0.1 `netlogit`: Network Logistic Regression for Dichotomous Proximity Matrix Dependent Variables

Use network logistic squares regression analysis for a dependent variable that is a binary-valued proximity matrix (a.k.a. sociomatrices, adjacency matrices, or matrix representations of directed graphs).

Syntax

```
> z.out <- zelig(y ~ x1 + x2, model = "netlogit", data = mydata)
> x.out <- setx(z.out)
> s.out <- sim(z.out, x = x.out)
```

Examples

1. Basic Example

   Load the sample data and format it for social network analysis:

   ```
   > data(friendship)
   ```

   Estimate model:

   ```
   > z.out <- zelig(friends ~ advice + prestige + perpower, model = "netlogit",
   +     data = friendship)
   > summary(z.out)
   ```

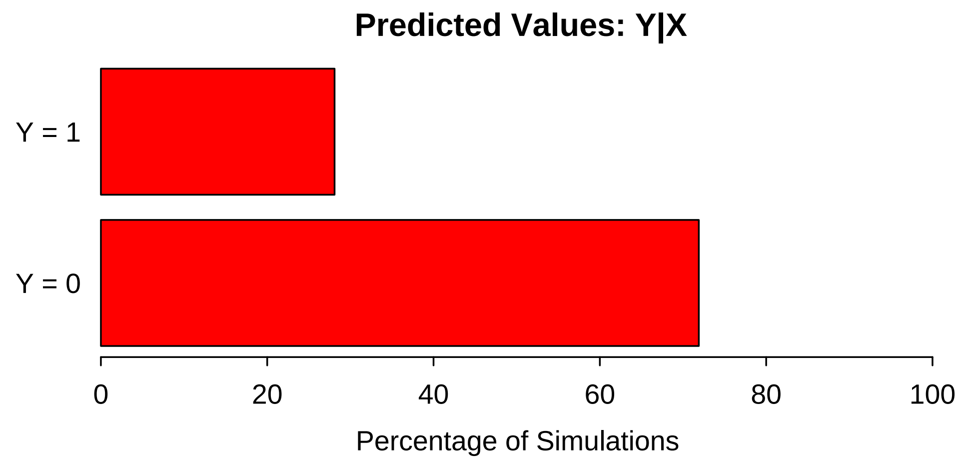
   Setting values for the explanatory variables to their default values:

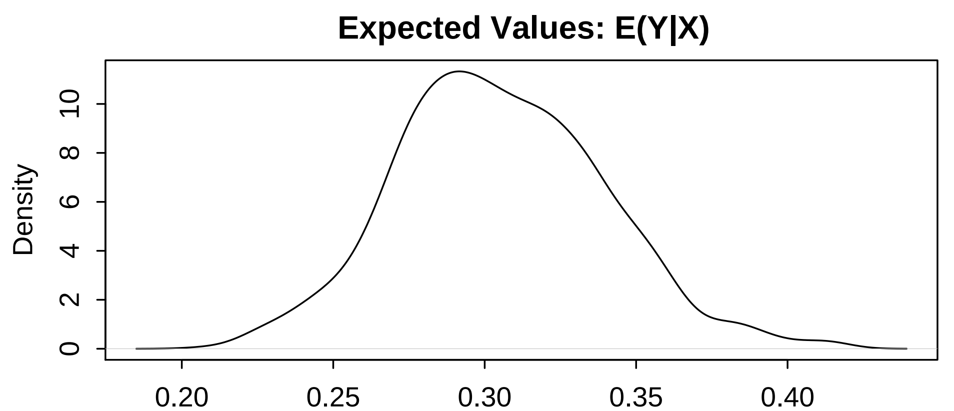
   ```
   > x.out <- setx(z.out)
   ```

   Simulating quantities of interest from the sampling distribution.

   ```
   > s.out <- sim(z.out, x = x.out)
   > summary(s.out)

   > plot(s.out)
   ```





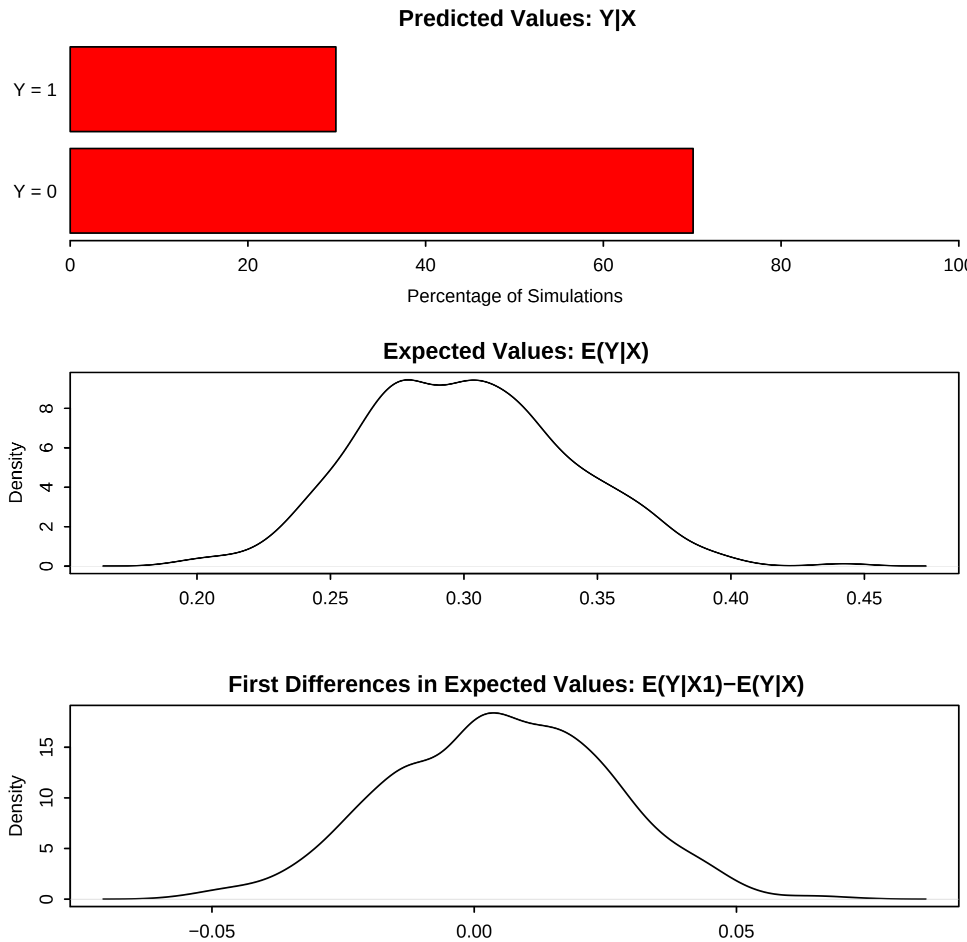
2. Simulating First Differences

   Estimating the risk difference (and risk ratio) between low personal power (25th percentile) and high education (75th percentile) while all the other variables are held at their default values.

```
> x.high <- setx(z.out, perpower = quantile(friendship$perpower,
+     prob = 0.75))
> x.low <- setx(z.out, educate = quantile(friendship$perpower,
+     prob = 0.25))

> s.out2 <- sim(z.out, x = x.high, x1 = x.low)
> summary(s.out2)


> plot(s.out2)
```



Model

The `netlogit` model performs a logistic regression of the sociomatrix $\mathbf{Y}$, a $m \times m$ matrix representing network ties, on a set of sociomatrices $\mathbf{X}$. This network regression model is a directly analogue to standard logistic regression element-wise on the appropriately vectorized matrices. Sociomatrices are vectorized by creating Y, an $m^2 \times 1$ vector to represent the sociomatrix. The vectorization which produces the Y vector from the $\mathbf{Y}$ matrix is preformed by simple row-concatenation of $\mathbf{Y}$. For example if $\mathbf{Y}$ is a 15×15 matrix, the $\mathbf{Y}_{1,1}$ element is the first element of Y, and the $\mathbf{Y}_{21}$ element is the second element of Y and so on. Once the input matrices are vectorized, standard logistic regression is performed.

Let Y_i be the binary dependent variable, produced by vectorizing a binary sociomatrix, for observation i which takes the value of either 0 or 1.

- The *stochastic component* is given by

$$\begin{aligned} Y_i &\sim \text{Bernoulli}(y_i|\pi_i) \\ &= \pi_i^{y_i}(1-\pi_i)^{1-y_i} \end{aligned}$$

where $\pi_i = \Pr(Y_i = 1)$.

- The *systematic component* is given by:

$$\pi_i = \frac{1}{1 + \exp(-x_i \beta)}.$$

where x_i is the vector of k covariates for observation i and β is the vector of coefficients.

Quantities of Interest

The quantities of interest for the network logistic regression are the same as those for the standard logistic regression.

- The expected values (`qi$ev`) for the netlogit model are simulations of the predicted probability of a success:

$$E(Y) = \pi_i = \frac{1}{1 + \exp(-x_i \beta)}.$$

  given draws of β from its sampling distribution.

- The predicted values (`qi$pr`) are draws from the Binomial distribution with mean equal to the simulated expected value π_i.

- The first difference (`qi$fd`) for the logit model is defined as

$$FD = \Pr(Y = 1|x_1) - \Pr(Y = 1|x)$$

Output Values

The output of each Zelig command contains useful information which you may view. For example, you run `z.out <- zelig(y   x, model ="netlogit", data)`, then you may examine the available information in `z.out` by using `names(z.out)`, see the coefficients by using `z.out$coefficients`, and a default summary of information through `summary(z.out)`. Other elements available through the `$` operator are listed below.

- From the `zelig()` output stored in `z.out`, you may extract:
  - `coefficients`: parameter estimates for the explanatory variables.
  - `fitted.values`: the vector of fitted values for the explanatory variables.
  - `residuals`: the working residuals in the final iteration of the IWLS fit.
  - `linear.predictors`: the vector of $x_i \beta$.
  - `aic`: Akaike's Information Criterion (minus twice the maximized log-likelihood plus twice the number of coefficients).

- `bic`: the Bayesian Information Criterion (minus twice the maximized log-likelihood plus the number of coefficients times log n).
- `df.residual`: the residual degrees of freedom.
- `df.null`: the residual degrees of freedom for the null model.
- `zelig.data`: the input data frame if `save.data = TRUE`

- From `summary(z.out)`, you may extract:
  - `mod.coefficients`: the parameter estimates with their associated standard errors, p-values, and t statistics.
  - `cov.scaled`: a $k \times k$ matrix of scaled covariances.
  - `cov.unscaled`: a $k \times k$ matrix of unscaled covariances.
  - `ctable`: a 2×2 table of predicted vs. actual values. Each cell tabulates whether the predicted value $\widehat{Y} \in \{0, 1\}$ corresponds to the observed $Y \in \{0, 1\}$.

- From the `sim()` output stored in `s.out`, you may extract:
  - `qi$ev`: the simulated expected probabilities for the specified values of `x`.
  - `qi$pr`: the simulated predicted values for the specified values of `x`.
  - `qi$fd`: the simulated first differences in the expected probabilities simulated from `x` and `x1`.

Contributors

The network logistic regression is part of the sna package by Carter T. Butts. Please cite the model as

.

In addition, advanced users may wish to refer to `help(netlogit)`. Sample data are fictional. Skyler J. Cranmer added Zelig functionality.