The `equateIRT` package computes:

- **Direct equating coefficients** (between two forms with common items).
- **Chain equating coefficients** (through a chain of forms with common items in pairs).
- **Average (bisector) equating coefficients** (between two forms connected through more than one path).
- **Equated scores** with **true score equating** and **observed score equating** methods.
- **Standard errors** of all equating coefficients and equated scores.
Load the package and the data

```r
> library("equateIRT")
> data("data2pl")
```

Estimate a two parameter logistic model for 5 data sets with the R package ltm

```r
> library("ltm")
> m1 <- ltm(data2pl[[1]] ~ z1)
> m2 <- ltm(data2pl[[2]] ~ z1)
> m3 <- ltm(data2pl[[3]] ~ z1)
> m4 <- ltm(data2pl[[4]] ~ z1)
> m5 <- ltm(data2pl[[5]] ~ z1)
```
> estm1 <- import.ltm(m1, display = FALSE)
> estm2 <- import.ltm(m2, display = FALSE)
> estm3 <- import.ltm(m3, display = FALSE)
> estm4 <- import.ltm(m4, display = FALSE)
> estm5 <- import.ltm(m5, display = FALSE)
> estm1$coeff[1:3, ]

(Intercept) z1
I1 -0.06213808 1.076155
I2 -0.03090993 1.122379
I3 -0.07939847 1.091369

> estm1$var[1:3, 1:3]

[,1] [,2] [,3]
[1,] 0.0012285184 0.0002460322 0.0002391000
[2,] 0.0002460322 0.0012628923 0.0002495126
[3,] 0.0002391000 0.0002495126 0.0012407430
Create lists of coefficients and covariance matrices

```r
> estc <- list(estm1$coef, estm2$coef, estm3$coef, 
+ estm4$coef, estm5$coef)
> estv <- list(estm1$var, estm2$var, estm3$var, 
+ estm4$var, estm5$var)
> test <- paste("test", 1:5, sep = "")
```

Create an object of class `modIRT`

```r
> mod2pl <- modIRT(coef = estc, var = estv, 
+ names = test, display = FALSE)
> coef(mod2pl$test1)[1:5]
```

```
0.05774085 0.02753964 0.07275128 0.41568210 -0.00716265
```
The linkage plan

```r
> lplan <- linkp(coef = estc)
> lplan

[1,] 20  10  0   0  10
[2,] 10  20 10  0   0
[3,]  0  10 20 10  0
[4,]  0  0 10 20 10
[5,] 10  0  0 10 20
```
A graphic of the linkage plan with package sna

```r
library(sna)
set.seed(6)
gplot(lplan, displaylabels = T, vertex.sides = 4,
+ vertex.cex = 3, vertex.rot = 45, usearrows = FALSE,
+ label.pos = 5, label.cex = 2, vertex.col = 0)
```
Estimation of direct equating coefficients between Forms 1 and 2 using the mean-mean method

```r
> l12 <- direc(mod1 = mod2pl[1], mod2 = mod2pl[2],
+ method = "mean-mean")
> l12

Direct equating coefficients
Method: mean-mean
Link: test1.test2

> summary(l12)

Link: test1.test2
Method: mean-mean
Equating coefficients:
   Estimate  StdErr
A  1.21004 0.028981
B -0.14199 0.028127
```
Estimation of all direct equating coefficients between forms with common items using the mean-mean method

```r
> direclist2pl <- alldirec(mods = mod2pl, 
+   method = "mean-mean")
> direclist2pl

Direct equating coefficients
Method: mean-mean
Links:
test1.test2
test1.test5
test2.test1
test2.test3
test3.test2
test3.test4
test4.test3
test4.test5
test5.test1
test5.test4
```
Direct equating coefficients for Forms 1 and 2

> summary(direclist2pl, link="test1.test2")

Link: test1.test2
Method: mean-mean
Equating coefficients:
  Estimate  StdErr
A   1.21004  0.028981
B  -0.14199  0.028127
Estimation of all chain equating coefficients of length 4

```r
> cec4 <- chainec(r = 4, direclist = direclist2pl)
> cec4

Chain equating coefficients
Method: mean-mean
Paths:
test4.test5.test1.test2
test3.test2.test1.test5
test5.test1.test2.test3
test4.test3.test2.test1
test5.test4.test3.test2
test1.test2.test3.test4
test1.test5.test4.test3
test2.test3.test4.test5
test2.test1.test5.test4
test3.test4.test5.test1
```

Michela Battauz ()
The R package equateIRT
June 6, 2016 11 / 22
Chain equating coefficients for path \{1, 2, 3, 4\}

> summary(cec4, path="test1.test2.test3.test4")

Path: test1.test2.test3.test4
Method: mean-mean
Equating coefficients:

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>StdErr</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.25323</td>
<td>0.052310</td>
</tr>
<tr>
<td>B</td>
<td>-0.49789</td>
<td>0.048492</td>
</tr>
</tbody>
</table>
Estimation of all chain equating coefficients of length 4 from Form 1 to Form 4

```r
> cec14 <- chainec(r = 4, direclist = direclist2pl,
+ f1 = "test1", f2 = "test4")
> cec14

Chain equating coefficients
Method: mean-mean
Paths:
test1.test2.test3.test4

> summary(cec14)

Path: test1.test2.test3.test4
Method: mean-mean
Equating coefficients:
   Estimate    StdErr
A  1.25323  0.052310
B -0.49789  0.048492
```
Estimation of chain equating coefficient for path \{1,5,4\}

```r
> pth <- c(paste("test", c(1,5,4), sep = ""))
> pth <- data.frame(t(pth), stringsAsFactors = FALSE)
> chainec154 <- chainec(direclist = direclist2pl, + pths = pth)
> summary(chainec154)
Path: test1.test5.test4
Method: mean-mean
Equating coefficients:
   Estimate StdErr
A  1.15857  0.037200
B -0.39971  0.041721
```
Estimation of bisector equating coefficients

```r
> ecall <- c(cec14, chainec154)
> fec <- bisectorec(ecall = ecall, weighted = TRUE, + unweighted = TRUE)
> fec

Bisector and weighted bisector equating coefficients
Method: mean-mean

Link: test1.test4
Paths:
  test1.test2.test3.test4
  test1.test5.test4
```
Bisector equating coefficients

> summary(fec)

Link: test1.test4
Method: mean-mean

Equating coefficients:

<table>
<thead>
<tr>
<th>Path</th>
<th>Estimate</th>
<th>StdErr</th>
</tr>
</thead>
<tbody>
<tr>
<td>A test1.test2.test3.test4</td>
<td>1.25323</td>
<td>0.052310</td>
</tr>
<tr>
<td>A test1.test5.test4</td>
<td>1.15857</td>
<td>0.037200</td>
</tr>
<tr>
<td>A bisector</td>
<td>1.20480</td>
<td>0.030609</td>
</tr>
<tr>
<td>A weighted bisector</td>
<td>1.18885</td>
<td>0.029302</td>
</tr>
<tr>
<td>B test1.test2.test3.test4</td>
<td>-0.49789</td>
<td>0.048492</td>
</tr>
<tr>
<td>B test1.test5.test4</td>
<td>-0.39971</td>
<td>0.041721</td>
</tr>
<tr>
<td>B bisector</td>
<td>-0.44766</td>
<td>0.029673</td>
</tr>
<tr>
<td>B weighted bisector</td>
<td>-0.43112</td>
<td>0.029033</td>
</tr>
</tbody>
</table>
Extract the equating coefficients

```r
> eqc(fec)

<table>
<thead>
<tr>
<th>link</th>
<th>path</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 test1.test4 test1.test2.test3.test4</td>
<td>1.253235</td>
<td>-0.4978899</td>
<td></td>
</tr>
<tr>
<td>2 test1.test4</td>
<td>test1.test5.test4</td>
<td>1.158568</td>
<td>-0.3997148</td>
</tr>
<tr>
<td>3 test1.test4</td>
<td>bisector</td>
<td>1.204801</td>
<td>-0.4476611</td>
</tr>
<tr>
<td>4 test1.test4</td>
<td>weighted bisector</td>
<td>1.188853</td>
<td>-0.4311214</td>
</tr>
</tbody>
</table>
```
extract item parameters of two forms being equated in the original scale and item parameters of the first form converted into the scale of the second form.

```r
> itm(fec, bistype = "weighted")
```

<table>
<thead>
<tr>
<th>Item</th>
<th>test1</th>
<th>test4</th>
<th>test1.as.test4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dffclt.I1</td>
<td>0.05774085</td>
<td>NA</td>
<td>-0.36247602</td>
</tr>
<tr>
<td>Dffclt.I10</td>
<td>0.65469024</td>
<td>NA</td>
<td>0.34720876</td>
</tr>
<tr>
<td>Dffclt.I2</td>
<td>0.02753964</td>
<td>NA</td>
<td>-0.39838080</td>
</tr>
<tr>
<td>Dffclt.I21</td>
<td>NA</td>
<td>-0.18987389</td>
<td>NA</td>
</tr>
</tbody>
</table>

...  

<table>
<thead>
<tr>
<th>Item</th>
<th>test1</th>
<th>test4</th>
<th>test1.as.test4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dscrmn.I1</td>
<td>1.07615468</td>
<td>NA</td>
<td>0.90520453</td>
</tr>
<tr>
<td>Dscrmn.I10</td>
<td>1.34017474</td>
<td>NA</td>
<td>1.12728428</td>
</tr>
<tr>
<td>Dscrmn.I2</td>
<td>1.12237949</td>
<td>NA</td>
<td>0.94408640</td>
</tr>
<tr>
<td>Dscrmn.I21</td>
<td>NA</td>
<td>0.96336089</td>
<td>NA</td>
</tr>
</tbody>
</table>

...
Equated scores with the true score equating method

```r
> score(fec, bistype = "weighted")
```

The following scores are not attainable: 0

<table>
<thead>
<tr>
<th>theta</th>
<th>test4</th>
<th>test1.as.test4</th>
<th>StdErr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.2020971</td>
<td>1</td>
<td>1.015003 4.461492e-02</td>
</tr>
<tr>
<td>2</td>
<td>-2.4345213</td>
<td>2</td>
<td>1.954738 5.927049e-02</td>
</tr>
<tr>
<td>3</td>
<td>-1.9550888</td>
<td>3</td>
<td>2.892492 6.650045e-02</td>
</tr>
<tr>
<td>4</td>
<td>-1.5909128</td>
<td>4</td>
<td>3.840790 7.029825e-02</td>
</tr>
<tr>
<td>5</td>
<td>-1.2876722</td>
<td>5</td>
<td>4.804165 7.274594e-02</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.0679930</td>
<td>15</td>
<td>15.134866 1.102907e-01</td>
</tr>
<tr>
<td>16</td>
<td>1.3734260</td>
<td>16</td>
<td>16.171075 1.048635e-01</td>
</tr>
<tr>
<td>17</td>
<td>1.7408695</td>
<td>17</td>
<td>17.185619 9.409659e-02</td>
</tr>
<tr>
<td>18</td>
<td>2.2252693</td>
<td>18</td>
<td>18.169485 7.647648e-02</td>
</tr>
<tr>
<td>19</td>
<td>3.0011510</td>
<td>19</td>
<td>19.111786 4.937866e-02</td>
</tr>
<tr>
<td>20</td>
<td>42.1465163</td>
<td>20</td>
<td>20.000000 3.822034e-15</td>
</tr>
</tbody>
</table>
Equated scores with the observed score equating method

```r
> score(fec, method = "OSE", bistype = "weighted")

test4 test1.as.test4 StdErr
1   0   -0.01489569  0.03103768
2   1    0.95282270  0.04646485
3   2    1.90871813  0.05574421
4   3    2.86555916  0.06178572
5   4    3.82986670  0.06613656
6   5    4.80499566  0.06981820
... 
15 14   14.05761874  0.10609144
16 15   15.10211616  0.10423844
17 16   16.13709851  0.09904507
18 17   17.15778076  0.08991198
19 18   18.15960149  0.07642006
20 19   19.13868111  0.05836730
21 20   20.09377896  0.03589919
```
A comparison of equated scores obtained with 2 different chains, bisector and weighted bisector methods

```r
> score(chainec154, scores = 17)

theta test4 test1.as.test4 StdErr
1 1.74087 17 17.24468 0.1280981

> score(cec4, path = "test1.test2.test3.test4", scores = 17)

theta test4 test1.as.test4 StdErr
1 1.74087 17 17.06646 0.1988616

> score(fec, bistype = "unweighted", scores = 17)

theta test4 test1.as.test4 StdErr
1 1.74087 17 17.15531 0.1057769

> score(fec, bistype = "weighted", scores = 17)

theta test4 test1.as.test4 StdErr
1 1.74087 17 17.18562 0.0940969
```
