

# Package ‘ArCo’

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**Title** Artificial Counterfactual Package

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**BugReports** <https://github.com/gabrielrvsc/ARCO/issues>

**Description** Set of functions to analyse and estimate Artificial Counterfactual models from Carvalho, Masini and Medeiros (2016) <[DOI:10.2139/ssrn.2823687](https://doi.org/10.2139/ssrn.2823687)>.

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data.q1

*A generated dataset used in the examples*


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### Description

This data contains 100 observations of 20 variables generated using the dgp from Carvalho, Masini and Medeiros (2016). Each variable is one ArCo unit. The intervention took place on the first unit at  $t_0=51$  by adding a constant equal to 0.628, which is one standard deviation of the treated unit variable before the intervention.

### Usage

```
data(data.q1)
```

### Format

A matrix with 100 rows and 20 variables.

### References

Carvalho, C., Masini, R., Medeiros, M. (2016) "ArCo: An Artificial Counterfactual Approach For High-Dimensional Panel Time-Series Data."

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data.q2

*A dataset used in the examples*


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### Description

This data is a list with two matrixes, each have 100 observations and 6 variables. It was generated using the dgp from Carvalho, Masini and Medeiros (2016). In the ArCo context, each matrix is a variable and each variable in the matrixes is an unit. The intervention took place on the first unit at  $t_0=51$  by adding constants of 0.840 and 0.511 (one standar deviation before the intervention) on variables (matrixes) 1 and 2.

### Usage

```
data(data.q2)
```

### Format

A list with 2 matrixes of 100 rows and 6 variables.

### References

Carvalho, C., Masini, R., Medeiros, M. (2016) "ArCo: An Artificial Counterfactual Approach For High-Dimensional Panel Time-Series Data."

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estimate_t0	<i>Estimates the intervention time on a given treated unit</i>
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### Description

Estimates the intervention time on a given treated unit based on any model supplied by the user.

### Usage

```
estimate_t0(data, fn = NULL, p.fn = NULL, start = 0.4, end = 0.9,
  treated.unit = 1, lag = 0, Xreg = NULL, ...)
```

### Arguments

data	A list of matrixes or data frames of length $q$ . Each matrix is $T \times n$ and it contains observations of a single variable for all units and all periods of time. Even in the case of a single variable ( $q=1$ ), the matrix must be inside a list.
fn	The function used to estimate the first stage model. This function must receive only two arguments in the following order: $X$ (independent variables), $y$ (dependent variable). If the model requires additional arguments they must be supplied inside the function $fn$ . If not supplied the default is the <code>lm</code> function.
p.fn	The forecasting function used to estimate the counterfactual using the first stage model (normally a predict function). This function also must receive only two arguments in the following order: model (model estimated in the first stage), newdata (out of sample data to estimate the second stage). If the prediction requires additional arguments they must be supplied inside the function $p.fn$ .
start	Initial value of $\lambda_0$ to be tested.
end	Final value of $\lambda_0$ to be tested.
treated.unit	Single number indicating the unit where the intervention took place.
lag	Number of lags in the first stage model. Default is 0, i.e. only contemporaneous variables are used.
Xreg	Exogenous controls.
...	Additional arguments used in the function $fn$ .

### Details

This description may be useful to clarify the notation and understand how the arguments must be supplied to the functions.

- **units:** Each unit is indexed by a number between  $1, \dots, n$ . They are for exemple: countries, states, municipalities, firms, etc.
- **Variables:** For each unit and for every time period  $t = 1, \dots, T$  we observe  $q_i \geq 1$  variables. They are for example: GDP, inflation, sales, etc.
- **Intervention:** The intervention took place only in the treated unit at time  $t_0 = \lambda_0 * T$ , where  $\lambda_0$  is in  $(0,1)$ .

**Value**

A list with the following items:

t0	Estimated t0.
delta.norm	The norm of the delta corresponding to t0.
call	The matched call.

**See Also**

[fitArCo](#)

**Examples**

```
#####
## === Example for q=1 === ##
#####
data(data.q1)
# = First unit was treated on t=51 by adding
# a constant equal to one standard deviation.

data=list(data.q1) # = Even if q=1 the data must be in a list

## == Fitting the ArCo using linear regression == ##

# = creating fn and p.fn function = #
fn=function(X,y){
  return(lm(y~X))
}
p.fn=function(model,newdata){
  b=coef(model)
  return(cbind(1,newdata)%*%b)
}

t0a=estimate_t0(data = data,fn = fn, p.fn = p.fn, treated.unit = 1 )

#####
## === Example for q=2 === ##
#####

# = First unit was treated on t=51 by adding constants of one standard deviation.
# for the first and second variables
data(data.q2) # data is already a list

t0b=estimate_t0(data = data.q2,fn = fn, p.fn = p.fn, treated.unit = 1, start=0.4)
```

fitArCo

*Estimates the ArCo using the model selected by the user***Description**

Estimates the Artificial Counterfactual using any model supplied by the user, calculates the most relevant statistics and allows for the counterfactual confidence intervals to be estimated by block bootstrap.

The model must be supplied by the user through the arguments `fn` and `p.fn`. The first determines which function will be used to estimate the model and the second determines the forecasting function. For more details see the examples and the description on the arguments.

**Usage**

```
fitArCo(data, fn = NULL, p.fn = NULL, treated.unit, t0, lag = 0,
        Xreg = NULL, alpha = 0.05, boot.cf = FALSE, R = 100, l = 3,
        VCOV.type = c("iid", "var", "nw", "varhac"), VCOV.lag = 1,
        bandwidth.kernel = NULL, kernel.type = c("QuadraticSpectral", "Truncated",
        "Bartlett", "Parzen", "TukeyHanning"), VHAC.max.lag = 5,
        prewhitening.kernel = FALSE, ...)
```

**Arguments**

<code>data</code>	A list of matrixes or data frames of length <code>q</code> . Each matrix is $T \times n$ and it contains observations of a single variable for all units and all periods of time. Even in the case of a single variable ( $q=1$ ), the matrix must be inside a list.
<code>fn</code>	The function used to estimate the first stage model. This function must receive only two arguments in the following order: <code>X</code> (independent variables), <code>y</code> (dependent variable). If the model requires additional arguments they must be supplied inside the function <code>fn</code> . If not supplied the default is the <code>lm</code> function.
<code>p.fn</code>	The forecasting function used to estimate the counterfactual using the first stage model (normally a predict function). This function also must receive only two arguments in the following order: <code>model</code> (model estimated in the first stage), <code>newdata</code> (out of sample data to estimate the second stage). If the prediction requires additional arguments they must be supplied inside the function <code>p.fn</code> .
<code>treated.unit</code>	Single number indicating the unit where the intervention took place.
<code>t0</code>	Single number indicating the intervention period.
<code>lag</code>	Number of lags in the first stage model. Default is 0, i.e. only contemporaneous variables are used.
<code>Xreg</code>	Exogenous controls.
<code>alpha</code>	Significance level for the delta confidence bands.
<code>boot.cf</code>	Should bootstrap confidence intervals for the counterfactual be calculated (default=FALSE).
<code>R</code>	Number of bootstrap replications in case <code>boot.cf=TRUE</code> .

1	Block length for the block bootstrap.
VCOV.type	Type of covariance matrix for the delta. "iid" for standard covariance matrix, "var" or "varhac" to use prewhitened covariance matrix using VAR models, "varhac" selects the order of the VAR automatically and "nw" for Newey West. In the last case the user may select the kernel type and combine the kernel with the VAR prewhitening. For more details see Andrews and Monahan (1992).
VCOV.lag	Lag used on the robust covariance matrix if VCOV.type is different from "iid".
bandwidth.kernel	Kernel bandwidth. If NULL the bandwidth is automatically calculated.
kernel.type	Kernel to be used for VCOV.type="nw".
VHAC.max.lag	Maximum lag of the VAR in case VCOV.type="varhac".
prewhitening.kernel	If TRUE and VCOV.type="nw", the covariance matrix is calculated with prewhitening (default=FALSE).
...	Additional arguments used in the function fn.

### Details

This description may be useful to clarify the notation and understand how the arguments must be supplied to the functions.

- units: Each unit is indexed by a number between  $1, \dots, n$ . They are for example: countries, states, municipalities, firms, etc.
- Variables: For each unit and for every time period  $t = 1, \dots, T$  we observe  $q_i \geq 1$  variables. They are for example: GDP, inflation, sales, etc.
- Intervention: The intervention took place only in the treated unit at time  $t_0 = \lambda_0 * T$ , where  $\lambda_0$  is in  $(0,1)$ .

### Value

An object with S3 class fitArCo.

cf	estimated counterfactual
fitted.values	In sample fitted values for the pre-treatment period.
model	A list with q estimated models, one for each variable. Each element in the list is the output of the fn function.
delta	The delta statistics and its confidence interval.
p.value	ArCo p-value.
data	The data used.
t0	The intervention period used.
treated.unit	The treated unit used.
omega	Residual standard deviation.
residuals	model residuals.
boot.cf	A list with the bootstrap result (boot.cf=TRUE) or logical FALSE (boot.cf=FALSE). In the first case, each element in the list refers to one bootstrap replication of the counterfactual, i. e. the list length is R.
call	The matched call.

## References

Carvalho, C., Masini, R., Medeiros, M. (2016) "ArCo: An Artificial Counterfactual Approach For High-Dimensional Panel Time-Series Data."

Andrews, D. W., & Monahan, J. C. (1992). An improved heteroskedasticity and autocorrelation consistent covariance matrix estimator. *Econometrica: Journal of the Econometric Society*, 953-966.

## See Also

[plot](#), [estimate\\_t0](#), [panel\\_to\\_ArCo\\_list](#)

## Examples

```
#####
## === Example for q=1 === ##
#####
data(data.q1)
# = First unit was treated on t=51 by adding
# a constant equal to one standard deviation

data=list(data.q1) # = Even if q=1 the data must be in a list

## == Fitting the ArCo using linear regression == ##
# = creating fn and p.fn function = #
fn=function(X,y){
  return(lm(y~X))
}
p.fn=function(model,newdata){
  b=coef(model)
  return(cbind(1,newdata) %*% b)
}

ArCo=fitArCo(data = data,fn = fn, p.fn = p.fn, treated.unit = 1 , t0 = 51)

#####
## === Example for q=2 === ##
#####

# = First unit was treated on t=51 by adding constants of one standard deviation
# for the first and second variables

data(data.q2) # data is already a list

## == Fitting the ArCo using the package glmnet == ##
## == Quadratic Spectral kernel weights for two lags == ##

## == Fitting the ArCo using the package glmnet == ##
## == Bartlett kernel weights for two lags == ##
require(glmnet)
set.seed(123)
ArCo2=fitArCo(data = data.q2,fn = cv.glmnet, p.fn = predict,treated.unit = 1 , t0 = 51,
```

```
VCOV.type = "nw", kernel.type = "QuadraticSpectral", VCOV.lag = 2)
```

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inflationNFP	<i>Dataset used on the empirical example by Carvalho, Masini and Medeiros (2016).</i>
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### Description

This is the data from the *nota fiscal paulista* (NFP) example from Carvalho, Masini and Medeiros (2016). The variables are the food away from home component of the inflation and the GDP for 9 metropolitan areas in Brazil. Each variable is represented by a matrix inside the list. The treated unit is the Sao Paulo metropolitan area, which is the first column in each matrix. The treatment took place at  $t_0 = 34$ .

### Usage

```
data(inflationNFP)
```

### Format

A list with two matrixes of 56 rows and 9 variables.

### References

Carvalho, C., Masini, R., Medeiros, M. (2016) "ArCo: An Artificial Counterfactual Approach For High-Dimensional Panel Time-Series Data."

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panel_to_ArCo_list	<i>Transforms a balanced panel into a list of matrices compatible with the fitArCo function</i>
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### Description

Transforms a balanced panel into a list of matrices compatible with the fitArCo function. The user must identify the columns with the time, the unit identifier and the variables.

### Usage

```
panel_to_ArCo_list(panel, time, unit, variables)
```

### Arguments

panel	Balanced panel in a data.frame with columns for units and time.
time	Name or index of the time column.
unit	Name or index of the unit column.
variables	Names or indexes of the columns containing the variables.



**See Also**[fitArCo](#)**Examples**

```
# = Generate a small panel as example = #
set.seed(123)
time=sort(rep(1:100,2))
unit=rep(c("u1","u2"),100)
v1=rnorm(200)
v2=rnorm(200)
panel=data.frame(time=time,unit=unit,v1=v1,v2=v2)
head(panel)

data=panel_to_ArCo_list(panel,time="time",unit="unit",variables = c("v1","v2"))
head(data$v1)
```

---

plot.fitArCo	<i>Plots realized values and the counterfactual estimated by the fitArCo function</i>
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**Description**

Plots realized values and the counterfactual estimated by the fitArCo function. The plotted variables will be on the same level as supplied to the fitArCo function.

**Usage**

```
## S3 method for class 'fitArCo'
plot(x, ylab = NULL, main = NULL, plot = NULL,
     ncol = 1, display.fitted = FALSE, y.min = NULL, y.max = NULL,
     confidence.bands = FALSE, alpha = 0.05, ...)
```

**Arguments**

x	An ArCo object estimated using the fitArCo function.
ylab	n dimensional character vector, where n is the length of the plot argument or n=q if plot=NULL.
main	n dimensional character vector, where n is the length of the plot argument or n=q if plot=NULL.
plot	n dimensional numeric vector where each element represents an ArCo unit. If NULL, all units will be plotted. If, for example, plot=c(1,2,5) only units 1 2 and 5 will be plotted according to the order specified by the user on the fitArCo.
ncol	Number of columns when multiple plots are displayed.
display.fitted	If TRUE the fitted values of the first step estimation are also plotted (default=FALSE).

y.min	n dimensional numeric vector defining the lower bound for the y axis. n is the length of the plot argument or n=q if plot=NULL
y.max	n dimensional numeric vector defining the upper bound for the y axis. n is the length of the plot argument or n=q if plot=NULL
confidence.bands	TRUE to plot the counterfactual confidence bands (default=FALSE). If the ArCo was estimated without bootstrap this argument will be forced to FALSE.
alpha	Significance level for the confidence bands.
...	Other graphical parameters to plot.

**See Also**[fitArCo](#)**Examples**

```
#####
## == Example based on the q=1 fitArCo == ##
#####
# = First unit was treated on t=51 by adding
# a constant equal to one standard deviation
data(data.q1)
data=list(data.q1) # = Even if q=1 the data must be in a list
## == Fitting the ArCo using linear regression == ##
# = creating fn and p.fn function = #
fn=function(X,y){
  return(lm(y~X))
}
p.fn=function(model,newdata){
  b=coef(model)
  return(cbind(1,newdata) %*% b)}
ArCo=fitArCo(data = data,fn = fn, p.fn = p.fn, treated.unit = 1 , t0 = 51)
plot(ArCo)
```

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