**spxtregress postestimation** — Postestimation tools for spxtregress

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## Postestimation commands

The following postestimation command is of special interest after `spxtregress`:

| Command | Description |
|---|---|
| `estat impact` | direct, indirect, and total impacts |

The following standard postestimation commands are also available:

| Command | Description |
|---|---|
| `contrast` | contrasts and ANOVA-style joint tests of parameters |
| `estat ic` | Akaike's, consistent Akaike's, corrected Akaike's, and Schwarz's Bayesian information criteria (AIC, CAIC, AICc, and BIC, respectively) |
| `estat summarize` | summary statistics for the estimation sample |
| `estat vce` | variance–covariance matrix of the estimators (VCE) |
| `estimates` | cataloging estimation results |
| `etable` | table of estimation results |
| `lincom` | point estimates, standard errors, testing, and inference for linear combinations of parameters |
| `lrtest` | likelihood-ratio test |
| `margins` | marginal means, predictive margins, marginal effects, and average marginal effects |
| `marginsplot` | graph the results from margins (profile plots, interaction plots, etc.) |
| `nlcom` | point estimates, standard errors, testing, and inference for nonlinear combinations of parameters |
| `predict` | predictions, residuals, influence statistics, and other diagnostic measures |
| `predictnl` | point estimates, standard errors, testing, and inference for generalized predictions |
| `pwcompare` | pairwise comparisons of parameters |
| `test` | Wald tests of simple and composite linear hypotheses |
| `testnl` | Wald tests of nonlinear hypotheses |

# predict

## Description for predict

`predict` creates a new variable containing predictions such as the reduced-form mean, the direct mean, the indirect mean, or the linear prediction.

## Menu for predict

Statistics > Postestimation

## Syntax for predict

`predict` [ *type* ] *newvar* [ *if* ] [ *in* ] [ , *statistic* ]

| *statistic* | Description |
|---|---|
| Main | |
| `rform` | reduced-form mean; the default |
| `direct` | direct mean |
| `indirect` | indirect mean |
| `xb` | linear prediction |

These statistics are only available in a subset of the estimation sample.

## Options for predict

Main

`rform`, the default, calculates the reduced-form mean. It is the predicted mean of the dependent variable conditional on the independent variables and any spatial lags of the independent variables. See *Methods and formulas*.

`direct` calculates the direct mean. It is a unit's predicted contribution to its own reduced-form mean. The direct and indirect means sum to the reduced-form mean.

`indirect` calculates the indirect mean. It is the predicted sum of the other units' contributions to a unit's reduced-form mean.

`xb` calculates the predicted linear combination of the independent variables.

# margins

## Description for margins

`margins` estimates margins of response for reduced-form mean, direct mean, indirect mean, and linear predictions.

## Menu for margins

Statistics > Postestimation

## Syntax for margins

`margins` [*marginlist*] [`,` *options*]

`margins` [*marginlist*] `,` `predict(`*statistic* `...)` [`predict(`*statistic* `...)` `...`] [*options*]

| *statistic* | Description |
|---|---|
| `rform` | reduced-form mean; the default |
| `direct` | direct mean |
| `indirect` | indirect mean |
| `xb` | linear prediction |

For the full syntax, see [R] **margins**.

## Remarks for margins

The computations that `margins` must do to calculate standard errors can sometimes be time consuming. Time will depend on the complexity of the spatial model and the number of spatial units in the data. You may want to fit your model with a subsample of your data, run `margins`, and extrapolate to estimate the time required to run `margins` on the full sample. See [P] **timer** and [P] **rmsg**.

# estat impact

## Description for estat impact

`estat impact` estimates the mean of the direct, indirect, and total impacts of independent variables on the reduced-form mean of the dependent variable.

## Syntax for estat impact

`estat impact` [*varlist*] [*if*] [*in*] [`,` `nolog`]

*varlist* is a list of independent variables, including factor variables, taken from the fitted model. By default, all independent variables from the fitted model are used.

`collect` is allowed; see **[U] 11.1.10 Prefix commands**.

## Option for estat impact

Main

nolog suppresses the calculation progress log that shows the percentage completed. By default, the log is displayed.

## Remarks for estat impact

estat impact is essential for interpreting the output of spxtregress. See [SP] **Intro 7**, example 1 of [SP] **spregress**, and examples 1 and 2 of [SP] **spxtregress** for explanations and examples.

## Stored results for estat impact

estat impact stores the following in r():

Scalars

| | |
|---|---|
| r(N) | number of observations |

Macros

| | |
|---|---|
| r(xvars) | names of independent variables |

Matrices

| | |
|---|---|
| r(b_direct) | vector of estimated direct impacts |
| r(Jacobian_direct) | Jacobian matrix for direct impacts |
| r(V_direct) | estimated variance–covariance matrix of direct impacts |
| r(b_indirect) | vector of estimated indirect impacts |
| r(Jacobian_indirect) | Jacobian matrix for indirect impacts |
| r(V_indirect) | estimated variance–covariance matrix of indirect impacts |
| r(b_total) | vector of estimated total impacts |
| r(Jacobian_total) | Jacobian matrix for total impacts |
| r(V_total) | estimated variance–covariance matrix of total impacts |

# Methods and formulas

Methods and formulas are presented under the following headings:

*Predictions*
*Reduced-form mean*
*Direct and indirect means*
*Linear predictor*
*Impacts in random-effects models*
*Impacts in fixed-effects models*

## Predictions

To motivate the predictions, consider the vector form of a spatial panel autoregressive model

$$\mathbf{y}_{nt} = \lambda\mathbf{W}\mathbf{y}_{nt} + \mathbf{X}_{nt}\boldsymbol{\beta} + \mathbf{c}_n + \boldsymbol{\epsilon}_{nt} \qquad t = 1, 2, \ldots, T \tag{1}$$

where

$\mathbf{y}_{nt}$ is the $n \times 1$ vector containing each unit's dependent-variable observations for time period $t$,

$\mathbf{W}\mathbf{y}_{nt}$ is a spatial lag of $\mathbf{y}_{nt}$,

$\mathbf{X}_{nt}$ is the matrix of independent-variable observations for time period $t$,

$\mathbf{c}_n$ are individual effects, which can be either fixed effects or random effects,

$\boldsymbol{\epsilon}_{nt}$ are the vector errors, and

$\lambda$ and $\boldsymbol{\beta}$ are the coefficients.

Any spatial lags of the independent variables are assumed to be in $\mathbf{X}_{nt}$. Spatial lags of the error do not affect the reduced-form, direct, or indirect means, so they are not included in (1) for simplicity.

### Reduced-form mean

Equation (1) represents the spatial autoregressive model as a system of equations. The solution to this system is

$$\mathbf{y}_{nt} = (\mathbf{I} - \lambda\mathbf{W})^{-1}(\mathbf{X}_{nt}\boldsymbol{\beta} + \mathbf{c}_n + \boldsymbol{\epsilon}_{nt}) \tag{2}$$

To simplify later notation, we define $\tilde{\mathbf{y}}_{nt}$ as $\mathbf{y}_{nt}$ minus the spatial spillover of the individual effects $\mathbf{c}_n$.

$$\begin{aligned}\tilde{\mathbf{y}}_{nt} &= \mathbf{y}_{nt} - (\mathbf{I} - \lambda\mathbf{W})^{-1}\mathbf{c}_n \\ &= (\mathbf{I} - \lambda\mathbf{W})^{-1}(\mathbf{X}_{nt}\boldsymbol{\beta} + \boldsymbol{\epsilon}_{nt})\end{aligned} \tag{3}$$

For the random-effects model, the individual effects $\mathbf{c}_n$ are treated as part of random errors. Thus, (2) implies that the mean of $\mathbf{y}_{nt}$ conditional on the independent variables and their spatial lags is

$$E(\mathbf{y}_{nt} \,|\, \mathbf{X}_{nt}, \mathbf{W}) = (\mathbf{I} - \lambda\mathbf{W})^{-1}(\mathbf{X}_{nt}\boldsymbol{\beta}) \tag{4}$$

This is known as the reduced-form mean because the solution in (2) is known as the reduced form of the model. The predicted reduced-form mean substitutes estimates of $\lambda$ and $\boldsymbol{\beta}$ into (4).

For the fixed-effects model, the individual effects $\mathbf{c}_n$ are treated as fixed effects, and they cannot be consistently estimated. The reduced-form prediction after `spxtregress, fe` is the conditional mean of $\tilde{\mathbf{y}}_{nt}$ given the independent variables and their spatial lags:

$$E(\tilde{\mathbf{y}}_{nt} \,|\, \mathbf{X}_{nt}, \mathbf{W}) = (\mathbf{I} - \lambda\mathbf{W})^{-1}(\mathbf{X}_{nt}\boldsymbol{\beta}) \tag{5}$$

### Direct and indirect means

To define the direct mean and the indirect mean, let

$$\mathbf{S}_n = (\mathbf{I} - \lambda\mathbf{W})^{-1}$$

and let $\mathbf{S}_d$ be a matrix with diagonal elements of $\mathbf{S}_n$ on its diagonal and with all off-diagonal elements set to 0.

The direct means are

$$\mathbf{S}_d\mathbf{X}_{nt}\boldsymbol{\beta}$$

which capture the contributions of each unit's independent variables on its own reduced-form mean. Substituting estimates of $\lambda$ and $\boldsymbol{\beta}$ produces the predictions.

The indirect means capture the contributions of the other units' independent variables on a unit's reduced-form mean. They are

$$\left\{(\mathbf{I} - \lambda\mathbf{W})^{-1} - \mathbf{S}_d\right\}\mathbf{X}_{nt}\boldsymbol{\beta}$$

### Linear predictor

The linear predictor is $\mathbf{X}_{nt}\boldsymbol{\beta}$.

## Impacts in random-effects models

The total impact of an independent variable **x** is the average of the marginal effects it has on the reduced-form mean of $\mathbf{y}_{nt}$,

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\partial E(\mathbf{y}_{it}|\mathbf{X}_{nt},\mathbf{W})}{\partial x_{jt}}$$

where $E(\mathbf{y}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})$ is the $i$th element of the vector $E(\mathbf{y}_{nt}\,|\,\mathbf{X}_{nt},\mathbf{W})$, whose formula is given in (3), and $x_{jt}$ is the $j$th unit's value for **x** at time $t$.

The direct impact of an independent variable **x** is the average of the direct, or own, marginal effects:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\frac{\partial E(\mathbf{y}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})}{\partial x_{it}}$$

The indirect impact of an independent variable **x** is the average of the indirect, or spillover, marginal effects:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\sum_{j=1,j\neq i}^{n}\frac{\partial E(\mathbf{y}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})}{\partial x_{jt}}$$

LeSage and Pace (2009, 36–37) call the average direct impact the "average total direct impact" and they call the average indirect impact the "average total indirect impact".

## Impacts in fixed-effects models

The total impact of an independent variable **x** is the average of the marginal effects it has on the reduced-form mean of $\tilde{\mathbf{y}}_{nt}$,

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\partial E(\tilde{\mathbf{y}}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})}{\partial x_{jt}}$$

where $E(\tilde{\mathbf{y}}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})$ is the $i$th element of the vector $E(\tilde{\mathbf{y}}_{nt}\,|\,\mathbf{X}_{nt},\mathbf{W})$, whose formula is given in (5), and $x_{jt}$ is the $j$th unit's value for **x** at time $t$.

The direct impact of an independent variable **x** is the average of the direct, or own, marginal effects:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\frac{\partial E(\tilde{\mathbf{y}}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})}{\partial x_{it}}$$

The indirect impact of an independent variable **x** is the average of the indirect, or spillover, marginal effects:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{i=1}^{n}\sum_{j=1,j\neq i}^{n}\frac{\partial E(\tilde{\mathbf{y}}_{it}\,|\,\mathbf{X}_{nt},\mathbf{W})}{\partial x_{jt}}$$

# Reference

LeSage, J., and R. K. Pace. 2009. *Introduction to Spatial Econometrics.* Boca Raton, FL: Chapman and Hall/CRC. https://doi.org/10.1201/9781420064254.

## Also see

[SP] **spxtregress** — Spatial autoregressive models for panel data

**[U] 20 Estimation and postestimation commands**

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