Supplement to ‘Statistical Modelling of Citation Exchange Between Statistics Journals’

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This document illustrates the `R` (R Core Team, 2015) code accompanying Varin, Cattelan and Firth (2015). The files needed to replicate the analyses in the paper are contained in the compressed folder `JRSS-PR-SA-Dec-13-0008_supplement.zip`. The figures and tables in the paper differ in minor respects from those produced in this document due to some manual editing for inclusion in the paper.

1 Cross-citation data

The 47×47 cross-citation matrix $\mathbf{C} = [c_{ij}]$ is in file `cross-citation-matrix.csv`:

```
Cmatrix <- as.matrix(read.csv("Data/cross-citation-matrix.csv",
                              row.names = 1))
```

Journals are identified in $\mathbf{C}$ through the journal abbreviations listed in Table 1 of the paper:

```
journal.abbr <- rownames(Cmatrix)
journal.abbr

##  [1] "AmS"    "AISM"   "AoS"    "ANZS"   "Bern"   "BioJ"   "Bcs"
##  [8] "Bka"    "Biost"  "CJS"    "CSSC"   "CSTM"   "CmpSt"  "CSDA"
## [15] "EES"    "Envr"   "ISR"    "JABES"  "JASA"   "JAS"    "JBS"
## [22] "JCGS"   "JMA"    "JNS"    "JRSS-A" "JRSS-B" "JRSS-C" "JSCS"
## [29] "JSPI"   "JSS"    "JTSA"   "LDA"    "Mtka"   "SJS"    "StataJ"
## [36] "StCmp"  "Stats"  "StMed"  "SMMR"   "StMod"  "StNee"  "StPap"
## [43] "SPL"    "StSci"  "StSin"  "Tech"   "Test"
```

2 Cluster analysis

Computation of the matrix of the total number of citations exchanged between pairs of journals $\mathbf{T} = [t_{ij}]$ defined in formula (1) of the paper:

```r
Tmatrix <- Cmatrix + t(Cmatrix)
diag(Tmatrix) <- diag(Cmatrix)
```

Hierchical clustering of journals with complete linkage using distance $d_{ij} = 1 - \rho_{ij}$, where ρ_{ij} is the Pearson correlation between journals i and j:

```r
journals.cluster <- hclust(d = as.dist(1 - cor(Tmatrix)))
```

Dendrogram (Figure 1 of this document):

```r
plot(journals.cluster, sub = "", xlab = "")
```

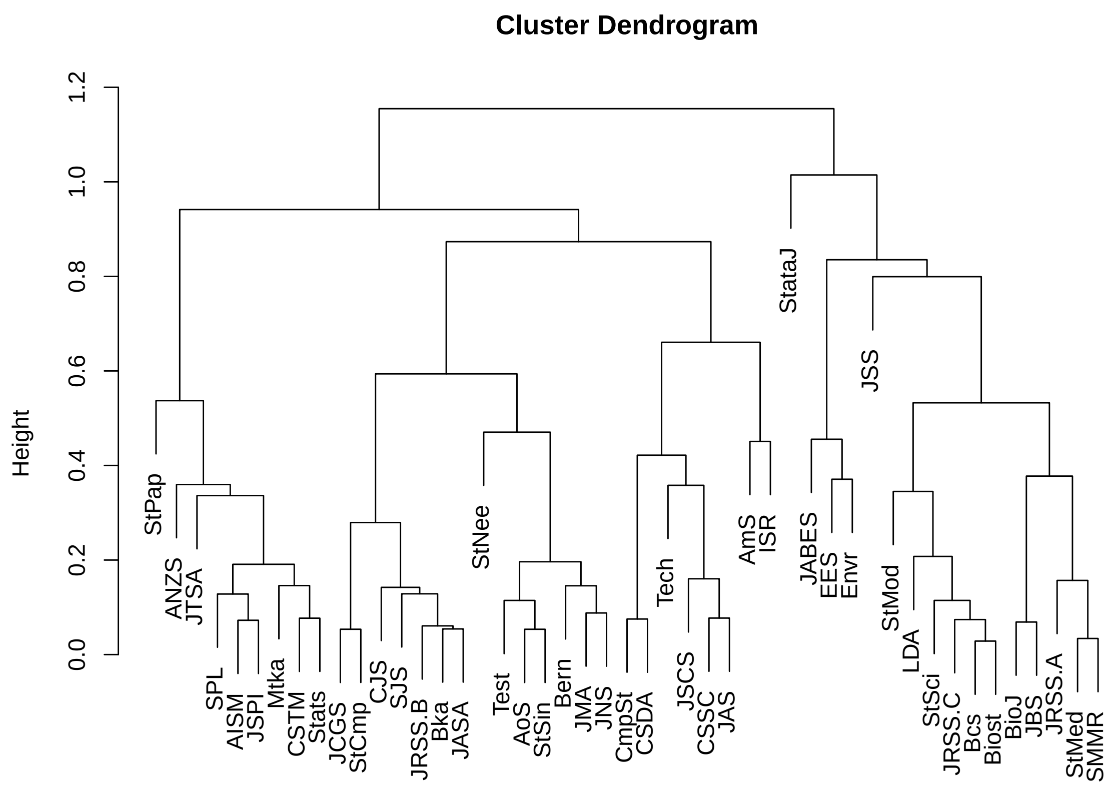


Figure 1: Dendrogram of the hierarchical cluster analysis of journals.

3 Quasi-Stigler model

The quasi-Stigler model is fitted with the `BradleyTerry2` package (Turner and Firth, 2012):

```r
require(BradleyTerry2)
```

Re-arrange data in a form suitable for the `BradleyTerry2` package:

```r
Cdata <- countsToBinomial(Cmatrix)
```

Fit the model:

```r
fit <- BTm(outcome = cbind(win1, win2),
           player1 = player1, player2 = player2, data = Cdata)
```

Estimation of the overdispersion parameter defined in formula (7) of the paper:

```r
npairs <- NROW(Cdata)
njournals <- nlevels(Cdata$player1)
phi <- sum(residuals(fit, "pearson")^2) / (npairs - (njournals - 1))
phi

## [1] 1.759027
```

3.1 Journal residuals

Computation of the 'journal residuals' discussed in Section 5.2 of the paper:

```r
journal.res <- rep(NA, njournals)
res <- residuals(fit, type = "pearson")
coefs <- c(0, coef(fit)) # 0 is the coefficient of the first journal
for(i in 1:njournals){
    A <- which(Cdata$player1 == journal.abbr[i])
    B <- which(Cdata$player2 == journal.abbr[i])
    y <- c(res[A], -res[B])
    x <- c(-coefs[Cdata$player2[A]], -coefs[Cdata$player1[B]])
    journal.res[i] <- sum(y * x) / sqrt(phi * sum(x ^ 2))
}
names(journal.res) <- journal.abbr
```

Normal probability plot of journal residuals with 95% envelope (Figure 2) computed with function `qqPlot` from package `car` (Fox and Weisberg, 2011):

```
require(car)
qqPlot(journal.res, ylab = "Sorted journal residuals",
       xlab = "Normal quantiles")
```

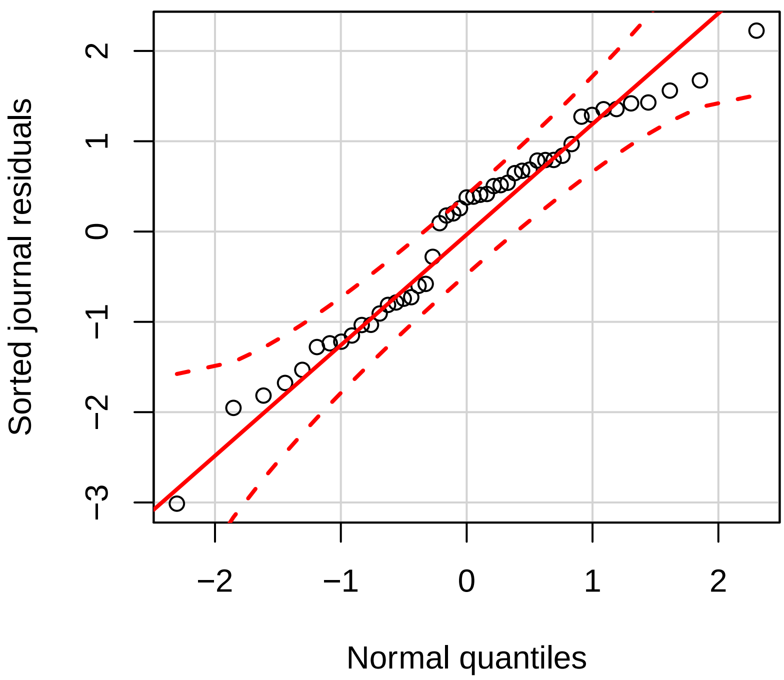


Figure 2: Normal probability plot of journal residuals with 95% envelope.

Scatterplot of journal residuals against estimated export scores (Figure 3 in this document):

```
plot(journal.res ~ coefs, ylab = "Journal residuals",
     xlab = "Export scores")
```

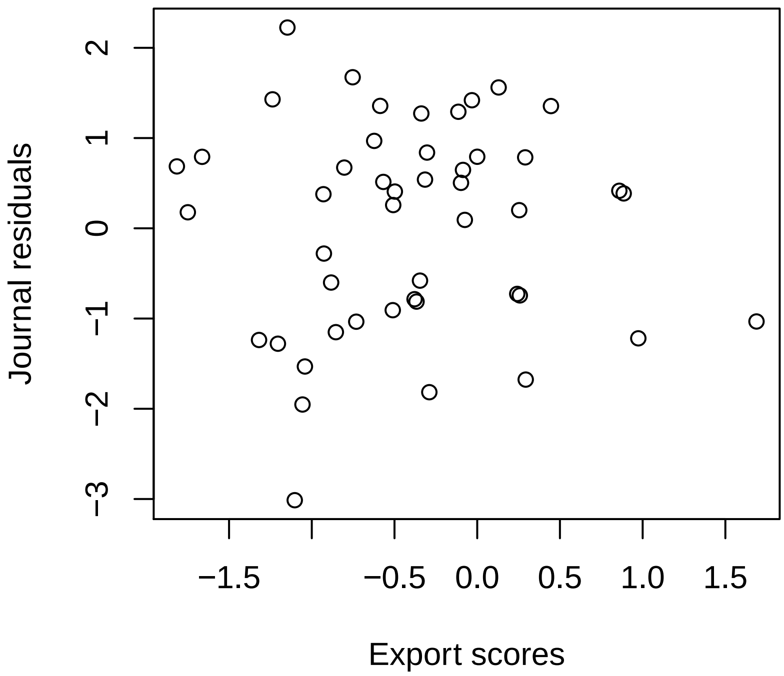


Figure 3: Scatterplot of journal residuals against estimated export scores.

3.2 Quasi standard errors

Quasi standard errors discussed in Section 5.3 of the paper, computed with the `qvcalc` package (Firth, 2012):

```
require(qvcalc)
cov.matrix <- matrix(0, nrow = njournals, ncol = njournals)
cov.matrix[-1, -1] <- vcov(fit)
qse <- qvcalc(phi * cov.matrix , estimates = c(0, coef(fit)),
              labels = journal.abbr)
```

By default, the `BTm` function in the `BradleyTerry2` package fits the Bradley-Terry model with a 'corner constraint', *i.e.*, the export score of the first journal in alphabetic order is fixed to zero. In the paper, results are displayed with the 'more democratic' zero-sum parameterization:

```
export.scores <- qse$qvframe$estimate
export.scores <- export.scores - mean(export.scores)
names(export.scores) <- journal.abbr
```

Table of estimates and standard errors in decreasing order:

```
sort.id <- sort(export.scores, decreasing = TRUE,
                index.return = TRUE)$ix
fit.table <- data.frame(quasi = export.scores[sort.id],
                        qse = qse$qvframe$quasiSE[sort.id])
fit.table
```

```
##              quasi        qse
## JRSS-B  2.0911231 0.10513395
## AoS     1.3767352 0.07386382
## Bka     1.2884149 0.08119563
## JASA    1.2619488 0.06014319
## Bcs     0.8485257 0.07245316
## .               .          .
## .               .          .
## JAS    -1.4126066 0.15093299
```

Centipede plot (Figure 4) drawn with the `plotrix` package (Lemon, 2006):

```
require(plotrix)
segs <- apply(fit.table, 1, function(x) x[1] + c(0, -1.96, 1.96) * x[2])
centipede.plot(segs, left.labels = journal.abbr[sort.id],
               right.labels = round(export.scores[sort.id], 2),
               xlab = "Export Scores")
```

4 Ranking lasso

Read the ranking-lasso code (Masarotto and Varin, 2012):

```
source("R-code/ranking-lasso.R")
```

Computation of the complete path of the adaptive ranking lasso estimation[1]:

```
## time consuming
rlasso <- ranking.lasso(y = fit$model$Y, X = fit$model$X,
                        adaptive = TRUE)
```

The object `rlasso` returns a list containing the following components:

[1] **Warning**: The computation is relatively time-consuming, it takes about 70 seconds on a MacBook Air 1.8 GHz Intel Core i7 with 4 GB RAM. Function `ranking.lasso` is designed for moderate-size tournament data; the code can, and should, be re-designed for more efficient computation in larger applications.

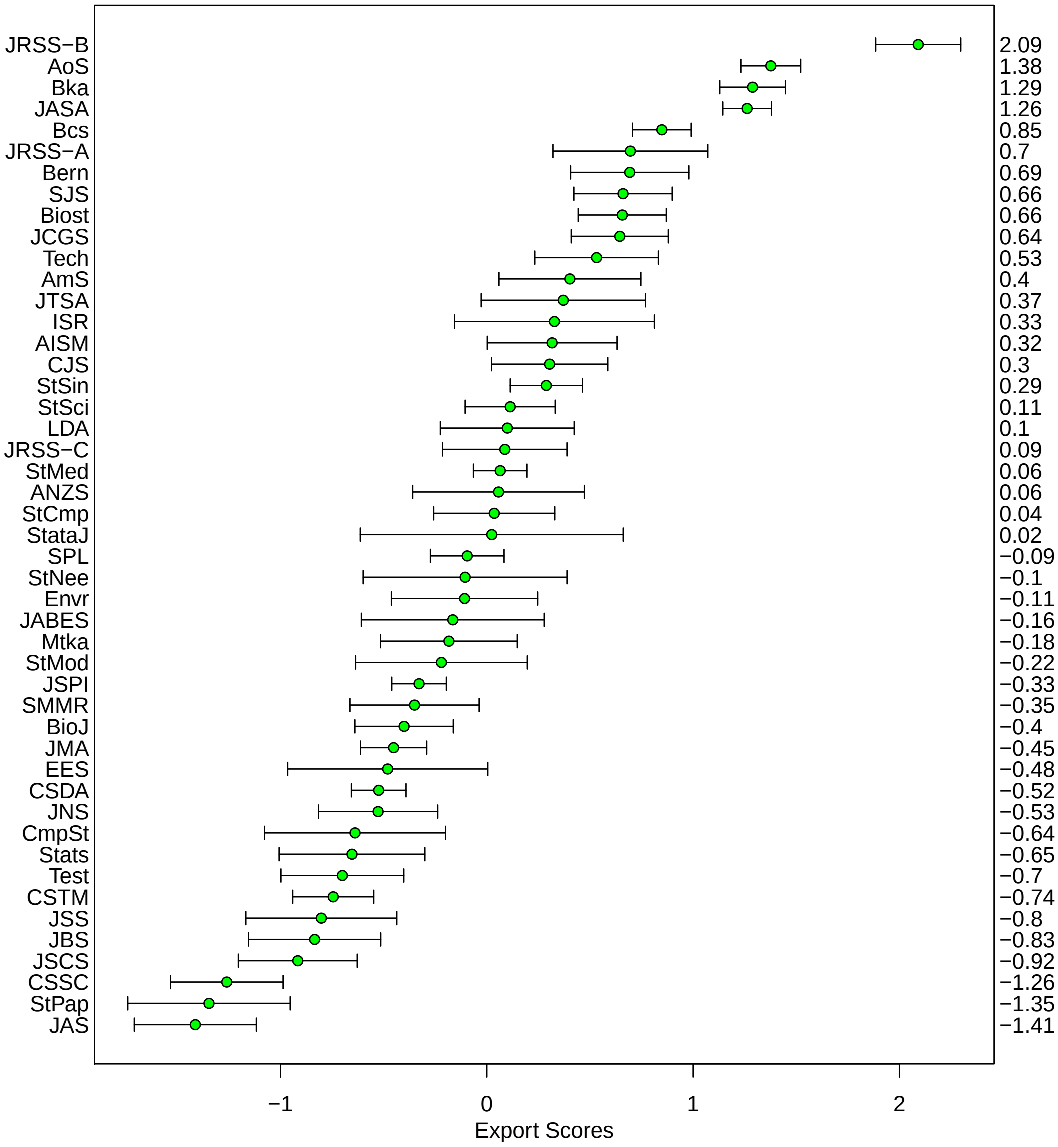


Figure 4: Centipede plot of estimated export scores with 95% comparison intervals.

`s` k-dimensional vector of standardized bounds $s/\max(s)$;

`beta` $k \times p$ matrix of ranking lasso estimates, where k is the number of bounds s and p is the number of model parameters;

`lik` k-dimensional vector of minus log-likelihoods computed at the various ranking lasso estimates;

`df` k-dimensional vector of the number of groups identified by the various ranking lasso estimates (degrees of freedom).

Zero-sum parameterization of lasso estimates:

```
lasso.scores <- cbind(0, rlasso$beta)
colnames(lasso.scores) <- journal.abbr
lasso.scores <- lasso.scores - rowMeans(lasso.scores)
```

Selection of best solution according to TIC defined in Section 5.5 of the paper:

```
tic <- 2 * rlasso$lik + 2 * phi * rlasso$df
best <- max(which.min(tic))
```

TIC identifies 11 groups, however the penultimate and the third to the last have grouped export scores that differ in the third decimal place only. Tables 4 and 5 of the paper are based upon results rounded to the second decimal, and thus the penultimate and the third-to-last groups are merged accordingly.
Update the summary fit table with the ranking lasso estimates:

```
fit.table <- data.frame(fit.table, lasso = lasso.scores[best, sort.id])
fit.table
```

```
##              quasi        qse      lasso
## JRSS-B   2.0911231 0.10513395  1.8696128
## AoS      1.3767352 0.07386382  1.1669128
## Bka      1.2884149 0.08119563  1.1061128
## JASA     1.2619488 0.06014319  1.1061128
## Bcs      0.8485257 0.07245316  0.6480128
## .                .          .          .
## .                .          .          .
## JAS     -1.4126066 0.15093299 -0.8826872
```

Ranking lasso path plot (Figure 5 in this document):

```
plot(x = c(0,rlasso$s,1), y = lasso.scores[, 1],
     ylim = range(lasso.scores), type = "l",
     xlab = "s/max(s)", ylab = "Export Scores")
for(i in 2:njournals)
        lines(x = c(0,rlasso$s,1), y = lasso.scores[,i] )
abline(v = rlasso$s[best], lty = "dashed")
abline(h = 0, lty = "dotted")
```

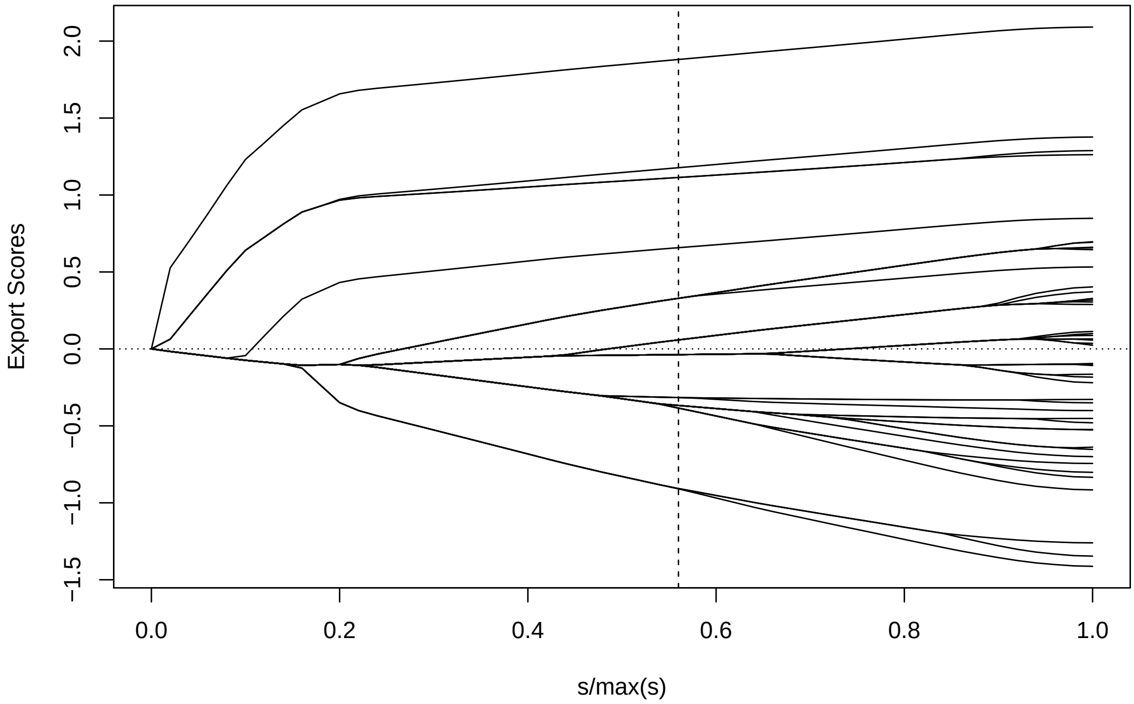


Figure 5: Path plot of the ranking lasso. The vertical dashed line corresponds to the best solution according to TIC.

5 Comparison with RAE 2008 results

5.1 Scoring the RAE submissions according to journal-ranking measures

The RAE 2008 submissions for Unit of Assessment 22 'Statistics and Operational Research' are online at
`http://www.rae.ac.uk/submissions/outstore/CSV-ANSI/ByUOA/22%20-%20Statistics%20and%20Operational%20Research.zip`
and from that source we use the two files `RA2.csv` and `Institution.csv`.

```
RA2 <- read.csv("Data/RAE-UoA22/RA2.csv", as.is = TRUE)
institutions <- read.csv("Data/RAE-UoA22/Institution.csv", as.is = TRUE)
```

The RA2 dataset contains details of all research outputs that were submitted for assessment.
Some minor data-tidying was needed, mainly to code coherently a joint submission that was made by Edinburgh and Heriot-Watt Universities, and to remove rows and columns that will not be used here:

```r
source("R-code/tidy-the-RAE-downloads.R")
```

The resulting data frame, named `RA2.ja`, contains only those RAE-submitted research outputs classified as 'Journal Article'.
Now read in the file `RAE22-journals.csv` — the result of some rather tedious work! — which uniquely identifies each different representation of a journal name in the RA2 data. And use those unambiguous short names[2] in place of the text from the `Publisher` field of the RA2 data:

```r
journals <- read.csv("Data/RAE22-journals.csv", as.is = TRUE)
row.names(journals) <- journals$RAE.name
RA2.ja$Publisher <- journals[RA2.ja$Publisher, "shortName"]
```

Also a table of short names for the 30 departments of RAE sub-panel 22, 'Statistics and Operational Research', to use in the `Institution` field of the RA2 data:

```r
depts <- read.csv("Data/RAE22-depts.csv")
row.names(depts) <- as.character(depts$depts)
RA2.ja$Institution <- as.character(RA2.ja$Institution)
RA2.ja$Institution <- depts[RA2.ja$Institution, "shortName"]
```

Around 68% of the journal articles are in the JCR *Statistics and Probability* category. Let's look at how that varies across the 30 departments:

```r
attach(RA2.ja)
tapply(Publisher, Institution, function(P) {1 - mean(P == "other")})

##         Bath     Bristol      Brunel   Cambridge      Durham
##    0.8750000   0.7000000   0.3666667   0.6610169   0.6111111
## Edinburgh+HW     Glasgow   Greenwich    Imperial        Kent
##    0.5607477   0.6428571   0.2500000   0.8400000   0.9069767
##    Lancaster       Leeds   Liverpool   LondonMet         LSE
##    0.7432432   0.7948718   0.7500000   0.5454545   0.7959184
##   Manchester   Newcastle  Nottingham          OU      Oxford
##    0.8666667   0.7073171   0.8787879   1.0000000   0.5888889
##     Plymouth        QMUL     Reading     Salford   Sheffield
##    0.6428571   0.8571429   0.6285714   0.2580645   0.5675676
##  Southampton    StAndrews  Strathclyde        UCL     Warwick
##    0.6857143   0.8636364   0.2045455   0.6250000   0.8115942

detach(RA2.ja)
```

[2]Note that the short names used here are different from the abbreviations defined in Table 1 of the paper.

Leave out Brunel, Greenwich, Salford and Strathclyde from the analysis, and eliminate their factor levels:

```
RA2.ja <- RA2.ja[!(RA2.ja$Institution %in%
                    c("Brunel", "Greenwich", "Salford", "Strathclyde")), ]
RA2.ja$Institution <- factor(as.character(RA2.ja$Institution))
attach(RA2.ja)
probstats.fraction.of.articles <- tapply(Publisher, Institution,
    function(P) {1 - mean(P == "other")})
detach(RA2.ja)
##  all of these remaining fractions are now > 0.5
probstats.fraction.of.articles

##         Bath      Bristol    Cambridge       Durham Edinburgh+HW
##    0.8750000    0.7000000    0.6610169    0.6111111    0.5607477
##      Glasgow     Imperial         Kent    Lancaster        Leeds
##    0.6428571    0.8400000    0.9069767    0.7432432    0.7948718
##    Liverpool    LondonMet          LSE   Manchester    Newcastle
##    0.7500000    0.5454545    0.7959184    0.8666667    0.7073171
##   Nottingham           OU       Oxford     Plymouth         QMUL
##    0.8787879    1.0000000    0.5888889    0.6428571    0.8571429
##      Reading    Sheffield  Southampton    StAndrews          UCL
##    0.6285714    0.5675676    0.6857143    0.8636364    0.6250000
##      Warwick
##    0.8115942
```

Now focus only on papers that appeared in the JCR *Statistics and Probability* journals. Around 72% of journal articles submitted by the remaining 26 departments are in that set:

```
RA2.ja.statprob <- RA2.ja[RA2.ja$Publisher != "other", ]
nrow(RA2.ja.statprob) / nrow(RA2.ja)

## [1] 0.7223587
```

The various journal-ranking scores — but only for those journals that appear in the RAE submissions — are collected in file `journal-scores.csv`:

```
journal.scores <- read.csv("Data/journal-scores.csv")
journal.scores$SM <- exp(journal.scores$SM)
journal.scores$SM.grouped <- exp(journal.scores$SM.grouped)
```

(The Stigler-model scores are exponentiated prior to the further analysis below.)
Next each journal article from the RA2 database is scored, as described in Section 6.2 of the paper:

```r
row.names(journal.scores) <- journal.scores$shortName
RA2.ja.statprob$II <- journal.scores[RA2.ja.statprob$Publisher, "II"]
RA2.ja.statprob$I2 <- journal.scores[RA2.ja.statprob$Publisher, "I2"]
RA2.ja.statprob$I2no <- journal.scores[RA2.ja.statprob$Publisher, "I2no"]
RA2.ja.statprob$I5 <- journal.scores[RA2.ja.statprob$Publisher, "I5"]
RA2.ja.statprob$AI <- journal.scores[RA2.ja.statprob$Publisher, "AI"]
RA2.ja.statprob$SM <- journal.scores[RA2.ja.statprob$Publisher, "SM"]
RA2.ja.statprob$SM.grouped <- journal.scores[RA2.ja.statprob$Publisher,
                                              "SM.grouped"]
```

All of the 882 journal articles that remain here are scored by the 'global' measures `II`, `I2`, `I2no`, `I5` and `AI`, while around 65% of these articles are in the Statistics list from Table 1 of the paper and so are scored also by `SM` and `SM.grouped`. Let's look at how that fraction varies across the 26 departments:

```r
attach(RA2.ja.statprob)
stats.fraction.of.probstats <- tapply(SM, Institution,
                                 function(x) {1 - mean(is.na(x))})
detach(RA2.ja.statprob)
stats.fraction.of.probstats

##         Bath      Bristol    Cambridge       Durham Edinburgh+HW
##    0.5476190    0.5714286    0.4358974    0.5454545    0.4166667
##      Glasgow     Imperial         Kent    Lancaster        Leeds
##    0.8888889    0.9523810    0.7692308    0.8545455    0.7096774
##    Liverpool    LondonMet          LSE   Manchester    Newcastle
##    0.2666667    0.8333333    0.4102564    0.3589744    0.7586207
##   Nottingham           OU       Oxford     Plymouth         QMUL
##    0.6551724    0.9615385    0.3773585    0.8888889    0.9666667
##      Reading    Sheffield  Southampton    StAndrews          UCL
##    0.7727273    0.5714286    0.9166667    0.8421053    0.8571429
##      Warwick
##    0.4821429
```

What fraction of articles are in the 47 Statistics journals, for each department?

```r
stats.fraction.of.articles <- probstats.fraction.of.articles *
    stats.fraction.of.probstats
stats.fraction.of.articles

##         Bath      Bristol    Cambridge       Durham Edinburgh+HW
##    0.4791667    0.4000000    0.2881356    0.3333333    0.2336449
##      Glasgow     Imperial         Kent    Lancaster        Leeds
##    0.5714286    0.8000000    0.6976744    0.6351351    0.5641026
```

```
##     Liverpool     LondonMet           LSE    Manchester     Newcastle
##     0.2000000     0.4545455     0.3265306     0.3111111     0.5365854
##    Nottingham            OU        Oxford      Plymouth          QMUL
##     0.5757576     0.9615385     0.2222222     0.5714286     0.8285714
##       Reading     Sheffield   Southampton     StAndrews           UCL
##     0.4857143     0.3243243     0.6285714     0.7272727     0.5357143
##       Warwick
##     0.3913043
```

So thirteen of the 26 departments have less than half of their RAE-submitted journal articles in the identified 47 Statistics journals of Table 1 in the paper.

5.2 Journal-based mean scores for departments

Rate the departmental RAE submissions, by averaging over all journal articles scored:

```
attach(RA2.ja.statprob)
II.mean <- tapply(II, Institution, function(vec) mean(na.omit(vec)))
I2.mean <- tapply(I2, Institution, function(vec) mean(na.omit(vec)))
I2no.mean <- tapply(I2no, Institution, function(vec) mean(na.omit(vec)))
I5.mean <- tapply(I5, Institution, function(vec) mean(na.omit(vec)))
AI.mean <- tapply(AI, Institution, function(vec) mean(na.omit(vec)))
SM.mean <- tapply(SM, Institution, function(vec) mean(na.omit(vec)))
SM.grouped.mean <- tapply(SM.grouped, Institution,
                          function(vec) mean(na.omit(vec)))
detach(RA2.ja.statprob)
means <- data.frame(II.mean, I2.mean, I2no.mean, I5.mean, AI.mean,
                    SM.mean, SM.grouped.mean)
```

Do the same averaging but only using scores for the restricted set of 47 Statistics journals that were scored by the Stigler model:

```
RA2.ja.stat <- RA2.ja.statprob[!is.na(RA2.ja.statprob$SM), ]
attach(RA2.ja.stat)
II.mean.r <- tapply(II, Institution, function(vec) mean(na.omit(vec)))
I2.mean.r <- tapply(I2, Institution, function(vec) mean(na.omit(vec)))
I2no.mean.r <- tapply(I2no, Institution,
                      function(vec) mean(na.omit(vec)))
I5.mean.r <- tapply(I5, Institution, function(vec) mean(na.omit(vec)))
AI.mean.r <- tapply(AI, Institution, function(vec) mean(na.omit(vec)))
SM.mean.r <- tapply(SM, Institution, function(vec) mean(na.omit(vec)))
SM.grouped.mean.r <- tapply(SM.grouped, Institution,
                            function(vec) mean(na.omit(vec)))
```

```r
detach(RA2.ja.stat)
means.r <- data.frame(II.mean.r, I2.mean.r, I2no.mean.r,
              I5.mean.r, AI.mean.r, SM.mean.r, SM.grouped.mean.r)
```

Note that `SM.mean` and `SM.mean.r` are of course the same, as are `SM.grouped.mean` and `SM.grouped.mean.r`.

5.3 Comparison with the published RAE assessments

The file `RAE22-outputs-subprofiles.csv` is an extract, specific to the 26 departments of interest in RAE Unit of Assessment 22 'Statistics and Operational Research', from the full set of RAE-result 'sub-profiles' published online at `http://www.rae.ac.uk/pubs/2009/pro/#sub`. These sub-profiles are specific to the assessment of departments' *research outputs*:

```r
RAEprofiles <- read.csv("Data/RAE22-outputs-subprofiles.csv")
```

From that file can be constructed various candidate 'RAE score' values for the departments' research outputs:

```r
RAE.4star <- RAEprofiles$X4star
RAE.34star <- RAEprofiles$X4star + RAEprofiles$X3star
RAE.34star.wtd <- RAEprofiles$X4star + RAEprofiles$X3star/3
```

In what follows, as explained in the paper, we use `RAE.34star.wtd`.
We can now look at correlations between RAE score and the various journal-rating scores (as in Table 6 of the paper):

```r
cor(means, RAE.34star.wtd)

##                      [,1]
## II.mean         0.3409859
## I2.mean         0.4683247
## I2no.mean       0.4875652
## I5.mean         0.4978970
## AI.mean         0.7295643
## SM.mean         0.8140549
## SM.grouped.mean 0.8188923
```

The second row of Table 6 shows correlations based on scoring only the smaller subset of 47 Statistics journals:

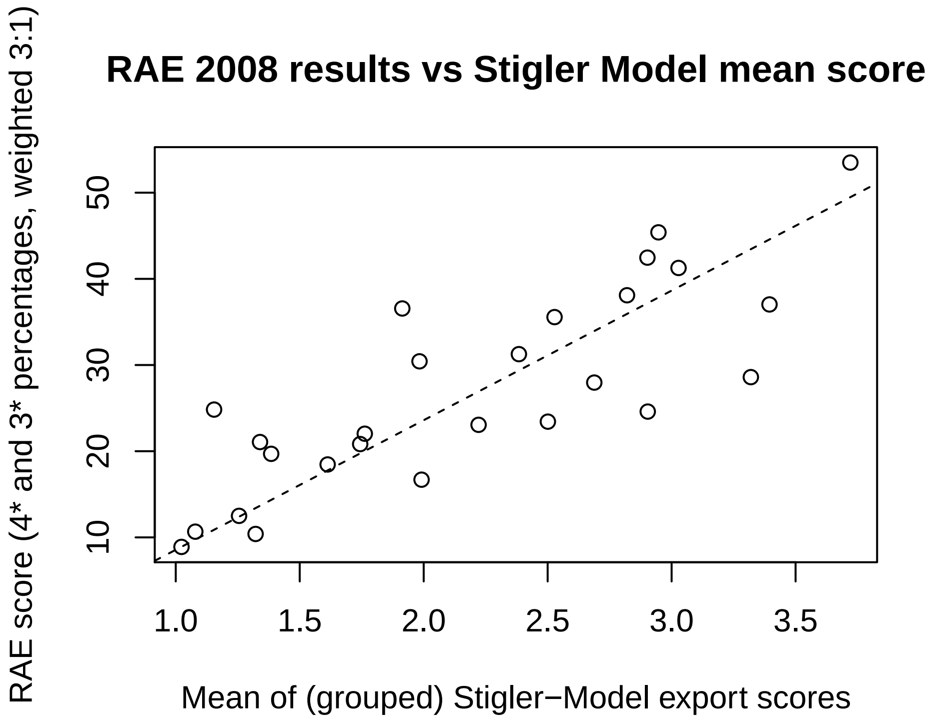
```
cor(means.r, RAE.34star.wtd)

##                        [,1]
## II.mean.r         0.3417413
## I2.mean.r         0.6878651
## I2no.mean.r       0.7030977
## I5.mean.r         0.7340262
## AI.mean.r         0.7919254
## SM.mean.r         0.8140549
## SM.grouped.mean.r 0.8188923
```

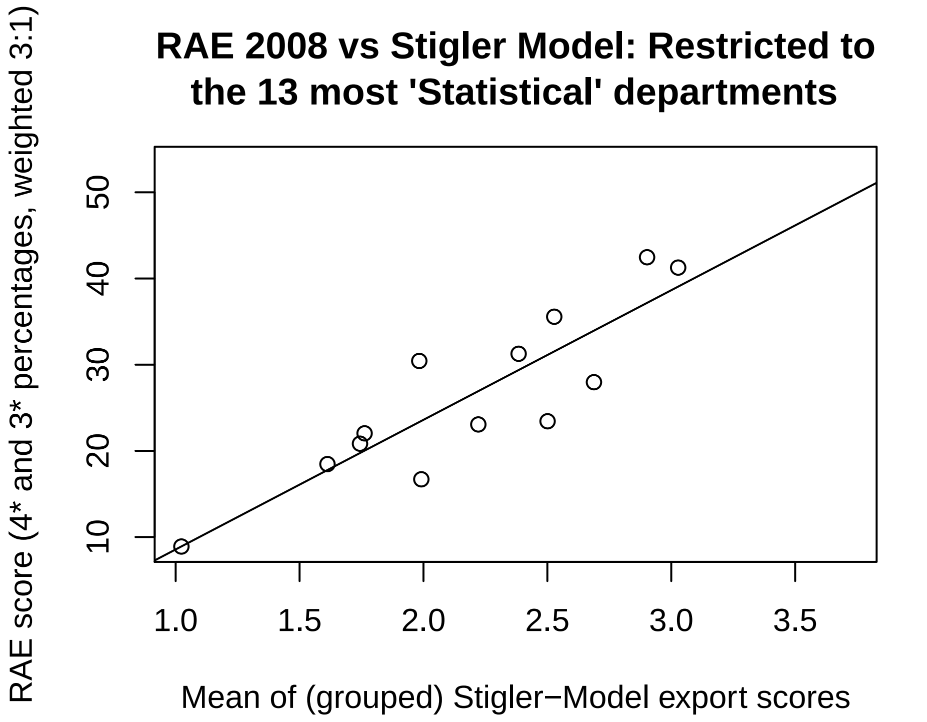
The graphs shown in Figure 6 of the paper are drawn as follows:

```
## Left panel of Figure 6
the.line <- lm(RAE.34star.wtd ~ SM.grouped.mean,
               weights = as.numeric(stats.fraction.of.articles > 0.5))
plot(SM.grouped.mean, RAE.34star.wtd,
     xlab = "Mean of (grouped) Stigler-Model export scores",
     ylab = "RAE score (4* and 3* percentages, weighted 3:1)",
     main = "RAE 2008 results vs Stigler Model mean score")
abline(the.line, lty = "dashed")
```

The outlier-identifying labels seen in Figure 6 of the paper were added by hand, using the `identify` function.

```
## Right panel of Figure 6
plotting.colours <- ifelse(stats.fraction.of.articles > 0.5,
                           "black", "white")
plot(SM.grouped.mean, RAE.34star.wtd,
     xlab = "Mean of (grouped) Stigler-Model export scores",
     ylab = "RAE score (4* and 3* percentages, weighted 3:1)",
     main = "RAE 2008 vs Stigler Model: Restricted to
the 13 most 'Statistical' departments",
     col = plotting.colours)
abline(the.line)
```


RAE 2008 results vs Stigler Model mean score
RAE score (4* and 3* percentages, weighted 3:1)
10
20
30
40
50
1.0
1.5
2.0
2.5
3.0
3.5
Mean of (grouped) Stigler−Model export scores


RAE 2008 vs Stigler Model: Restricted to
the 13 most 'Statistical' departments
RAE score (4* and 3* percentages, weighted 3:1)
10
20
30
40
50
1.0
1.5
2.0
2.5
3.0
3.5
Mean of (grouped) Stigler−Model export scores

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