

# Package ‘linprog’

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**Title** Linear Programming / Optimization

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**Depends** R (>= 2.4.0), lpSolve

**Description** Can be used to solve Linear Programming / Linear Optimization problems by using the simplex algorithm.

**License** GPL (>= 2)

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print.solveLP                    *Print Objects of Class solveLP*

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### Description

This method prints the results of the Linear Programming algorithm.

### Usage

```
## S3 method for class 'solveLP'  
print( x, digits=6, ...)
```

### Arguments

x	an object returned by <a href="#">solveLP</a> .
digits	number of digits to print.
...	currently ignored.

### Value

print.solveLP invisibly returns the object given in argument x.

### Author(s)

Arne Henningsen

### See Also

[solveLP](#), [summary.solveLP](#), [readMps](#), [writeMps](#)

### Examples

```
## example of Steinhauser, Langbehn and Peters (1992)  
## Not run: library( linprog )  
  
## Production activities  
cvec <- c(1800, 600, 600) # gross margins  
names(cvec) <- c("Milk", "Bulls", "Pigs")  
  
## Constraints (quasi-fix factors)  
bvec <- c(40, 90, 2500) # endowment  
names(bvec) <- c("Land", "Stable", "Labor")  
  
## Needs of Production activities  
Amat <- rbind( c( 0.7, 0.35, 0 ),  
              c( 1.5, 1, 3 ),  
              c( 50, 12.5, 20 ) )
```

```
## Maximize the gross margin
res <- solveLP( cvec, bvec, Amat, TRUE )

## print the results
print( res )
```

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readMps	<i>Read MPS Files</i>
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### Description

This function reads MPS files - the standard format for Linear Programming problems.

### Usage

```
readMps( file, solve=FALSE, maximum=FALSE )
```

### Arguments

file	a character string naming the file to read.
solve	logical. Should the problem be solved after reading it from the file (using <a href="#">solveLP</a> )?
maximum	logical. Should we maximize or minimize (the default)?

### Details

Equality constraints and 'greater than'-bounds are not implemented yet.

### Value

readMps returns a list containing following objects:

name	the name of the Linear Programming problem.
cvec	vector $c$ .
bvec	vector $b$ .
Amat	matrix $A$ .
res	if solve is TRUE, it contains the results of the solving process (an object of class <a href="#">solveLP</a> ).

### Author(s)

Arne Henningsen

### See Also

[solveLP](#), [writeMps](#)

**Examples**

```

## example of Steihauser, Langbehn and Peters (1992)
## Production activities
cvec <- c(1800, 600, 600) # gross margins
names(cvec) <- c("Cows", "Bulls", "Pigs")

## Constraints (quasi-fix factors)
bvec <- c(40, 90, 2500) # endowment
names(bvec) <- c("Land", "Stable", "Labor")

## Needs of Production activities
Amat <- rbind( c( 0.7,  0.35,  0 ),
               c( 1.5,  1,    3 ),
               c( 50,  12.5,  20 ) )

## Write to MPS file
writeMps( "steinh.mps", cvec, bvec, Amat, "Steihauser" )

## delete all LP objects
rm( cvec, bvec, Amat )

## Read LP data from MPS file and solve it.
lp <- readMps( "steinh.mps", TRUE, TRUE )

## Print the results
lp$res

## remove the MPS file
file.remove( "steinh.mps" )

```

---

solveLP

*Solve Linear Programming / Optimization Problems*


---

**Description**

Minimizes (or maximizes)  $c'x$ , subject to  $Ax \leq b$  and  $x \geq 0$ .

Note that the inequality signs  $\leq$  of the individual linear constraints in  $Ax \leq b$  can be changed with argument `const.dir`.

**Usage**

```

solveLP( cvec, bvec, Amat, maximum = FALSE,
         const.dir = rep( "<=", length( bvec ) ),
         maxiter = 1000, zero = 1e-9, tol = 1e-6, dualtol = tol,
         lpSolve = FALSE, solve.dual = FALSE, verbose = 0 )

```

**Arguments**

<code>cvec</code>	vector $c$ (containing $n$ elements).
<code>bvec</code>	vector $b$ (containing $m$ elements).
<code>Amat</code>	matrix $A$ (of dimension $m \times n$ ).
<code>maximum</code>	logical. Should we maximize or minimize (the default)?
<code>const.dir</code>	vector of character strings giving the directions of the constraints: each value should be one of "<," "<=," "=", "==," ">," or ">=". (In each pair the two values are identical.)
<code>maxiter</code>	maximum number of iterations.
<code>zero</code>	numbers smaller than this value (in absolute terms) are set to zero.
<code>tol</code>	if the constraints are violated by more than this number, the returned component status is set to 3.
<code>dualtol</code>	if the constraints in the dual problem are violated by more than this number, the returned status is non-zero.
<code>lpSolve</code>	logical. Should the package 'lpSolve' be used to solve the LP problem?
<code>solve.dual</code>	logical value indicating if the dual problem should also be solved.
<code>verbose</code>	an optional integer variable to indicate how many intermediate results should be printed (0 = no output; 4 = maximum output).

**Details**

This function uses the Simplex algorithm of George B. Dantzig (1947) and provides detailed results (e.g. dual prices, sensitivity analysis and stability analysis).

If the solution  $x = 0$  is not feasible, a 2-phase procedure is applied.

Values of the simplex tableau that are actually zero might get small (positive or negative) numbers due to rounding errors, which might lead to artificial restrictions. Therefore, all values that are smaller (in absolute terms) than the value of zero (default is  $1e-10$ ) are set to 0.

Solving the Linear Programming problem by the package `lpSolve` (of course) requires the installation of this package, which is available on CRAN (<https://cran.r-project.org/package=lpSolve>). Since the `lpSolve` package uses C-code and this (`linprog`) package is not optimized for speed, the former is much faster. However, this package provides more detailed results (e.g. dual values, stability and sensitivity analysis).

This function has not been tested extensively and might not solve all feasible problems (or might even lead to wrong results). However, you can export your LP to a standard MPS file via `writeMps` and check it with other software (e.g. `lp_solve`, see <http://lpsolve.sourceforge.net/5.5/>). Equality constraints are not implemented yet.

**Value**

`solveLP` returns a list of the class `solveLP` containing following objects:

<code>opt</code>	optimal value (minimum or maximum) of the objective function.
<code>solution</code>	vector of optimal values of the variables.
<code>iter1</code>	iterations of Simplex algorithm in phase 1.

<code>iter2</code>	iterations of Simplex algorithm in phase 2.
<code>basvar</code>	vector of basic (=non-zero) variables (at optimum).
<code>con</code>	matrix of results regarding the constraints: 1st column = maximum values (=vector $b$ ); 2nd column = actual values; 3rd column = differences between maximum and actual values; 4th column = dual prices (shadow prices); 5th column = valid region for dual prices.
<code>allvar</code>	matrix of results regarding all variables (including slack variables): 1st column = optimal values; 2nd column = values of vector $c$ ; 3rd column = minimum of vector $c$ that does <i>not</i> change the solution; 4th column = maximum of vector $c$ that does <i>not</i> change the solution; 5th column = derivatives to the objective function; 6th column = valid region for these derivatives.
<code>status</code>	numeric. Indicates if the optimization did succeed: 0 = success; 1 = lpSolve did not succeed; 2 = solving the dual problem did not succeed; 3 = constraints are violated at the solution (internal error or large rounding errors); 4 = simplex algorithm phase 1 did not find a solution within the number of iterations specified by argument <code>maxiter</code> ; 5 = simplex algorithm phase 2 did not find the optimal solution within the number of iterations specified by argument <code>maxiter</code> .
<code>lpStatus</code>	numeric. Return code of <code>lp</code> (only if argument <code>lpSolve</code> is TRUE).
<code>dualStatus</code>	numeric. Return code from solving the dual problem (only if argument <code>solve.dual</code> is TRUE).
<code>maximum</code>	logical. Indicates whether the objective function was maximized or minimized.
<code>Tab</code>	final 'Tableau' of the Simplex algorithm.
<code>lpSolve</code>	logical. Has the package 'lpSolve' been used to solve the LP problem.
<code>solve.dual</code>	logical. Argument <code>solve.dual</code> .
<code>maxiter</code>	numeric. Argument <code>maxiter</code> .

### Author(s)

Arne Henningsen

### References

Dantzig, George B. (1951), *Maximization of a linear function of variables subject to linear inequalities*, in Koopmans, T.C. (ed.), *Activity analysis of production and allocation*, John Wiley & Sons, New York, p. 339-347.

Steinhauser, Hugo; Cay Langbehn and Uwe Peters (1992), *Einfuehrung in die landwirtschaftliche Betriebslehre. Allgemeiner Teil*, 5th ed., Ulmer, Stuttgart.

Witte, Thomas; Joerg-Frieder Deppe and Axel Born (1975), *Lineare Programmierung. Einfuehrung fuer Wirtschaftswissenschaftler*, Gabler-Verlag, Wiesbaden.

**See Also**

[readMps](#) and [writeMps](#)

**Examples**

```
## example of Steinhauser, Langbehn and Peters (1992)
## Production activities
cvec <- c(1800, 600, 600) # gross margins
names(cvec) <- c("Cows", "Bulls", "Pigs")

## Constraints (quasi-fix factors)
bvec <- c(40, 90, 2500) # endowment
names(bvec) <- c("Land", "Stable", "Labor")

## Needs of Production activities
Amat <- rbind( c( 0.7,  0.35,  0 ),
               c( 1.5,  1,    3 ),
               c( 50,  12.5,  20 ) )

## Maximize the gross margin
solveLP( cvec, bvec, Amat, TRUE )

## example 1.1.3 of Witte, Deppe and Born (1975)
## Two types of Feed
cvec <- c(2.5, 2 ) # prices of feed
names(cvec) <- c("Feed1", "Feed2")

## Constraints (minimum (<0) and maximum (>0) contents)
bvec <- c(-10, -1.5, 12)
names(bvec) <- c("Protein", "Fat", "Fibre")

## Matrix A
Amat <- rbind( c( -1.6, -2.4 ),
               c( -0.5, -0.2 ),
               c( 2.0,  2.0 ) )

## Minimize the cost
solveLP( cvec, bvec, Amat )

# the same optimisation using argument const.dir
solveLP( cvec, abs( bvec ), abs( Amat ), const.dir = c( ">=", ">=", "<=" ) )

## There are also several other ways to put the data into the arrays, e.g.:
bvec <- c( Protein = -10.0,
          Fat      = -1.5,
          Fibre   = 12.0 )
cvec <- c( Feed1 = 2.5,
          Feed2 = 2.0 )
Amat <- matrix( 0, length(bvec), length(cvec) )
```

```
rownames(Amat) <- names(bvec)
colnames(Amat) <- names(cvec)
Amat[ "Protein", "Feed1" ] <- -1.6
Amat[ "Fat",     "Feed1" ] <- -0.5
Amat[ "Fibre",  "Feed1" ] <-  2.0
Amat[ "Protein", "Feed2" ] <- -2.4
Amat[ "Fat",     "Feed2" ] <- -0.2
Amat[ "Fibre",  "Feed2" ] <-  2.0
solveLP( cvec, bvec, Amat )
```

---

summary.solveLP

*Summary Results for Objects of Class solveLP*

---

### Description

These methods prepare and print summary results of the Linear Programming algorithm.

### Usage

```
## S3 method for class 'solveLP'
summary(object,...)
## S3 method for class 'summary.solveLP'
print(x,...)
```

### Arguments

object	an object returned by <code>solveLP</code> .
x	an object returned by <code>summary.solveLP</code> .
...	currently ignored.

### Value

`summary.solveLP` returns an object of class `summary.solveLP`. `print.summary.solveLP` invisibly returns the object given in argument `x`.

### Author(s)

Arne Henningsen

### See Also

[solveLP](#), [print.solveLP](#), [readMps](#), [writeMps](#)



**Examples**

```
## example of Steihauser, Langbehn and Peters (1992)
## Not run: library( linprog )

## Production activities
cvec <- c(1800, 600, 600) # gross margins
names(cvec) <- c("Milk", "Bulls", "Pigs")

## Constraints (quasi-fix factors)
bvec <- c(40, 90, 2500) # endowment
names(bvec) <- c("Land", "Stable", "Labor")

## Needs of Production activities
Amat <- rbind( c( 0.7, 0.35, 0 ),
               c( 1.5, 1, 3 ),
               c( 50, 12.5, 20 ) )

## Maximize the gross margin
res <- solveLP( cvec, bvec, Amat, TRUE )

## prepare and print the summary results
summary( res )
```

---

writeMps

*Write MPS Files*


---

**Description**

This function writes MPS files - the standard format for Linear Programming problems.

**Usage**

```
writeMps( file, cvec, bvec, Amat, name="LP" )
```

**Arguments**

file	a character string naming the file to write.
cvec	vector $c$ .
bvec	vector $b$ .
Amat	matrix $A$ .
name	an optional name for the Linear Programming problem.

**Details**

The exported LP can be solved by running other software on this MPS file (e.g. lp\_solve, see <http://lpsolve.sourceforge.net/5.5/>).

**Author(s)**

Arne Henningsen

**See Also**

[solveLP](#), [readMps](#)

**Examples**

```
## example of Steinhauser, Langbehn and Peters (1992)
## Production activities
cvec <- c(1800, 600, 600) # gross margins
names(cvec) <- c("Cows", "Bulls", "Pigs")

## Constraints (quasi-fix factors)
bvec <- c(40, 90, 2500) # endowment
names(bvec) <- c("Land", "Stable", "Labor")

## Needs of Production activities
Amat <- rbind( c( 0.7,  0.35,  0 ),
               c( 1.5,  1,    3 ),
               c( 50,  12.5,  20 ) )

## Write to MPS file
writeMps( "steinh.mps", cvec, bvec, Amat, "Steinhauser" )

## remove the MPS file
file.remove( "steinh.mps" )
```

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