

# Package ‘deaR’

September 5, 2022

**Type** Package

**Title** Conventional and Fuzzy Data Envelopment Analysis

**Version** 1.2.6

**Author** Vicente Coll-Serrano, Vicente Bolos, Rafael Benitez Suarez <rabesua@uv.es>

**Maintainer** Vicente Bolos <vicente.bolos@uv.es>

**Description** Set of functions for Data Envelopment Analysis. It runs both classic and fuzzy DEA models. See: Banker, R.; Charnes, A.; Cooper, W.W. (1984). <doi:10.1287/mnsc.30.9.1078>, Charnes, A.; Cooper, W.W.; Rhodes, E. (1981). <doi:10.1287/mnsc.27.6.668>.

**License** GPL

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.2.0

**Depends** R (>= 3.5)

**Imports** lpSolve, ggplot2, tidyr, plotly, igraph, writexl, dplyr, methods, gridExtra, grDevices

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2022-09-05 10:20:09 UTC

## R topics documented:

bootstrap_basic . . . . .	3
Coelli_1998 . . . . .	5
Coll_Blasco_2006 . . . . .	6
cross_efficiency . . . . .	7
cross_efficiency_fuzzy . . . . .	10
Departments . . . . .	11
Doyle_Green_1994 . . . . .	13
Economy . . . . .	14
EconomyLong . . . . .	15

efficiencies	16
efficiencies.dea	17
efficiencies.dea_fuzzy	18
Electric_plants	19
Fortune500	20
Fried1993	21
FuzzyExample	22
Golany_Roll_1989	23
Grifell_Lovell_1999	25
Guo_Tanaka_2001	26
Hotels	27
Hua_Bian_2007	28
is.dea	30
is.deadata	30
is.deadata_fuzzy	31
is.dea_fuzzy	32
is.friends	32
Kao_Liu_2003	34
lambdas	35
Leon2003	36
Libraries	37
Lim_Zhu_2015	38
malmquist_index	40
maximal_friends	42
modelfuzzy_guotanaka	44
modelfuzzy_kaoliu	46
modelfuzzy_possibilistic	48
model_additive	49
model_addsupereff	52
model_basic	54
model_deaps	58
model_fdh	60
model_multiplier	61
model_nonradial	64
model_profit	65
model_rdm	68
model_sbmeff	69
model_sbmsupereff	71
model_supereff	73
multipliers	75
PFT1981	76
plot.dea	78
plot.dea_fuzzy	79
Power_plants	80
read_data	81
read_data_fuzzy	83
read_malmquist	85
references	87

rts . . . . .	88
Ruggiero2007 . . . . .	89
slacks . . . . .	90
summary.dea . . . . .	91
summary.dea_fuzzy . . . . .	92
Supply_Chain . . . . .	93
targets . . . . .	94
Tone2001 . . . . .	95
Tone2003 . . . . .	96
undesirable_basic . . . . .	97

<b>Index</b>	<b>99</b>
--------------	-----------

---

bootstrap_basic	<i>Bootstrapping DEA</i>
-----------------	--------------------------

---

## Description

To bootstrap efficiency scores, `deaR` uses the algorithm proposed by Simar and Wilson (1998). For now, the function `bootstrap_basic` can only be used with basic DEA models.

## Usage

```
bootstrap_basic(datadea,
               orientation = c("io", "oo"),
               rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
               L = 1,
               U = 1,
               B = 2000,
               h = NULL,
               alpha = 0.05)
```

## Arguments

<code>datadea</code>	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
<code>orientation</code>	A string, equal to "io" (input oriented) or "oo" (output oriented).
<code>rts</code>	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
<code>L</code>	Lower bound for the generalized returns to scale (grs).
<code>U</code>	Upper bound for the generalized returns to scale (grs).
<code>B</code>	Number of bootstrap iterations.
<code>h</code>	Bandwidth of smoothing window. By default $h=0.014$ (You can set $h$ to any other value). The optimal bandwidth factor can also be calculated following the proposals of Silverman (1986) and Daraio y Simar (2007). So, $h="h1"$ is the optimal $h$ referred as "robust normal-reference rule" (Daraio and Simar, 2007

p.60),  $h="h2"$  is the value of  $h1$  but instead of the factor 1.06 with the factor 0.9,  $h="h3"$  is the value of  $h1$  adjusted for scale and sample size (Daraio and Simar, 2007 p.61), and  $h="h4"$  is the bandwidth provided by a Gaussian kernel density estimate.

alpha                    Between 0 and 1 (for confidence intervals).

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

### References

Behr, A. (2015). *Production and Efficiency Analysis with R*. Springer.

Bogetoft, P.; Otto, L. (2010). *Benchmarking with DEA, SFA, and R*. Springer.

Daraio, C.; Simar, L. (2007). *Advanced Robust and Nonparametric Methods in Efficiency Analysis: Methodology and Applications*. New York: Springer.

Färe, R.; Grosskopf, S.; Kokkenlenberg, E. (1989). "Measuring Plant Capacity, Utilization and Technical Change: A Nonparametric Approach". *International Economic Review*, 30(3), 655-666.

Löthgren, M.; Tambour, M. (1999). "Bootstrapping the Data Envelopment Analysis Malmquist Productivity Index". *Applied Economics*, 31, 417-425.

Silverman, B.W. (1986). *Density Estimation for Statistics and Data Analysis*. London: Chapman and Hall.

Simar, L.; Wilson, P.W. (1998). "Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models". *Management Science*, 44(1), 49-61.

Simar, L.; Wilson, P.W. (1999). "Estimating and Bootstrapping Malmquist Indices". *European Journal of Operational Research*, 115, 459-471.

Simar, L.; Wilson, P.W. (2008). *Statistical Inference in Nonparametric Frontier Models: Recent Developments and Perspective*. In H.O. Fried; C.A. Knox Lovell and S.S. Schmidt (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. New York: Oxford University Press. doi: [10.1093/acprof:oso/9780195183528.001.0001](https://doi.org/10.1093/acprof:oso/9780195183528.001.0001)

### Examples

```
# To replicate the results in Simar y Wilson (1998, p. 58) you have to
# set B=2000 (in the example B = 100 to save time)
data("Electric_plants")
data_example <- read_data(Electric_plants,
                          ni = 3,
                          no = 1)
result <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "vrs",
```

```
result$score_bc
result$CI
```

B = 100)

---

Coelli\_1998

*Data: Coelli, Rao and Battese (1998).*

---

### Description

Data of five DMUs with two inputs and one output. Prices for inputs are available. Price for output is not from Coelli et al. (1998).

### Usage

```
data("Coelli_1998")
```

### Format

Data frame with 6 rows and 5 columns. Definition of inputs (X) and outputs (Y):

**Input1** Input 1

**Input2** Input 2

**Output** Output

**Price\_input1** Price input 1

**Price\_input2** Price input 2

**Price\_output** Price output

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Source

Coelli, T.; Prasada Rao, D.S.; Battese, G.E. An introduction to efficiency and productivity analysis. Boston: Kluwer Academic Publishers.

### See Also

[read\\_data](#)

### Examples

```
# Example. Replication of results in Coelli et al. (1998, p.166).
# Cost efficiency model.
data("Coelli_1994")
# Selection of prices: data_prices is the trasnpose where the prices for inputs are.
data_prices <- t(Coelli_1998[,5:6])

data_example <- read_data(Coelli_1998,
                          dmus=1,
                          ni=2,
                          no=1)
result <- model_profit(data_example,
                       price_input=data_prices,
                       rts="crs",
                       restricted_optimal=FALSE)
# notice that the option by default is restricted_optimal=TRUE
efficiencies(result)
```

---

Coll\_Blasco\_2006

*Data: Coll and Blasco (2006).*

---

### Description

Data of six authorized dealers with two inputs and two outputs.

### Usage

```
data("Coll_Blasco_2006")
```

### Format

Data frame with 6 rows and 5 columns. Definition of inputs (X) and outputs (Y):

**x1 = Employees** Number of employees

**x2 = Capital** Impairment of assets

**y1 = Vehicles** Number of vehicles sold

**y2 = Orders** Number of orders received at the garage

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)



**Arguments**

datadea	An object of class dea or deadata. If it is of class dea it must have been obtained with some of the multiplier DEA models.
dmu_eval	A numeric vector. Only the multipliers of DMUs in dmu_eval are computed. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
epsilon	Numeric, multipliers must be $\geq$ epsilon.
orientation	A string, equal to "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
selfapp	Logical. If it is TRUE, self-appraisal is included in the average scores of A and e.
correction	Logical. If it is TRUE, a correction is applied in the "vrs" input-oriented model in order to avoid negative cross-efficiencies, according to Lim & Zhu (2015).
M2	Logical. If it is TRUE, it computes Method II for aggressive/benevolent estimations.
M3	Logical. If it is TRUE, it computes Method III for aggressive/benevolent estimations.

**Note**

(1) We can obtain negative cross-efficiency in the input-oriented DEA model under no constant returns-to-scale. However, the same does not happen in the case of the output-oriented VRS DEA model. For this reason, the proposal of Lim and Zhu (2015) is implemented in deaR to calculate the input-oriented cross-efficiency model under no constant returns-to-scale.

(2) The multiplier model can have alternate optimal solutions (see note 1 in model\_multiplier). So, depending on the optimal weights selected we can obtain different cross-efficiency scores.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**References**

Sexton, T.R., Silkman, R.H.; Hogan, A.J. (1986). Data envelopment analysis: critique and extensions. In: Silkman RH (ed) Measuring efficiency: an assessment of data envelopment analysis, vol 32. Jossey-Bass, San Francisco, pp 73–104. doi: [10.1002/ev.1441](https://doi.org/10.1002/ev.1441)

Doyle, J.; Green, R. (1994). "Efficiency and cross efficiency in DEA: derivations, meanings and the uses", *Journal of Operational Research Society*, 45(5), 567–578. DOI: 10.2307/2584392

Cook, W.D.; Zhu, J. (2015). DEA Cross Efficiency. In: Zhu, J. (ed) *Data Envelopment Analysis. A Handbook of Models and Methods*. International Series in Operations Research & Management Science, vol 221. Springer, Boston, MA, 23-43 doi: [10.1007/9781489975539\\_2](https://doi.org/10.1007/9781489975539_2)

Lim, S.; Zhu, J. (2015). "DEA Cross-Efficiency Under Variable Returns to Scale". *Journal of Operational Research Society*, 66(3), p. 476-487. doi: [10.1057/jors.2014.13](https://doi.org/10.1057/jors.2014.13)

### See Also

[model\\_multiplier](#), [cross\\_efficiency\\_fuzzy](#)

### Examples

```
# Example 1.
# Arbitrary formulation. Input-oriented model under constant returns-to-scale.
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989,
                          inputs = 2:4,
                          outputs = 5:6)
result <- cross_efficiency(data_example,
                           orientation = "io",
                           rts = "crs",
                           selfapp = TRUE)

result$Arbitrary$cross_eff
result$Arbitrary$e

# Example 2.
# Benevolent formulation (method II). Input-oriented.
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989,
                          inputs = 2:4,
                          outputs = 5:6)
result <- cross_efficiency(data_example,
                           orientation = "io",
                           selfapp = TRUE)

result$M2_ben$cross_eff
result$M2_ben$e

# Example 3.
# Benevolent formulation (method III). Input-oriented.
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989,
                          inputs = 2:4,
                          outputs = 5:6)
result <- cross_efficiency(data_example,
                           orientation = "io",
                           selfapp = TRUE)

result$M3_ben$cross_eff
result$M3_ben$e
```

```

# Example 4.
# Arbitrary formulation. Output-oriented.
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989,
                          inputs = 2:4,
                          outputs = 5:6)
result <- cross_efficiency(data_example,
                           orientation = "oo",
                           selfapp = TRUE)
result$Arbitrary$cross_eff
result$Arbitrary$e

# Example 5.
# Arbitrary formulation. Input-oriented model under vrs returns-to-scale.
data("Lim_Zhu_2015")
data_example <- read_data(Lim_Zhu_2015,
                          ni = 1,
                          no = 5)
cross <- cross_efficiency(data_example,
                           epsilon = 0,
                           orientation = "io",
                           rts = "vrs",
                           selfapp = TRUE,
                           M2 = FALSE,
                           M3 = FALSE)
cross$Arbitrary$e

```

---

cross\_efficiency\_fuzzy

*Cross efficiency fuzzy tables*

---

### Description

Computes the cross-efficiency fuzzy table from DEA data or a Guo-Tanaka DEA model solution. The (crisp) relative efficiencies for the case  $h = 1$  are obtained from the CCR model (`model_multiplier`).

### Usage

```

cross_efficiency_fuzzy(datadea,
                       orientation = c("io", "oo"),
                       h = 1,
                       selfapp = TRUE)

```

### Arguments

<code>datadea</code>	An object of class <code>dea_fuzzy</code> or <code>deadata_fuzzy</code> . If it is of class <code>dea_fuzzy</code> it must have been obtained with <code>model_fuzzy_guotanaka</code> .
<code>orientation</code>	A string, equal to "io" (input-oriented) or "oo" (output-oriented).

h                    A numeric vector with the h-levels (in [0,1]).  
 selfapp            Logical. If it is TRUE, self-appraisal is included in the average scores of A and e.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics*.

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
 University of Valencia (Spain)

### References

Doyle, J.; Green, R. (1994). "Efficiency and Cross Efficiency in DEA: Derivations, Meanings and the Uses", *Journal of Operational Research Society*, 45(5), 567–578. doi: [10.2307/2584392](https://doi.org/10.2307/2584392)

Guo, P.; Tanaka, H. (2001). "Fuzzy DEA: A Perceptual Evaluation Method", *Fuzzy Sets and Systems*, 119, 149–160. doi: [10.1016/S01650114\(99\)001062](https://doi.org/10.1016/S01650114(99)001062)

León, T.; Liern, V.; Ruiz, J.L.; Sirvent, I. (2003). "A Fuzzy Mathematical Programming Approach to the assessment of efficiency with DEA Models", *Fuzzy Sets Systems*, 139(2), 407–419. doi: [10.1016/S01650114\(02\)006085](https://doi.org/10.1016/S01650114(02)006085)

Sexton, T.R., Silkman, R.H.; Hogan, A.J. (1986). Data envelopment analysis: critique and extensions. In: Silkman RH (ed) *Measuring efficiency: an assessment of data envelopment analysis*, vol 32. Jossey-Bass, San Francisco, pp 73–104. doi: [10.1002/ev.1441](https://doi.org/10.1002/ev.1441)

### Examples

```
data("Guo_Tanaka_2001")
datadea <- read_data_fuzzy(datadea = Guo_Tanaka_2001,
                          inputs.mL = 2:3,
                          inputs.dL = 4:5,
                          outputs.mL = 6:7,
                          outputs.dL = 8:9)
result <- cross_efficiency_fuzzy(datadea = datadea,
                                h = seq(0, 1, 0.2))
```

---

 Departments

*Data: Tomkins and Green (1988).*


---

### Description

Data from 20 University accounting departments in the UK.

### Usage

```
data("Departments")
```

**Format**

Data frame with 20 rows and 11 columns. Definition of inputs (X) and outputs (Y):

**x1 = Staff** Average Full Time Academic Staff 82/3-84/5)  
**x2 = Salaries** 1984-5 Salaries Academics and Related (in pounds))  
**x3 = Other\_Exp** 1984-5 Other Expenses (in pounds)  
**y1 = Undergrad** Average Number Undergraduates 82/3-84/5  
**y2 = Research\_post** Research Postgraduates  
**y3 = Taught\_post** Taught Postgraduates  
**y4 = Res\_co\_income** Research council income (in pounds)  
**y5 = Other\_res\_income** Other research income (in pounds)  
**y6 = Other\_income** Other income (in pounds)  
**y7 = Publications** Number of publications

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
 University of Valencia (Spain)

**Source**

Tomkins, C.; Green, R. (1988). "An Experiment in the Use of Data Envelopment Analysis for Evaluating the Efficiency of UK University Departments of Accounting", *Financial Accountability and Management*, 4(2), 147-164. doi: 10.1111/j.1468-0408.1988.tb00296.x

**See Also**

[read\\_data, model\\_basic](#)

**Examples**

```
# Example.
# Replication of results DEA1 in Tomkins and Green (1988)
data("Departments")
# Calculate Total income
Departments$Total_income <- Departments[,5]+Departments[,6]+Departments[,7]
data_example <- read_data(Departments,
                          inputs=9,
                          outputs=c(2,3,4,12))
result <- model_basic(data_example,
                     orientation="io",
                     rts="crs")
efficiencies(result) # Table 3 (p.156)
references(result) # Table 3 (p.157)
```

---

Doyle\_Green\_1994      *Data: Doyle and Green (1994).*

---

**Description**

Data adapted from Tomkins and Green (1988). 13 DMUs using 3 inputs to produce 2 outputs.

**Usage**

```
data("Doyle_Green_1994")
```

**Format**

Data frame with 13 rows and 6 columns. Definition of inputs (X) and outputs (Y):

**y1 = Undergraduate** Number of undergraduates

**y2 = Postgraduates** Number of postgraduates (taught and research)

**y3 = Research\_income** Research and other income

**y4 = Publications** Number of publications

**x1 = Salaries** Salaries of academic and related staff

**x2 = Other\_expenses** Other expenses

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Doyle, J.; Green, R. (1994). "Efficiency and cross efficiency in DEA: derivations, meanings and the uses", *Journal of Operational Research Society*, 45(5), 567–578. doi: 10.2307/2584392

**See Also**

[read\\_data](#), [model\\_multiplier](#), [cross\\_efficiency](#)

**Examples**

```

# Example.
data("Doyle_Green_1994")
data_example <- read_data(datadea = Doyle_Green_1994,
                          dmus = 1,
                          inputs = 6:7,
                          outputs = 2:5)
result <- cross_efficiency(data_example,
                           orientation = "io",
                           selfapp = TRUE)

result$Arbitrary$cross_eff
result$Arbitrary$e
# Aggressive using method II
result$M2_agg$cross_eff
# Aggressive using method III
result$M3_agg$cross_eff

```

---

Economy

*Data: Wang and Lan (2011).*


---

**Description**

Data of the industrial economy of China in 2005-2009 (data in wide format).

**Usage**

```
data("Economy")
```

**Format**

Data frame with 31 rows and 16 columns. Definition of inputs (X) and outputs (Y):

**x1 = Capital** Total assets (in 100 million RMB)

**x2 = Labor** Annual average employed persons (in 10000 persons)

**y1 = GIOV** Gross industrial output value (in 100 million RMB)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Wang, Y.; Lan, Y. (2011). "Measuring Malmquist Productivity Index: A New Approach Based on Double Frontiers Data Envelopment Analysis". *Mathematical and Computer Modelling*, 54, 2760-2771. doi: 10.1016/j.mcm.2011.06.064

**See Also**

[read\\_malmquist](#), [malmquist\\_index](#)

**Examples**

```
# Example . Data in wide format.
# Replication of results in Wang and Lan (2011, p. 2768)
data("Economy")
data_example <- read_malmquist(Economy,
                              nper=5,
                              arrangement="horizontal",
                              ni = 2,
                              no = 1)
result <- malmquist_index(data_example)
```

---

EconomyLong

*Data: Wang and Lan (2011).*

---

**Description**

Data of the industrial economy of China in 2005-2009 (data in long format).

**Usage**

```
data("EconomyLong")
```

**Format**

Data frame with 155 rows and 5 columns. Definition of inputs (X) and outputs (Y):

**x1 = Capital** Total assets (in 100 million RMB)

**x2 = Labor** Annual average employed persons (in 10000 persons)

**y1 = GIOV** Gross industrial output value (in 100 million RMB)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Wang, Y.; Lan, Y. (2011). "Measuring Malmquist Productivity Index: A New Approach Based on Double Frontiers Data Envelopment Analysis". *Mathematical and Computer Modelling*, 54, 2760-2771. doi: 10.1016/j.mcm.2011.06.064

**See Also**

[read\\_malmquist](#), [malmquist\\_index](#)

**Examples**

```
# Example. Data in long format.
# Replication of results in Wang and Lan (2011, p. 2768)
data("EconomyLong")
data_example <- read_malmquist(EconomyLong,
                              percol=2,
                              arrangement="vertical",
                              ni = 2,
                              no = 1)
result <- malmquist_index(data_example)
```

---

efficiencies

*Efficiencies*

---

**Description**

Extract the scores (optimal objective values) of the evaluated DMUs from a DEA / DEA fuzzy solution. Note that these scores may not always be interpreted as efficiencies.

**Usage**

```
efficiencies(x, ...)
```

**Arguments**

x	DEA / DEA fuzzy object
...	ignored

---

efficiencies.dea      *Efficiencies*

---

## Description

Extract the scores (optimal objective values) of the evaluated DMUs from a DEA solution. Note that these scores may not always be interpreted as efficiencies.

## Usage

```
## S3 method for class 'dea'  
efficiencies(x, ...)
```

## Arguments

x                    Object of class dea or dea\_fuzzy obtained with some of the dea model functions.  
...                  Other options (for compatibility reasons)

## Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

## Examples

```
# Replication results model DEA1 in Tomkins and Green (1988)  
data("Departments")  
# Calculate Total income  
Departments$Total_income <- Departments[, 5] + Departments[, 6] + Departments[, 7]  
data_DEA1 <- read_data(Departments,  
                      inputs = 9,  
                      outputs = c(2, 3, 4, 12))  
result <- model_basic(data_DEA1,  
                      orientation = "io",  
                      rts = "crs")  
efficiencies(result) # Table 3 (p.156)
```

---

 efficiencies.dea\_fuzzy

*Efficiencies*


---

### Description

Extract the scores (optimal objective values) of the evaluated DMUs from a DEA fuzzy solution. Note that these scores may not always be interpreted as efficiencies.

### Usage

```
## S3 method for class 'dea_fuzzy'
efficiencies(x, ...)
```

### Arguments

x                    Object of class dea or dea\_fuzzy obtained with some of the dea model functions.  
 ...                  Other options (for compatibility)

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Examples

```
# Replication results model DEA1 in Tomkins and Green (1988)
data("Departments")
# Calculate Total income
Departments$Total_income <- Departments[, 5] + Departments[, 6] + Departments[, 7]
data_DEA1 <- read_data(Departments,
                       inputs = 9,
                       outputs = c(2, 3, 4, 12))
result <- model_basic(data_DEA1,
                     orientation = "io",
                     rts = "crs")
efficiencies(result) # Table 3 (p.156)
```

---

Electric\_plants      *Data: Färe, Grosskopf and Kokkelenberg (1989).*

---

### Description

Data of 19 coal-fired steam-electric generating plants operating in Illinois in 1978. Each plant uses 3 inputs to produce 1 output.

### Usage

```
data("Electric_plants")
```

### Format

Data frame with 18 rows and 5 columns. Definition of inputs (X) and outputs (Y):

**x1 = Labor** Labor average annual employment

**x2 = Fuel** Fuel  $10^{10}$  Btu

**x3 = Capital** Capital MW (fixed input)

**y1 = Output** Output  $10^6$  Kwh

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Source

Färe, R.; Grosskopf, S.; Kokkelenberg, E. (1989). "Measuring Plant Capacity, Utilization and Technical Change: A Nonparametric Approach". *International Economic Review*, 30(3), 655-666.

Simar, L.; Wilson, P.W. (1998). "Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models". *Management Science*, 44(1), 49-61.

### See Also

[read\\_data](#), [model\\_basic](#)

### Examples

```
# Example. Replication of results in Simar and Wilson (1998, p.59)
data("Electric_plants")
data_example <- read_data(Electric_plants,
                          dmus = 1,
                          ni=3,
                          no=1)
result <- model_basic(data_example,
                     orientation="io",
                     rts="vrs")
efficiencies(result)
```

---

Fortune500

*Data: Zhu (2014).*

---

### Description

This dataset consists of 15 firms from the Fortune 500 list 1995 (<https://fortune.com/fortune500/>) with 3 inputs and 2 outputs.

### Usage

```
data("Fortune500")
```

### Format

Data frame with 15 rows and 6 columns. Definition of inputs (X) and outputs (Y):

**x1 = Assets** Assets (millions of dollars)

**x2 = Equity** Equity (millions of dollars)

**x3 = Employees** Number of employees

**y1 = Revenue** Revenue (millions of dollars)

**y2 = Profit** Profit (millions of dollars)

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

### Source

Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets.* 3rd Edition Springer, New York. doi: 10.1007/978-3-319-06647-9

**See Also**

[read\\_data](#), [model\\_multiplier](#)

**Examples**

```
data("Fortune500")
data_Fortune <- read_data(datadea = Fortune500,
                        dmus = 1,
                        inputs = 2:4,
                        outputs = 5:6)
result <- model_multiplier(data_Fortune,
                          epsilon=0.000001,
                          orientation="io",
                          rts="crs")
# results for General Motors and Ford Motor are not shown
# by deaR because the solution is infeasible
efficiencies(result)
multipliers(result)
```

---

Fried1993

*Data: Fried, Knox Lovell and Schmidt (1993).*

---

**Description**

Data of 11 DMUs with two inputs and one output.

**Usage**

```
data("Fried1993")
```

**Format**

Data frame with 11 rows and 4 columns. Definition of inputs (X) and outputs (Y):

**x1** Input 1

**x2** Input 2

**y1** Output 1

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Ali, A.I.; Seiford, L.M. (1993). The Mathematical Programming Approach to Efficiency Analysis. In Fried, H.O.; Knox Lovell, C.A.; Schmidt, S.S.(eds.), The Measurement of Productive Efficiency. Techniques and Applications. New York: Oxford University Press.

**See Also**

[read\\_data](#), [model\\_basic](#)

**Examples**

```
# Example. Replication of results in Ali and (1993, p.143).
data("Fried1993")
data_example <- read_data(Fried1993,
                          ni=2,
                          no=1)
result <- model_basic(data_example,
                     orientation="oo",
                     rts="vrs")
efficiencies(result)
targets(result)
```

---

FuzzyExample

*Data: Fuzzy data reading example.*

---

**Description**

Synthetic dataset of 5 DMUs with 3 inputs and 3 outputs containing fuzzy and crisp data.

**Usage**

```
data("FuzzyExample")
```

**Format**

Data frame with 5 rows and 15 columns.

**DMU** DMU names

**Input1.mL** First Input (crisp numbers)

**Input2.mL** Second Input (left centers)

**Input2.mR** Second Input (right centers)

**Input2.dL** Second Input (left radii)

**Input2.dR** Second Input (right radii)

**Input3.mL** Third Input (centers)

**Input3.dL** Third Input (radii)

**Output1.mL** First Output (crisp numbers)  
**Output2.mL** Second Output (left centers)  
**Output2.mR** Second Output (right centers)  
**Output2.dL** Second Output (radii)  
**Output3.mL** Third Output (centers)  
**Output3.dL** Third Output (left radii)  
**Output3.dR** Third Output (right radii)

#### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

#### See Also

[read\\_data\\_fuzzy](#)

#### Examples

```
# Example. Reading the data.
data("FuzzyExample")
datafuzzy <- read_data_fuzzy(FuzzyExample,
                             inputs.mL = c(2, 3, 7),
                             inputs.mR = c(NA, 4, NA),
                             inputs.dL = c(NA, 5, 8),
                             inputs.dR = c(NA, 6, NA),
                             outputs.mL = c(9, 10, 13),
                             outputs.mR = c(NA, 11, NA),
                             outputs.dL = c(NA, 12, 14),
                             outputs.dR = c(NA, NA, 15))
```

---

Golany\_Roll\_1989

*Data: Golany and Roll (1989).*

---

#### Description

Data of 13 DMUs using 3 inputs to produce 2 outputs.

#### Usage

```
data("Golany_Roll_1989")
```

**Format**

Data frame with 13 rows and 6 columns. Definition of inputs (X) and outputs (Y):

**x1** Input 1

**x2** Input 2

**x3** Input 3

**y1** Output 1

**y1** Output 2

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Golany, B.; Roll, Y. (1989). "An Application Procedure for DEA". *OMEGA, International Journal of Management Science*, 17(3), 237-250. doi: 10.1016/0305-0483(89)90029-7

**See Also**

[read\\_data, model\\_multiplier, cross\\_efficiency](#)

**Examples**

```
# Example.
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989,
                          dmus = 1,
                          inputs = 2:4,
                          outputs = 5:6)
result <- cross_efficiency(data_example,
                           orientation = "io",
                           selfapp = TRUE)
result$Arbitrary$cross_eff
result$Arbitrary$e
```

---

Grifell\_Lovell\_1999    *Data: Grifell-Tatjé and Lovell (1999).*

---

**Description**

Data of 8 DMUs producing 1 output (Y) by using 1 input (X) for two periods of time.

**Usage**

```
data("Grifell_Lovell_1999")
```

**Format**

Data frame with 16 rows and 4 columns. Definition of inputs (X) and outputs (Y):

**X** Input

**Y** Output

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Source**

Grifell-Tatjé, E.; Lovel, C.A.K. (1999). "A Generalized Malmquist productivity index". *Top*, 7(1), 81-101.

**See Also**

[read\\_malmquist](#), [malmquist\\_index](#)

**Examples**

```
# Example. Replication of results in Grifell-Tatjé and Lovell (1999, p. 100).
data("Grifell_Lovell_1999")
data_example <- read_malmquist(Grifell_Lovell_1999,
                              percol=1,
                              dmus = 2,
                              inputs = 3,
                              outputs = 4,
                              arrangement="vertical")

result_fgnc <- malmquist_index(data_example,
```

```

orientation= "oo",
rts="vrs",
type1 = "cont",
type2 = "fgnz")

result_fgnz$mi

```

---

Guo\_Tanaka\_2001

*Data: Guo and Tanaka (2001).*


---

### Description

Data of 5 DMUs with two symmetric triangular fuzzy inputs,  $X_j=(x_j, \alpha_j)$ , and two symmetric triangular fuzzy outputs,  $Y_j=(y_j, \beta_j)$ .

### Usage

```
data("Guo_Tanaka_2001")
```

### Format

Data frame with 5 rows and 9 columns. Definition of fuzzy inputs (X) and fuzzy outputs (Y):

**x1** Input 1

**x2** Input 2

**alpha1** spread vector Input 1

**alpha2** spread vector Input 2

**y1** Output 1

**y2** Output 2

**beta1** spread vector Output 1

**beta2** spread vector Output 2

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Source

Guo, P.; Tanaka, H. (2001). "Fuzzy DEA: A Perceptual Evaluation Method", *Fuzzy Sets and Systems*, 119, 149–160. doi: 10.1016/S0165-0114(99)00106-2

**See Also**

[read\\_data\\_fuzzy](#), [modelfuzzy\\_guotanaka](#), [cross\\_efficiency\\_fuzzy](#)

**Examples**

```
data("Guo_Tanaka_2001")
data_example <- read_data_fuzzy(Guo_Tanaka_2001,
                                dmus=1,
                                inputs.mL=2:3,
                                inputs.dL=4:5,
                                outputs.mL=6:7,
                                outputs.dL=8:9)
result <- modelfuzzy_guotanaka(data_example,
                                h = seq(0,1,by=0.1),
                                orientation="io")
efficiencies(result)
```

---

Hotels

*Data: Wu, Tsai and Zhou (2011).*

---

**Description**

This dataset consists of 23 four- and five-plum ITHs in Taipei in 2006. Authors consider 4 inputs and 3 outputs.

**Usage**

```
data("Hotels")
```

**Format**

Data frame with 23 rows and 8 columns. Definition of inputs (X) and outputs (Y):

**x1 = Employees** Total number of employees)

**x2 = Guest\_rooms** Total number of guest rooms)

**x3 = Area\_F&B** Total area of F&B departments (in 36 square-feet)

**x4 = Operating\_cost** Total operating cost (in NT\$)

**y1 = Room\_revenue** Room revenues (in NT\$)

**y2 = F&B\_revenue** F&B revenues (in NT\$)

**y3 = Other\_revenue** Other revenues (in NT\$)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Wu, J.; Tsai, H. and Zhou, Z. (2011). "Improving efficiency in International tourist hotels in Taipei using a non-radial DEA mode", *International Journal of Contemporary Hospitality Management*, 23(1), 66-83. doi: 10.1108/095961111111101670

**See Also**

[read\\_data, model\\_nonradial](#)

**Examples**

```
# Example. Replication of results in Wu,Tsai and Zhou (2011)
data("Hotels")
data_hotels <- read_data(Hotels,
                        dmus = 1,
                        inputs = 2:5,
                        outputs = 6:8)
result <- model_nonradial(data_hotels,
                          orientation="oo",
                          rts="vrs")
efficiencies(result)
```

---

Hua\_Bian\_2007

*Data: Hua and Bian (2007).*

---

**Description**

Data of 30 DMUs with two desirable inputs, two desirable outputs and one undesirable output.

**Usage**

```
data("Hua_Bian_2007")
```

**Format**

Data frame with 30 rows and 6 columns. Definition of inputs (X) and outputs (Y):

**x1 = D-Input1** Desirable Input 1

**x2 = D-Input2** Desirable Input 2

**y1 = D-Output1** Desirable Output 1

**y2 = D-Output2** Desirable Output 2

**y3 = UD-Output1** Undesirable Output 1

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics*.

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Source**

Hua Z.; Bian Y. (2007). DEA with Undesirable Factors. In: Zhu J., Cook W.D. (eds) *Modeling Data Irregularities and Structural Complexities in Data Envelopment Analysis*. Springer, Boston, MA. doi: 10.1007/978-0-387-71607-7\_6

**See Also**

[read\\_data, model\\_basic](#)

**Examples**

```
# Example. Replication of results in Hua and Bian (2007).
data("Hua_Bian_2007")
# The third output is an undesirable output
data_example <- read_data(Hua_Bian_2007,
                          ni=2,
                          no=3,
                          ud_outputs=3)

# Translation parameter (vtrans_o) is set to 1500
result <- model_basic(data_example,
                     orientation="oo",
                     rts="vrs",
                     vtrans_o=1500)
eff <- efficiencies(result)
1/eff # results M5 in Table 6-5 (p.119)
```

is.dea                      *dea class check.*

---

**Description**

Checks whether an R object is of dea class or not.

**Usage**

```
is.dea(x)
```

**Arguments**

x                      Any **R** object.

**Value**

Returns TRUE if its argument is a dea object (that is, has "dea" amongst its classes) and FALSE otherwise.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

---

is.deadata                      *deadata class check.*

---

**Description**

Checks whether an R object is of deadata class or not.

**Usage**

```
is.deadata(x)
```

**Arguments**

x                      Any **R** object.

**Value**

Returns TRUE if its argument is a deadata object (that is, has "deadata" amongst its classes) and FALSE otherwise.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

---

is.deadata\_fuzzy      *deadata\_fuzzy class check.*

---

**Description**

Checks whether an R object is of deadata\_fuzzy class or not.

**Usage**

```
is.deadata_fuzzy(x)
```

**Arguments**

x                      Any **R** object.

**Value**

Returns TRUE if its argument is a deadata\_fuzzy object (that is, has "deadata\_fuzzy" amongst its classes) and FALSE otherwise.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

---

is.dea\_fuzzy            *dea\_fuzzy class check.*

---

### Description

Checks whether an R object is of dea\_fuzzy class or not.

### Usage

```
is.dea_fuzzy(x)
```

### Arguments

x                      Any **R** object.

### Value

Returns TRUE if its argument is a dea\_fuzzy object (that is, has "dea\_fuzzy" amongst its classes) and FALSE otherwise.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

---

is.friends            *Friends check.*

---

### Description

Checks whether a subset of DMUs is friends or not, according to Tone (2010).

### Usage

```
is.friends(datadea,
          dmu_eval = NULL,
          dmu_ref = NULL,
          rts = c("crs", "vrs", "nirs", "ndrs"),
          tol = 1e-6)
```

**Arguments**

<code>datadea</code>	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
<code>dmu_eval</code>	A numeric vector containing the subset of DMUs to be checked. If NULL (default), all DMUs are considered.
<code>dmu_ref</code>	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
<code>rts</code>	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing) or "ndrs" (non-decreasing).
<code>tol</code>	Numeric, a tolerance margin for checking efficiency. It is $1e-6$ by default.

**Value**

Returns TRUE if `dmu_eval` is friends of `dmu_ref`, and FALSE otherwise.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Tone, K. (2010). "Variations on the theme of slacks-based measure of efficiency in DEA", *European Journal of Operational Research*, 200, 901-907. doi: [10.1016/j.ejor.2009.01.027](https://doi.org/10.1016/j.ejor.2009.01.027)

**See Also**

[maximal\\_friends](#), [model\\_sbmeff](#)

**Examples**

```
data("PFT1981")
datadea <- read_data(PFT1981, ni = 5, no = 3)
subset1 <- c(15, 16, 17, 19) # Subset of DMUs to be checked
result1 <- is.friends(datadea = datadea,
                     dmu_eval = subset1,
                     dmu_ref = 1:20) # We only consider a cluster formed by the first 20 DMUs
subset2 <- c(15, 16, 17, 20) # Another subset of DMUs to be checked
result2 <- is.friends(datadea = datadea,
                     dmu_eval = subset2,
                     dmu_ref = 1:20) # We only consider a cluster formed by the first 20 DMUs
```

Kao\_Liu\_2003

*Data: Kao and Liu (2003).***Description**

Data of 24 university libraries in Taiwan with one input and five outputs.

**Usage**

```
data("Kao_Liu_2003")
```

**Format**

Data frame with 24 rows and 11 columns. Definition of fuzzy inputs (X) and fuzzy outputs (Y):

**x1 = Patronage** It is a weighted sum of the standardized scores of faculty, graduate students, undergraduate students, and extension students in the range of 0 and 1.

**y1 = Collections** Books, serials, microforms, audiovisual works, and database.

**y2 = Personnel** Classified staff, unclassified staff, and student assistants.

**y3 = Expenditures** Capital expenditure, operating expenditure, and special expenditure.

**y4 = Buildings** Area and seats

**y5 = Services** Operating hours, attendance, circulation, communication channels, range of services, amount of services, etc.

**beta3\_l** lower spread vector Expenditures

**beta3\_u** upper spread vector Expenditures

**beta5\_l** lower spread vector Services

**beta5\_u** upper spread vector Services

**Note**

There are three observations that are missing: expenditures of Library 24 and services of Library 22 and Library 23. Kao and Liu (2000b) represent the expenditures of Library 24 by the triangular fuzzy number  $Y=(0.11; 0.41; 1.0)$ . The services of Library 22 and Library 23 are expressed by a same triangular fuzzy number  $Y=(0.41; 0.69; 1.0)$ .

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Kao, C., Liu, S.T. (2003). "A mathematical programming approach to fuzzy efficiency ranking", *International Journal of Production Economics*, 85, doi: 10.1016/S0925-5273(03)00026-4

**See Also**

[read\\_data\\_fuzzy](#), [model\\_basic](#)

**Examples**

```
# Example. Replication of results in Kao and Liu (2003, p.152)
data_example <- read_data_fuzzy(Kao_Liu_2003,
                                dmus=1,
                                inputs.mL= 2,
                                outputs.mL= 3:7,
                                outputs.dL=c(NA,NA,8,NA,10),
                                outputs.dR=c(NA,NA,9,NA,11))
result <- modelfuzzy_kaoliu(data_example,
                             kaoliu_modelname = "basic",
                             orientation="oo",
                             rts="vrs",
                             alpha=0)
eff <- efficiencies(result)
eff
```

---

lambdas

*Lambdas*


---

**Description**

Extract the lambdas of the DMUs from a dea or dea\_fuzzy solution.

**Usage**

```
lambdas(deasol)
```

**Arguments**

deasol                    Object of class dea or dea\_fuzzy obtained with some of the dea model functions.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics*.

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Examples**

```

data("Coll_Blasco_2006")
data_example <- read_data(Coll_Blasco_2006,
                          ni = 2,
                          no = 2)
result <- model_multiplier(data_example,
                          orientation = "io",
                          rts = "crs")

lambdas(result)

```

---

Leon2003

*Data: Leon, Liern, Ruiz and Sirvent (2003).*


---

**Description**

Data of 8 DMUs with one symmetric triangular fuzzy inputs:  $X_j=(x_j, \alpha_j)$ , and one symmetric triangular fuzzy outputs:  $Y_j=(y_j, \beta_j)$ .

**Usage**

```
data("Leon2003")
```

**Format**

Data frame with 8 rows and 5 columns. Definition of fuzzy inputs (X) and fuzzy outputs (Y):

**x1** Input 1

**alpha1** spread vector Input 1

**y1** Output 1

**beta1** spread vector Output 1

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Leon, T.; Liern, V. Ruiz, J.; Sirvent, I. (2003). "A Possibilistic Programming Approach to the Assessment of Efficiency with DEA Models", *Fuzzy Sets and Systems*, 139, 407–419. doi: 10.1016/S0165-0114(02)00608-5

**See Also**

[read\\_data\\_fuzzy](#), [modelfuzzy\\_possibilistic](#), [cross\\_efficiency\\_fuzzy](#), [modelfuzzy\\_guotanaka](#)

**Examples**

```
# Example. Replication of results in Leon et. al (2003, p. 416)
data("Leon2003")
data_example <- read_data_fuzzy(Leon2003,
                                dmus = 1,
                                inputs.mL = 2,
                                inputs.dL=3,
                                outputs.mL = 4,
                                outputs.dL=5)
result <- modelfuzzy_possibilistic(data_example,
                                   h = seq(0,1,by=0.1),
                                   orientation="io",
                                   rts="vrs")

efficiencies(result)
```

---

Libraries

*Data: Cooper, Seiford and Tone (2007).*

---

**Description**

Data for 23 public libraries of the Tokyo Metropolitan Area in 1986.

**Usage**

```
data("Libraries")
```

**Format**

Data frame with 23 rows and 7 columns. Definition of inputs (X) and outputs (Y):

**x1 = AREA** Floor area (unit=1000 m2)

**x2 = BOOKS** Number of books (unit=1000)

**x3 = STAFF** Staff

**x4 = POPULATION** Population (unit=1000)

**y1 = REGISTERED** Registered residents (unit=1000)

**y2 = BORROWED** Borrowed books (unit=1000)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Source**

Cooper, W.W.; Seiford, L.M. and Tone, K. (2007). Data Envelopment Analysis. A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Springer

**See Also**

[read\\_data, model\\_basic](#)

**Examples**

```
# Example 1. Non-controllable input (POPULATION).
# Replication of results in Cooper, Seiford and Tone (2007, p.221)
data(Libraries)
# POPULATION (non-controllable input) is the forth input.
data_example <- read_data(Libraries,
                        dmus=1,
                        inputs=2:5,
                        nc_inputs=4,
                        outputs=6:7)
result <- model_basic(data_example,
                    orientation="io",
                    rts="crs")

efficiencies(result)
targets(result)

# Example 2. Non-discretionary input (POPULATION).
data(Libraries)
# POPULATION (non-controllable input) is the forth input.
data_example2 <- read_data(Libraries,
                        dmus=1,
                        inputs=2:5,
                        nd_inputs=4,
                        outputs=6:7)
result2 <- model_basic(data_example2,
                    orientation="io",
                    rts="crs")

efficiencies(result2)
targets(result2)
```

---

Lim\_Zhu\_2015

*Data: Lim and Zhu (2015).*

---

**Description**

Data of 37 R&D project proposal relating to the Turkish iron and steel industry. Authors consider one input and five outputs.



---

malmquist_index	<i>Malmquist index</i>
-----------------	------------------------

---

### Description

This function calculates the conventional input/output oriented Malmquist index under constant or variable returns-to-scale.

### Usage

```
malmquist_index(datadealist,
                dmu_eval = NULL,
                dmu_ref = NULL,
                orientation = c("io", "oo"),
                rts = c("crs", "vrs"),
                type1 = c("cont", "seq", "glob"),
                type2 = c("fgnz", "rd", "gl", "bias"),
                tc_vrs = FALSE)
```

### Arguments

<code>datadealist</code>	A list with the data at different times, including DMUs, inputs and outputs.
<code>dmu_eval</code>	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
<code>dmu_ref</code>	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
<code>orientation</code>	A string, equal to "io" (input oriented) or "oo" (output oriented).
<code>rts</code>	A string, determining the type of returns to scale, equal to "crs" (constant) or "vrs" (variable).
<code>type1</code>	A string, equal to "cont" (contemporary), "seq" (sequential) or "glob" (global).
<code>type2</code>	A string, equal to "fgnz" (Fare et al. 1994), "rd" (Ray and Desli 1997), "gl" (generalized) or "bias" (biased).
<code>tc_vrs</code>	Logical. If it is FALSE, it computes the vrs bias malmquist index by using the technical change under crs (Fare and Grosskopf 1996). Otherwise, it uses the technical change under vrs.

### Value

A numeric list with Malmquist index and other parameters.

### Note

In the results: EC = Efficiency Change, PTEC = Pure Technical Efficiency Change, SEC = Scale Efficiency Change, TC = Technological Change, MI = Malmquist Index

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**References**

Caves, D.W.; Christensen, L. R.; Diewert, W.E. (1982). "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity". *Econometrica*, 50(6), 1393-1414.

Fare, R.; Grifell-Tatje, E.; Grosskopf, S.; Lovell, C.A.K. (1997). "Biased Technical Change and the Malmquist Productivity Index". *Scandinavian Journal of Economics*, 99(1), 119-127.

Fare, R.; Grosskopf, S.; Lindgren, B.; Roos, P. (1989). "Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach". Discussion paper n. 89-3. Southern Illinois University. Illinois.

Fare, R.; Grosskopf, S.; Lindgren, B.; Roos, P. (1992). "Productivity changes in Swedish Pharmacies 1980-89: A nonparametric Malmquist Approach". *Journal of productivity Analysis*, 3(3), 85-101.

Fare, R.; Grosskopf, S.; Norris, M.; Zhang, Z. (1994). "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries". *American Economic Review*, 84(1), 66-83.

Fare, R.; Grosskopf, S.; Roos, P. (1998), Malmquist Productivity Indexes: A Survey of Theory and Practice. In: Fare R., Grosskopf S., Russell R.R. (eds) *Index Numbers: Essays in Honour of Sten Malmquist*. Springer.

Grifell-Tatje, E.; Lovell, C.A.K. (1999). "A Generalized Malmquist productivity index". *Top*, 7(1), 81-101.

Pastor, J.T.; Lovell, C.A.k. (2005). "A global Malmquist productivity index". *Economics Letters*, 88, 266-271.

Ray, S.C.; Desli, E. (1997). "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries: Comment". *The American Economic Review*, 87(5), 1033-1039.

Shestalova, V. (2003). "Sequential Malmquist Indices of Productivity Growth: An Application to OECD Industrial Activities". *Journal of Productivity Analysis*, 19, 211-226.

**Examples**

```
# Example 1. With dataset in wide format.
# Replication of results in Wang and Lan (2011, p. 2768)
data("Economy")
data_example <- read_malmquist(datadea = Economy,
                              nper = 5,
                              arrangement = "horizontal",
                              ni = 2,
                              no = 1)
result <- malmquist_index(data_example, orientation = "io")
mi <- result$mi
```

```

effch <- result$ec
tech <- result$tc

# Example 2. With dataset in long format.
# Replication of results in Wang and Lan (2011, p. 2768)
data("EconomyLong")
data_example2 <- read_malmquist(EconomyLong,
                                percol = 2,
                                arrangement = "vertical",
                                inputs = 3:4,
                                outputs = 5)
result2 <- malmquist_index(data_example2, orientation = "io")
mi2 <- result2$mi
effch2 <- result2$ec
tech2 <- result2$tc

# Example 3. Replication of results in Grifell-Tatje and Lovell (1999, p. 100).
data("Grifell_Lovell_1999")
data_example <- read_malmquist(Grifell_Lovell_1999,
                                percol = 1,
                                dmus = 2,
                                inputs = 3,
                                outputs = 4,
                                arrangement = "vertical")
result_fgnc <- malmquist_index(data_example,
                                orientation = "oo",
                                rts = "vrs",
                                type1 = "cont",
                                type2 = "fgnc")
mi_fgnc <- result_fgnc$mi

result_rd <- malmquist_index(data_example,
                                orientation = "oo",
                                rts = "vrs",
                                type1 = "cont",
                                type2 = "rd")
mi_rd <- result_rd$mi

result_gl <- malmquist_index(data_example,
                                orientation = "oo",
                                rts = "vrs",
                                type1 = "cont",
                                type2 = "gl")
mi_gl <- result_gl$mi

```

**Description**

Finds the maximal friends subsets of a given set of DMUs, according to Tone (2010). It uses a descending algorithm in order to find directly maximal subsets.

**Usage**

```
maximal_friends(datadea,  
               dmu_ref = NULL,  
               rts = c("crs", "vrs", "nirs", "ndrs"),  
               tol = 1e-6,  
               silent = FALSE)
```

**Arguments**

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set, i.e. the cluster of DMUs from which we want to find maximal friends. If NULL (default), all DMUs are considered.
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing) or "ndrs" (non-decreasing).
tol	Numeric, a tolerance margin for checking efficiency. It is $1e-6$ by default.
silent	Logical, if FALSE (default) steps are printed.

**Value**

A list with numeric vectors representing maximal friends subsets of DMUs.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Tone, K. (2010). "Variations on the theme of slacks-based measure of efficiency in DEA", *European Journal of Operational Research*, 200, 901-907. doi: [10.1016/j.ejor.2009.01.027](https://doi.org/10.1016/j.ejor.2009.01.027)

**See Also**

[is.friends](#), [model\\_sbmeff](#)

**Examples**

```
## Not run:
data("PFT1981")
datadea <- read_data(PFT1981, ni = 5, no = 3)
# We find maximal friends of a cluster formed by the first 20 DMUs
result <- maximal_friends(datadea = datadea,
                          dmu_ref = 1:20)

## End(Not run)
```

---

modelfuzzy\_guotanaka *Fuzzy DEA model*

---

**Description**

Solve the Fuzzy input-oriented and output-oriented DEA model proposed by Guo and Tanaka (2001) under constant returns-to-scale. In `deaR` is implemented the LP problem given by the model (16) in Guo and Tanaka (2001, p.155). The fuzzy efficiencies are calculated according to equations in (17) (Guo and Tanaka, 2001, p.155). The (crisp) relative efficiencies and multipliers for the case  $h = 1$  are obtained from the CCR model (`model_multiplier`).

**Usage**

```
modelfuzzy_guotanaka(datadea,
                     dmu_eval = NULL,
                     dmu_ref = NULL,
                     orientation = c("io", "oo"),
                     h = 1)
```

**Arguments**

<code>datadea</code>	The data, including DMUs, inputs and outputs.
<code>dmu_eval</code>	A numeric vector containing which DMUs have to be evaluated. If <code>NULL</code> (default), all DMUs are considered.
<code>dmu_ref</code>	A numeric vector containing which DMUs are the evaluation reference set. If <code>NULL</code> (default), all DMUs are considered.
<code>orientation</code>	A string, equal to "io" (input oriented) or "oo" (output oriented).
<code>h</code>	A numeric vector with the h-levels (in $[0,1]$ ).

**Value**

An object of class `deadata_fuzzy`.

**Note**

The optimal solution of model (16) is not unique.



```

                                orientation = "io")
efficiencies(result2)

```

---

modelfuzzy\_kaoliu      *Fuzzy DEA model.*

---

### Description

Solve the fuzzy DEA model by Kao and Liu (2000)

### Usage

```

modelfuzzy_kaoliu(datadea,
                  dmu_eval = NULL,
                  kaoliu_modelname = c("basic", "additive", "addsupereff",
                                       "deaps", "fdh", "multiplier", "nonradial",
                                       "sbmeff", "sbmsupereff", "supereff"),
                  alpha = 1,
                  ...)

```

### Arguments

datadea	The data, including DMUs, inputs and outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
kaoliu_modelname	a string containing the name of the model.
alpha	A numeric vector with the alpha-cuts (in [0,1]). If alpha>1, it determines the number of alpha-cuts, equispatially distributed in [0,1].
...	dmu_ref, orientation, rts and other model parameters.

### Value

An object of class `deadata_fuzzy`.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

## References

- Boscá, J.E.; Liern, V.; Sala, R.; Martínez, A. (2011). "Ranking Decision Making Units by Means of Soft Computing DEA Models". *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, 19(1), p.115-134.
- Emrouznejad, A.; Tavana, M.; Hatami-Marbini, A. (2014). "The State of the Art in Fuzzy Data Envelopment Analysis", in A. Emrouznejad and M. Tavana (eds.), *Performance Measurement with Fuzzy Data Envelopment Analysis*. *Studies in Fuzziness and Soft Computing* 309. Springer, Berlin.
- Hatami-Marbini, A.; Emrouznejad, A.; Tavana, M. (2011). "A Taxonomy and Review of the Fuzzy Data Envelopment Analysis Literature: Two Decades in the Making", *European Journal of Operational Research*, 214, 457–472.
- Kao, C.; Liu, S.T. (2000). "Fuzzy efficiency measures in data envelopment analysis, *Fuzzy Sets and Systems*", 119, 149–160.
- Kao, C., Liu, S.T., (2000). "Data envelopment analysis with missing data: An application to university libraries in Taiwan", *Journal of the Operational Research Society*, 51, 897–905.
- Kao, C., Liu, S.T. (2003). "A mathematical programming approach to fuzzy efficiency ranking", *International Journal of Production Economics*, 85.

## See Also

[model\\_basic](#), [model\\_multiplier](#), [modelfuzzy\\_possibilistic](#), [modelfuzzy\\_guotanaka](#)

## Examples

```
# Example 1.
# Replication of results in Boscá, Liern, Sala and Martínez (2011, p.125)
data("Leon2003")
data_example <- read_data_fuzzy(datadea = Leon2003,
                               inputs.mL = 2,
                               inputs.dL = 3,
                               outputs.mL = 4,
                               outputs.dL = 5)
result <- modelfuzzy_kaoliu(data_example,
                            kaoliu_modelname = "basic",
                            alpha = seq(0, 1, by = 0.1),
                            orientation = "io",
                            rts = "vrs")

efficiencies(result)

# Example 2.
# Replication of results in Kao and Liu (2003, p.152)
data("Kao_Liu_2003")
data_example <- read_data_fuzzy(Kao_Liu_2003,
                               inputs.mL = 2,
                               outputs.mL = 3:7,
                               outputs.dL = c(NA, NA, 8, NA, 10),
                               outputs.dR = c(NA, NA, 9, NA, 11))
result <- modelfuzzy_kaoliu(data_example,
                            kaoliu_modelname = "basic",
                            orientation = "oo",
```

```

                                rts = "vrs",
                                alpha = 0)
sol <- efficiencias(result)
eff <- data.frame(1 / sol$Worst, 1 / sol$Best)
names(eff) <- c("eff_lower", "eff_upper")
eff

```

---

modelfuzzy\_possibilistic

*Possibilistic Fuzzy DEA model.*

---

### Description

Solve the possibilistic fuzzy DEA model proposed by León et. al (2003).

### Usage

```

modelfuzzy_possibilistic(datadea,
                          dmu_eval = NULL,
                          poss_modelname = c("basic"),
                          h = 1,
                          ...)

```

### Arguments

datadea	The data, including DMUs, inputs and outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
poss_modelname	a string containing the name of the model.
h	A numeric vector with the h-levels (in [0,1]).
...	dmu_ref, orientation, rts and other model parameters.

### Value

An object of class `deadata_fuzzy`.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

## References

Emrouznejad, A.; Tavana, M.; Hatami-Marbini, A. (2014). "The State of the Art in Fuzzy Data Envelopment Analysis", in A. Emrouznejad and M. Tavana (eds.), Performance Measurement with Fuzzy Data Envelopment Analysis. Studies in Fuzziness and Soft Computing 309. Springer, Berlin. doi: [10.1007/9783642413728\\_1](https://doi.org/10.1007/9783642413728_1)

Hatami-Marbini, A.; Emrouznejad, A.; Tavana, M. (2011). "A Taxonomy and Review of the Fuzzy Data Envelopment Analysis Literature: Two Decades in the Making", European Journal of Operational Research, 214, 457–472. doi: [10.1016/j.ejor.2011.02.001](https://doi.org/10.1016/j.ejor.2011.02.001)

Léon, T.; Liern, V. Ruiz, J.; Sirvent, I. (2003). "A Possibilistic Programming Approach to the Assessment of Efficiency with DEA Models", Fuzzy Sets and Systems, 139, 407–419. doi: [10.1016/S01650114\(02\)006085](https://doi.org/10.1016/S01650114(02)006085)

## See Also

[model\\_basic](#), [modelfuzzy\\_kaoliu](#), [modelfuzzy\\_guotanaka](#)

## Examples

```
# Replication of results in Leon et. al (2003, p. 416)
data("Leon2003")
data_example <- read_data_fuzzy(Leon2003,
                                inputs.mL = 2,
                                inputs.dL = 3,
                                outputs.mL = 4,
                                outputs.dL = 5)
result <- modelfuzzy_possibilistic(data_example,
                                   h = seq(0, 1, by = 0.1),
                                   orientation = "io",
                                   rts = "vrs")

efficiencies(result)
```

---

model\_additive

*Additive DEA model.*

---

## Description

Solve the additive model of Charnes et. al (1985). With the current version of deaR, it is possible to solve input-oriented, output-oriented, and non-oriented additive dea model under constant and non-constant returns-to-scale.

Besides, the user can set weights for the input slacks and/or output slacks. So, it is also possible to solve weighted additive models. For example: Measure of Inefficiency Proportions (MIP), Range Adjusted Measure (RAM), etc.

**Usage**

```
model_additive(datadea,
               dmu_eval = NULL,
               dmu_ref = NULL,
               orientation = NULL,
               weight_slack_i = 1,
               weight_slack_o = 1,
               rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
               L = 1,
               U = 1,
               compute_target = TRUE,
               returnlp = FALSE,
               ...)
```

**Arguments**

<code>datadea</code>	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
<code>dmu_eval</code>	A numeric vector containing which DMUs have to be evaluated. If <code>NULL</code> (default), all DMUs are considered.
<code>dmu_ref</code>	A numeric vector containing which DMUs are the evaluation reference set. If <code>NULL</code> (default), all DMUs are considered.
<code>orientation</code>	This parameter is either <code>NULL</code> (default) or a string, equal to "io" (input-oriented) or "oo" (output-oriented). It is used to modify the weight slacks. If input-oriented, <code>weight_slack_o</code> are taken 0. If output-oriented, <code>weight_slack_i</code> are taken 0.
<code>weight_slack_i</code>	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the input slacks. If 0, output-oriented.
<code>weight_slack_o</code>	A value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the output slacks. If 0, input-oriented.
<code>rts</code>	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
<code>L</code>	Lower bound for the generalized returns to scale (grs).
<code>U</code>	Upper bound for the generalized returns to scale (grs).
<code>compute_target</code>	Logical. If it is <code>TRUE</code> , it computes targets.
<code>returnlp</code>	Logical. If it is <code>TRUE</code> , it returns the linear problems (objective function and constraints).
<code>...</code>	Ignored, for compatibility issues.

**Note**

In this model, the efficiency score is the sum of the slacks. Therefore, a DMU is efficient when the objective value (`objval`) is zero.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Charnes, A.; Cooper, W.W.; Golany, B.; Seiford, L.; Stuz, J. (1985) "Foundations of Data Envelopment Analysis for Pareto-Koopmans Efficient Empirical Production Functions", *Journal of Econometrics*, 30(1-2), 91-107. doi: [10.1016/03044076\(85\)901332](https://doi.org/10.1016/03044076(85)901332)

Charnes, A.; Cooper, W.W.; Lewin, A.Y.; Seiford, L.M. (1994). *Data Envelopment Analysis: Theory, Methology, and Application*. Boston: Kluwer Academic Publishers. doi: [10.1007/97894011-06375](https://doi.org/10.1007/97894011-06375)

Cooper, W.W.; Park, K.S.; Pastor, J.T. (1999). "RAM: A Range Adjusted Measure of Inefficiencies for Use with Additive Models, and Relations to Other Models and Measures in DEA". *Journal of Productivity Analysis*, 11, p. 5-42. doi: [10.1023/A:1007701304281](https://doi.org/10.1023/A:1007701304281)

**See Also**

[model\\_addsupereff](#)

**Examples**

```
# Example 1.
# Replication of results in Charnes et. al (1994, p. 27)
x <- c(2, 3, 6, 9, 5, 4, 10)
y <- c(2, 5, 7, 8, 3, 1, 7)
data_example <- data.frame(dmus = letters[1:7], x, y)
data_example <- read_data(data_example,
                          ni = 1,
                          no = 1)
result <- model_additive(data_example,
                        rts = "vrs")

efficiencies(result)
slacks(result)
lambdas(result)

# Example 2.
# Measure of Inefficiency Proportions (MIP).
x <- c(2, 3, 6, 9, 5, 4, 10)
y <- c(2, 5, 7, 8, 3, 1, 7)
data_example <- data.frame(dmus = letters[1:7], x, y)
data_example <- read_data(data_example, ni = 1, no = 1)
result2 <- model_additive(data_example, rts = "vrs",
                          weight_slack_i = 1 / data_example[["input"]],
                          weight_slack_o = 1 / data_example[["output"]])

slacks(result2)
```

```

# Example 3.
# Range Adjusted Measure of Inefficiencies (RAM).
x <- c(2, 3, 6, 9, 5, 4, 10)
y <- c(2, 5, 7, 8, 3, 1, 7)
data_example <- data.frame(dmus=letters[1:7], x, y)
data_example <- read_data(data_example, ni = 1, no = 1)
range_i <- apply(data_example[["input"]], 1, max) - apply(data_example[["input"]], 1, min)
range_o <- apply(data_example[["output"]], 1, max) - apply(data_example[["output"]], 1, min)
w_range_i <- 1 / (range_i * (dim(data_example[["input"]])[1] + dim(data_example[["output"]])[1]))
w_range_o <- 1 / (range_o * (dim(data_example[["input"]])[1] + dim(data_example[["output"]])[1]))
result3 <- model_additive(data_example, rts = "vrs",
                        weight_slack_i = w_range_i,
                        weight_slack_o = w_range_o)

slacks(result3)

```

---

model_addsupereff	<i>Additive super-efficiency DEA model.</i>
-------------------	---

---

### Description

Solve the additive super-efficiency model proposed by Du, Liang and Zhu (2010). It is an extension of the SBM super-efficiency to the additive DEA model.

### Usage

```

model_addsupereff(datadea,
                  dmu_eval = NULL,
                  dmu_ref = NULL,
                  orientation = NULL,
                  weight_slack_i = NULL,
                  weight_slack_o = NULL,
                  rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
                  L = 1,
                  U = 1,
                  compute_target = TRUE,
                  returnlp = FALSE,
                  ...)

```

### Arguments

datadea	The data, including n DMUs, m inputs and s outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.

orientation	This parameter is either NULL (default) or a string, equal to "io" (input-oriented) or "oo" (output-oriented). It is used to modify the weight slacks. If input-oriented, weight_slack_o are taken 0. If output-oriented, weight_slack_i are taken 0.
weight_slack_i	A value, vector of length m, or matrix m x ne (where ne is the length of dmu_eval) with the weights of the input superslacks (t_input). If 0, output-oriented. If weight_slack_i is the matrix of the inverses of inputs (of DMUS in dmu_eval), the model is unit invariant.
weight_slack_o	A value, vector of length s, or matrix s x ne (where ne is the length of dmu_eval) with the weights of the output superslacks (t_output). If 0, input-oriented. If weight_slack_o is the matrix of the inverses of outputs (of DMUS in dmu_eval), the model is unit invariant.
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
compute_target	Logical. If it is TRUE, it computes targets, projections and slacks.
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints).
...	Ignored, for compatibility issues.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics*.

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### References

Du, J.; Liang, L.; Zhu, J. (2010). "A Slacks-based Measure of Super-efficiency in Data Envelopment Analysis. A Comment", *European Journal of Operational Research*, 204, 694-697. doi: [10.1016/j.ejor.2009.12.007](https://doi.org/10.1016/j.ejor.2009.12.007)

Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets*. 3rd Edition Springer, New York. Doi: 10.1007/978-3-319-06647-9.

### See Also

[model\\_additive](#), [model\\_supereff](#), [model\\_sbmsupereff](#)

## Examples

```
# Replication of results in Du, Liang and Zhu (2010, Table 6, p.696)
data("Power_plants")
Power_plants <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result <- model_addsupereff(Power_plants,
                            rts = "crs")
efficiencies(result)
```

---

model\_basic

*Basic (radial) DEA model.*

---

## Description

Solve input and output oriented basic DEA models (envelopment form) under constant (CCR DEA model), variable (BCC DEA model), non-increasing, non-decreasing or generalized returns to scale. By default, models are solved in a two-stage process (DEA slacks are maximized).

The model\_basic function allows to treat with non-discretionary, uncontrollable and undesirable inputs/outputs.

Finally, you can use the model\_basic function to solve directional DEA models by choosing orientation = "dir".

## Usage

```
model_basic(datadea,
            dmu_eval = NULL,
            dmu_ref = NULL,
            orientation = c("io", "oo", "dir"),
            dir_input = NULL,
            dir_output = NULL,
            rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
            L = 1,
            U = 1,
            maxslack = TRUE,
            weight_slack_i = 1,
            weight_slack_o = 1,
            vtrans_i = NULL,
            vtrans_o = NULL,
            compute_target = TRUE,
            compute_multiplier = FALSE,
            returnlp = FALSE,
            ...)
```

**Arguments**

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
orientation	A string, equal to "io" (input oriented), "oo" (output oriented), or "dir" (directional).
dir_input	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the input directions. If <code>dir_input == input matrix (of DMUS in dmu_eval)</code> and <code>dir_output == 0</code> , it is equivalent to input oriented ( $\beta = 1 - \text{efficiency}$ ). If <code>dir_input</code> is omitted, input matrix (of DMUS in <code>dmu_eval</code> ) is assigned.
dir_output	A value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the output directions. If <code>dir_input == 0</code> and <code>dir_output == output matrix (of DMUS in dmu_eval)</code> , it is equivalent to output oriented ( $\beta = \text{efficiency} - 1$ ). If <code>dir_output</code> is omitted, output matrix (of DMUS in <code>dmu_eval</code> ) is assigned.
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
maxslack	Logical. If it is TRUE, it computes the max slack solution.
weight_slack_i	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the input slacks for the max slack solution.
weight_slack_o	A value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the output slacks for the max slack solution.
vtrans_i	Numeric vector of translation for undesirable inputs with non-directional orientation. If <code>vtrans_i[i]</code> is NA, then it applies the "max + 1" translation to the $i$ -th undesirable input. If <code>vtrans_i</code> is a constant, then it applies the same translation to all undesirable inputs. If <code>vtrans_i</code> is NULL, then it applies the "max + 1" translation to all undesirable inputs.
vtrans_o	Numeric vector of translation for undesirable outputs with non-directional orientation, analogous to <code>vtrans_i</code> , but applied to outputs.
compute_target	Logical. If it is TRUE, it computes targets of the max slack solution.
compute_multiplier	Logical. If it is TRUE, it computes multipliers (dual solution) when orientation is "io" or "oo".
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints) of stage 1.
...	Ignored, for compatibility issues.

**Note**

(1) With undesirable inputs/outputs and non-directional orientation, you should select "vrs" returns to scale (BCC model) in order to maintain translation invariance (Seiford and Zhu, 2002). If deaR detects that you are not specifying  $rts = "vrs"$ , it makes the change to "vrs" automatically.

(2) With undesirable inputs and non-directional orientation use input-oriented BCC model, and with undesirable outputs and non-directional orientation use output-oriented BCC model. Alternatively, you can also treat the undesirable outputs as inputs and then apply the input-oriented BCC model (similarly with undesirable inputs).

(3) With  $orientation = "dir"$  (directional distance function model), efficient DMUs are those for which  $\beta = 0$ .

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**References**

Charnes, A.; Cooper, W.W.; Rhodes, E. (1978). "Measuring the efficiency of decision making units", *European Journal of Operational Research* 2, 429–444.

Charnes, A.; Cooper, W.W.; Rhodes, E. (1979). "Short communication: Measuring the efficiency of decision making units", *European Journal of Operational Research* 3, 339.

Charnes, A.; Cooper, W.W.; Rhodes, E. (1981). "Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through", *Management Science*, 27(6), 668-697.

Banker, R.; Charnes, A.; Cooper, W.W. (1984). "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science*; 30; 1078-1092.

Undesirable inputs/outputs:

Pastor, J.T. (1996). "Translation Invariance in Data Envelopment Analysis: a Generalization", *Annals of Operations Research*, 66(2), 91-102.

Seiford, L.M.; Zhu, J. (2002). "Modeling undesirable factors in efficiency evaluation", *European Journal of Operational Research* 142, 16-20.

Färe, R. ; Grosskopf, S. (2004). "Modeling undesirable factors in efficiency evaluation: Comment", *European Journal of Operational Research* 157, 242-245.

Hua Z.; Bian Y. (2007). *DEA with Undesirable Factors*. In: Zhu J., Cook W.D. (eds) *Modeling Data Irregularities and Structural Complexities in Data Envelopment Analysis*. Springer, Boston, MA.

Non-discretionary/Non-controllable inputs/outputs:

Banker, R.; Morey, R. (1986). "Efficiency Analysis for Exogenously Fixed Inputs and Outputs", *Operations Research*; 34; 513-521.

Ruggiero J. (2007). Non-Discretionary Inputs. In: Zhu J., Cook W.D. (eds) Modeling Data Irregularities and Structural Complexities in Data Envelopment Analysis. Springer, Boston, MA.

Directional DEA model:

Chambers, R.G.; Chung, Y.; Färe, R. (1996). "Benefit and Distance Functions", Journal of Economic Theory, 70(2), 407-419.

Chambers, R.G.; Chung, Y.; Färe, R. (1998). "Profit Directional Distance Functions and Nerlovian Efficiency", Journal of Optimization Theory and Applications, 95, 351-354.

### See Also

[model\\_multiplier](#), [model\\_supereff](#)

### Examples

```
# Example 1. Basic DEA model with desirable inputs/outputs.
# Replication of results in Charnes, Cooper and Rhodes (1981).
data("PFT1981")
# Selecting DMUs in Program Follow Through (PFT)
PFT <- PFT1981[1:49, ]
PFT <- read_data(PFT,
                 inputs = 2:6,
                 outputs = 7:9 )
eval_pft <- model_basic(PFT,
                       orientation = "io",
                       rts = "crs")
eff <- efficiencies(eval_pft)
s <- slacks(eval_pft)
lamb <- lambdas(eval_pft)
tar <- targets(eval_pft)
ref <- references(eval_pft)
returns <- rts(eval_pft)

# Example 2. Basic DEA model with undesirable outputs.
# Replication of results in Hua and Bian (2007).
data("Hua_Bian_2007")
# The third output is an undesirable output.
data_example <- read_data(Hua_Bian_2007,
                          ni = 2,
                          no = 3,
                          ud_outputs = 3)
# Translation parameter (vtrans_o) is set to 1500
result <- model_basic(data_example,
                     orientation = "oo",
                     rts = "vrs",
                     vtrans_o = 1500)
eff <- efficiencies(result)
1 / eff # results M5 in Table 6-5 (p.119)

# Example 3. Basic DEA model with non-discretionary (fixed) inputs.
# Replication of results in Ruggiero (2007).
data("Ruggiero2007")
```

```
# The second input is a non-discretionary input.
datadea <- read_data(Ruggiero2007,
                    ni = 2,
                    no = 1,
                    nd_inputs = 2)
result <- model_basic(datadea,
                     orientation = "io",
                     rts = "crs")
efficiencies(result)
```

---

model\_deaps

*Preference Structure DEA model.*


---

### Description

With this non-radial DEA model (Zhu, 1996), the user can specify the preference input (or output) weights that reflect the relative degree of desirability of the adjustments of the current input (or output) levels.

### Usage

```
model_deaps(datadea,
            dmu_eval = NULL,
            dmu_ref = NULL,
            weight_eff = 1,
            orientation = c("io", "oo"),
            rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
            L = 1,
            U = 1,
            restricted_eff = TRUE,
            maxslack = TRUE,
            weight_slack = 1,
            compute_target = TRUE,
            returnlp = FALSE,
            ...)
```

### Arguments

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
weight_eff	Preference weights. If input-oriented, it is a value, vector of length $m$ , or matrix $m \times ne$ (where $ne$ is the length of <code>dmu_eval</code> ) with the weights applied to the input efficiencies. If output-oriented, it is a value, vector of length $s$ , or matrix $s \times ne$ with the weights applied to the output efficiencies.

orientation	A string, equal to "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
restricted_eff	Logical. If it is TRUE, the efficiencies are restricted to be $\leq 1$ (input-oriented) or $\geq 1$ (output-oriented).
maxslack	Logical. If it is TRUE, it computes the max slack solution.
weight_slack	If input-oriented, it is a value, vector of length $s$ , or matrix $s \times ne$ with the weights of the output slacks for the max slack solution. If output-oriented, it is a value, vector of length $m$ , or matrix $m \times ne$ with the weights of the input slacks for the max slack solution.
compute_target	Logical. If it is TRUE, it computes targets of the max slack solution.
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints) of stage 1.
...	Ignored, for compatibility issues.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

### References

Zhu, J. (1996). "Data Envelopment Analysis with Preference Structure", *The Journal of the Operational Research Society*, 47(1), 136. DOI: 10.2307/2584258

Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets. 3rd Edition* Springer, New York. DOI: 10.1007/978-3-319-06647-9

### See Also

[model\\_nonradial](#), [model\\_profit](#), [model\\_sbmeff](#)

### Examples

```
data("Fortune500")
data_deaps <- read_data(datadea = Fortune500,
                      ni = 3,
                      no = 2)
result <- model_deaps(data_deaps,
                     weight_eff = c(1, 2, 3),
```

```

                                orientation = "io",
                                rts = "vrs")
efficiencies(result)

```

---

model\_fdh

*Free disposal hull (FDH) model.*


---

### Description

FDH model allows the free disposability to construct the production possibility set. The central feature of the FDH model is the lack of convexity for its production possibility set (Thrall, 1999).

### Usage

```

model_fdh(datadea,
          fdh_modelname = c("basic"),
          ...)

```

### Arguments

datadea	The data, including DMUs, inputs and outputs.
fdh_modelname	A string containing the name of the model to apply FDH.
...	dmu_eval, dmu_ref, orientation and other model parameters.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### References

Cherchye, L.; Kuosmanen, T.; Post, T. (2000). "What Is the Economic Meaning of FDH? A Reply to Thrall". *Journal of Productivity Analysis*, 13(3), 263–267.

Deprins, D.; Simar, L. and Tulkens, H. (1984). *Measuring Labor-Efficiency in Post Offices*. In M. Marchand, P. Pestieau and H. Tulkens (eds.), *The Performance of Public Enterprises: Concepts and Measurement*. Amsterdam: North-Holland.

Sanei, M.; Mamizadeh Chatghayeb, S. (2013). "Free Disposal Hull Models in Supply Chain Management", *International Journal of Mathematical Modelling and Computations*, 3(3), 125-129.

Thrall, R. M. (1999). "What Is the Economic Meaning of FDH?", *Journal of Productivity Analysis*, 11(3), 243–50.

**Examples**

```

# Example 1. FDH input-oriented.
# Replication of results in Sanei and Mamizadeh Chatghayeb (2013)
data("Supply_Chain")
data_fdh1 <- read_data(Supply_Chain,
                      inputs = 2:4,
                      outputs = 5:6)
result <- model_fdh(data_fdh1) # by default orientation = "io"
efficiencies(result)

# Example 2. FDH output-oriented.
# Replication of results in Sanei and Mamizadeh Chatghayeb (2013)
data("Supply_Chain")
data_fdh2 <- read_data(Supply_Chain,
                      inputs = 5:6,
                      outputs = 7:8)
result2 <- model_fdh(data_fdh2,
                    orientation = "oo")
efficiencies(result2)

```

---

model_multiplier	<i>Multiplier DEA model</i>
------------------	-----------------------------

---

**Description**

Solve input-oriented and output-oriented basic DEA models (multiplicative form) under constant (CCR DEA model), variable (BCC DEA model), non-increasing, non-decreasing or generalized returns to scale. It does not take into account uncontrollable, non-discretionary or undesirable inputs/outputs.

**Usage**

```

model_multiplier(datadea,
                dmu_eval = NULL,
                dmu_ref = NULL,
                epsilon = 0,
                orientation = c("io", "oo"),
                rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
                L = 1,
                U = 1,
                returnlp = FALSE,
                compute_lambda = TRUE,
                ...)

```

**Arguments**

datadea	The data, including DMUs, inputs and outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
epsilon	Numeric, multipliers must be $\geq$ epsilon.
orientation	A string, equal to "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints).
compute_lambda	Logical. If it is TRUE, it computes the dual problem and lambdas.
...	Ignored, for compatibility issues.

**Note**

- (1) Very important with the multiplier model: "The optimal weights for an efficient DMU need not be unique" (Cooper, Seiford and Tone, 2007:31). "Usually, the optimal weights for inefficient DMUs are unique, the exception being when the line of the DMU is parallel to one of the boundaries of the feasible region" (Cooper, Seiford and Tone, 2007:32).
- (2) The measure of technical input (or output) efficiency obtained by using multiplier DEA models is better the smaller the value of epsilon.
- (3) Epsilon is usually set equal to  $10^{-6}$ . However, if epsilon is not set correctly, the multiplier model can be infeasible (Zhu,2014:49).

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**References**

- Charnes, A.; Cooper, W.W. (1962). "Programming with Linear Fractional Functionals", *Naval Research Logistics Quarterly* 9, 181-185. doi: [10.1002/nav.3800090303](https://doi.org/10.1002/nav.3800090303)
- Charnes, A.; Cooper, W.W.; Rhodes, E. (1978). "Measuring the Efficiency of Decision Making Units", *European Journal of Operational Research* 2, 429-444. doi: [10.1016/03772217\(78\)901388](https://doi.org/10.1016/03772217(78)901388)

Charnes, A.; Cooper, W.W.; Rhodes, E. (1979). "Short Communication: Measuring the Efficiency of Decision Making Units", *European Journal of Operational Research* 3, 339. doi: [10.1016/0377-2217\(79\)902297](https://doi.org/10.1016/0377-2217(79)902297)

Golany, B.; Roll, Y. (1989). "An Application Procedure for DEA", *OMEGA International Journal of Management Science*, 17(3), 237-250. doi: [10.1016/03050483\(89\)900297](https://doi.org/10.1016/03050483(89)900297)

Seiford, L.M.; Thrall, R.M. (1990). "Recent Developments in DEA. The Mathematical Programming Approach to Frontier Analysis", *Journal of Econometrics* 46, 7-38. doi: [10.1016/0304-4076\(90\)90045U](https://doi.org/10.1016/0304-4076(90)90045U)

Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets*. 3rd Edition Springer, New York. DOI: 10.1007/978-3-319-06647-9

### See Also

[model\\_basic](#), [cross\\_efficiency](#)

### Examples

```
# Example 1.
# Replication of results in Golany and Roll (1989).
data("Golany_Roll_1989")
data_example <- read_data(datadea = Golany_Roll_1989[1:10, ],
                          inputs = 2:4,
                          outputs = 5:6)
result <- model_multiplier(data_example,
                           epsilon = 0,
                           orientation = "io",
                           rts = "crs")

efficiencies(result)
multipliers(result)

# Example 2.
# Multiplier model with infeasible solutions (See note).
data("Fortune500")
data_Fortune <- read_data(datadea = Fortune500,
                          inputs = 2:4,
                          outputs = 5:6)
result2 <- model_multiplier(data_Fortune,
                            epsilon = 1e-6,
                            orientation = "io",
                            rts = "crs")

# Results for General Motors and Ford Motor are not shown by deaR
# because the solution is infeasible.
efficiencies(result2)
multipliers(result2)
```

---

model_nonradial	<i>Non-radial DEA model.</i>
-----------------	------------------------------

---

### Description

Non-radial DEA model allows for non-proportional reductions in each input or augmentations in each output.

### Usage

```
model_nonradial(datadea,
               dmu_eval = NULL,
               dmu_ref = NULL,
               orientation = c("io", "oo"),
               rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
               L = 1,
               U = 1,
               maxslack = TRUE,
               weight_slack = 1,
               compute_target = TRUE,
               returnlp = FALSE,
               ...)
```

### Arguments

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
orientation	A string, equal to "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
maxslack	Logical. If it is TRUE, it computes the max slack solution.
weight_slack	If input-oriented, it is a value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the output slacks for the max slack solution. If output-oriented, it is a value, vector of length $m$ , or matrix $m \times n$ with the weights of the input slacks for the max slack solution.
compute_target	Logical. If it is TRUE, it computes targets of the max slack solution.
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints) of stage 1.
...	Ignored, for compatibility issues.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2)*. *Applied Economics*.

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Banker, R.D.; Morey, R.C. (1986). "Efficiency Analysis for Exogenously Fixed Inputs and Outputs", *Operations Research*, 34, 80-97. doi: [10.1287/opre.34.4.513](https://doi.org/10.1287/opre.34.4.513)

Färe, R.; Lovell, C.K. (1978). "Measuring the Technical Efficiency of Production", *Journal of Economic Theory*, 19(1), 150-162. doi: [10.1016/00220531\(78\)900601](https://doi.org/10.1016/00220531(78)900601)

Wu, J.; Tsai, H.; Zhou, Z. (2011). "Improving Efficiency in International Tourist Hotels in Taipei Using a Non-Radial DEA Model", *International Journal of Contemporary Hospitality Management*, 23(1), 66-83. doi: [10.1108/095961111111101670](https://doi.org/10.1108/095961111111101670)

Zhu, J. (1996). "Data Envelopment Analysis with Preference Structure", *The Journal of the Operational Research Society*, 47(1), 136. doi: [10.2307/2584258](https://doi.org/10.2307/2584258)

**See Also**

[model\\_deaps](#), [model\\_profit](#), [model\\_sbmeff](#)

**Examples**

```
# Replication of results in Wu, Tsai and Zhou (2011)
data("Hotels")
data_hotels <- read_data(Hotels,
                        inputs = 2:5,
                        outputs = 6:8)
result <- model_nonradial(data_hotels,
                        orientation = "oo",
                        rts = "vrs")

efficiencies(result)
```

---

model\_profit

*Profit efficiency DEA model.*

---

**Description**

Cost, revenue and profit efficiency DEA models.

**Usage**

```

model_profit(datadea,
             dmu_eval = NULL,
             dmu_ref = NULL,
             price_input = NULL,
             price_output = NULL,
             rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
             L = 1,
             U = 1,
             restricted_optimal = TRUE,
             returnlp = FALSE,
             ...)

```

**Arguments**

datadea	The data, including n DMUs, m inputs and s outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
price_input	Unit prices of inputs for cost or profit efficiency models. It is a value, vector of length m, or matrix m x ne (where ne is the length of dmu_eval).
price_output	Unit prices of outputs for revenue or profit efficiency models. It is a value, vector of length s, or matrix s x ne.
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
restricted_optimal	Logical. If it is TRUE, the optimal inputs are restricted to be $\leq$ inputs (for cost efficiency models) or the optimal outputs are restricted to be $\geq$ outputs (for revenue efficiency models).
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints) of stage 1.
...	Ignored, for compatibility issues.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

## References

Coelli, T.; Prasada Rao, D.S.; Battese, G.E. (1998). An introduction to efficiency and productivity analysis. Jossey-Bass, San Francisco, pp 73–104. doi: [10.1002/ev.1441](https://doi.org/10.1002/ev.1441)

Coelli, T.; Prasada Rao, D.S.; Battese, G.E. An introduction to efficiency and productivity analysis. Boston: Kluwer Academic Publishers.

## See Also

[model\\_deaps](#), [model\\_nonradial](#), [model\\_sbmeff](#)

## Examples

```
# Example 1. Replication of results in Coelli et al. (1998, p.166).
# Cost efficiency model.
data("Coelli_1998")
# Selection of prices: input_prices is the transpose where the prices for inputs are.
input_prices <- t(Coelli_1998[, 5:6])

data_example1 <- read_data(Coelli_1998,
                          ni = 2,
                          no = 1)
result1 <- model_profit(data_example1,
                       price_input = input_prices,
                       rts = "crs",
                       restricted_optimal = FALSE)
# notice that the option by default is restricted_optimal = TRUE
efficiencies(result1)

# Example 2. Revenue efficiency model.
data("Coelli_1998")
# Selection of prices for output: output_prices is the transpose where the prices for outputs are.
output_prices <- t(Coelli_1998[, 7])
data_example2 <- read_data(Coelli_1998,
                          ni = 2,
                          no = 1)
result2 <- model_profit(data_example2,
                       price_output = output_prices,
                       rts = "crs",
                       restricted_optimal = FALSE)
# notice that the option by default is restricted_optimal = TRUE
efficiencies(result2)

# Example 3. Profit efficiency model.
data("Coelli_1998")
# Selection of prices for inputs and outputs: input_prices and output_prices are
# the transpose where the prices (for inputs and outputs) are.
input_prices <- t(Coelli_1998[, 5:6])
output_prices <- t(Coelli_1998[, 7])
data_example3 <- read_data(Coelli_1998,
                          ni = 2,
                          no = 1)
```

```

result3 <- model_profit(data_example3,
                        price_input = input_prices,
                        price_output = output_prices,
                        rts = "crs",
                        restricted_optimal = FALSE)
# notice that the option by default is restricted_optimal = TRUE
efficiencies(result3)

```

---

model_rdm	<i>Range directional model.</i>
-----------	---------------------------------

---

### Description

Range directional model from Portela et al. (2004).

### Usage

```

model_rdm(datadea,
          dmu_eval = NULL,
          dmu_ref = NULL,
          orientation = c("no", "io", "oo"),
          irdm = FALSE,
          maxslack = TRUE,
          weight_slack_i = 1,
          weight_slack_o = 1,
          compute_target = TRUE,
          returnlp = FALSE,
          ...)

```

### Arguments

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
orientation	A string, equal to "no" (non-oriented), "io" (input oriented), or "oo" (output oriented).
irdm	Logical. If it is TRUE, it applies the IRDM (inverse range directional model).
maxslack	Logical. If it is TRUE, it computes the max slack solution.
weight_slack_i	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the input slacks for the max slack solution.
weight_slack_o	A value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with the weights of the output slacks for the max slack solution.

compute\_target Logical. If it is TRUE, it computes targets of the max slack solution.

returnlp Logical. If it is TRUE, it returns the linear problems (objective function and constraints) of stage 1.

... Ignored, for compatibility issues.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

### References

Portela, M.; Thanassoulis, E.; Simpson, G. (2004). "Negative data in DEA: a directional distance approach applied to bank branches", *Journal of the Operational Research Society*, 55 1111-1121.

---

model_sbmeff	<i>Slack based measure (SBM) of efficiency model.</i>
--------------	---

---

### Description

Calculate the SBM model proposed by Tone (2001).

### Usage

```
model_sbmeff(datadea,
             dmu_eval = NULL,
             dmu_ref = NULL,
             weight_input = 1,
             weight_output = 1,
             orientation = c("no", "io", "oo"),
             rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
             L = 1,
             U = 1,
             kaizen = FALSE,
             maxfr = NULL,
             tol = 1e-6,
             silent = FALSE,
             compute_target = TRUE,
             returnlp = FALSE,
             ...)
```

**Arguments**

datadea	The data, including $n$ DMUs, $m$ inputs and $s$ outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
weight_input	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with weights to inputs corresponding to the relative importance of items.
weight_output	A value, vector of length $s$ , or matrix $s \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with weights to outputs corresponding to the relative importance of items.
orientation	A string, equal to "no" (non-oriented), "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
kaizen	Logical. If TRUE, the kaizen version of SBM (Tone 2010), also known as SBM-Max, is computed.
maxfr	A list with the maximal friends sets, as it is returned by function <code>maximal_friends</code> . If NULL (default) this list is computed internally.
tol	Numeric, a tolerance margin for checking efficiency (only for the kaizen version).
silent	Logical. If FALSE (default) it prints all the messages from function <code>maximal_friends</code> .
compute_target	Logical. If it is TRUE, it computes targets.
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints). If kaizen is TRUE it is ignored.
...	Other options (currently not implemented)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics*.

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Tone, K. (2001). "A Slacks-Based Measure of Efficiency in Data Envelopment Analysis", *European Journal of Operational Research*, 130, 498-509. doi: [10.1016/S03772217\(99\)004075](https://doi.org/10.1016/S03772217(99)004075)

Tone, K. (2010). "Variations on the theme of slacks-based measure of efficiency in DEA", *European Journal of Operational Research*, 200, 901-907. doi: [10.1016/j.ejor.2009.01.027](https://doi.org/10.1016/j.ejor.2009.01.027)

Cooper, W.W.; Seiford, L.M.; Tone, K. (2007). Data Envelopment Analysis. A Comprehensive Text with Models, Applications, References and DEA-Solver Software. 2nd Edition. Springer, New York. doi: [10.1007/9780387452838](https://doi.org/10.1007/9780387452838)

### See Also

[model\\_nonradial](#), [model\\_deaps](#), [model\\_profit](#), [model\\_sbmsupereff](#)

### Examples

```
# Replication of results in Tone (2001, p.505)
data("Tone2001")
data_example <- read_data(Tone2001,
                          ni = 2,
                          no = 2)
result_SBM <- model_sbmeff(data_example,
                           orientation = "no",
                           rts = "crs")
result_CCR <- model_basic(data_example,
                          orientation = "io",
                          rts = "crs")

efficiencies(result_SBM)
efficiencies(result_CCR)
slacks(result_SBM)
slacks(result_CCR)

# Example. Replication of results in Tone (2003), pp 10-11 case 1:1.
data("Tone2003")
data_example <- read_data(Tone2003,
                          ni = 1,
                          no = 2,
                          ud_outputs = 2)
result <- model_sbmeff(data_example,
                       rts = "vrs")

efficiencies(result)
targets(result)
```

---

model\_sbmsupereff

*Slack based measure of superefficiency model*

---

### Description

Slack based measure of superefficiency model (Tone 2002) with n DMUs, m inputs, s outputs...

**Usage**

```

model_sbmsupereff(datadea,
                  dmu_eval = NULL,
                  dmu_ref = NULL,
                  weight_input = 1,
                  weight_output = 1,
                  orientation = c("no", "io", "oo"),
                  rts = c("crs", "vrs", "nirs", "ndrs", "grs"),
                  L = 1,
                  U = 1,
                  compute_target = TRUE,
                  compute_rho = FALSE,
                  kaizen = FALSE,
                  silent = FALSE,
                  returnlp = FALSE)

```

**Arguments**

datadea	The data, including DMUs, inputs and outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
weight_input	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with weights to inputs corresponding to the relative importance of items.
weight_output	A value, vector of length $m$ , or matrix $m \times n_e$ (where $n_e$ is the length of <code>dmu_eval</code> ) with weights to outputs corresponding to the relative importance of items.
orientation	A string, equal to "no" (non-oriented), "io" (input-oriented) or "oo" (output-oriented).
rts	A string, determining the type of returns to scale, equal to "crs" (constant), "vrs" (variable), "nirs" (non-increasing), "ndrs" (non-decreasing) or "grs" (generalized).
L	Lower bound for the generalized returns to scale (grs).
U	Upper bound for the generalized returns to scale (grs).
compute_target	Logical. If it is TRUE, it computes targets, superslacks ( <code>t_input</code> and <code>t_output</code> ) and slacks.
compute_rho	Logical. If it is TRUE, it computes the SBM efficiency score (applying <code>model_sbmeff</code> ) of the DMU ( <code>project_input</code> , <code>project_output</code> ).
kaizen	Logical. If TRUE, the kaizen version of SBM (Tone 2010), also known as SBM-Max, is computed for the efficiency score of the DMU ( <code>project_input</code> , <code>project_output</code> ).
silent	Logical. If FALSE (default) it prints all the messages from function <code>maximal_friends</code> .
returnlp	Logical. If it is TRUE, it returns the linear problems (objective function and constraints).

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Tone, K. (2002). "A slacks-based measure of super-efficiency in data envelopment analysis", *European Journal of Operational Research*, 143, 32-41. doi: [10.1016/S03772217\(01\)003241](https://doi.org/10.1016/S03772217(01)003241)

Tone, K. (2010). "Variations on the theme of slacks-based measure of efficiency in DEA", *European Journal of Operational Research*, 200, 901-907. doi: [10.1016/j.ejor.2009.01.027](https://doi.org/10.1016/j.ejor.2009.01.027)

Cooper, W.W.; Seiford, L.M.; Tone, K. (2007). *Data Envelopment Analysis. A Comprehensive Text with Models, Applications, References and DEA-Solver Software.* 2nd Edition. Springer, New York. doi: [10.1007/9780387452838](https://doi.org/10.1007/9780387452838)

**See Also**

[model\\_sbmeff](#), [model\\_supereff](#), [model\\_addsupereff](#)

**Examples**

```
# Replication of results in Tone(2002, p.39)
data("Power_plants")
data_example <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result <- model_sbmsupereff(data_example,
                            orientation = "io",
                            rts = "crs")

efficiencies(result)
slacks(result)$slack_input
references(result)
```

---

model\_supereff

*Radial superefficiency basic DEA model*

---

**Description**

Solve Andersen and Petersen radial Super-efficiency DEA model.

**Usage**

```
model_supereff(datadea,
               dmu_eval = NULL,
               dmu_ref = NULL,
               supereff_modelname = c("basic"),
               ...)
```

**Arguments**

datadea	The data, including DMUs, inputs and outputs.
dmu_eval	A numeric vector containing which DMUs have to be evaluated. If NULL (default), all DMUs are considered.
dmu_ref	A numeric vector containing which DMUs are the evaluation reference set. If NULL (default), all DMUs are considered.
supereff_modelname	A string containing the name of the radial model to apply super-efficiency.
...	orientation, rts and other model parameters.

**Note**

- (1) Radial super-efficiency model under variable (vrs, nirs, ndrs, grs) returns to scale can be infeasible for certain DMUs. See example 2.
- (2) DMUs with infeasible solution are not shown in the results.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Andersen, P.; Petersen, N.C. (1993). "A procedure for ranking efficient units in data envelopment analysis", *Management Science*, 39, 1261-1264.

Tone, K. (2002). "A slacks-based measure of super-efficiency in data envelopment analysis", *European Journal of Operational Research*, 143, 32-41.

**See Also**

[model\\_basic](#), [model\\_sbmsupereff](#), [model\\_addsupereff](#)

**Examples**

```

# Example 1.
# Replication of results in Tone (2002, p.38)
data("Power_plants")
data_example <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result <- model_supereff(data_example,
                        orientation = "io",
                        rts = "crs")
eff <- efficiencies(result)

# Example 2.
# Results of Super-efficiency with vrs returns to scale show infeasibility solutions
# for DMUs D4 and D6 (these DMUs are not shown in deaR results).
data("Power_plants")
data_example2 <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result2 <- model_supereff(data_example2,
                         orientation = "io",
                         rts = "vrs")
eff2 <- efficiencies(result2)

```

---

multipliers

*Multipliers*


---

**Description**

Extract the multipliers of the DMUs from a dea or dea\_fuzzy solution.

**Usage**

```
multipliers(deasol)
```

**Arguments**

deasol            Object of class dea or dea\_fuzzy obtained with some of the dea model functions.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Examples**

```

data("Coll_Blasco_2006")
data_example <- read_data(Coll_Blasco_2006,
                          ni = 2,
                          no = 2)
result <- model_multiplier(data_example,
                           orientation = "io",
                           rts = "crs")

multipliers(result)

```

---

PFT1981

*Data: Charnes, Cooper and Rhodes (1981).*


---

**Description**

Data from Project Follow Through (PTF) in public school education. There are 49 DMUs (school sites) in PFT and 21 DMUs in Non-Follow Through (NFT). Authors consider 3 outputs (Y) and 5 inputs (X).

**Usage**

```
data("PFT1981")
```

**Format**

Data frame with 70 rows and 10 columns. Definition of inputs (X) and outputs (Y):

**Y1 = Reading** Total Reading Scores (as measured by the Metropolitan Achievement Test).

**Y2 = Math** Total Math Scores (total mathematics score by the Metropolitan Achievement Test).

**Y3 = Coopersmith** Total Coopersmith Scores (Coopersmith self-esteem inventory, intended as a measure of self-esteem).

**X1 = Education** Education level of mother (as measured in terms of percentage of high school graduates among female parents).

**X2 = Occupation** Occupation Index (highest occupation of a family member according to a pre-arranged rating scale).

**X3 = Parental** Parental Visit Index (representing the number of visits to the school site).

**X4 = Counseling** Counseling Index (parent counselling index calculated from data on time spent with child on school-related topics such as reading together, etc.).

**X5 = Teachers** Number of Teachers (number of teachers at a given site).

**Program** PFT or NFT.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Charnes, A.; Cooper, W.W.; Rhodes, E. (1981). "Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through", *Management Science*, 27(6), 668-697. doi: 10.1287/mnsc.27.6.668

**See Also**

[read\\_data, model\\_basic](#)

**Examples**

```
# Example 1. Replication of results in Charnes, Cooper and Rhodes (1981)
data("PFT1981")
# selecting DMUs in Project Follow Through (PFT)
PFT <- PFT1981[1:49,]
PFT <- read_data(PFT,
                 dmus=1,
                 inputs=2:6,
                 outputs=7:9 )
eval_pft <- model_basic(PFT,
                       orientation="io",
                       rts="crs")
eff_pft <- efficiencies(eval_pft)

# Example 2. Replication of results in Charnes, Cooper and Rhodes (1981)
data("PFT1981")
# selecting DMUs in Non-Follow Through (NFT)
NFT <- PFT1981[50:70,]
NFT <- read_data(NFT,
                 dmus=1,
                 inputs=2:6,
                 outputs=7:9 )
eval_nft <- model_basic(NFT,
                       orientation="io",
                       rts="crs")
eff_nft <- efficiencies(eval_nft)
```

---

plot.dea	<i>Plot for DEA models.</i>
----------	-----------------------------

---

### Description

Plot some attribute of a DEA model (conventional, fuzzy or Malmquist).

### Usage

```
## S3 method for class 'dea'
plot(x, showPlots = TRUE, ...)
```

### Arguments

x	An object of class "dea" obtained by a dea model function.
showPlots	Logical. When TRUE (default) the plots are shown one by one. When it is FALSE the plots are not shown and are returned by the function (invisibly) as a list.
...	Ignored, for compatibility issues.

### Value

Depending on the model it returns a single data.frame containing: efficiencies, slacks, lambdas, targets, references or a list of data.frames with the cross-efficiencies computed with different methods (Arbitrary, Method II or Method III (see CITA)) or, in case the model is a malmquist index, a single data.frame with the coefficients for the different periods.

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### References

# Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets*. 3rd Edition Springer, New York. DOI: 10.1007/978-3-319-06647-9

**Examples**

```
data_example <- read_data(datadea = Fortune500,
                          inputs = 2:4,
                          outputs = 5:6)
result <- model_basic(data_example)
plot(result)
```

---

plot.dea\_fuzzy            *Plot for Fuzzy DEA models.*

---

**Description**

Plot some attribute of a Fuzzy DEA model (Guo-Tanaka and Kao-Liu models).

**Usage**

```
## S3 method for class 'dea_fuzzy'
plot(x, showPlots = TRUE, ...)
```

**Arguments**

x	An object of class "dea_fuzzy" obtained by a fuzzy dea model function.
showPlots	Logical. When TRUE (default) the plots are shown one by one. When it is FALSE the plots are not shown and are returned by the function (invisibly) as a list.
...	Ignored, for compatibility issues.

**Value**

Depending on the model it returns ...

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

#<sup>1</sup> Zhu, J. (2014). *Quantitative Models for Performance Evaluation and Benchmarking. Data Envelopment Analysis with Spreadsheets*. 3rd Edition Springer, New York. DOI: 10.1007/978-3-319-06647-9

---

Power\_plants

*Data: Tone (2002).*

---

### Description

This dataset consists of six power plants with 4 inputs (X) and 2 outputs (Y).

### Usage

```
data("Power_plants")
```

### Format

Data frame with 15 rows and 7 columns. Definition of inputs (X) and outputs (Y):

**x1** Manpower required

**x2** Construction costs in millions of dollars

**x3** Annual maintenance costs in millions of dollars

**x4** Number of villages to be evacuated

**y1** Power generated in megawatts

**y2** Safety level

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Source

Andersen, P.; Petersen, N.C. (1993). "A procedure for ranking efficient units in data envelopment analysis", *Management Science*, 39, 1261-1264.

Doyle, J. and Green R. (1993). "Data envelopment analysis and multiple criteria decision making", *Omega*, 21 (6), 713-715. doi: 10.1016/0305-0483(93)90013-B

Tone, K. (2002). "A slacks-based measure of super-efficiency in data envelopment analysis", *European Journal of Operational Research*, 143, 32-41. doi: 10.1016/S0377-2217(01)00324-1

### See Also

[read\\_data](#), [model\\_supereff](#), [model\\_sbmsupereff](#)

**Examples**

```

# Example 1. Radial super-efficiency model.
# Replication of results in Tone (2002)
data("Power_plants")
data_example <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result <- model_supereff(data_example,
                        orientation="io",
                        rts="crs")
eff <- efficiencies(result)
eff

# Example 2. SBM super-efficiency model.
data("Power_plants")
data_example <- read_data(Power_plants,
                          ni = 4,
                          no = 2)
result2 <- model_sbmsupereff(data_example,
                             orientation="io",
                             rts="crs")

efficiencies(result2)
slacks(result2)$input
references(result2)

```

---

read\_data

*read\_data*


---

**Description**

This function creates, from a data frame, a `deadata` structure, which is as list with fields `input`, `output`, `dmunames`, `nc_inputs`, `nc_outputs`, `nd_inputs`, `nd_outputs`.

**Usage**

```

read_data(datadea = NULL,
          ni = NULL,
          no = NULL,
          dmus = 1,
          inputs = NULL,
          outputs = NULL,
          nc_inputs = NULL,
          nc_outputs = NULL,
          nd_inputs = NULL,
          nd_outputs = NULL,
          ud_inputs = NULL,
          ud_outputs = NULL)

```

**Arguments**

datadea	Data frame with DEA data.
ni	Number of inputs, if inputs are in columns 2:(ni + 1) (if DMUs are in the first column) or 1:ni (no DMUs column).
no	Number of outputs, if outputs are in columns (ni + 2):(ni + no + 1) (if DMUs are in the first column) or (ni + 1):(ni + no) (no DMUs column). If not specified, DMUs are in the first column.
dmus	Column (number or name) of DMUs (optional). By default, it is the first column. If there is not any DMU column, then it must be NULL.
inputs	Columns (numbers or names) of inputs (optional). It prevails over ni. Alternatively to datadea, it can be a matrix with the inputs (DMUs in columns). In this case, DMUs names are taken from the columns names.
outputs	Columns (numbers or names) of outputs (optional). It prevails over no. Alternatively to datadea, it can be a matrix with the outputs (DMUs in columns).
nc_inputs	A numeric vector containing the indices of non-controllable inputs.
nc_outputs	A numeric vector containing the indices of non-controllable outputs.
nd_inputs	A numeric vector containing the indices of non-discretionary inputs.
nd_outputs	A numeric vector containing the indices of non-discretionary outputs.
ud_inputs	A numeric vector containing the indices of undesirable (good) inputs.
ud_outputs	A numeric vector containing the indices of undesirable (bad) outputs.

**Value**

An object of class `deadata`

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Examples**

```
data("Coll_Blasco_2006")
data_example <- read_data(datadea = Coll_Blasco_2006,
                          ni = 2,
                          no = 2)

# This is the same as:
data_example <- read_data(Coll_Blasco_2006,
                          inputs = 2:3,
                          outputs = 4:5)

# And the same as:
dmunames <- c("A", "B", "C", "D", "E", "F")
```

```

nd <- length(dmunames) # Number of DMUs
inputnames <- c("Employees", "Capital")
ni <- length(inputnames) # Number of Inputs
outputnames <- c("Vehicles", "Orders")
no <- length(outputnames) # Number of Outputs
inputs <- matrix(c(8, 8, 11, 15, 14, 12, 12, 13, 11, 18, 18, 20),
                 nrow = ni, ncol = nd, dimnames = list(inputnames, dmunames))
outputs <- matrix(c(14, 20, 25, 42, 8, 30, 25, 8, 40, 22, 24, 30),
                  nrow = no, ncol = nd, dimnames = list(outputnames, dmunames))
data_example <- read_data(inputs = inputs,
                          outputs = outputs)
# If the first input is a non-controllable input:
data_example <- read_data(Coll_Blasco_2006,
                          inputs = 2:3,
                          outputs = 4:5,
                          nc_inputs = 1)
# If the second output is a non-discretionary output:
data_example <- read_data(Coll_Blasco_2006,
                          inputs = 2:3,
                          outputs = 4:5,
                          nd_outputs = 2)
# If the second input is a non-discretionary input and the second output is an undesirable:
data_example <- read_data(Coll_Blasco_2006,
                          inputs = 2:3,
                          outputs = 4:5,
                          nd_inputs = 2,
                          ud_outputs = 2)

```

---

read\_data\_fuzzy

*read\_data\_fuzzy*


---

## Description

This function creates, from a data frame, a `deadata_fuzzy` structure, which is a list with fields `input`, `output` and `dmunames`. At the same time, `input` and `output` are lists with fields `mL`, `mR`, `dL` and `dR`. " alt" alt

## Usage

```

read_data_fuzzy(datadea,
                 dmus = 1,
                 inputs.mL = NULL,
                 inputs.mR = NULL,
                 inputs.dL = NULL,
                 inputs.dR = NULL,
                 outputs.mL = NULL,
                 outputs.mR = NULL,
                 outputs.dL = NULL,

```

```

outputs.dR = NULL,
nc_inputs = NULL,
nc_outputs = NULL,
nd_inputs = NULL,
nd_outputs = NULL,
ud_inputs = NULL,
ud_outputs = NULL)

```

### Arguments

<code>datadea</code>	Data frame with DEA data.
<code>dmus</code>	Column (number or name) of DMUs (optional). By default, it is the first column. If there is not any DMU column, then it must be NULL.
<code>inputs.mL</code>	Where are (columns) the mL (left centers) of trapezoidal fuzzy inputs in <code>datadea</code> . If an input is triangular or crisp, we put the column where the centers or the crisp values are, respectively. Alternatively to <code>datadea</code> , <code>inputs.mL</code> can be a matrix of size (number of inputs x number of DMUs) with the mL of trapezoidal fuzzy inputs, the centers of triangular inputs, and the crisp values of crisp inputs. In this case, DMUs names are taken from the columns names.
<code>inputs.mR</code>	Where are (columns) the mR (right centers) of trapezoidal fuzzy inputs in <code>datadea</code> . If an input is triangular or crisp, we put NA. Alternatively to <code>datadea</code> , <code>inputs.mR</code> can be a matrix of size (number of inputs x number of DMUs) with the mR of trapezoidal fuzzy inputs, the centers of triangular inputs, and the crisp values of crisp inputs. If all inputs are triangular or crisp, then <code>inputs.mR</code> must be NULL (default) or equal to <code>inputs.mL</code> .
<code>inputs.dL</code>	Where are (columns) the dL (left radii) of trapezoidal and triangular fuzzy inputs in <code>datadea</code> . If an input is symmetric, we put the column where the radii are. If an input is rectangular or crisp, we put NA. Alternatively to <code>datadea</code> , <code>inputs.dL</code> can be a matrix of size (number of inputs x number of DMUs) with the dL of trapezoidal and triangular fuzzy inputs. If an input is rectangular or crisp, its radius is zero. If all inputs are rectangular or crisp, then <code>inputs.dL</code> must be NULL (default) or a zero matrix.
<code>inputs.dR</code>	Where are (columns) the dR (right radii) of trapezoidal and triangular fuzzy inputs in <code>datadea</code> . If an input is symmetric, rectangular or crisp, we put NA. Alternatively to <code>datadea</code> , <code>inputs.dR</code> can be a matrix of size (number of inputs x number of DMUs) with the dR of trapezoidal and triangular fuzzy inputs. If an input is rectangular or crisp, its radius is zero. If all inputs are symmetric, rectangular or crisp, then <code>inputs.dR</code> must be NULL (default) or equal to <code>inputs.dL</code> .
<code>outputs.mL</code>	Analogous to <code>inputs.mL</code> , but relating to outputs.
<code>outputs.mR</code>	Analogous to <code>inputs.mR</code> , but relating to outputs.
<code>outputs.dL</code>	Analogous to <code>inputs.dL</code> , but relating to outputs.
<code>outputs.dR</code>	Analogous to <code>inputs.dR</code> , but relating to outputs.
<code>nc_inputs</code>	A numeric vector containing the indices of non-controllable inputs.

nc_outputs	A numeric vector containing the indices of non-controllable outputs.
nd_inputs	A numeric vector containing the indices of non-discretionary inputs.
nd_outputs	A numeric vector containing the indices of non-discretionary outputs.
ud_inputs	A numeric vector containing the indices of undesirable (good) inputs.
ud_outputs	A numeric vector containing the indices of undesirable (bad) outputs.

**Value**

An object of class `deadata_fuzzy`.

**Examples**

```
# Example 1. If inputs and/or outputs are symmetric triangular fuzzy numbers
data("Leon2003")
data_example <- read_data_fuzzy(datadea = Leon2003,
                               inputs.mL = 2,
                               inputs.dL = 3,
                               outputs.mL = 4,
                               outputs.dL = 5)

# Example 2. If inputs and/or outputs are non-symmetric triangular fuzzy numbers
data("Kao_Liu_2003")
data_example <- read_data_fuzzy(Kao_Liu_2003,
                               inputs.mL = 2,
                               outputs.mL = 3:7,
                               outputs.dL = c(NA, NA, 8, NA, 10),
                               outputs.dR = c(NA, NA, 9, NA, 11))
```

---

read\_malmquist      *read\_malmquist*

---

**Description**

This function creates, from a data frame, a list `deadata`.

**Usage**

```
read_malmquist(datadea,
               nper = NULL,
               percol = NULL,
               arrangement = c("horizontal", "vertical"),
               ...)
```

**Arguments**

datadea	Dataframe with DEA data.
nper	Number of time periods (with dataset in wide format).
percol	Column of time period (with dataset in long format).
arrangement	Horizontal with data in wide format. Vertical with data in long format.
...	Other options to be passed to the read_data function

**Value**

An object of class deadata

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Examples**

```
# Example 1. If you have a dataset in wide format.
data("Economy")
data_example <- read_malmquist(datadea = Economy,
                              nper = 5,
                              arrangement = "horizontal",
                              ni = 2,
                              no = 1)

# This is the same as:
data_example <- read_malmquist(datadea = Economy,
                              nper = 5,
                              arrangement = "horizontal",
                              inputs = 2:3,
                              outputs = 4)

# Example 2. If you have a dataset in long format.
data("EconomyLong")
data_example2 <- read_malmquist(EconomyLong,
                                percol = 2,
                                arrangement = "vertical",
                                inputs = 3:4,
                                outputs = 5)
```

---

 references

 References
 

---

### Description

Extract the reference set for each DMU (inefficient DMUs and efficient DMUs that are combination of other efficient DMUs) from a DEA model solution.

### Usage

```
references(deasol,
           thr = 1e-4)
```

### Arguments

deasol	Object of class dea obtained with some of the DEA model functions.
thr	Tolerance threshold (for avoiding misdetection of efficient DMUs due to round-off errors)

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Examples

```
# Replication results model DEA1 in Tomkins and Green (1988).
data("Departments")
# Calculate Total income
Departments$Total_income <- Departments[, 5] + Departments[, 6]+Departments[, 7]
data_DEA1 <- read_data(Departments,
                      inputs = 9,
                      outputs = c(2, 3, 4, 12))
result <- model_basic(data_DEA1,
                     orientation = "io",
                     rts = "crs")
references(result) # Table 3 (p.157)
```



---

Ruggiero2007

*Data: Ruggiero (2007).*

---

### Description

Simulated data of 35 DMUs with two inputs and one output.

### Usage

```
data("Ruggiero2007")
```

### Format

Data frame with 35 rows and 4 columns. Definition of inputs (X) and outputs (Y):

**x1** Input 1

**x2** Input 2

**y1** Output 1

### Author(s)

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

### Source

Ruggiero J. (2007). Non-Discretionary Inputs. In: Zhu J., Cook W.D. (eds) *Modeling Data Irregularities and Structural Complexities in Data Envelopment Analysis*. Springer, Boston, MA. doi: 10.1007/978-0-387-71607-7\_5

### See Also

[read\\_data](#), [model\\_basic](#)

### Examples

```
# Example. Replication of results in Ruggiero (2007).
data("Ruggiero2007")
# the second input is a non-discretionary input
datadea <- read_data(Ruggiero2007,
                    ni=2,
                    no=1,
                    nd_inputs=2)
result <- model_basic(datadea,
```



summary.dea

*Summary conventional DEA models.***Description**

Summary of the results obtained by a conventional DEA model.

**Usage**

```
## S3 method for class 'dea'
summary(object, exportExcel = TRUE, filename = NULL, returnList = FALSE, ...)
```

**Arguments**

object	An object of class "dea" obtained by a dea model function.
exportExcel	Logical value. If TRUE (default) the results are also exported to an Excel file
filename	Character string. Absolute filename (including path) of the exported Excel file. If NULL, then the name of the file will be "ResultsDEA"+timestamp.xlsx.
returnList	Logical value. If TRUE then the results are given as a list of data frames. If FALSE (default) all the data frames are merged into a single data frame.
...	Ignored. Used for compatibility issues.

**Value**

Depending on the model it returns a single data.frame containing: efficiencies, slacks, lambdas, targets, references or a list of data.frames with the cross-efficiencies computed with different methods (Arbitrary, Method II or Method III (see CITA)) or, in case the model is a malmquist index, a single data.frame with the coefficients for the different periods.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**References**

Charnes, A.; Cooper, W.W.; Rhodes, E. (1981). "Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through", *Management Science*, 27(6), 668-697. <https://pubsonline.informs.org/doi/abs/10.1287/mnsc.27.6.668>

## Examples

```

data("PFT1981")
# Selecting DMUs in Program Follow Through (PFT)
PFT <- PFT1981[1:49, ]
PFT <- read_data(PFT,
                 inputs = 2:6,
                 outputs = 7:9 )
eval_pft <- model_basic(PFT,
                       orientation = "io",
                       rts = "crs")
summary(eval_pft, exportExcel = FALSE)

```

---

summary.dea\_fuzzy      *Summary Fuzzy DEA models.*

---

## Description

Summary of the results obtained by a fuzzy DEA model.

## Usage

```

## S3 method for class 'dea_fuzzy'
summary(object, ..., exportExcel = TRUE, filename = NULL, returnList = FALSE)

```

## Arguments

object	An object of class "dea_fuzzy" obtained with a fuzzy dea model function (modelfuzzy_guotanaka, modelfuzzy_kaoliu, modelfuzzy_possibilistic).
...	Extra options
exportExcel	Logical value. If TRUE (default) the results are also exported to an Excel file
filename	Character string. Absolute filename (including path) of the exported Excel file. If NULL, then the name of the file will be "ResultsDEA"+timestamp.xlsx.
returnList	Logical value. If TRUE then the results are given as a list of data frames. If FALSE (default) all the data frames are merged into a single data frame.

## Value

If the model is that from Guo and Tanaka (modelfuzzy\_guotanaka), it returns a data.frame with columns: DMU, alpha cuts and efficiencies. For the possibilistic model (modelfuzzy\_possibilistic) it returns a data.frame with columns: DMU, alpha-cuts, efficiencies and the corresponding lambda values For the Kao and Liu model (modelfuzzy\_kaoliu), the result may depend on the crisp sub-model used. It will contain a data.frame with the efficiencies (if any), the slacks and superslacks (if any), the lambda values and the targets.

If exportExcel is TRUE, then an Excel file will be created containing as many sheets as necessary depending on the variables returned.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**References**

León, T.; Liern, V. Ruiz, J.; Sirvent, I. (2003). "A Possibilistic Programming Approach to the Assessment of Efficiency with DEA Models", *Fuzzy Sets and Systems*, 139, 407–419. doi: [10.1016/S01650114\(02\)006085](https://doi.org/10.1016/S01650114(02)006085)

**Examples**

```
data("Leon2003")
data_example <- read_data_fuzzy(Leon2003,
                                inputs.mL = 2,
                                inputs.dL = 3,
                                outputs.mL = 4,
                                outputs.dL = 5)
result <- modelfuzzy_possibilistic(data_example,
                                   h = seq(0, 1, by = 0.1),
                                   orientation = "io",
                                   rts = "vrs")
summary(result, exportExcel = FALSE)
```

---

 Supply\_Chain

 Data: Sanei and Mamizadeh Chatghayeb (2013).
 

---

**Description**

Data of 17 supply chain (buyer-supplier relationship in manufacturing).

**Usage**

```
data("Supply_Chain")
```

**Format**

Data frame with 17 rows and 8 columns. Definition of inputs (X) and outputs (Y):

**X1 to X3** Inputs of buyers

**I1 to I2** Outputs of buyers, Inputs of suppliers

**Y1 to Y2** Outputs of suppliers

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Source**

Sanei, M.; Mamizadeh Chatghayeb, S. (2013). “Free Disposal Hull Models in Supply Chain Management”, *International Journal of Mathematical Modelling and Computations*, 3(3), 125-129.

**See Also**

[read\\_data, model\\_fdh](#)

**Examples**

```
# Example. FDH input-oriented.
# Replication of results in Sanei and Mamizadeh Chatghayeb (2013)
data("Supply_Chain")
data_fdh1 <- read_data(Supply_Chain,
                      dmus=1,
                      inputs= 2:4,
                      outputs=5:6)
# by default orientation="io"
result <- model_fdh(data_fdh1)
efficiencies(result)
```

---

targets

*Targets*

---

**Description**

Extract the targets of the DMUs from a dea or dea\_fuzzy solution.

**Usage**

```
targets(deasol)
```

**Arguments**

deasol            Object of class dea or dea\_fuzzy obtained with some of the DEA model functions.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Examples**

```
data("Coll_Blasco_2006")
data_example <- read_data(Coll_Blasco_2006,
                          ni = 2,
                          no = 2)
result <- model_multiplier(data_example,
                           orientation = "io",
                           rts = "crs")

targets(result)
```

---

Tone2001

*Data: Tone (2001).*

---

**Description**

Data of 5 DMUs producing 2 outputs by using 2 inputs

**Usage**

```
data("Tone2001")
```

**Format**

Data frame with 5 rows and 5 columns. Definition of inputs (X) and outputs (Y):

**x1** Input1

**x2** Input2

**y1** Output1

**y2** Output2

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Source**

Tone, K. (2001). "A Slacks-Based Measure of Efficiency in Data Envelopment Analysis", *European Journal of Operational Research*, 130, 498-509. doi: 10.1016/S0377-2217(99)00407-5

**See Also**

[read\\_data](#), [model\\_sbmeff](#)

**Examples**

```
# Example. Replication of results in Tone (2001, p. 505)
data("Tone2001")
data_example <- read_data(Tone2001,
                          ni = 2,
                          no = 2)
result <- model_sbmeff(data_example,
                       orientation = "no",
                       rts = "crs")

efficiencies(result)
slacks(result)
```

---

Tone2003

*Data: Tone (2003).*

---

**Description**

Data of 9 DMUs producing 2 outputs, being second output undesirable, by using 1 input.

**Usage**

```
data("Tone2003")
```

**Format**

Data frame with 9 rows and 4 columns. Definition of inputs (X) and outputs (Y):

**x** Input

**yg** Output1 ("good" output)

**yb** Output2 (undesirable "bad" output)

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolos** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benitez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*

University of Valencia (Spain)

**Source**

Tone, K. (2003). "Dealing with undesirable outputs in DEA: A Slacks-Based Measure (SBM) approach", GRIPS Research Report Series I-2003-0005.

**See Also**

[read\\_data](#), [model\\_sbmeff](#)

**Examples**

```
# Example. Replication of results in Tone (2003), pp 10-11.
data("Tone2003")
data_example <- read_data(Tone2003,
                          ni = 1,
                          no = 2,
                          ud_outputs = 2)
result <- model_sbmeff(data_example,
                      rts = "vrs")
efficiencies(result)
targets(result)
```

---

undesirable\_basic

*Undesirable inputs and outputs for basic DEA model.*

---

**Description**

This function transforms a `deadata` or `deadata_fuzzy` class with inputs and outputs into a `deadata` or `deadata_fuzzy` class with good inputs and/or outputs, and bad (undesirable) inputs and/or outputs. Onwards, it is recommended to use a dea model with variable returns to scale (vrs).

**Usage**

```
undesirable_basic(datadea,
                  vtrans_i = NULL,
                  vtrans_o = NULL)
```

**Arguments**

<code>datadea</code>	The data, including DMUs, inputs and outputs.
<code>vtrans_i</code>	Numeric vector of translation for undesirable inputs. If <code>vtrans_i[i]</code> is NA, then it applies the "max + 1" translation to the i-th undesirable input. If <code>vtrans_i</code> is a constant, then it applies the same translation to all undesirable inputs. If <code>vtrans_i</code> is NULL, then it applies the "max + 1" translation to all undesirable inputs.
<code>vtrans_o</code>	Numeric vector of translation for undesirable outputs, analogous to <code>vtrans_i</code> , but applied to outputs.

**Value**

An object of class `deadata` or `deadata_fuzzy`.

**Author(s)**

**Vicente Coll-Serrano** (<vicente.coll@uv.es>). *Quantitative Methods for Measuring Culture (MC2). Applied Economics.*

**Vicente Bolós** (<vicente.bolos@uv.es>). *Department of Business Mathematics*

**Rafael Benítez** (<rafael.suarez@uv.es>). *Department of Business Mathematics*  
University of Valencia (Spain)

**Examples**

```
data("Hua_Bian_2007")
# The third output is an undesirable output.
data_example <- read_data(Hua_Bian_2007,
                          ni = 2,
                          no = 3,
                          ud_outputs = 3)
# rts must be "vrs" for undesirable inputs/outputs:
# Translation parameter is set to (max + 1)
result <- model_basic(data_example,
                      orientation = "oo",
                      rts = "vrs")
```

# Index

## \* datasets

- Coelli\_1998, 5
  - Coll\_Blasco\_2006, 6
  - Departments, 11
  - Doyle\_Green\_1994, 13
  - Economy, 14
  - EconomyLong, 15
  - Electric\_plants, 19
  - Fortune500, 20
  - Fried1993, 21
  - FuzzyExample, 22
  - Golany\_Roll\_1989, 23
  - Grifell\_Lovell\_1999, 25
  - Guo\_Tanaka\_2001, 26
  - Hotels, 27
  - Hua\_Bian\_2007, 28
  - Kao\_Liu\_2003, 34
  - Leon2003, 36
  - Libraries, 37
  - Lim\_Zhu\_2015, 38
  - PFT1981, 76
  - Power\_plants, 80
  - Ruggiero2007, 89
  - Supply\_Chain, 93
  - Tone2001, 95
  - Tone2003, 96
- bootstrap\_basic, 3
- Coelli\_1998, 5
- Coll\_Blasco\_2006, 6
- cross\_efficiency, 7, 13, 24, 39, 63
- cross\_efficiency\_fuzzy, 9, 10, 27, 37, 45
- Departments, 11
- Doyle\_Green\_1994, 13
- Economy, 14
- EconomyLong, 15
- efficiencies, 16
- efficiencies.dea, 17
- efficiencies.dea\_fuzzy, 18
- Electric\_plants, 19
- Fortune500, 20
- Fried1993, 21
- FuzzyExample, 22
- Golany\_Roll\_1989, 23
- Grifell\_Lovell\_1999, 25
- Guo\_Tanaka\_2001, 26
- Hotels, 27
- Hua\_Bian\_2007, 28
- is.dea, 30
- is.dea\_fuzzy, 32
- is.deadata, 30
- is.deadata\_fuzzy, 31
- is.friends, 32, 43
- Kao\_Liu\_2003, 34
- lambdas, 35
- Leon2003, 36
- Libraries, 37
- Lim\_Zhu\_2015, 38
- malmquist\_index, 15, 16, 25, 40
- maximal\_friends, 33, 42
- model\_additive, 49, 53
- model\_addsupereff, 51, 52, 73, 74
- model\_basic, 12, 19, 22, 29, 35, 38, 45, 47, 49, 54, 63, 74, 77, 89
- model\_deaps, 58, 65, 67, 71
- model\_fdh, 60, 94
- model\_multiplier, 9, 13, 21, 24, 39, 45, 47, 57, 61
- model\_nonradial, 28, 59, 64, 67, 71
- model\_profit, 59, 65, 65, 71
- model\_rdm, 68

model\_sbmeff, [33](#), [43](#), [59](#), [65](#), [67](#), [69](#), [73](#), [96](#),  
[97](#)  
model\_sbmsupereff, [53](#), [71](#), [71](#), [74](#), [80](#)  
model\_supereff, [53](#), [57](#), [73](#), [73](#), [80](#)  
modelfuzzy\_guotanaka, [27](#), [37](#), [44](#), [47](#), [49](#)  
modelfuzzy\_kaoliu, [45](#), [46](#), [49](#)  
modelfuzzy\_possibilistic, [37](#), [45](#), [47](#), [48](#)  
multipliers, [75](#)  
  
PFT1981, [76](#)  
plot.dea, [78](#)  
plot.dea\_fuzzy, [79](#)  
Power\_plants, [80](#)  
  
read\_data, [5](#), [7](#), [12](#), [13](#), [19](#), [21](#), [22](#), [24](#), [28](#), [29](#),  
[38](#), [39](#), [77](#), [80](#), [81](#), [89](#), [94](#), [96](#), [97](#)  
read\_data\_fuzzy, [23](#), [27](#), [35](#), [37](#), [83](#)  
read\_malmquist, [15](#), [16](#), [25](#), [85](#)  
references, [87](#)  
rts, [88](#)  
Ruggiero2007, [89](#)  
  
slacks, [90](#)  
summary.dea, [91](#)  
summary.dea\_fuzzy, [92](#)  
Supply\_Chain, [93](#)  
  
targets, [94](#)  
Tone2001, [95](#)  
Tone2003, [96](#)  
  
undesirable\_basic, [97](#)