

# Package ‘gnrprod’

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**Title** Estimates Gross Output Functions

**Version** 1.1.2

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**Description** Estimation of gross output production functions and productivity in the presence of numerous fixed (nonflexible) and a single flexible input using the nonparametric identification strategy specified in Gandhi, Navarro, and Rivers (2020) <[doi:10.1086/707736](https://doi.org/10.1086/707736)>. Monte Carlo evidence from the paper demonstrates high performance in estimating production function elasticities.

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|          |  |
|----------|--|
| coef.gnr | <i>Print gross output function estimates</i> |
|----------|--|

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**Description**

Print or return a numeric matrix of the estimated parameters from an object of class 'gnr'.

**Usage**

```
## S3 method for class 'gnr'
coef(object, ...)
```

**Arguments**

|        |                           |
|--------|---------------------------|
| object | an object of class 'gnr'. |
| ...    | currently not used.       |

**Value**

the named vector of parameter estimates contained in an object of class 'gnr'.

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|           |  |
|-----------|--|
| colombian | <i>Colombian plant-level production data</i> |
|-----------|--|

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**Description**

Plant-level production data for the food products industry (International Standard Industrial Classification code 311) in Colombia.

**Usage**

```
colombian
```

**Format**

A data frame with seven variables:

|       |   |
|-------|---|
| share | log intermediate input's revenue share              |
| id    | firm id   |
| year  | the last two digits of a year between 1981 and 1991 |
| RG0   | log of real gross output with base year 1981        |
| L     | log labor in level employee years                   |
| K     | log real capital stock with base year 1981          |
| RI    | log real intermediate inputs with base year 1981    |

For a complete listing of data, see [doi:10.1086/707736](https://doi.org/10.1086/707736).

## References

Gandhi, Amit, Salvador Navarro, and David Rivers. 2020. "On the Identification of Gross Output Production Functions." *Journal of Political Economy*, 128(8): 2973-3016. doi:10.1086/707736.

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|         |  |
|---------|--|
| gnrflex | <i>Estimate flexible input elasticity: Gandhi, Navarro, Rivers (GNR) share regression; first stage</i> |
|---------|--|

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## Description

The `gnrflex` function implements the first stage (share regression) of the GNR production function estimation routine, nonparametrically identifying the flexible input elasticity of the production function. This function is called within the main wrapper function `gnrprod`. If the production-related inputs are characters, a `data.frame` must be specified under `data`. Alternatively, matrices/vectors may be directly specified without specifying `data`. `gnrprod` currently supports only one flexible input. The parameters are optimized using the Gauss-Newton algorithm. `gnrflex` currently supports only one flexible input.

For details, see Gandhi, Navarro, and Rivers (2020).

## Usage

```
gnrflex(output, fixed, flex, share, id, time, data, control)
```

## Arguments

|                      |   |
|----------------------|---|
| <code>output</code>  | name (character) of variable of log gross output in data or a numeric vector.   |
| <code>fixed</code>   | name (character or character vector) of variables of log fixed inputs in data or a numeric matrix.  |
| <code>flex</code>    | name (character) of variable of log flexible input in data or a numeric vector.   |
| <code>share</code>   | name (character) of variable of log intermediate input's revenue share in data or a numeric vector.   |
| <code>id</code>      | name (character) of variable of firm id in data or a numeric vector.  |
| <code>time</code>    | name (character) of variable of time in data or a numeric vector.   |
| <code>data</code>    | <code>data.frame</code> containing all variables with names specified by arguments above (left empty if arguments above are vector/matrix rather than strings). |
| <code>control</code> | an optional list of convergence settings. See <code>gnrflex.control</code> for listing.   |

## Value

a list of class 'gnrflex' containing three elements:

`elas`: a list containing six elements describing the share regression:

- `flex_elas`: a numeric vector of the estimated flexible input elasticity for each observation.

- `coefficients`: a numeric vector of the coefficients of the estimator scaled by a constant. See Gandhi, Navarro, and Rivers (2020, p. 2994, equation (21)).
- `residuals`: a numeric vector of the residuals.
- `SSR`: sum of squared residuals.
- `iterations`: number of iterations performed.
- `convergence`: boolean indicating whether convergence was achieved.

`arg`: a list containing eight elements to be passed to the second stage function `gnriv`:

- `input`: a numeric matrix (S3: `poly`) of the polynomial expansion of all inputs.
- `input_degree`: a numeric matrix corresponding to `input` denoting each vector's degree.
- `all_input`: a numeric matrix of the inputs without polynomial expansion.
- `big_Y`: a numeric vector of persistent productivity minus the constant of integration. See Gandhi, Navarro, and Rivers (2020, p. 2991, equation (16)).
- `D_coef`: a numeric vector equaling `coef` divided by an estimate of the constant.
- `id`: a numeric vector of the firm ids.
- `time`: a numeric vector of time.
- `degree`: the degree of the share regression.
- `fixed_names`: the names of fixed inputs. To be used in the second stage.

`control`: the list of convergence control parameters. See `gnrflex.control` for available parameters.

## References

Gandhi, Amit, Salvador Navarro, and David Rivers. 2020. "On the Identification of Gross Output Production Functions." *Journal of Political Economy*, 128(8): 2973-3016. doi:10.1086/707736.

Davidson, Russell, James G. MacKinnon. 1993. "The Gauss-Newton Regression." In *Estimation and Inference in Econometrics*, 176-207. New York: Oxford University Press.

## Examples

```
require(gnrprod)
data <- colombian
industry_311_flex <- gnrflex(output = "RG0", fixed = c("L", "K"),
                           flex = "RI", share = "share", id = "id",
                           time = "year", data = data,
                           control = list(degree = 2, maxit = 200))
```

---

|                 |                                      |
|-----------------|--------------------------------------|
| gnrflex.control | <i>Control parameters in gnrflex</i> |
|-----------------|--------------------------------------|

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### Description

Allows the user to modify convergence parameters of Gauss Newton algorithm used in the `gnrflex` function.

### Usage

```
gnrflex.control(degree = 3, maxit = 100, reltol = 1e-5,
               initial_step = 100, min_factor = 1e-5)
```

### Arguments

|                           |   |
|---------------------------|---|
| <code>degree</code>       | degree of share regression polynomial. Defaults to 3.   |
| <code>maxit</code>        | maximum number of iterations. Defaults to 100.  |
| <code>reltol</code>       | relative convergence tolerance. Defaults to 1e-5.   |
| <code>initial_step</code> | a scaling parameter specifying the initial step-size factor used in each iteration of the Gauss-Newton algorithm. <code>initial_step</code> is halved in each convergence step. |
| <code>min_factor</code>   | the minimum value that the step-size factor can take on in the convergence step of any iteration of the Gauss-Newton algorithm.   |

### Value

a list containing five elements: `degree`, `maxit`, `reltol`, `initial_step`, and `min_factor`.

---

|                    |  |
|--------------------|--|
| <code>gnriv</code> | <i>Estimate fixed input elasticity and total productivity: Gandhi, Navarro, Rivers (GNR) lags as instruments; second stage</i> |
|--------------------|--|

---

### Description

The `gnriv` function implements the second stage of the GNR production function estimation routine, nonparametrically identifying the fixed input elasticities of the production function and total productivity. This function accepts an object of class `'gnrflex'`. The parameters are optimized using the function `optim`.

For details, see Gandhi, Navarro, and Rivers (2020).

### Usage

```
gnriv(object, control, ...)
```

**Arguments**

object            object of class 'gnrflex'.  
 control          an optional list of convergence settings. See [gnriv.control](#) for listing.  
 ...              additional optional arguments passed to optim.

**Value**

a list of class 'gnriv' containing three elements:  
 fixed\_elas: a numeric matrix of estimated elasticities of fixed inputs for each observation.  
 productivity: a numeric vector of estimated total productivity.  
 control: the list of convergence control parameters. See [gnriv.control](#) for available parameters.

**References**

Gandhi, Amit, Salvador Navarro, and David Rivers. 2020. "On the Identification of Gross Output Production Functions." *Journal of Political Economy*, 128(8): 2973-3016. doi:10.1086/707736.

**Examples**

```
require(gnrprod)
data <- colombian
## Not run:
industry_311_flex <- gnrflex(output = "RGO", fixed = c("L", "K"),
                           flex = "RI", share = "share", id = "id",
                           time = "year", data = data,
                           control = list(degree_w = 2, maxit = 200))

industry_311_fixed <- gnriv(industry_311_flex,
                           control = list(trace = 1))
## End(Not run)
```

---

|               |                                    |
|---------------|------------------------------------|
| gnriv.control | <i>Control parameters in gnriv</i> |
|---------------|------------------------------------|

---

**Description**

Allows the user to modify convergence parameters of Gauss Newton algorithm used in the [gnriv](#) function

**Usage**

```
gnriv.control(degree_w = 3, degree_tau = -1, method = "BFGS", ...)
```

**Arguments**

|            |  |
|------------|--|
| degree_w   | degree of Markov process for persistent productivity. Defaults to 3.   |
| degree_tau | degree of expansion for constant of integration. Defaults to the degree of first stage.  |
| method     | the method of optimization passed to <code>optim</code> . Defaults to "BFGS." See <code>optim</code> under 'Details' for listing of available methods. |
| ...        | additional optional control parameters passed to <code>optim</code> . See <code>optim</code> for available parameters.                                 |

**Value**

a list containing degree and method and any additional parameters in ...

---

|         |   |
|---------|---|
| gnrprod | <i>Estimate production functions and productivity: Gandhi, Navarro, and Rivers (2020)</i> |
|---------|---|

---

**Description**

The `gnrprod` function is the front end of the `gnrprod` package. It estimates production functions and productivity in two stages: `gnrflex` (estimate flexible input elasticity) and `gnriv` (estimate fixed input elasticities and productivity). If the production-related inputs are characters, a `data.frame` must be specified under `data`. Alternatively, matrices/vectors may be directly specified without specifying `data`. `gnrprod` currently supports only one flexible input.

**Usage**

```
gnrprod(output, fixed, flex, share, in_price = NULL,
        out_price = NULL, id, time, data, B = NULL,
        fs_control = NULL, ss_control = NULL, ...)
```

**Arguments**

|           |  |
|-----------|--|
| output    | name (character) of variable of log gross output in data or a numeric vector.  |
| fixed     | name (character or character vector) of variables of log fixed inputs in data or a numeric matrix.                             |
| flex      | name (character) of variable of log flexible input in data or a numeric vector.  |
| share     | name (character) of variable of log intermediate input's revenue share in data or a numeric vector.                            |
| in_price  | optional (required if share is not specified) name (character) of variable of common flexible input price or a numeric vector. |
| out_price | optional (required if share is not specified) name (character) of variable of common output price or a numeric vector.         |
| id        | name (character) of variable of firm ID in data or a numeric vector.   |

|            |   |
|------------|---|
| time       | name (character) of variable of time in data or a numeric vector.   |
| data       | <a href="#">data.frame</a> containing all variables with names specified by arguments above (left empty if arguments above are vector/matrix rather than strings).  |
| B          | number of bootstrap repetitions to retrieve standard errors of elasticity estimates. By default, <code>gnrprod</code> does not bootstrap, i.e., <code>B = NULL</code> . Setting <code>B &gt; 1</code> will output bootstrapped standard errors. |
| fs_control | an optional list of convergence settings of the first stage. See <a href="#">gnrflex.control</a> for listing.   |
| ss_control | an optional list of convergence settings of the second stage. See <a href="#">gnriv.control</a> for listing.  |
| ...        | additional optional arguments to be passed to <code>optim</code> in the second stage.   |

### Value

a list of class 'gnr' with five elements:

`estimates`: a list with two elements: `elas` the parameter estimates and `std_errors` the standard errors.

`data`: a [data.frame](#) containing: `output`, `fixed`, `flex`, `share`, `id`, `time`, estimated elasticities for each observation, estimated productivity, and first stage residuals.

`first_stage`: a list containing five elements describing the share regression (first stage):

- `coefficients`: a numeric vector of the coefficients of the first stage estimator scaled by a constant. See Gandhi, Navarro, and Rivers (2020, p. 1994, equation (21)).
- `SSR`: sum of squared residual.
- `iterations`: number of iterations performed.
- `convergence`: boolean indicating whether convergence was achieved.
- `control`: list of convergence control parameters (see [gnrflex.control](#)).

`second_stage`: a list containing four elements describing the second stage:

- `optim_method`: the method for optimization. Defaults to 'BFGS'. See [optim](#) for a listing of available methods.
- `optim_info`: the returned list of the [optim](#) function estimating the coefficients of the constant of integration. See Gandhi, Navarro, and Rivers (2020, p. 1994, equation (21)).
- `optim_control`: the list of control parameters passed to [optim](#).
- `degree_w`: degree of Markov process for persistent productivity.
- `degree_tau`: degree of expansion for constant of integration.

`call`: the function call.

### References

Gandhi, Amit, Salvador Navarro, and David Rivers. 2020. "On the Identification of Gross Output Production Functions." *Journal of Political Economy*, 128(8): 2973-3016. doi:10.1086/707736.



**Examples**

```
require(gnrprod)
data <- colombian
industry_311 <- gnrprod(output = "RGO", fixed = c("L", "K"),
  flex = "RI", share = "share", id = "id",
  time = "year", data = data,
  fs_control = list(degree = 2, maxit = 200),
  ss_control = list(trace = 1))
```

---

print.gnr                    *Printing gross output function estimates*

---

**Description**

Print estimates of the parameters in a gross output function and names of the output, input, and data from [gnrprod](#).

**Usage**

```
## S3 method for class 'gnr'
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

**Arguments**

|        |  |
|--------|--|
| x      | an object of class 'gnr'.                              |
| digits | the number of significant figures to use for printing. |
| ...    | currently not used.                                    |

**Value**

print.gnr has no return value and only prints a brief overview of elements contained in an object of class 'gnr' as described in the description.

---

print.gnrflex                *Printing first stage estimate*

---

**Description**

Print estimate of the flexible input elasticity, the sum of squared residuals, and convergence status from [gnrflex](#).

**Usage**

```
## S3 method for class 'gnrflex'
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

**Arguments**

|        |  |
|--------|--|
| x      | an object of class 'gnrflex'.                          |
| digits | the number of significant figures to use for printing. |
| ...    | currently not used.                                    |

**Value**

print.gnrflex has no return value and only prints a brief overview of elements contained in an object of class 'gnrflex' as described in the description.

---

|             |  |
|-------------|--|
| print.gnriv | <i>Printing second stage estimates</i> |
|-------------|--|

---

**Description**

Print estimates of the fixed input elasticities, productivity, objective function value, and convergence status from [gnriv](#).

**Usage**

```
## S3 method for class 'gnriv'  
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

**Arguments**

|        |  |
|--------|--|
| x      | an object of class 'gnriv'.                            |
| digits | the number of significant figures to use for printing. |
| ...    | currently not used.                                    |

**Value**

print.gnriv has no return value and only prints a brief overview of elements contained in an object of class 'gnriv' as described in the description.

---

|                   |   |
|-------------------|---|
| print.summary.gnr | <i>Printing a summary of gross output function estimation</i> |
|-------------------|---|

---

**Description**

Print a summary of the gross output function estimation routine from [gnrprod](#): names of output and inputs, summary statistics of the estimated productivity, the function estimates and standard errors if applicable, and convergence information.

**Usage**

```
## S3 method for class 'summary.gnr'
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

**Arguments**

|        |  |
|--------|--|
| x      | an object of class 'summary.gnr'.                      |
| digits | the number of significant figures to use for printing. |
| ...    | currently not used.                                    |

**Value**

print.gnr has no return value and only prints the elements contained in an object of class 'summary.gnr' as described in the description.

---

|             |  |
|-------------|--|
| summary.gnr | <i>Summarizing gross output function estimates</i> |
|-------------|--|

---

**Description**

Return a summary of the estimation routine for gross output functions from [gnrprod](#).

**Usage**

```
## S3 method for class 'gnr'
summary(object, ...)
```

**Arguments**

|        |                           |
|--------|---------------------------|
| object | an object of class 'gnr'. |
| ...    | currently not used.       |

**Value**

a list of class 'summary.gnr' containing 14 elements:

- `output_name`: the name of the output variable.
- `fixed_names`: a vector of the names of fixed input variables.
- `flex_name`: the name of the flexible input variable.
- `data`: data returned by `gnrprod`.
- `data_name`: the name of data.
- `fs_conv`: a boolean indicating if convergence was achieved in the first stage.
- `ss_conv`: the convergence code of `optim` used in the second stage.
- `productivity`: matrix of the estimated total productivity.
- `fs_iter`: the number of iterations in the first stage.
- `fs_SSR`: sum of squared residuals in the first stage.
- `ss_iter`: the number of iterations in the second stage.
- `ss_val`: the value of the objective function in the second stage.
- `ss_iter`: the number of iterations in the second stage.
- `ss_mes`: the convergence message in the second stage.

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