. (Melbourne), A.Stat

Career History

1977-78	Statistician, ICI Explosives Factory, Deer Park
1979-86	Research Officer, Research Scientist, Senior Research Scientist And Statistics and Computing Team Leader, ICI Central Research Laboratories, Ascot Vale
1987-1989	Lecturer, Department of Mathematics, Computing and Operations Research, Footscray Institute of Technology
(1989)	Visiting Scientist, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
1990-2003	Senior Lecturer, Department of Computer and Mathematical Sciences, Victoria University of Technology
2003-2004	Senior Statistician, Insureware
2004-2006	Senior Lecturer and Deputy Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2007- 2012	Senior Lecturer and Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2011- 2012	Associate Professor and Co-ordinator of Statistical Support, Victoria University.
2012-	Director, ESQUANT Statistical Consulting

Research and Consulting Experience

- A Ph.D. from the University of Melbourne entitled “Two-factor interactions in non-regular foldover designs.”

- Ten years with ICI Australia as an industrial statistician initially with the Explosives group and eventually with the research group.

- Two six month periods (Professional Experience Program and Outside Studies Program) at the Center for Quality and Productivity Improvement, at the University of Wisconsin-Madison. The Center, founded and directed by Professor George Box, conducts innovative practical research in modern methods of quality improvement and is an internationally recognised forum for the exchange of ideas between experts in various disciplines, from industry and government as well as academia.

- Extensive consulting and training on behalf of the Centre for Applied Computing and Decision Analysis based at VUT for the following companies:

Data Sciences	Initiating Explosives Systems
Analytical Science Consultants	Saftec
Glaxo Australia	Datacraft Australia
Enterprise Australia	ICI Australia
The LEK partnership	Kaolin Australia
BP Australia	AMCOR
Melbourne Water	Kinhill Group
Australian Pulp and Paper Institute	

- Operated the Statistical Consulting Service at Victoria University of Technology from 1992-2003.

- From 2003-2004 worked as a Senior Statistician with Insureware on the analysis of long-tailed liability data.

- From December 2004 to December 2006, Deputy Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.

- From January 2007 to December 2012, Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.
- Extensive consulting and training on behalf of the Monash University Statistical Consulting Service for the following companies and organisations:

Australian Tax Office	Department of Human Services
J D McDonald	IMI Research
Port of Melbourne Corporation	Incitec Pivot
Agricola, Wunderlich & Associates	Parks Victoria
Australian College of Consultant Physicians	ANZ
Department of Justice	CRF(Colac Otway)
Australian Football League Players' Association	United Energy
ETSA	ENA

- From May 2011 to February 2013, Associate Professor and Co-ordinator of Statistical Support, Victoria University.
- From February 2013, Extensive consulting and training as Research Director of ESQUANT Statistical Consulting for the following companies and organisations:

United Energy & Multinet Gas	Choros
Competition Economists Group	Electricity Networks Association
SFG Consulting	Victoria University Office for Research
Engineered Wood Panels Association of Australasia	Monash University Department of Social Work
DBP	MAV
Deakin University Department of Psychology	

Postgraduate Supervision

Principal Supervisor

Gregory Simmons (1994-1997). M.Sc. completed. "Properties of some minimum run resolution IV designs."

Tony Sahama (1995-2003). Ph.D. completed. "Some practical issues in the design and analysis of computer experiments."

Ewa Sztendur (1999-2005). Ph.D. completed. "Precision of the path of steepest ascent in response surface methodology." [As a result of this thesis, Ewa was awarded the 2006 Victoria University Vice-Chancellor's Peak Award for Research and Research Training-Research Degree Graduate.]

Co-supervisor

Keith Hart (1996-1997). M.Sc. completed. "Mean reversion in asset prices and asset allocations in funds management."

Jyoti Behera (1999-2000). M.Eng. completed. "Simulation of container terminals."

Ray Summit (2001-2004). Ph.D. completed. "Analysis of warranty data for automobile data."

Rob Moore (2001-2007). Ph.D. completed. "Computer recognition of musical instruments.

M.Sc. Minor Theses

Milena Shtifelman (1999). Completed. (Monash University Accident Research Centre). "Modelling interactions of factors influencing road trauma trends in Victoria."

Rohan Weliwita (2002). Completed. "Modelling road accident trauma data."

Theses Examination

One M.Sc. major thesis (University of Melbourne) and one M.Sc minor thesis (Victoria University).

Workshops

Victoria University

- Experimental Design.
- Longitudinal Data Analysis.
- Statistics for Biological Sciences.
- Introductory Statistics for Research.
- Software Packages for Statistics.
- Design and Analysis of Questionnaires and Sample Surveys.
- Introductory SPSS.
- Statistics for Biological Sciences using R.
- Statistics for Biological Sciences using SPSS.
- Research Design and Statistics.

Monash University

- Expert Stats Seminars for higher degree research students on Software Packages for Statistics, Questionnaire Design, Analysis of Survey Data, and Multivariate Statistics.
- Introduction to Statistics for Pharmacy.
- Statistical Analysis for Social Workers.
- Statistical Methods for Social Workers.
- SPSS for Social Workers.

ESQUANT Statistical Consulting

- Introduction to Structual Equation Modelling using Lavaan and R.
- Introduction to Stata.
- Introduction to Structual Equatuon Modelling with Stata.

Other

- Design of Experiments for ICI Australia (One day course).
- Design of Experiments for Quality Assurance-including Taguchi Methods. A 2-day professional development short course on behalf of the Centre for Manufacturing Advanced Engineering Centre.
- Design of Experiments for the Australian Pulp and Paper Institute.
- Statistical Methods for ANZ Analytics.

Teaching Experience

Monash University

- Business Statistics (First Year), Marketing Research Analysis (Second Year), Survey Data Analysis (Third Year-Clayton and Caulfield).

Victoria University of Technology

- Applied Statistics (First Year), Linear Statistical Models, Sampling and Data Analysis (Second Year), Experimental Design (Third Year).
- Statistics for Engineers, Statistics for Nurses, Statistics for Occupational Health.
- Forecasting (Graduate Diploma in Business Science)

Sessional Teaching

- RMIT (1991, 1996-2002) Design of Experiments for Masters in Quality Management.
- AGSM (1993-1997): Total Quality Management for Graduate Management Qualification.
- Various other: The University of Melbourne, Enterprise Australia, Swinburne Institute of Technology.

Industry Projects

Over 30 projects for the following companies and organisations:

Gas and Fuel Corporation	Ford Australia
Mobil Australia	Fibremakers
ICI Australia	Western General Hospital
Data Sciences	Keilor City Council
AMCOR	Composite Buyers
Davids	Email Westinghouse
Craft Coverings	Australian Wheat Board
CSL	Holding Rubber
Viplas Olympic	Melbourne Water
Federal Airports Corporation	

Publications

Chapters in Books

1. Sztendur, E.M. and Diamond, N.T., (2001). “Inequalities for the precision of the path of steepest ascent in response surface methodology,” in Cho, Y.J, Kim, J.K., and Dragomir, S.S. (eds.) *Inequality Theory and Applications Volume 1*, Nova Publications.

Journal Articles

1. Diamond, N.T., (1991). “Two visits to Wisconsin,” *Quality Australia*, **7**, 30-31.

2. Diamond, N.T., (1991). “The use of a class of foldover designs as search designs,” *Austral. J. Statist*, **33**, 159-166.

3. Diamond, N.T., (1995). “Some properties of a foldover design,” *Austral. J. Statist*, **37**, 345-352.

4. Watson, D.E.R., Hallett, R.F., and Diamond, N.T., (1995). “Promoting a collegial approach in a multidisciplinary environment for a total quality improvement process in higher education, ” *Assessment & Evaluation in Higher Education*, **20**, 77–88.

5. Van Matre, J. and Diamond, N.T., (1996). "Team work and design of experiments," Quality Engineering, 9, 343–348.

6. Diamond, N.T., (1999). "Overlap probabilities and delay detonators," *Teaching Statistics*, **21**, 52–53. Also published in "Getting the Best from Teaching Statistics", one of the best 50 articles from volumes 15 to 21 of *Teaching Statistics*.

7. Cerone, P. and Diamond, N.T., (2000). "On summing permutations and some statistical properties," *The International Journal of Mathematical Education in Science and Technology*, **32**, 477-485.

8. Behera, J.M., Diamond, N.T., Bhuta, C.J. and Thorpe, G.R.,(2000). "The impact of job assignment rules for straddle carriers on the throughput of container terminal detectors," *Journal of Advanced Transportation*, **34**, 415-454.

9. Sahama, T. and Diamond, N.T., (2001). "Sample size considerations and augmentation of computer experiments," *The Journal of Statistical Computation and Simulation*, **68**, 307-319.

10. Paul, W. and Diamond, N.T., (2001). "Designing a monitoring program for environmental regulation: Part 1-The operating characteristic curve," *Water*: Journal of Australian Water Association, October 2001, 50-54.

11. Sztendur, E.M. and Diamond, N.T., (2002). "Extension to confidence region calculations for the path of steepest ascent," *Journal of Quality Technology*, **34**, 288-295.

12. Paul, W. and Diamond, N.T., (2002). "Designing a monitoring program for environmental regulation: Part 2-Melbourne Water case study," *Water*: Journal of Australian Water Association, February 2002, 33-36.

13. Steart, D.C., Greenwood, D.R., Boon, P.I. and Diamond, N.T., (2002) "Transport of leaf litter in upland streams of Eucalyptus and Nothofagus forests in South Eastern Australia," *Archiv Für Hydrobiologie,* **156**, 43-61.

14. Peachey, T. C., Diamond, N. T., Abramson, D. A., Sudholt, W., Michailova, A., and Amirriazi, S. (2008). "Fractional factorial design for parameter sweep experiments using Nimrod/E," *Sci. Program.*, **16**(2-3), 217–230.

15. Sahama, T.R. and Diamond, N.T. (2009) "Computer Experiment-A case study for modelling and simulation of Manufacturing Systems," *Australian Journal of Mechanical Engineering*, **7**(1), 1–8.

16. Booth, R., Brookes, R., and Diamond, N. (2012) " The declining player share of AFL clubs and league revenue 2001-2009: Where has the money gone?," *Labour and Industry* 22:4, 433–446.

17. Booth, R., Brookes, R., and Diamond, N. (2012) "Theory and Evidence on Player Salaries and Revenues in the AFL 2001-2009," Accepted for publication in *Economics and Labour Relations Review.*

18. Chambers, J.D., Bethwaite, B., Diamond, N.T., Peachey, T.C., Ambramson, D., Petrou, S., and Thomas, E.A. (2012) "Parametric computation predicts a multiplicative interaction between synaptic strength parameters controls properties of gamma oscillations," *Frontiers in Computational Neuroscience* Volume 6, Article 53 doi:103389/fncom.2012.00053.

19. Sztendur, E.M. and Diamond, N.T. (2013). "Using fractional factorial designs for variable importance in Random Forest models," *World Academy of Science, Engineering and Technology,* **71**, 1974–1978.

20. de Bruin, C.L., Deppeler, J.M., Moore, D.W., and Diamond, N.T. (2013) "Public school-based interventions for adolescents and young adults with an autism sprectrum disorder: a meta-analysis," *Review of Educational Research* prepublished 17 September 2013. DOI: 10.3102/0034654313498621

21. Jackson, M., Sztendur, E., Diamond, N., Byles, J. and Bruck, D."Sleep Difficulties and the Development of Depression and Anxiety: A Longitudinal Study of Young Australian Women", accepted for publication in *Archives of Women's Mental Health.*

22. Jackson, M., Sztendur. , E., N.T. Diamond., Byles, E.J., and Bruck, D. “Chronic sleeping difficulties in non-depressed young women: a longitudinal population-based investigation”. *Sleep Medicine*. DOI: 10.1016/j.sleep.2015.05.008

23. Jackson, M., Sztendur, E., N.T. Diamond, Byles, E.J, and Bruck, D. “Sleep difficulties and the development of depression and anxiety: A longitudinal study of young Australian women”, published in *Archives of Women's Mental Health* Volume 17, issue 3. DOI: 10.1007/s00737-014-0417-8.

24. Levinger, P., N.T. Diamond, Menz, H.B, Wee, E., Margelis, S., Stewart, A.G. ” Development and validation of a questionnaire assessing discrepancy between patients' pre-surgery expectations and abilities and post-surgical outcomes following knee replacement surgery.” published in *Knee Surgery Sports Traumatology Arthroscopy* November 2014. DOI: 10.1007/s00167-014-3432-4

Refereed Conference Papers

1. Behera, J., Diamond, N.T., Bhuta, C. and Thorpe, G., (1999). “Simulation: a decision support tool for improving the efficiency of the operation of road vehicles in container terminals,” 9th ASIM Dedicated Conference, Berlin, February 2000, 75-86.

2. Jutrisa, I., Diamond, N.T. and Cerone. P., (1999). “Frame size effects on throughput and return traffic in reliable satellite broadcast transmission, ” 16th International Teletraffic Congress, Edinburgh, Scotland.

3. Diamond, N.T. and Sztendur, E.M. (2002). “The use of consulting problems in introductory statistics classes”, *Proceedings of the 6th International Conference on the Teaching of Statistics.*

4. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). “Simulation Reliability Estimation from Early Failure Data, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 368-390.

5. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). “Simulation Reliability Estimation from Early Failure Data II, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 391-396.

6. Sahama, T. And Diamond, N.T. (2008). “Computer Experiment-A case study for modelling and simulation of Manufacturing Systems,” 9th Global Conference on Manufacturing and Management.

7. Jackson, M.L., Diamond, N.T., Sztendur E.M., Bruck, D. (2013). “The Role of Sleep Difficulties in the Subsequent Development of Depression and Anxiety in a Longitudinal Study of Young Australian Women, ” *American Professional Sleep Societies Scientific Meeting, Baltimore, MA* (Selected for an Honorable Mention Award) and *25th Annual Scientific Meeting of the Australasian Sleep Association, Brisbane, October.*

Reports

A number of confidential reports for ICI Australia from 1977-1987.

Victoria University

VU1. Diamond, N.T (1990). “Professional Experience Program at the Center for Quality and Productivity Improvement,” Footscray Institute of Technology.

VU2. Bisgaard, S. and Diamond, N.T (1991). “A discussion of Taguchi's methods of confirmatory trials,” Report No. 60. Center for Quality and Productivity Improvement, University of Wisconsin-Madison.

VU3. Diamond, N.T (1996). “Outside Studies Program at the Center for Quality and Productivity Improvement,” Victoria University of Technology.

VU4. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU5. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU6. Diamond, N.T (1998). "Statistical Analysis of BOD and SS compliance rates and license limits at ETP and WTP," prepared for Melbourne Water.

VU7. Diamond, N.T (1998). "Fate of pollutants at WTP-method for determining safety margins," prepared for Egis consulting group.

VU8. Bromley, M. and Diamond, N.T (2002). "The manufacture of Laboratory coreboard using various chip furnishes," prepared for Orica adhesives and resins.

Monash University

M1. Hyndman, R.J, Diamond, N.T. and de Silva, A. (2004). "A review of the methodology for identifying potential risky agents," prepared for the Australian Tax Office.

M2. Diamond, N.T. and Hyndman, R.J. (2005). "Sample Size for Maternal and Child Heath Service Evaluation," prepared for the Department of Human Services.

M3. Diamond, N.T. (2005). "Analysis of Customer Satisfaction Survey 2005," prepared for JD Macdonald.

M4. Diamond, N.T. (2005). "Analysis of 2005 Orientation Survey," prepared for Monash Orientation.

M5. Diamond, N.T. (2005). "Analysis of Before and After and Sequential Monadic Concept Consumer Surveys," prepared for IMI-Research.

M6. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: First Year Students," prepared for CHEQ, Monash University.

M7. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: The Best and Worst, " prepared for CHEQ, Monash University.

M8. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: The Best and Worst for First Year Students," prepared for CHEQ, Monash University.

M9. Diamond, N.T. (2005). "Technical Document for DUKC Uncertainty Study," prepared for Port of Melbourne Corporation.

M10. Diamond, N.T. (2005). "DUKC Uncertainty Study-Summary of Results," prepared for Port of Melbourne Corporation.

M11. Diamond, N.T. (2005). "Number of Ship trials for DUKC Uncertainty Study," prepared for Port of Melbourne Corporation.

M12. Diamond, N.T. (2005). "Threshold Criteria for Touch Bottom Probabilities," prepared for Port of Melbourne Corporation.

M13. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst," prepared for CHEQ, Monash University.

M14. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst for First Year Students," prepared for CHEQ, Monash University.

M15. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: A Statistical Analysis," prepared for CHEQ, Monash University.

M16. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: 2005 vs. Pre-2005 Students," prepared for CHEQ, Monash University.

M17. Diamond, N.T. (2006). "Agreement of 110/116 and 111/117 items by Consultant Physicians," prepared for the Australian College of Consultant Physicians.

M18. Diamond, N.T. (2006). "Analysis of Statistical Issues regarding Cornish v Municipal Electoral Tribunal, " prepared for Agricola, Wunderlich & Associates.

M19. Diamond, N.T. (2006). "Analysis of Parks Victoria Staff Allocation," prepared for Parks Victoria.

M20. Diamond, N.T. and Hyndman, R.J. (2006). "Summary of Results of IPL Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M21. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student retention at Monash University", prepared for University retention committee.

M22. Sztendur, E.M. and Diamond, N.T. (2007) "An extension to a model for student retention at Monash University", prepared for University review of coursework committee.

M23. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student academic performance at Monash University", prepared for University review of coursework committee.

M24. Diamond, N.T. (2007). "Analysis of IB student 1st year results at Monash University 2003-2005", prepared for VTAC.

M25. Diamond, N.T. (2008). "Effect of smoking bans on numbers of clients utilising problem gambling counselling and problem gambling financial counselling", prepared for Department of Justice

M26. Diamond, N.T. (2008). "Development of Indices Based Approach for Forecasting Gambling Expenditure at a Local Government Area Level", prepared for Department of Justice

M27. Diamond, N.T. (2008). "Orientation 2007- Analysis of Quantitative results", prepared for University Orientation committee.

M28. Diamond, N.T. (2008). "Orientation 2007- Analysis of Qualitative results, prepared for University Orientation committee.

M29. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling Services-2002/03 to 2005/06", prepared for the Department of Justice.

M30. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Financial Counselling Services-2001/02 to 2005/06", prepared for the Department of Justice.

M31. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling and Problem Gambling Financial Counselling Services-2006/07", prepared for the Department of Justice.

M32. Diamond, N.T. (2008). "The effect of changes to Electronic Gaming Machine numbers on gambling expenditure", prepared for the Department of Justice.

M33. Diamond, N.T. (2009). "Adjustment of Mark Distributions", prepared for the Faculty of Law.

M34. Diamond, N.T. (2009). "Summary of Results for Dyno Nobel Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M35. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Multicollinearity and Reproducibility Issues", prepared for the Victorian Electricity Distributors.

M36. Booth, R., Diamond, N., and Brooks, R. (2010). "Financial Analysis of Revenues and Expenditures of the AFL and of the AFL Clubs", prepared for the Australian Football League Players' Association.

M37. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Sample Selection, and Standard Errors", prepared for the Victorian Electricity Distributors.

M38. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Joint Confidence Region and Other Multicollinearity Issues", prepared for the Victorian Electricity Distributors.

M39. Diamond, N. and Brooks, R. (2010). "Reconstructing the Beggs and Skeels Data Set", prepared for the Victorian Electricity Distributors.

M40. Diamond, N. and Brooks, R. (2010). "Response to AER Final Decision", prepared for the Victorian Electricity Distributors.

M41. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Faculty Results", prepared for Victoria University (6 reports).

M42. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Campus Results", prepared for Victoria University.

M43. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Qualitative analysis of comments", prepared for Victoria University (17 reports).

M44. Diamond, N. and Brooks, R. (2011). 'Review of SFG 2011 Dividend Drop-off Study'. prepared for Gilbert and Tobin on behalf of ETSA.

M45. Diamond, N. (2011). 'A review of "Using capture-mark-recapture methods to estimate fire starts in the United Energy distribution area", by Rho Environmetrics Pty.Ltd. and John Field Consulting Pty.Ltd', prepared for United Energy.

M46. Diamond, N., Brooks, R., and Macquarie, L. (2013). 'Estimation of Fair Value Curves', prepared for APA Group, Envestra, Multinet Gas, and SP AusNet. 7th February 2013.

ESQUANT Statistical Consulting

E1. Diamond, N.T. and Sztendur, E.M. (2013). "Assistance with Data Mining", prepared for confidential accounting firm. 21 January 2013.

E2. Diamond, N.T. (2013). "A review of NERA's analysis of McKenzie and Partington's EGARCH analysis,' prepared for Multinet Gas. 9 April 2013 and 5 August 2013.

E3. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). "Assessing the reliability of regression-based estimates of risk ," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 17 June 2013.

E4. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). 'The Vasicek adjustment to beta estimation in the Capital Asset Pricing Model," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 17 June 2013.

E5. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). "Comparison of OLS and LAD regression techniques for estimating beta," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 26 June 2013.

E6. Diamond, N.T., Brooks, R. and Young, D. (2013a). "Review of CEG Report: Estimating the debt risk premium, a report for United Energy", prepared by ESQUANT Statistical Consulting in conjunction with the Department of Econometrics and Business Statistics, Monash University, and the Competition Economists Group, 30th August 2013.

E7. Diamond, N.T. and Young, D. (2013). "Estimating Benchmark Distributions," For Chorus, in conjuction with Competition Economists Group. 2nd September 2013.

E8. Diamond, N.T. (2013). "Design of Sampling and Testing Program for Particleboard & MDF," for Engineered Wood Products Association of Australia. 6 September 2013.

E9. Diamond, N.T. (2013). “Regression Analysis for Credit Rating,” For Competition Economists Group. 17 September 2013.

E10. Diamond, N.T. (2013). “Cross-checking of ERA (WA) beta estimates,” For Competition Economists Group. 18 September 2013.

E11. Diamond, N.T. and Brooks, R. (2013b). “Review of ERA (WA) Yield Curve Analysis, a report for United Energy and Multinet Gas”, prepared by ESQUANT Statistical Consulting in conjunction with the Department of Econometrics and Business Statistics, Monash University, for United Energy and Multinet Gas, 26th September 2013.

E12. Diamond, N., Brooks, R and D. Young. The development of yield curves, zero coupon yields, and par value yields for corporate bonds. Technical report, ESQUANT Statistical Consulting in conjuction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University and Competition Economists Group, 2014. For United Energy and Multinet Gas in response to the AERs draft rate of return guidelines. 17 October 2013.

E13. N.T. Diamond. Comments on RBA measures of Australian corporate credit spread. Technical report, ESQUANT Statistical Consulting, 2014. For United Energy and Multinet Gas. 14 January 2014.

E14. N.T. Diamond and R. Brooks. Review of ERA (WA) yield curve analysis: Response to explanatory statement for the rate of return guidelines (released 16th december 2013). Technical report, ESQUANT Statistical Consulting in conjuction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University, 2014. For United Energy and Multinet Gas. 14 January 2014.

E15. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Developing protocol for establishing compliance part 1. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 5 March 2014.

E16. N.T. Diamond. Paid parental leave survey: Data manipulation. Technical report, ESQUANT Statistical Consulting, 2014. For Ms Samone McCurdy, Department of Social Work, Monash University, 11 March 2014.

E17. N.T. Diamond. Mens behaviour change program: Update to comparisons of survey 1 and 2. Technical report, ESQUANT Statistical Consulting, 2014. For Professor Thea Brown and Ms Paula Fernandez Arias, Department of Social Work, Monash University, 14 March 2014.

E18. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Developing protocol for establishing compliance part 2. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 28 March 2014.

E19. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Comments on stages B and C. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 15 April 2014.

E20. N.T. Diamond and R. Brooks. A review of measures of Australian corporate credit spreads published by the Reserve bank of Australia: Submission to the issues paper (Return on debt: Choice of third party data service provider) released by the Australian Energy Regulator (April 2014). Technical report, ESQUANT Statistical Consulting in conjunction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University, 2014. For United Energy and Multinet Gas. 19 May 2014.

E21. N.T.Diamond. Comments on Incenta Economic Consulting Report: Methods for extrapolation of the debt risk premium. Technical report, ESQUANT Statistical Consulting. 10 June 2014.

E22. Diamond, N.T. and Brooks, R. (2015). “Evaluation of Methods for Extrapolating Australian Corporate Credit Spreads published by the Reserve Bank of Australia, a report prepared for United Energy and Multinet Gas”; ESQUANT Statistical Consulting, 29th April 2015.

E23. J.Ockerby, D.Young, Y.Liu and N.T. Diamond. “Benchmarking prices for DTCS”, a report for Optus in conjuction with Competition Economists Group. May 2015.

E24. J.Ockerby, Y.Liu and N.T. Diamond. “Critique of EI’s approach,” a report for Optus in conjuction with Competition Economists Group. July 2015.

E25. Diamond, N.T. (2015). “Analysis of Ovarian Cancer Survey,” a report for the Centre for Community Driven Research, 4 September 2015.

E26. Diamond, N.T. (2015). “AER information request United Energy - Number 032 Return on debt,” a report for Uniyed Energy and Multinet Gas, 21 September 2015.

Professional Service

- President, Victorian Branch, Statistical Society of Australia, 2001-2002.
    - Terms as Council Member, Vice-President, and Past President.
- Referee: *Australian and New Zealand Journal of Statistics*, *Biometrika*, *Journal of Statistical Software*

CURRICULUM VITAE: Jeremy Thomas Rothfield

CAREER SUMMARY:

Jeremy is an accomplished economist who specializes in the analysis of the return on debt, the return on equity, and the valuation of imputation credits. He has a keen interest in debt markets, fixed income assets, infrastructure and utilities. He is currently acting as a consultant for ESQUANT Statistical Consulting. In his immediately preceding role, as the Manager of Network Regulation and Compliance at United Energy and Multinet Gas, (UE and MG), he was responsible for an ongoing project which was run in conjunction with other industry participants. The project was about the application of theory and empirical methods to improve the analysis of the rate of return.

Formerly, as a regulatory economist within UE and MG, Jeremy contributed to the development of incentive schemes and demand management programmes. He implemented and managed a regulatory compliance regime.

He previously worked as a consultant in economic advisory firms and provided advice to superannuation funds and other clients about direct equity investments in infrastructure assets. He was engaged in multi-disciplinary teams and contributed to the formulation of government policies affecting, respectively, the energy and gaming industries. Jeremy achieved successful outcomes from projects by remaining client-focused and attentive to the needs of key stakeholders.

TECHNICAL QUALIFICATIONS AND EXPERTISE:

Jeremy delivers authoritative advice, underpinned by rigorous analysis, to executive management, lawyers, and other affected parties. He has a sound grasp of regulatory frameworks in the energy and water industries.

- Jeremy has significant expertise in the use of economic cost-benefit analysis.
- He is well versed in the application of quantitative methods, including financial modelling, econometrics, and time series macro-economic modelling.
- He is proficient with Excel, can write macros using Visual Basic, and is competent with Access. He is also an experienced user of the Bloomberg subscription service and analytical tools.
- He is an experienced user of the GEMPACK suite of general equilibrium modelling programs and possesses the skills necessary to construct economic models which can be represented algebraically.
- He is familiar with emerging climate change issues and has an interest in non-market valuation techniques which can be used in environmental applications more generally.
- Jeremy is comfortable dealing with large datasets, and, in the context of his PhD thesis, managed a database comprised of nearly one million property transaction records. He used Microsoft Access to perform data management tasks, and Excel for most front-end data processing.

TERTIARY EDUCATION:

Monash University, Australia, 2003 – 2008	Awarded a PhD in Economic Modelling, following the successful completion of course work, and the submission of a thesis. The thesis topic was: The economic impact of a national programme to place electricity distribution infrastructure underground.
University of Essex, U.K., 1993 – 1995	Awarded an M.A. in Economics with Distinction. During his studies, Jeremy was the recipient of an award from the European Social Fund. A dissertation was prepared and submitted covering the topic of rural to urban migration in developing countries.
University of Bristol, U.K., 1990-1993	Awarded a B.Sc. in Economics and Accounting, with First Class Honours.

PROFESSIONAL EXPERIENCE:

United Energy and Multinet Gas (UE and MG), Melbourne, Australia	
Manager, Network Regulation and Compliance	July 2011 to November 2015

Key responsibilities:

- Over-arching responsibility for the contribution by UE and MG to the rate of return guideline consultation that was hosted by the Australian Energy Regulator (AER) in 2013. Providing leadership for activities across industry associations, notably the Energy Networks Association (ENA). Liaising with other stakeholders, including consumer groups, government representatives, other regulators, and other businesses.
- Preparation and management of the return on capital component of five-yearly pricing reviews, including the Gas Access Arrangement Review (GAAR), and the Electricity Distribution Pricing Review (EDPR).
- Overseeing the development of strategic positions in relation to other economic regulatory issues, such as economic benchmarking, total factor productivity, and the use of price and revenue caps.
- Managed UE and MG input to AER consultations on the development of spread sheet models used to determine weighted average distribution prices.
- Provided assistance and training to finance. Liaison with finance about the debt issuance programme and hedging.

United Energy and Multinet Gas (UE and MG), Melbourne, Australia	
Regulatory Economist	June 2009 – July 2011

Key responsibilities:

- Prepared written submissions for governments, regulators and rule-makers. The submissions were on behalf of UE and/or MG, or an industry group.
- Participated in negotiations with governments, other industry stakeholders, and regulators, with a view to influencing the on-going development and operation of national and state based codes, regulations and guidelines. The ultimate objective was to obtain beneficial financial outcomes for electricity and gas distribution businesses.
- Exercised strategic leadership on critical price-review related matters, and demonstrated initiative and ingenuity in particular areas of expertise.
- The establishment and management of a compliance regime for the two businesses. The compliance function had previously been out-sourced. Jeremy completed annual reviews of compliance in relation to the relevant codes, guidelines, licenses, rules and statutory obligations. Occasional requests from the AER were handled expeditiously. A system of bi-monthly compliance meetings was instigated and maintained.

WorleyParsons, Melbourne, Australia	
Senior environmental economist	2008 to 2009

Key responsibilities:

- Assisted the firm to move towards a more holistic, broadly-based method of project evaluation. The firm developed “EcoNomics”, a system for measuring a wide range of costs and benefits associated with project alternatives. The effects on environmental variables were quantified explicitly and then incorporated into business decision-making.

Achievements:

- Lead economist working on the valuation of externalities for infrastructure projects. Jeremy was responsible for finding dollar metrics or benchmarks for hard-to-measure intangible assets which have an impact on sustainability. The project highlights included:
  - *Sustainability dilemma project II*, undertaken for the Water Corporation of Western Australia. Jeremy investigated the feasibility of installing reticulated sewerage systems in towns in regional Western Australia. An economic cost benefit analysis was undertaken. Several categories of benefit were quantified, including the value to public health of the installation of reticulated sewerage systems.

- *Busselton Wastewater Treatment Plant*, undertaken for the Water Corporation of Western Australia. A full cost-benefit analysis was performed. Jeremy measured the economic consequences of the loss of an area of sea-grass in Geographe Bay. - *An assessment of an Integrated Wood Processing Plant,* undertaken for Verve Energy. Jeremy developed a financial model to quantify the economic benefits of the attenuation of salinity in the wheat belt of Western Australia. The problem of salinity would be eased by the establishment of an Oil Mallee plantation.

Centre of Policy Studies, Monash University, Australia	
Economic modeler (part-time while undertaking PhD studies).	2005 to 2008
Key responsibilities: • Contributing to research projects as required, and undertaking *ad hoc* analysis for senior research fellows.	
Achievements: • Preparing reports for EnergySafe, Victoria, on the economic issues related to the removal of overhead power lines, and their replacement with underground electricity distribution infrastructure. • Producing a yearly, global statistical compendium of the wine industry. - The publication was dense and Jeremy was responsible for data collection, programming, analysis, and presentation of the results in electronic format. • Contributing to the on-going development of the Monash Multi-Regional Forecasting Model (MMRF). The model was used, in the context of the Garnaut Review and Treasury modelling exercise, to assess the consequences for the Australian economy of the introduction of an emissions trading scheme (ETS).	

ACIL Tasman, Melbourne, Australia	
Economic modeler (part-time while undertaking PhD studies).	2003 to 2005
Key responsibilities: • Senior consultant, managing other economists on specific projects.	
Achievements: • Strategic advice to the chief executive, Nick Morris, on a joint venture with Oxford Economic Forecasting (UK). • *Economic contribution study of Foster's Group activities,* undertaken for Carlton and United Breweries. • *Review of the Maxwell recommendations on occupational, health and safety*, performed for the Victorian Department of Treasury and Finance. A cost-benefit analysis was undertaken of recommendations for changes to OH&S legislation as set out in a government commissioned report written by a lawyer. The analysis was done within a regulatory impact statement (RIS) framework.	

Access Economics, Melbourne, Australia		
Senior Economist		2002 to 2003
Economist		2000 to 2002
Key responsibilities	• Application of economic principles and theory, econometrics and macro-economic modelling. • Participation in consultancy projects, working across jurisdictions. • Business development, including sourcing new clients and writing and costing proposals for work.	
Achievements	Jeremy was engaged in consultancy projects of different types across a range of industry sectors. The broad groupings by activity and industry can be summarized as follows: Macro-economic modelling, urban economics, transport economics, health care, occupational health	

	and safety, micro-economic reform and competition policy, gambling industry economics, energy consulting projects, other infrastructure and agricultural industries. Examples of projects in which Jeremy played a major role are presented below.
Urban economics	• A framework was developed to assess the economic effects of a proposed retail and commercial property development at Melbourne's Docklands, on behalf of MAB Corporation. This was accompanied by quantification of measurable impacts, such as travel time savings, and commercial property values. The work was undertaken in August 2001, and then updated in August 2002.
Transport economics	• *Review of costs for the Speedrail project.* I assessed a wide range of information about the Speedrail project that had been submitted by the project proponents. My remit was to provide recommendations to the Department of Finance and Administration.
Micro-economic reform and competition policy	• *Assessing the Economic Impact of the Privatisation of Victorian Electricity and Gas Utilities*. The study was commissioned by TXU Ltd., an integrated gas and electricity utility, in late 2000, and involved a review of Victoria's energy privatisation program of the mid-1990s. A number of different approaches were taken to measuring the economic consequences of restructuring of the energy industry in Victoria and Australia. • *National Competition Policy Review of Victorian Gaming Machine Legislation* (August 2000). Jeremy prepared a submission on behalf of TABCORP, one of two Victorian gaming machine operators.
Gambling industry economics	• *Insights into problem gambling provided by the Household Expenditure Survey (HES)* (March 2001). A report was prepared for Tattersall's, based on a detailed investigation of the unit record files of the 1998-99 ABS Household Expenditure Survey. • Strategic advice for TABCORP, a Victorian gaming machine operator, on the socio-economic impact of placing gaming machines in particular suburban localities.
Energy consulting projects	• *Risk analysis of a potential investment in ElectranetSA*, the South Australian electricity transmission provider (August 2003). This involved the detailed review of a Macquarie Bank financial model, which sought to reconstruct the building blocks of a regulatory decision, (by the Australian Competition and Consumer Commission), on transmission revenue controls. • *Review of wholesale energy market contracts for ActewAGL*, the principal energy market retailer in the ACT (April 2003). • Advisory work for the National Generators' Forum (NGF) on the development of a response to proposed bidding/re-bidding rule changes in the National Electricity Market (October 2002). Adopting a public policy perspective, Jeremy evaluated and improved upon submissions by NGF members covering a raft of technical issues under the National Electricity Code. • An investigation of the desirability of implementing full retail contestability in electricity and gas supply in the ACT (May 2002). The study was commissioned by the ACT Electricity and Water Corporation, and assessed a range of costs and benefits that would result from the introduction of full user choice for households and businesses. • *Economic analysis of proposed electricity price increase*s (December 2001). Access Economics was commissioned by five Victorian electricity retailers to analyse their case for retail electricity price increases commencing from 2002. The proposed price changes had been rejected by the Victorian Office of the Regulator General, (ORG). The firm analysed information provided by the retailers and prepared a well-founded critique of the ORG's rebuttal. • *Economic Impact of a Natural Gas Pipeline from Victoria to South Australia,* undertaken for TXU *(*April 2000). This study analysed and reported on the likely economic benefits arising from the establishment of a gas pipeline from south-western Victoria to Adelaide, South Australia. The impacts were evaluated in terms of an increase in competition for the supply of gas, a potential stimulus to industry, fewer disruptions to gas supply, the prolongation of Cooper Basin gas reserves, promoting regional development, and encouraging gas

	exploration and development.
Other infrastructure	• Jeremy conducted a full appraisal of the regulatory and *force majeure* risks of investing in infrastructure assets, with a particular emphasis on regulated businesses in the energy sector. The results of the work were condensed into a report which was submitted to the board of a superannuation fund client. • Economic and financial evaluation of Brisbane Airport (April 2000). This project, undertaken for a potential investor, involved a thorough review of the patronage projections for Brisbane Airport, in conjunction with an assessment of air traffic movements. A full range of other issues was also considered, bringing the analysis up to the standard of a due diligence. • Jeremy participated in the preparation of quarterly reports on non-listed investments (excluding property) for superannuation fund clients. The investments covered included ports, forestry plantations, a hospital, and energy sector businesses.

KPMG Consulting, Melbourne, Australia	
Consultant Economist, Competition and Regulation Group	1998 to 1999

Synopsis

- Jeremy worked on a range of consultancy assignments including two major National Competition Policy (NCP) Legislation Reviews. His role was to design and implement the empirical study component of each Review. This entailed financial modelling and/or econometric estimations.

A description is provided below of the projects to which Jeremy contributed in a substantive way.

- *NCP Review of Victorian Wine Grapes Legislation*. This well-received project involved a competition policy appraisal of two Wine Grape Marketing Orders made under the *Agricultural Industry Development Act 1990*. Granger causality tests were performed to unravel the relationship between indicator and actual grape prices. A simultaneous equation model was constructed for sultana grape prices.
- *NCP Review of Commonwealth and State Pharmacy Legislation*. A submission was prepared for this ongoing review on behalf of the Pharmacy Guild of Australia. Jeremy conducted econometric estimations based on a translog function using Guild survey data. The work was scrutinised by Dr Joe Hirschberg, senior lecturer in Economics at the University of Melbourne. The conclusions reached refuted those drawn in an earlier analysis by the Bureau of Industry Economics.
- *The Evaluation of Strategies for Managing in a Regulated Environment*. This report prepared for Westar, a newly privatised Victorian gas distributor, analysed the impact on Westar's "target revenue" of changes to the timing of capital outlays, operations and maintenance spending. The empirical work made use of a spreadsheet-based financial model developed by KPMG for the Victorian Treasury's *Energy Projects Division (EPD)*.
- *Port of Fiji Tariffs Review and Restructure.* The Maritime and Ports Authority of Fiji commissioned KPMG to restructure and simplify its tariffs structure. The move to a fixed fee tariff schedule was intended to be revenue-neutral. Jeremy applied the *EPD's* financial model to the task. Projections were made of shipping traffic, cargo volumes, costs and capital works. The current-cost accounting depreciation modules were extended to 2015.
- *Longitudinal Community Impact Study.* This assignment was part of the Victorian Casino and Gaming Authority's 1998-99 research programme. Jeremy played a major role in this project including writing the proposal, participating in consultations, providing comment on the draft survey, and designing the empirical component of the work. Panel regressions were undertaken using quarterly data on net player expenditure for 68 local government areas of Victoria. The effect on player losses of variables such as social security expenditure was investigated.

National Institute of Economic and Industry Research, (NIEIR), Melbourne, Australia	
Economic analyst	1995 to 1998

Key responsibilities:

- Preparing forecasts covering OECD economies and Australia's major trading partners. Maintaining NIEIR's international model by updating historical data and recalibrating equations of the model sub-routines.
- Delivering presentations at both NIEIR and external conferences on such topics as the Asian financial crisis and the difficulties of switching to a single European currency.
- Preparing and updating NIEIR's short and medium term forecasts of the Australian economy. Compiling the monthly *Natstat leading indicators* bulletin, reports about which featured regularly in the financial media.

Achievements:

- Making worthwhile contributions to consultancy projects for corporate and government clients. Acquiring knowledge of input-output industry linkages and the statistical releases prepared by the Australian Bureau of Statistics (ABS). Undertaking selected assignments with limited or no supervision.

INTERESTS AND HOBBIES:

- Water-sports enthusiast - enjoying sailing, scuba diving and swimming (amateur competitor).
- Qualified British Sub-Aqua Club diving instructor, with nearly five hundred dives logged.
- Keen snow-skier and member of a ski club in Victoria.
- Avid supporter of eco-tourism and participated in a three-month long conservation project on Mafia Island, in Tanzania.

LANGUAGES:

- English – native speaker.
- French – proficient, following school studies and the completion of a course in advanced spoken and written French. A Diploma was obtained from the Alliance Francaise Internationale.
- Kiswahili – fluent.

PROFESSIONAL REFEREES:

Professional referees are available upon request.