

# Package ‘DJL’

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**Type** Package

**Title** Distance Measure Based Judgment and Learning

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**Depends** R (>= 3.4.0), car, lpSolveAPI

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**Description** Implements various decision support tools related to the Econometrics & Technometrics. Subroutines include correlation reliability test, Mahalanobis distance measure for outlier detection, combinatorial search (all possible subset regression), non-parametric efficiency analysis measures: DDF (directional distance function), DEA (data envelopment analysis), HDF (hyperbolic distance function), SBM (slack-based measure), and SF (shortage function), benchmarking, Malmquist productivity analysis, risk analysis, technology adoption model, new product target setting, network DEA, dynamic DEA, intertemporal budgeting, etc.

**License** GPL-2

**LazyData** true

**NeedsCompilation** no

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dataset.airplane.2017 *Dataset of commercial airplanes from 1965 to 2017.*

---

## Description

Commercial airplanes from 1965 to 2017.

## Usage

```
data(dataset.airplane.2017)
```

## Columns

[ , 1] Name Airplane name  
 [ , 2] EIS Entry into service  
 [ , 3] Range Maximum range at full payload in 1,000km  
 [ , 4] P. cap Passenger capacity  
 [ , 5] PFE Passenger fuel efficiency in passengers\*km/L (log scale)  
 [ , 6] C. spd Cruising speed in km/hr  
 [ , 7] M. spd Maximum speed in km/hr

## Author(s)

Dong-Joon Lim, PhD

## Source

<http://www.airbus.com/aircraftfamilies>  
<http://www.boeing.com/commercial>

## References

Lim, Dong-Joon, and Timothy R. Anderson. Time series benchmarking analysis for new product scheduling: who are the competitors and how fast are they moving forward?. *Advances in DEA Theory and Applications: with Examples in Forecasting Models*. (2017): 443-458.

## Examples

```
# Load dataset
data(dataset.airplane.2017)
```

---

```
dataset.engine.2015  Dataset of auto engines from MY2005 to MY2015.
```

---

## Description

Auto engines from MY2005 to MY2015.

## Usage

```
data(dataset.engine.2015)
```

## Columns

```
[ ,1] Name Vehicle name
[ ,2] MY Model year
[ ,3] Cylinder The number of cylinder
[ ,4] Displacement Displacement in liter
[ ,5] CO2 CO2 emission in gram/mile
[ ,6] Power Engine power in HP
[ ,7] Torque Engine torque in lb.ft
[ ,8] Type Engine system and fuel type
```

## Author(s)

Dong-Joon Lim, PhD

## Source

```
http://www.fueleconomy.gov
http://www.autoevolution.com
```

## References

D.-J. Lim, Internal combustion engine race: naturally aspirated vs turbo/super-charged, *working paper* (2015).

**Examples**

```
# Load dataset
data(dataset.engine.2015)
```

---

dataset.hev.2013	<i>Dataset of hybrid electric vehicles from MY1997 to MY2013.</i>
------------------	---

---

**Description**

Hybrid electric vehicles from MY1997 to MY2013.

**Usage**

```
data(dataset.hev.2013)
```

**Columns**

```
[, 1] Name Vehicle name
[, 2] MY Model year
[, 3] MSRP. 2013 MSRP converted to 2013 value
[, 4] Acc Acceleration (0-100km) in km/h/s
[, 5] MPG MPG in mile/gallon
[, 6] MPGe MPG equivalence for PHEV in mile/gallon
```

**Author(s)**

Dong-Joon Lim, PhD

**Source**

<http://www.fueleconomy.gov>

**References**

Lim, Dong-Joon, et al. "Comparing technological advancement of hybrid electric vehicles (HEV) in different market segments." *Technological Forecasting and Social Change* 97 (2015): 140~153.

**Examples**

```
# Load dataset
data(dataset.hev.2013)
```



**Author(s)**

Dong-Joon Lim, PhD

**References**

Chambers, Robert G., Yangho Chung, and Rolf Fare. "Profit, directional distance functions, and Nerlovian efficiency." *Journal of optimization theory and applications* 98.2 (1998): 351~364.

Fare, Rolf, and Shawna Grosskopf. "Directional distance functions and slacks-based measures of efficiency." *European journal of operational research* 200.1 (2010): 320~322.

**See Also**

[dm.ddf](#) Distance measure using DDF

[dm.dea](#) Distance measure using DEA

[dm.hdf](#) Distance measure using HDF

[dm.sbm](#) Distance measure using SBM

[dm.sf](#) Distance measure using SF

**Examples**

```
# Additive form directional distance function
# ready
x <- matrix(c(5, 1, 4), ncol = 1)
y <- matrix(c(8, 3, 5, 6, 4, 1), ncol = 2)
g <- matrix(c(1), nrow = 3, ncol = 3)
w <- matrix(c(1, 0), ncol = 2)
# go
dm.ddf(x, y, "crs", g, w)

# Multiplicative form directional distance function
# ready
g <- cbind(x, y)
# go
dm.ddf(x, y, "crs", g, w)
```

---

dm.dea

*Distance measure using DEA*


---

**Description**

Implements *Charnes & Cooper's* data envelopment analysis (radial & oriented measure).

**Usage**

```
dm.dea(xdata, ydata, rts="crs", orientation,
       se=FALSE, sg="ssm", date=NULL, ncv=NULL, env=NULL, cv="convex", o=NULL)
```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "i" Input-orientation "o" Output-orientation
se	Implements <i>Andersen &amp; Petersen's</i> super-efficiency model if TRUE
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
date	Production date ( $n$ by $1$ )
ncv	Non-controllable variable index(binary) for internal NDF ( $1$ by $(m+s)$ )
env	Environment index for external NDF ( $n$ by $1$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
o	DMU index to calc. NULL(default) will calc for all

**Value**

\$eff	Efficiency score
\$lambda	Intensity vector
\$xslack	Input slack
\$yslack	Output slack
\$vx	Input (dual) weight
\$uy	Output (dual) weight
\$w	Free (dual) variable

**Author(s)**

Dong-Joon Lim, PhD

**References**

Charnes, Abraham, William W. Cooper, and Edwardo Rhodes. "Measuring the efficiency of decision making units." *European journal of operational research* 2.6 (1978): 429-444.

Charnes, Abraham, William W. Cooper, and Edwardo Rhodes. "Evaluating program and managerial efficiency: an application of data envelopment analysis to program follow through." *Management science* 27.6 (1981): 668~697.

Banker, Rajiv D., and Richard C. Morey. "Efficiency analysis for exogenously fixed inputs and outputs." *Operations Research* 34.4 (1986): 513~521.

Ruggiero, John. "On the measurement of technical efficiency in the public sector." *European Journal of Operational Research* 90.3 (1996): 553~565.

Fried, Harold O., CA Knox Lovell, and Shelton S. Schmidt, eds. The measurement of productive efficiency and productivity growth. *Oxford University Press*, 2008.

### See Also

[dm.ddf](#) Distance measure using DDF  
[dm.dea](#) Distance measure using DEA  
[dm.hdf](#) Distance measure using HDF  
[dm.sbm](#) Distance measure using SBM  
[dm.sf](#) Distance measure using SF

### Examples

```
# Reproduce Table 3.9 (p.348) in Fried, H.O. et al.(2008)
# ready
X <- data.frame(x1 = c(8, 6, 3, 10, 6, 8, 8, 4),
               x2 = c(8, 4.6, 1.9, 9, 3.6, 3.6, 9, 1.9))
Y <- data.frame(y1 = c(8, 5, 2, 9, 4.5, 4.5, 7, 2))
C <- data.frame(x1 = 0, x2 = 1, y1 = 0)

# go
data.frame(ALL_CRIS = dm.dea(X, Y, "crs", "i")$eff,
           ALL_VRS = dm.dea(X, Y, "vrs", "i")$eff,
           NDF_CRIS = dm.dea(X, Y, "crs", "i", ncv = C)$eff,
           NDF_VRS = dm.dea(X, Y, "vrs", "i", ncv = C)$eff,
           row.names = LETTERS[1 : 8])
```

---

 dm.dynamic.bc

*Dynamic DEA in the presence of intertemporal Budget Constraints*


---

### Description

Employs the Farrell measure on carry-over budget as well as input or output

### Usage

```
dm.dynamic.bc(xdata, ydata, zdata, bdata, rts="crs", orientation="i", wv=NULL)
```

**Arguments**

xdata	Input array ( $n$ by $m$ by $t$ )
ydata	Output array ( $n$ by $s$ by $t$ )
zdata	Budget(spent) array ( $n$ by $b$ by $t$ )
bdata	Budget(secured) array ( $n$ by $b$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "i" Input-orientation (default) "o" Output-orientation
wv	Weight vector for scalarization ( $1$ by $m$ or $s$ )

**Value**

\$eff.s	System Efficiency
\$eff.t	Period Efficiency
\$lambda	Intensity vectors
\$xslack	Input slack
\$yslack	Output slack
\$zslack	Budget(spent) slack
\$aslack	Budget(available) slack

**Author(s)**

Dong-Joon Lim, PhD

**References**

Lim, D.-J., M.-S., Kim, & K.-W., Lee. (2020). "A revised dynamic DEA model with budget constraints." *International Transactions in Operational Research (In press)*.

**See Also**

[dm.dea](#) Distance measure using DEA

**Examples**

```
# Load data
df.io <- array(c(2, 4, 8, 4, 1, 2, 2, 2, 3, 6, 12, 6,
               5, 4, 3, 8, 1, 1, 1, 1, 5, 4, 3, 8),
              c(4, 3, 2),
              dimnames = list(LETTERS[1:4], c("X", "Y", "Z"), c("t1", "t2")))
df.Z.0 <- array(c(9, 12, 18, 24), c(4, 1), dimnames = list(LETTERS[1:4], c("Z^0")))
```

```
# Run
dm.dynamic.bc(df.io[,1,], df.io[,2,], df.io[,3,], df.Z.0)
```

---

dm.hdf                      *Distance measure using HDF*

---

### Description

Implements *Fare's* hyperbolic distance function (semi-radial & non-oriented measure).

### Usage

```
dm.hdf(xdata, ydata, rts="crs",
       wd=NULL, se=FALSE, sg="ssm", date=NULL, cv="convex", o=NULL)
```

### Arguments

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
wd	Weak disposability vector indicating (an) undesirable output(s) ( $I$ by $s$ )
se	Implements super-efficiency model alike <i>Anderson &amp; Peterson's</i> model if TRUE
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
date	Production date ( $n$ by $I$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
o	DMU index to calc. NULL(default) will calc for all

### Value

\$eff	Efficiency score
\$lambda	Intensity vector
\$mu	Secondary intensity vector for weak disposability under VRS
\$xslack	Input slack
\$yslack	Output slack
\$iteration	The number of iteration to obtain the hyperbolic efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**References**

Fare, R., Shawna Grosskopf, and CA Knox Lovell. The Measurement of Efficiency of Production. *Boston: Kulwer-Nijhoff* (1985).

Fare, Rolf, et al. "Estimating the hyperbolic distance function: A directional distance function approach." *European Journal of Operational Research* 254.1 (2016): 312~319.

**See Also**

[dm.ddf](#) Distance measure using DDF  
[dm.dea](#) Distance measure using DEA  
[dm.hdf](#) Distance measure using HDF  
[dm.sbm](#) Distance measure using SBM  
[dm.sf](#) Distance measure using SF

**Examples**

```
# Reproduce Table 2 in Fare et al.(2016)
# ready
x <- data.frame(x1 = c(2, 4, 9, 6.5, 10, 6, 9))
y <- data.frame(y1 = c(3, 7, 10, 8.5, 4, 2, 8))

# go
sf <- dm.sf (x, y, "vrs")$eff
hdf <- dm.hdf(x, y, "vrs")$eff
matrix(t(cbind(sf, hdf)), 2, 7,
       dimnames = list(c("SF", "HDF"),
                       paste0("DMU_", c(letters[1:4], "o", "p", "q"))))
```

---

dm.mahalanobis

*Distance measure using Mahalanobis distance for outlier detection*


---

**Description**

Implements *Mahalanobis* distance measure for outlier detection. In addition to the basic distance measure, boxplots are provided with potential outlier(s) to give an insight into the early stage of data cleansing task.

**Usage**

```
dm.mahalanobis(data, from="median", p=10, plot=FALSE, v.index=NULL, layout=NULL)
```

**Arguments**

data	Dataframe
from	Datum point from which the distance is measured "mean" Mean of each column "median" Median of each column (default)
p	Percentage to which outlier point(s) is noted (default of 10)
plot	Switch for boxplot(s)
v.index	Numeric vector indicating column(s) to be printed in the boxplot. Default value of NULL will present all.
layout	Numeric vector indicating dimension of boxplots. Default value of NULL will find an optimal layout.

**Value**

\$dist	Mahalanobis distance from from
\$excluded	Excluded row(s) in row number
\$order	Distance order (decreasing) in row number
\$suspect	Potential outlier(s) in row number

**Author(s)**

Dong-Joon Lim, PhD

**References**

Hair, Joseph F., et al. Multivariate data analysis. Vol. 7. *Upper Saddle River, NJ*: Pearson Prentice Hall, 2006.

**Examples**

```
# Generate a sample dataframe
df <- data.frame(replicate(6, sample(0 : 100, 50)))

# go
dm.mahalanobis(df, plot = TRUE)
```

---

dm.network.dea

*Distance measure using DEA on a two-stage network structure*


---

**Description**

Implements *Charnes & Cooper's* data envelopment analysis (radial & oriented measure) on a two-stage network structure.

**Usage**

```
dm.network.dea(xdata.s1, ydata.s1=NULL, zdata, xdata.s2=NULL, ydata.s2,
               rts="crs", orientation="i", type="nc", leader="1st", ss=10^-4, o=NULL)
```

**Arguments**

xdata.s1	Input(s) vector in Stage 1 ( $n$ by $m.s1$ )
ydata.s1	Output(s) vector in Stage 1 ( $n$ by $s.s1$ )
zdata	Intermediate product(s) vector between Stage 1 and Stage 2 ( $n$ by $p$ )
xdata.s2	Input(s) vector in Stage 2 ( $n$ by $m.s2$ )
ydata.s2	Output(s) vector in Stage 2 ( $n$ by $s.s2$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "i" Input-orientation (default) "o" Output-orientation
type	Solution method "nc" Decentralized model (Stackelberg game approach) (default) "co" Centralized model (cooperative game approach)
leader	Preemptive priority for Decentralized model "1st" 1st stage as the leader (default) "2nd" 2nd stage as the leader
ss	Step size for heuristic search $10^{-4}$ (default)
o	DMU index to operate. NULL (default) will operate for all

**Value**

\$eff.s1	Efficiency score of Stage 1
\$eff.s2	Efficiency score of Stage 2
\$v.s1	Weight attached to input in Stage 1
\$u.s1	Weight attached to output in Stage 1
\$p	Weight attached to intermediate product
\$w.s1	Free variable for scaling in Stage 1
\$v.s2	Weight attached to input in Stage 2
\$u.s2	Weight attached to output in Stage 2
\$w.s2	Free variable for scaling in Stage 2

**Author(s)**

Dong-Joon Lim, Ph.D.

## References

Kao, Chiang, and Shiu-Nan Hwang. "Efficiency decomposition in two-stage data envelopment analysis: An application to non-life insurance companies in Taiwan." *European journal of operational research* 185.1 (2008): 418-429.

Cook, Wade D., Liang Liang, and Joe Zhu. "Measuring performance of two-stage network structures by DEA: a review and future perspective." *Omega* 38.6 (2010): 423-430.

Li, Yongjun, Yao Chen, Liang Liang, and Jianhui Xie. "DEA models for extended two-stage network structures." *Omega* 40.5 (2012): 611-618.

Lee, Hsuan-Shih. "Efficiency decomposition of the network DEA in variable returns to scale: An additive dissection in losses." *Omega* 100 (2021): 102212.

## See Also

[dm.dea](#) Distance measure using DEA

[dm.dynami.c.bc](#) Dynamic DEA for intertemporal budgeting

## Examples

```
# Reproduce Table 2 in W.D. Cook et al. (2010)
# ready
X <- data.frame(x1 = c(1178744, 1381822, 1177494, 601320, 6699063, 2627707, 1942833, 3789001,
  1567746, 1303249, 1962448, 2592790, 2609941, 1396002, 2184944, 1211716,
  1453797, 757515, 159422, 145442, 84171, 15993, 54693, 163297, 1544215),
  x2 = c(673512, 1352755, 592790, 594259, 3531614, 668363, 1443100, 1873530,
  950432, 1298470, 672414, 650952, 1368802, 988888, 651063, 415071,
  1085019, 547997, 182338, 53518, 26224, 10502, 28408, 235094, 828963))
Z <- data.frame(z1 = c(7451757, 10020274, 4776548, 3174851, 37392862, 9747908, 10685457, 17267266,
  11473162, 8210389, 7222378, 9434406, 13921464, 7396396, 10422297, 5606013,
  7695461, 3631484, 1141950, 316829, 225888, 52063, 245910, 476419, 7832893),
  z2 = c(856735, 1812894, 560244, 371863, 1753794, 952326, 643412, 1134600,
  546337, 504528, 643178, 1118489, 811343, 465509, 749893, 402881,
  342489, 995620, 483291, 131920, 40542, 14574, 49864, 644816, 667964))
Y <- data.frame(y1 = c(984143, 1228502, 293613, 248709, 7851229, 1713598, 2239593, 3899530,
  1043778, 1697941, 1486014, 1574191, 3609236, 1401200, 3355197, 854054,
  3144484, 692731, 519121, 355624, 51950, 82141, 0.1, 142370, 1602873),
  y2 = c(681687, 834754, 658428, 177331, 3925272, 415058, 439039, 622868,
  264098, 554806, 18259, 909295, 223047, 332283, 555482, 197947,
  371984, 163927, 46857, 26537, 6491, 4181, 18980, 16976, 477733))

# go
res.co <- dm.network.dea(xdata.s1 = X, zdata = Z, ydata.s2 = Y, type = "co")
res.nc.LF <- dm.network.dea(xdata.s1 = X, zdata = Z, ydata.s2 = Y, type = "nc", leader = "1st")
res.nc.FL <- dm.network.dea(xdata.s1 = X, zdata = Z, ydata.s2 = Y, type = "nc", leader = "2nd")

# print
data.frame(CO.s1 = res.co$eff.s1,
  CO.s2 = res.co$eff.s2,
  NC.LF.s1 = res.nc.LF$eff.s1,
  NC.LF.s2 = res.nc.LF$eff.s2,
  NC.FL.s1 = res.nc.FL$eff.s1,
```

```
NC.FL.s2 = res.nc.FL$eff.s2)
```

---

dm.sbm *Distance measure using SBM*

---

### Description

Implements *Tone's* slack-based model (non-radial & (non-)oriented measure).

### Usage

```
dm.sbm(xdata, ydata, rts="crs",
       orientation="n", se=FALSE, sg="ssm", date=NULL, cv="convex", o=NULL)
```

### Arguments

xdata	Input(s) vector ( <i>n</i> by <i>m</i> )
ydata	Output(s) vector ( <i>n</i> by <i>s</i> )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "n" Non-orientation (default) "i" Input-orientation "o" Output-orientation
se	Implements super-efficiency model alike <i>Anderson &amp; Peterson's</i> model if TRUE
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
date	Production date ( <i>n</i> by <i>I</i> )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
o	DMU index to calc. NULL(default) will calc for all

### Value

\$eff	Efficiency score
\$lambda	Intensity vector
\$xslack	Input slack
\$yslack	Output slack
\$xtarget	Input target
\$ytarget	Output target

**Author(s)**

Dong-Joon Lim, PhD

**References**

Tone, Kaoru. "A slacks-based measure of efficiency in data envelopment analysis." *European journal of operational research* 130.3 (2001): 498~509.

Tone, Kaoru. "A slacks-based measure of super-efficiency in data envelopment analysis." *European journal of operational research* 143 (2002): 32~41.

**See Also**

[dm.ddf](#) Distance measure using DDF

[dm.dea](#) Distance measure using DEA

[dm.hdf](#) Distance measure using HDF

[dm.sbm](#) Distance measure using SBM

[dm.sf](#) Distance measure using SF

**Examples**

```
# Reproduce Table 2 in Tone.(2001)
# ready
X <- data.frame(x1 = c(4, 6, 8, 8, 2),
                x2 = c(3, 3, 1, 1, 4))
Y <- data.frame(y1 = c(2, 2, 6, 6, 1),
                y2 = c(3, 3, 2, 1, 4))

# go
dm.sbm(X, Y)

# Reproduce Table 1 in Tone.(2002)
# Published input slacks are alternate optima (confirmed by Tone)
# ready
X <- data.frame(x1 = c(4, 7, 8, 4, 2, 10, 12),
                x2 = c(3, 3, 1, 2, 4, 1, 1))
Y <- data.frame(y1 = c(1, 1, 1, 1, 1, 1, 1))
# go
dm.sbm(X, Y, se = TRUE)

# Reproduce Table 4 in Tone.(2002)
# ready
X <- data.frame(x1 = c(80, 65, 83, 40, 52, 94),
                x2 = c(600, 200, 400, 1000, 600, 700),
                x3 = c(54, 97, 72, 75, 20, 36),
                x4 = c(8, 1, 4, 7, 3, 5))
Y <- data.frame(y1 = c(90, 58, 60, 80, 72, 96),
                y2 = c(5, 1, 7, 10, 8, 6))

# go
dm.sbm(X, Y, "crs", "i", se = TRUE)
```

---

dm.sf	<i>Distance measure using SF</i>
-------	----------------------------------

---

**Description**

Implements *Luenberger's* shortage (benefit) function (radial & non-oriented measure).

**Usage**

```
dm.sf(xdata, ydata, rts="crs", g=NULL,
      wd=NULL, se=FALSE, sg="ssm", date=NULL, cv="convex", o=NULL)
```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
g	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), xdata & ydata will be used
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
se	Implements super-efficiency model alike <i>Anderson &amp; Peterson's</i> model if TRUE
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
date	Production date ( $n$ by $1$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
o	DMU index to calc. NULL(default) will calc for all

**Value**

\$eff	Efficiency score
\$lambda	Intensity vector
\$mu	Secondary intensity vector for weak disposability under VRS
\$xslack	Input slack
\$yslack	Output slack
\$w	Input (dual) weight
\$p	Output (dual) weight
\$u	Free (dual) variable

**Author(s)**

Dong-Joon Lim, PhD

**References**

Luenberger, David G. "Benefit functions and duality." *Journal of mathematical economics* 21.5 (1992): 461~481.

Chambers, Robert G., Yangho Chung, and Rolf Fare. "Profit, directional distance functions, and Nerlovian efficiency." *Journal of optimization theory and applications* 98.2 (1998): 351~364.

**See Also**

[dm.ddf](#) Distance measure using DDF  
[dm.dea](#) Distance measure using DEA  
[dm.hdf](#) Distance measure using HDF  
[dm.sbm](#) Distance measure using SBM  
[dm.sf](#) Distance measure using SF

**Examples**

```
# Additive form shortage function
# ready
x <- matrix(c(5, 1, 4), ncol = 1)
y <- matrix(c(8, 3, 5, 6, 4, 1), ncol = 2)
g <- matrix(c(1), nrow = 3, ncol = 3)
w <- matrix(c(1, 0), ncol = 2)
# go
dm.sf(x, y, "crs", g, w)

# Multiplicative form shortage function
# ready
g <- cbind(x, y)
# go
dm.sf(x, y, "crs", g, w)
```

**Description**

Implements combinatorial (exhaustive) search algorithm, aka all-possible-subsets regression. As opposed to the sequential approach (stepwise, forward addition, or backward elimination) that has a potential bias resulting from considering only one variable for selection at a time, all possible combinations of the independent variables are examined, and sets satisfying designated conditions are returned.

**Usage**

```
ma.aps.reg(dv, iv, min=1, max, mad=FALSE, aic=FALSE, bic=FALSE,  
           model.sig=TRUE, coeff.sig=TRUE, coeff.vif=TRUE, coeff.cor=FALSE)
```

**Arguments**

dv	Dependent variable ( <i>r</i> by <i>I</i> )
iv	Independent variable(s) ( <i>r</i> by <i>c</i> )
min	Minimum number of independent variable to explore ( $\geq I$ )
max	Maximum number of independent variable to explore ( $\leq r/10$ )
mad	Returns mean absolute deviation when TRUE
aic	Returns Akaike's information criterion when TRUE
bic	Returns Bayesian information criterion when TRUE
model.sig	Returns models statistically significant only when TRUE
coeff.sig	Returns models with statistically significant coefficients only when TRUE
coeff.vif	Returns models with allowable level of multicollinearity only when TRUE
coeff.cor	Returns models without suppression effects only when TRUE

**Author(s)**

Dong-Joon Lim, PhD

**References**

Hair, Joseph F., et al. Multivariate data analysis. Vol. 7. *Upper Saddle River*, NJ: Pearson Prentice Hall, 2006.

**Examples**

```
# Load airplane dataset  
df <- dataset.airplane.2017  
  
# ready  
dv <- subset(df, select = 2)  
iv <- subset(df, select = 3 : 7)  
  
# go  
ma.aps.reg(dv, iv, 1, 3, mad = TRUE, coeff.cor = TRUE)
```

---

`map.corr`*Correlation mapping for reliability test*

---

**Description**

Implements a series of correlation analysis by dropping extreme data points one by one using *Mahalanobis* distance measure. Correlation reliability can be investigated with identified anchoring point(s). Correlation map as well as summary table is provided.

**Usage**

```
map.corr(data, from = "median", threshold = 0.3, r.name = FALSE)
```

**Arguments**

<code>data</code>	Dataframe
<code>from</code>	Datum point from which the distance is measured "mean" Mean of each column "median" Median of each column (default)
<code>threshold</code>	Threshold of correlation change to be noted on the map
<code>r.name</code>	Dropped points are shown in row name when TRUE

**Value**

`$reliability` Summary table

**Author(s)**

Dong-Joon Lim, PhD

**See Also**

[dm.mahalanobis](#) Distance measure using Mahalanobis distance

**Examples**

```
# Generate a sample dataframe
df <- data.frame(replicate(2, sample(0 : 100, 50)))

# go
map.corr(df)
```

map.soa.ddf

SOA mapping using DDF

**Description**

Employs dm.ddf over time to generate a state-of-the-art map.

**Usage**

```
map.soa.ddf(xdata, ydata, date,
            rts="crs", g=NULL, wd=NULL, sg="ssm", cv="convex", mk="dmu")
```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $1$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
g	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), xdata & ydata will be used
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
mk	Marker on the map "dmu" DMU index (default) "eff" Efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**See Also**

[map.soa.ddf](#) SOA mapping using DDF  
[map.soa.dea](#) SOA mapping using DEA  
[map.soa.hdf](#) SOA mapping using HDF  
[map.soa.sbm](#) SOA mapping using SBM  
[map.soa.sf](#) SOA mapping using SF

**Examples**

```
# Load engine dataset
df <- dataset.engine.2015

# Subset for forced induction systems
fis <- subset(df, grepl("^C..", df[, 8]))

# Parameters
x <- subset(fis, select = 4)
y <- subset(fis, select = 6 : 7)
d <- subset(fis, select = 2)
g <- matrix(c(1), nrow = nrow(x), ncol = 3)

# Generate an SOA map
map.soa.ddf(x, y, d, "crs", g)
```

---

map.soa.dea

*SOA mapping using DEA*


---

**Description**

Employs `dm.dea` over time to generate a state-of-the-art map.

**Usage**

```
map.soa.dea(xdata, ydata, date, rts="crs", orientation,
            sg="ssm", ncv=NULL, env=NULL, cv="convex", mk="dmu")
```

**Arguments**

<code>xdata</code>	Input(s) vector ( $n$ by $m$ )
<code>ydata</code>	Output(s) vector ( $n$ by $s$ )
<code>date</code>	Production date ( $n$ by $I$ )
<code>rts</code>	Returns to scale assumption " <code>crs</code> " Constant RTS (default) " <code>vrs</code> " Variable RTS " <code>irs</code> " Increasing RTS " <code>drs</code> " Decreasing RTS
<code>orientation</code>	Orientation of the measurement " <code>i</code> " Input-orientation " <code>o</code> " Output-orientation
<code>sg</code>	Employs second-stage optimization " <code>ssm</code> " Slack-sum maximization (default) " <code>max</code> " Date-sum maximization (only if <code>date</code> is defined) " <code>min</code> " Date-sum minimization (only if <code>date</code> is defined)
<code>ncv</code>	Non-controllable variable index(binary) for internal NDF ( $I$ by $(m+s)$ )

env	Environment index for external NDF ( <i>n</i> by <i>I</i> )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
mk	Marker on the map "dmu" DMU index (default) "eff" Efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**See Also**

[map.soa.ddf](#) SOA mapping using DDF  
[map.soa.dea](#) SOA mapping using DEA  
[map.soa.hdf](#) SOA mapping using HDF  
[map.soa.sbm](#) SOA mapping using SBM  
[map.soa.sf](#) SOA mapping using SF

**Examples**

```

# Load engine dataset
df <- dataset.engine.2015

# Subset for forced induction systems
fis <- subset(df, grepl("^C.", df[, 8]))

# Parameters
x <- subset(fis, select = 4)
y <- subset(fis, select = 6 : 7)
d <- subset(fis, select = 2)

# Generate an SOA map
map.soa.dea(x, y, d, "crs", "o")

```

---

map.soa.hdf

*SOA mapping using HDF*


---

**Description**

Employs dm.hdf over time to generate a state-of-the-art map.

**Usage**

```

map.soa.hdf(xdata, ydata, date,
            rts="crs", wd=NULL, sg="ssm", cv="convex", mk="dmu")

```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $1$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
mk	Marker on the map "dmu" DMU index (default) "eff" Efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**References**

D.-J. Lim, Internal combustion engine race: naturally aspirated vs turbo/super-charged, *working paper* (2015).

**See Also**

[map.soa.ddf](#) SOA mapping using DDF  
[map.soa.dea](#) SOA mapping using DEA  
[map.soa.hdf](#) SOA mapping using HDF  
[map.soa.sbm](#) SOA mapping using SBM  
[map.soa.sf](#) SOA mapping using SF

**Examples**

```
# Load engine dataset
df <- dataset.engine.2015

# Subset for SC/TC 8 cylinder engines
stc.8 <- subset(df, grepl("^C..", df[, 8]) & df[, 3] == 8)

# Parameters
```

```

x <- subset(stc.8, select = 4)
y <- subset(stc.8, select = 5:7)
d <- subset(stc.8, select = 2)

# Generate an SOA map
map.soa.hdf(x, y, d, "vrs")

```

map.soa.sbm

*SOA mapping using SBM***Description**

Employs dm.sbm over time to generate a state-of-the-art map.

**Usage**

```

map.soa.sbm(xdata, ydata, date,
            rts="crs", orientation="n", sg="ssm", cv="convex", mk="dmu")

```

**Arguments**

xdata	Input(s) vector ( <i>n</i> by <i>m</i> )
ydata	Output(s) vector ( <i>n</i> by <i>s</i> )
date	Production date ( <i>n</i> by <i>1</i> )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "n" Non-orientation (default) "i" Input-orientation "o" Output-orientation
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
mk	Marker on the map "dmu" DMU index (default) "eff" Efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**See Also**

[map.soa.ddf](#) SOA mapping using DDF  
[map.soa.dea](#) SOA mapping using DEA  
[map.soa.hdf](#) SOA mapping using HDF  
[map.soa.sbm](#) SOA mapping using SBM  
[map.soa.sf](#) SOA mapping using SF

**Examples**

```

# Load engine dataset
df <- dataset.engine.2015

# Subset for forced induction systems
fis <- subset(df, grepl("^C..", df[, 8]))

# Parameters
x <- subset(fis, select = 4)
y <- subset(fis, select = 6 : 7)
d <- subset(fis, select = 2)

# Generate an SOA map
map.soa.sbm(x, y, d)

```

---

map.soa.sf	<i>SOA mapping using SF</i>
------------	-----------------------------

---

**Description**

Employs `dm.sf` over time to generate a state-of-the-art map.

**Usage**

```
map.soa.sf(xdata, ydata, date,
           rts="crs", g=NULL, wd=NULL, sg="ssm", cv="convex", mk="dmu")
```

**Arguments**

<code>xdata</code>	Input(s) vector ( $n$ by $m$ )
<code>ydata</code>	Output(s) vector ( $n$ by $s$ )
<code>date</code>	Production date ( $n$ by $1$ )
<code>rts</code>	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
<code>g</code>	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), <code>xdata</code> & <code>ydata</code> will be used

wd	Weak disposability vector indicating (an) undesirable output(s) ( <i>I</i> by <i>s</i> )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization (only if date is defined) "min" Date-sum minimization (only if date is defined)
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
mk	Marker on the map "dmu" DMU index (default) "eff" Efficiency score

**Author(s)**

Dong-Joon Lim, PhD

**References**

D.-J. Lim, Internal combustion engine race: naturally aspirated vs turbo/super-charged, *working paper* (2015).

**See Also**

[map.soa.ddf](#) SOA mapping using DDF  
[map.soa.dea](#) SOA mapping using DEA  
[map.soa.hdf](#) SOA mapping using HDF  
[map.soa.sbm](#) SOA mapping using SBM  
[map.soa.sf](#) SOA mapping using SF

**Examples**

```
# Reproduce Table 2 in Lim, D-J. (2015)
# Load engine dataset
df <- dataset.engine.2015

# Subset for 4 cylinder engines
fce <- subset(df, df[, 3] == 4)

# Parameters
x <- subset(fce, select = 4)
y <- subset(fce, select = 5 : 7)
d <- subset(fce, select = 2)
g <- data.frame(0, y)
w <- matrix(c(1, 0, 0), ncol = 3)

# Generate an SOA map
map.soa.sf(x, y, d, "crs", g, w, mk = "eff")
```

---

plp	<i>Print LP object</i>
-----	------------------------

---

**Description**

Print an LP object line by line.

**Usage**

```
plp(x)
```

**Arguments**

x                    LP object defined by make.lp function in lpSolve library

**Author(s)**

Dong-Joon Lim, PhD

**References**

Berkelaar, Michel, Kjell Eikland, and Peter Notebaert. "Ipsolve: Open source (mixed-integer) linear programming system." *Eindhoven U. of Technology* 63 (2004).

**Examples**

```
# Declare an LP object
lp.temp <- make.lp(0, 61)

# Print the LP
plp(lp.temp)
```

---

roc.dea	<i>Rate of change (RoC) calculation using DEA</i>
---------	---

---

**Description**

Employs dm.dea over time to calculate RoCs.

**Usage**

```
roc.dea(xdata, ydata, date, t, rts="crs", orientation,
        sg="ssm", ftype="d", ncv=NULL, env=NULL, cv="convex")
```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $1$ )
t	A vantage point from which the RoC is captured
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "i" Input-orientation "o" Output-orientation
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
ftype	Frontier type "d" Dynamic frontier (default) "s" Static frontier
ncv	Non-controllable variable index(binary) for internal NDF ( $1$ by $(m+s)$ )
env	Environment index for external NDF ( $n$ by $1$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)

**Value**

\$eff_r	Efficiency at release (i.e., at each production date)
\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_past	RoC observed from the obsolete DMUs in the past
\$roc_avg	Average RoC
\$roc_local	Local RoC

**Author(s)**

Dong-Joon Lim, PhD

## References

Lim, Dong-Joon, Timothy R. Anderson, and Oliver Lane Inman. "Choosing effective dates from multiple optima in Technology Forecasting using Data Envelopment Analysis (TFDEA)." *Technological Forecasting and Social Change* 88 (2014): 91~97.

Lim, Dong-Joon, et al. "Comparing technological advancement of hybrid electric vehicles (HEV) in different market segments." *Technological Forecasting and Social Change* 97 (2015): 140~153.

Lim, Dong-Joon, and Dong-Hyuk Yang. "Assessment of Regulatory Requirements on Technological Changes: The Increasing Dominance of Downsized Turbo/Super-Charged Engines Over Naturally Aspirated Engines." *IEEE Access* 7 (2019): 84839-84848.

## See Also

[dm.dea](#) Distance measure using DEA  
[roc.dea](#) RoC calculation using DEA  
[map.soa.dea](#) SOA mapping using DEA  
[target.arrival.dea](#) Arrival target setting using DEA  
[target.spec.dea](#) Spec target setting using DEA

## Examples

```
# Reproduce Table 3 in Lim, D-J. et al.(2014)
# Load airplane dataset
df <- dataset.airplane.2017

# ready
x <- data.frame(Flew = rep(1, 28))
y <- subset(df, select = 3 : 7)
d <- subset(df, select = 2)

# go
roc.dea(x, y, d, 2007, "vrs", "o", "min", "d")$roc_past

# Reproduce Table 3 in Lim, D-J. et al.(2015)
# Load hev dataset
df <- dataset.hev.2013

# ready
x <- subset(df, select = 3)
y <- subset(df, select = 4 : 6)
d <- subset(df, select = 2)
c <- subset(df, select = 7)

# go
results <- roc.dea(x, y, d, 2013, "vrs", "o", "min", "d", env = c)
hev <- which(results$roc_local > 0)
data.frame(Class = c[hev, ],
           SOA = hev,
           LocalRoC = results$roc_local[hev, ])[order(c[hev, ]), ]
# NOTE: the published results include a typo on roc_local[82,]
#       this has been corrected in Lim, D-J. et al. (2016).
```

---

roc.hdf                      *Rate of change (RoC) calculation using HDF*

---

### Description

Employs dm.hdf over time to calculate RoCs.

### Usage

```
roc.hdf(xdata, ydata, date, t,
        rts="crs", wd=NULL, sg="ssm", ftype="d", cv="convex")
```

### Arguments

xdata	Input(s) vector ( <i>n</i> by <i>m</i> )
ydata	Output(s) vector ( <i>n</i> by <i>s</i> )
date	Production date ( <i>n</i> by <i>1</i> )
t	A vantage point from which the RoC is captured
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
wd	Weak disposability vector indicating (an) undesirable output(s) ( <i>1</i> by <i>s</i> )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
ftype	Frontier type "d" Dynamic frontier (default) "s" Static frontier
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)

### Value

\$eff_r	Efficiency at release (i.e., at each production date)
\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_past	RoC observed from the obsolete DMUs in the past
\$roc_avg	Average RoC
\$roc_local	Local RoC

**Author(s)**

Dong-Joon Lim, PhD

**References**

D.-J. Lim, Internal combustion engine race: naturally aspirated vs turbo/super-charged, *working paper* (2015).

**See Also**

[dm.hdf](#) Distance measure using HDF  
[roc.hdf](#) RoC calculation using HDF  
[map.soa.hdf](#) SOA mapping using HDF  
[target.arrival.hdf](#) Arrival target setting using HDF

**Examples**

```
# Load engine dataset
df <- dataset.engine.2015

# Subset for 8 cylinder TC-P engines
et <- subset(df, df[, 3] == 8 & df[, 8] == "TC-P")

# Parameters
x <- subset(et, select = 4)
y <- subset(et, select = 5 : 7)
d <- subset(et, select = 2)
w <- matrix(c(1, 0, 0), ncol = 3)

# Calc local Roc
roc.hdf(x, y, d, 2015, "vrs", w, "min")
```

---

roc.malmquist

*Malmquist Index: time-series productivity analysis*

---

**Description**

Employs distance measure over time to calculate the productivity changes.

**Usage**

```
roc.malmquist(xdata, ydata, tm=NULL, dm="dea", rts="crs", orientation,
              g=NULL, wd=NULL, ncv=NULL, env=NULL, cv="convex")
```

**Arguments**

xdata	Input(s) array ( $n$ by $m$ by $t$ )
ydata	Output(s) array ( $n$ by $s$ by $t$ )
tm	Tick mark of production dates (a vector length of $t$ )
dm	Distance measure to calculate the productivity "dea" Data Envelopment Analysis (default) "sbm" Slack Based Model "ddf" Directional Distance Function "hdf" Hyperbolic Distance Function "sf" Shortage Function
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
orientation	Orientation of the measurement "n" Non-orientation (default) "i" Input-orientation "o" Output-orientation
g	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), xdata & ydata will be used
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
ncv	Non-controllable variable index(binary) for internal NDF ( $1$ by $(m+s)$ )
env	Environment index for external NDF ( $n$ by $1$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)

**Value**

\$cu	Catching Up (aka technical efficiency change: TEC) index
\$fs	Frontier Shift (FS) Index
\$mi	Malmquist Index

**Author(s)**

Dong-Joon Lim, PhD

**References**

R. Fare, S. Grosskopf, and C. A. K. Lovell, Production Frontiers. *Cambridge University Press*, 1994.

**See Also**

[dm.ddf](#) Distance measure using DDF  
[dm.dea](#) Distance measure using DEA  
[dm.hdf](#) Distance measure using HDF  
[dm.sbm](#) Distance measure using SBM  
[dm.sf](#) Distance measure using SF

**Examples**

```

# Load data
df <- array(c(4, 3, 9, 10, 7, 4, 3, 5,
             5, 12, 3, 8, 1, 4, 14, 3,
             1, 1, 1, 1, 1, 1, 1, 1,
             3.4, 2, 10, 8, 10, 4, 1, 5,
             6, 10, 3.5, 7, 2, 4, 12, 3,
             1, 1, 1, 1, 1, 1, 1, 1,
             2.8, 1.8, 8, 7, 10, 3, 1, 5,
             5.7, 8.8, 2.8, 5, 2, 5, 9, 3,
             1, 1, 1, 1, 1, 1, 1, 1,
             2.2, 1.5, 8, 5, 8, 3, 1, 5,
             6, 8, 2.3, 3.5, 2, 5, 7, 3,
             1, 1, 1, 1, 1, 1, 1, 1),
           c(8, 3, 4))

# Run
roc.malmquist(df[,1:2,], df[,3,], dm = "sbm", orientation = "n")

```

roc.sf

*Rate of change (RoC) calculation using SF***Description**

Employs `dm.sf` over time to calculate RoCs. This function is valid only when multiplicative form of directional vector is used.

**Usage**

```
roc.sf(xdata, ydata, date, t,
      rts="crs", g=NULL, wd=NULL, sg="ssm", ftype="d", cv="convex")
```

**Arguments**

<code>xdata</code>	Input(s) vector ( <i>n</i> by <i>m</i> )
<code>ydata</code>	Output(s) vector ( <i>n</i> by <i>s</i> )
<code>date</code>	Production date ( <i>n</i> by <i>l</i> )
<code>t</code>	A vantage point from which the RoC is captured

rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
g	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), xdata & ydata will be used
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
f type	Frontier type "d" Dynamic frontier (default) "s" Static frontier
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)

**Value**

\$eff_r	Efficiency at release (i.e., at each production date)
\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_past	RoC observed from the obsolete DMUs in the past
\$roc_avg	Average RoC
\$roc_local	Local RoC

**Author(s)**

Dong-Joon Lim, PhD

**References**

D.-J. Lim, Internal combustion engine race: naturally aspirated vs turbo/super-charged, *working paper* (2015).

**See Also**

[dm.sf](#) Distance measure using SF  
[roc.sf](#) RoC calculation using SF  
[map.soa.sf](#) SOA mapping using SF  
[target.arrival.sf](#) Arrival target setting using SF

**Examples**

```
# Reproduce Mercedes-Benz CLA45 AMG's local RoC in Table 5 in Lim, D-J. (2015)
# Load engine dataset
df <- dataset.engine.2015

# Subset for 4 cylinder engines
fce <- subset(df, df[, 3] == 4)

# Parameters
x <- subset(fce, select = 4)
y <- subset(fce, select = 5 : 7)
d <- subset(fce, select = 2)
g <- as.matrix(data.frame(0, y))
w <- matrix(c(1, 0, 0), ncol = 3)

# Calc local Roc
roc.sf(x, y, d, 2014, "crs", g, w, "min")$roc_local[348, ]
```

---

target.arrival.dea      *Arrival target setting using DEA*

---

**Description**

Employs `dm.dea` over time to estimate the arrival of known specifications.

**Usage**

```
target.arrival.dea(xdata, ydata, date, t, rts="crs", orientation,
                   sg="ssm", ftype="d", ncv=NULL, env=NULL, cv="convex", anc=FALSE)
```

**Arguments**

<code>xdata</code>	Input(s) vector ( <i>n</i> by <i>m</i> )
<code>ydata</code>	Output(s) vector ( <i>n</i> by <i>s</i> )
<code>date</code>	Production date ( <i>n</i> by <i>1</i> )
<code>t</code>	A vantage point from which the RoC is captured
<code>rts</code>	Returns to scale assumption " <code>crs</code> " Constant RTS (default) " <code>vrs</code> " Variable RTS " <code>irs</code> " Increasing RTS " <code>drs</code> " Decreasing RTS
<code>orientation</code>	Orientation of the measurement " <code>i</code> " Input-orientation " <code>o</code> " Output-orientation

sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
f type	Frontier type "d" Dynamic frontier (default) "s" Static frontier
ncv	Non-controllable variable index(binary) for internal NDF ( $I$ by $(m+s)$ )
env	Environment index for external NDF ( $n$ by $I$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
anc	Implements a stepwise RoC computation if TRUE

**Value**

\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_avg	Average RoC
\$roc_anc	Local RoCs across the periods
\$roc_local	Local RoC
\$roc_ind	Individualized RoC
\$arrival_avg	Estimated arrival using roc_avg
\$arrival_seg	Estimated arrival using roc_ind

**Author(s)**

Dong-Joon Lim, PhD

**References**

Lim, Dong-Joon, Timothy R. Anderson, and Oliver Lane Inman. "Choosing effective dates from multiple optima in Technology Forecasting using Data Envelopment Analysis (TFDEA)." *Technological Forecasting and Social Change* 88 (2014): 91~97.

Lim, Dong-Joon, and Timothy R. Anderson. Time series benchmarking analysis for new product scheduling: who are the competitors and how fast are they moving forward?. *Advances in DEA Theory and Applications: with Examples in Forecasting Models*. (2017): 443-458.

**See Also**

[dm.dea](#) Distance measure using DEA  
[roc.dea](#) RoC calculation using DEA  
[map.soa.dea](#) SOA mapping using DEA  
[target.arrival.dea](#) Arrival target setting using DEA  
[target.spec.dea](#) Spec target setting using DEA

**Examples**

```
# Reproduce Table 4 in Lim, D-J., and Timothy R. Anderson.(2016)
# Load airplane dataset
df <- dataset.airplane.2017

# ready
x <- data.frame(Flew = rep(1, 28))
y <- subset(df, select = 3 : 7)
d <- subset(df, select = 2)

# go
target.arrival.dea(x, y, d, 2007, "vrs", "o", "min", "d")$arrival_seg
```

---

target.arrival.hdf      *Arrival target setting using HDF*

---

**Description**

Employs dm.hdf over time to estimate the arrival of known specifications.

**Usage**

```
target.arrival.hdf(xdata, ydata, date, t, rts="crs",
                  wd=NULL, sg="ssm", ftype="d", cv="convex", anc=FALSE)
```

**Arguments**

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $I$ )
t	A vantage point from which the RoC is captured
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
wd	Weak disposability vector indicating (an) undesirable output(s) ( $I$ by $s$ )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
ftype	Frontier type "d" Dynamic frontier (default) "s" Static frontier

cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
anc	Implements a stepwise RoC computation if TRUE

**Value**

\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_avg	Average RoC
\$roc_anc	Local RoCs across the periods
\$roc_local	Local RoC
\$roc_ind	Individualized RoC
\$arrival_avg	Estimated arrival using roc_avg
\$arrival_seg	Estimated arrival using roc_ind

**Author(s)**

Dong-Joon Lim, PhD

**References**

Lim, Dong-Joon, et al. "Comparing technological advancement of hybrid electric vehicles (HEV) in different market segments." *Technological Forecasting and Social Change* 97 (2015): 140~153.

Lim, Dong-Joon, and Timothy R. Anderson. Time series benchmarking analysis for new product scheduling: who are the competitors and how fast are they moving forward?. *Advances in DEA Theory and Applications: with Examples in Forecasting Models*. (2017): 443-458.

**See Also**

[dm.hdf](#) Distance measure using HDF  
[roc.hdf](#) RoC calculation using HDF  
[map.soa.hdf](#) SOA mapping using HDF  
[target.arrival.hdf](#) Arrival target setting using HDF

**Examples**

```
# Estimate arrivals of MY2015 SC/TC 8 cylinder engines
# Load engine dataset
df <- dataset.engine.2015

# Subset for SC/TC 8 cylinder engines
stc.8 <- subset(df, grepl("^C..", df[, 8]) & df[, 3] == 8)

# Parameters
x <- subset(stc.8, select = 4)
```

```

y <- subset(stc.8, select = 5:7)
d <- subset(stc.8, select = 2)

# Generate an SOA map
target.arrival.hdf(x, y, d, 2014, "vrs")

```

---

target.arrival.sf      *Arrival target setting using SF*

---

### Description

Employs `dm.sf` over time to estimate the arrival of known specifications. This function is valid only when multiplicative form of directional vector is used.

### Usage

```
target.arrival.sf(xdata, ydata, date, t, rts="crs", g=NULL,
                 wd=NULL, sg="ssm", ftype="d", cv="convex", anc=FALSE)
```

### Arguments

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $1$ )
t	A vantage point from which the RoC is captured
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
g	Directional vector indicating a measurement direction ( $n$ by $(m+s)$ ) By default (NULL), xdata & ydata will be used
wd	Weak disposability vector indicating (an) undesirable output(s) ( $1$ by $s$ )
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
ftype	Frontier type "d" Dynamic frontier (default) "s" Static frontier
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
anc	Implements a stepwise RoC computation if TRUE

**Value**

\$eff_t	Efficiency at t
\$lambda_t	Intensity vector at t
\$eft_date	Effective date
\$roc_avg	Average RoC
\$roc_anc	Local RoCs across the periods
\$roc_local	Local RoC
\$roc_ind	Individualized RoC
\$arrival_avg	Estimated arrival using roc_avg
\$arrival_seg	Estimated arrival using roc_ind

**Author(s)**

Dong-Joon Lim, PhD

**References**

Lim, Dong-Joon, et al. "Comparing technological advancement of hybrid electric vehicles (HEV) in different market segments." *Technological Forecasting and Social Change* 97 (2015): 140~153.

Lim, Dong-Joon, and Timothy R. Anderson. Time series benchmarking analysis for new product scheduling: who are the competitors and how fast are they moving forward?. *Advances in DEA Theory and Applications: with Examples in Forecasting Models*. (2017): 443-458.

**See Also**

[dm.sf](#) Distance measure using SF  
[roc.sf](#) RoC calculation using SF  
[map.soa.sf](#) SOA mapping using SF  
[target.arrival.sf](#) Arrival target setting using SF

**Examples**

```
# Estimate arrivals of MY2013 hev models
# Load hev dataset
df <- dataset.hev.2013

# ready
x <- subset(df, select = 3)
y <- subset(df, select = 4 : 6)
d <- subset(df, select = 2)
g <- data.frame(x, y)

# go
target.arrival.sf(x, y, d, 2012, "vrs", g)$arrival_seg
```

---

target.spec.dea      *Spec target setting using DEA*

---

### Description

Employs inverse DEA to estimate specifications(in/out-puts) to achieve a predetermined efficiency.

### Usage

```
target.spec.dea(xdata, ydata, date=NULL, t=NULL, dt=NULL, dmu, et="c",
               alpha=NULL, beta=NULL, wv=NULL, rts="crs", sg="ssm", ftype="d",
               ncv=NULL, env=NULL, cv="convex", bound=TRUE, pin=TRUE)
```

### Arguments

xdata	Input(s) vector ( $n$ by $m$ )
ydata	Output(s) vector ( $n$ by $s$ )
date	Production date ( $n$ by $1$ )
t	A vantage point from which the RoC is captured
dt	Delta $t$ i.e., specs are estimated within PPS at $t+dt$
dmu	DMU whose inputs(or outputs) are to be estimated
et	Efficiency target; default value ("c") retains the current efficiency
alpha	Perturbed input(s) of designated DMU ( $1$ by $m$ )
beta	Perturbed output(s) of designated DMU ( $1$ by $s$ )
wv	Weight vector for scalarization ( $1$ by $m$ or $s$ )
rts	Returns to scale assumption "crs" Constant RTS (default) "vrs" Variable RTS "irs" Increasing RTS "drs" Decreasing RTS
sg	Employs second-stage optimization "ssm" Slack-sum maximization (default) "max" Date-sum maximization "min" Date-sum minimization
ftype	Frontier type "d" Dynamic frontier (default) "s" Static frontier
ncv	Non-controllable variable index(binary) for internal NDF ( $1$ by $(m+s)$ )
env	Environment index for external NDF ( $n$ by $1$ )
cv	Convexity assumption "convex" Convexity holds (default) "fdh" Free disposal hull (this will override rts)
bound	Puts upper/lower bounds on alpha/beta if TRUE(default)
pin	Includes the perturbed DMU in the PPS if TRUE(default)

**Value**

\$alpha	Estimated input(s)
\$beta	Estimated output(s)
\$lambda	Intensity vector
\$xslack	Input slack
\$yslack	Output slack

**Author(s)**

Dong-Joon Lim, PhD

**References**

Lim, Dong-Joon, "Inverse DEA with frontier changes for new product target setting." *European Journal of Operational Research* 254.2 (2016): 510~516.

Wei, Quanling, Jianzhong Zhang, and Xiangsun Zhang. "An inverse DEA model for inputs/outputs estimate." *European Journal of Operational Research* 121.1 (2000): 151~163.

**See Also**

[dm.dea](#) Distance measure using DEA  
[roc.dea](#) RoC calculation using DEA  
[target.arrival.dea](#) Arrival target setting using DEA

**Examples**

```
# Reproduce Example 2 in Wei, Q. et al.(2000)
# ready
x <- matrix(c(1, 1, 1), 3)
y <- matrix(c(4, 8, 5, 8, 4, 5), 3)
a <- matrix(1.8, 1)
w <- matrix(c(0.5, 0.5), 1)

# go
target.spec.dea(x, y, dmu = 3, alpha = a, wv = w, rts = "crs")$beta

# Reproduce Table 4 in Lim, D-J. (2016)
# Load engine dataset
df <- dataset.engine.2015

# Subset for forced induction systems
fis <- subset(df, grepl("^C..", df[, 8]))

# ready
# Suppose one wants to estimate Porsche 911 turbo s' engine specs
# to retain its current competitiveness with downsized 3.5 litre engine in 2018.
# What might be the minimum specs to achieve this goal
# considering the technological changes we've seen so far?
# Plus, the CEO wants to put more emphasis on the torque improvement over HP.
```

```
d <- subset(fis, select = 2)
x <- subset(fis, select = 4)
y <- subset(fis, select = 6 : 7)
a <- as.matrix(3.5)
w <- matrix(c(0.3, 0.7), 1)

# go
target.spec.dea(x, y, d, 2015, 3, 262, alpha = a, wv = w, rts = "vrs", sg = "min")$beta
```

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