Package ‘ramchoice’

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Type Package

Title Revealed Preference and Attention Analysis in Random Limited Attention Models

Description It is widely documented in psychology, economics and other disciplines that socio-economic agent may not pay full attention to all available alternatives, rendering standard revealed preference theory invalid. This package implements the estimation and inference procedures of Cattaneo, Ma, Masatlioglu and Suleymanov (2020) <arXiv:1712.03448> and Cattaneo, Cheung, Ma, and Masatlioglu (2022) <arXiv:2110.10650>, which utilizes standard choice data to partially identify and estimate a decision maker's preference and attention. For inference, several simulation-based critical values are provided.

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Description

Information about socio-economic agent’s preference (consumer, firm, organization, voter, etc.) is important not only for understanding the decision-making process, but also for conducting welfare analysis and providing robust policy recommendations. However, it is widely documented in psychology, economics and other disciplines that decision makers may not pay full attention to all available alternatives, rendering standard revealed preference theory invalid.

This package implements the estimation and inference procedures documented in Cattaneo, Ma, Masatlioglu, and Suleymanov (2020), and Cattaneo, Cheung, Ma, and Masatlioglu (2024), which utilize standard choice data to partially identify decision maker’s preference and attention. For statistical inference, several simulation-based critical values are provided.

The following functions are provided: `revealPref` and `revealAtte` (the main functions for revealed preference and attention analysis), `sumData`, `genMat`, `logitAtte`, `logitSimu`. A simulated dataset `ramdata` is also included for illustration purposes.

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References


**Description**

`genMat` generates constraint matrices for a range of preference orderings according to (i) the monotonic attention assumption proposed by Cattaneo, Ma, Masatlioglu, and Suleymanov (2020), (ii) the attention overload assumption proposed by Cattaneo, Cheung, Ma, and Masatlioglu (2021), and (iii) the attentive-at-binaries restriction.

This function is embedded in `revealPref`.

**Usage**

```r
genMat(
  sumMenu,  # Numeric matrix, summary of choice problems, returned by `sumData`
  sumMsize,  # Numeric matrix, summary of choice problem sizes, returned by `sumData`
  pref_list = NULL,  # Numeric matrix, each row corresponds to one preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, ...), will be used.
  RAM = TRUE,  # Boolean, whether the restrictions implied by the random attention model of Cattaneo, Ma, Masatlioglu, and Suleymanov (2020) should be incorporated, that is, their monotonic attention assumption (default is TRUE).
  AOM = TRUE,  # Boolean, whether the restrictions implied by the attention overload model of Cattaneo, Cheung, Ma, and Masatlioglu (2021) should be incorporated, that is, their attention overload assumption (default is TRUE).
  limDataCorr = TRUE,  # Boolean, whether assuming limited data (default is TRUE). When set to FALSE, will assume all choice problems are observed. This option only applies when RAM is set to TRUE.
  attBinary = 1  # Numeric, between 1/2 and 1 (default is 1), whether additional restrictions (on the attention rule) should be imposed for binary choice problems (i.e., attentive at binaries).
)
```

**Arguments**

- `pref_list`: Numeric matrix, each row corresponds to one preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, ...), will be used.
- `RAM`: Boolean, whether the restrictions implied by the random attention model of Cattaneo, Ma, Masatlioglu, and Suleymanov (2020) should be incorporated, that is, their monotonic attention assumption (default is TRUE).
- `AOM`: Boolean, whether the restrictions implied by the attention overload model of Cattaneo, Cheung, Ma, and Masatlioglu (2021) should be incorporated, that is, their attention overload assumption (default is TRUE).
- `limDataCorr`: Boolean, whether assuming limited data (default is TRUE). When set to FALSE, will assume all choice problems are observed. This option only applies when RAM is set to TRUE.
- `attBinary`: Numeric, between 1/2 and 1 (default is 1), whether additional restrictions (on the attention rule) should be imposed for binary choice problems (i.e., attentive at binaries).
Value

\( R \)  
Matrices of constraints, stacked vertically.

\( \text{ConstN} \)  
The number of constraints for each preference, used to extract from \( R \) individual matrices of constraints.

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References


Examples

```r
# Load data
data(ramdata)

# Generate summary statistics
summaryStats <- sumData(ramdata$menu, ramdata$choice)

# Generate constraint matrices
constraints <- genMat(summaryStats$sumMenu, summaryStats$sumMsize)
constraints$ConstN
constraints$R[1:10, 1:10]
```

**Description**

`logitAtte` computes choice probabilities and attention frequencies for the logit attention rule considered by Brady and Rehbeck (2016). To be specific, for a choice problem \( S \) and its subset \( T \), the attention that \( T \) attracts is assumed to be proportional to its size: \(|T|^a\), where \( a \) is a parameter that one can specify. It will be assumed that the first alternative is the most preferred, and that the last alternative is the least preferred.

This function is useful for replicating the simulation results in Cattaneo, Ma, Masatlioglu, and Suleymanov (2020), and Cattaneo, Cheung, Ma, and Masatlioglu (2022).
**Usage**

```r
logitAtte(mSize = NULL, a = NULL)
```

**Arguments**

- `mSize`: Positive integer, size of the choice problem.
- `a`: Numeric, the parameter of the logit attention rule.

**Value**

- `choiceProb`: The vector of choice probabilities.
- `atteFreq`: The attention frequency.

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**References**


**Examples**

```r
logitAtte(mSize = 5, a = 2)
```

---

**logitSimu**  
*Choice Data Simulation Following the Logit Attention Rule*

**Description**

`logitSimu` simulates choice data according to the logit attention rule considered by Brady and Rehbeck (2016). To be specific, for a choice problem $S$ and its subset $T$, the attention that $T$ attracts is assumed to be proportional to its size: $|T|^a$, where $a$ is a parameter that one can specify. It will be assumed that the first alternative is the most preferred, and that the last alternative is the least preferred.

This function is useful for replicating the simulation results in Cattaneo, Ma, Masatlioglu, and Suleymanov (2020), and Cattaneo, Cheung, Ma, and Masatlioglu (2022).
Usage

logitSimu(n, uSize, mSize, a)

Arguments

n Positive integer, the effective sample size for each choice problem.

uSize Positive integer, total number of alternatives.

mSize Positive integer, size of the choice problem.

a Numeric, the parameter of the logit attention rule.

Value

menu The choice problems.

choice The simulated choices.

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References


Examples

set.seed(42)
logitSimu(n = 5, uSize = 6, mSize = 5, a = 2)
ramdata: Simulated Choice Data

Description

The file contains a standard choice data of 9,000 observations. There are five alternatives in the grand set.

See `revealPref` for revealed preference analysis, and `revealAtte` for revealed attention. `sumData` is a low-level function that computes summary statistics, and `genMat` generates constraint matrices subject to given preferences.

Format

- **menu** Numeric matrix of 0s and 1s, choice problems (1 indicates an alternative in the choice problem and 0 otherwise).
- **choice** Numeric matrix of 0s and 1s, choices (1 indicates an alternative being chosen).

rAtte: Revealed Preference Analysis in Random Limited Attention Models

Description

This has been replaced by `revealPref`.

Usage

```r
rAtte(
  menu, 
  choice, 
  pref_list = NULL, 
  method = "GMS", 
  nCritSimu = 2000, 
  BARatio2MS = 0.1, 
  BARatio2UB = 0.1, 
  MNRatioGMS = NULL, 
  RAM = TRUE, 
  AOM = TRUE, 
  limDataCorr = TRUE, 
  attBinary = 1
)
```
Arguments

- **menu**: Numeric matrix of 0s and 1s, the collection of choice problems.
- **choice**: Numeric matrix of 0s and 1s, the collection of choices.
- **pref_list**: Numeric matrix, each row corresponds to one preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, ...), will be used.
- **method**: String, the method for constructing critical values. Default is GMS (generalized moment selection). Other available options are LF (least favorable model), PI (plug-in method), 2MS (two-step moment selection), 2UB (two-step moment upper bound), or ALL (report all critical values).
- **nCritSimu**: Integer, number of simulations used to construct the critical value. Default is 2000.
- **BARatio2MS**: Numeric, beta-to-alpha ratio for two-step moment selection method. Default is 0.1.
- **BARatio2UB**: Numeric, beta-to-alpha ratio for two-step moment upper bound method. Default is 0.1.
- **MNRatioGMS**: Numeric, shrinkage parameter. Default is $\sqrt{1/\log(N)}$, where N is the sample size.
- **RAM**: Boolean, whether the restrictions implied by the RAM of Cattaneo et al. (2020) should be incorporated, that is, their monotonic attention assumption (default is TRUE).
- **AOM**: Boolean, whether the restrictions implied by the AOM of Cattaneo et al. (2022) should be incorporated, that is, their attention overload assumption (default is TRUE).
- **limDataCorr**: Boolean, whether assuming limited data (default is TRUE). When set to FALSE, will assume all choice problems are observed. This option only applies when RAM is set to TRUE.
- **attBinary**: Numeric, between 1/2 and 1 (default is 1), whether additional restrictions (on the attention rule) should be imposed for binary choice problems (i.e., attentive at binaries).

Value

- **sumStats**: Summary statistics, generated by `sumData`.
- **constraints**: Matrices of constraints, generated by `genMat`.
- **Tstat**: Test statistic.
- **critVal**: Critical values.
- **pVal**: P-values (only available for GMS, LF and PI).
- **method**: Method for constructing critical value.
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References

revealAtte

Revealed Attention Analysis in Random Limited Attention Models

Description
Given a random sample of choice problems and choices, revealAtte returns the upper and lower bounds on the attention frequency following the construction of Cattaneo, Cheung, Ma, and Masatlioglu (2024).

sumData is a low-level function that generates summary statistics. For revealed preference analysis, see revealPref.

Usage
```r
revealAtte(
  menu,            # Numeric matrix of 0s and 1s, the collection of choice problems.
  choice,          # Numeric matrix of 0s and 1s, the collection of choices.
  alternative = NULL,  # Numeric vector, the alternatives for which to compute bounds on the attention frequency. For example, c(1, 2, 4) means the first, second, and fourth alternatives.
  S = NULL,        #
  lower = TRUE,    #
  upper = TRUE,    #
  pref = NULL,     #
  nCritSimu = 2000,
  level = 0.95
)
```

Arguments
- `menu`: Numeric matrix of 0s and 1s, the collection of choice problems.
- `choice`: Numeric matrix of 0s and 1s, the collection of choices.
- `alternative`: Numeric vector, the alternatives for which to compute bounds on the attention frequency. For example, c(1, 2, 4) means the first, second, and fourth alternatives.
Numeric matrix of 0s and 1s, the collection of choice problems to compute bounds on the attention frequency.

lower
Boolean, whether lower bounds should be computed (default is TRUE).

upper
Boolean, whether upper bounds should be computed (default is TRUE).

pref
Numeric vector, corresponding to the preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, ..., ), will be used. This option only applies to the upper bounds (i.e., when upper is set to TRUE).

nCritSimu
Integer, number of simulations used to construct the critical value. Default is 2000.

level
Numeric, the significance level (default is 0.95).

Value

sumStats
Summary statistics, generated by sumData.

lowerBound
Matrix containing the lower bounds.

upperBound
Matrix containing the upper bounds.

critVal
The simulated critical value.

opt
Options used in the function call.

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References


Examples

# Load data
data(ramdata)

# Set seed, to replicate simulated critical values
set.seed(42)

# preference
pref <- matrix(c(1, 2, 3, 4, 5), ncol=5, byrow=TRUE)

# list of choice problems
S <- matrix(c(1, 0, 0, 0, 0, 0, 0),
revealPref

1, 1, 1, 0, 0,
1, 1, 1, 0, 1,
1, 1, 1, 1, 1), ncol=5, byrow=TRUE)
result <- revealAtte(menu = ramdata$menu, choice = ramdata$choice,
alternative = c(1,2), S = S,
lower = TRUE, upper = TRUE,
pref = pref)
summary(result)

revealPref
 Revealed Preference Analysis in Random Limited Attention Models

Description

Given a random sample of choice problems and choices, revealPref returns test statistics, critical values and p-values against a collection of preferences. Five methods for choosing critical values are available: (i) GMS: generalized moment selection (plug-in (estimated) moment conditions with shrinkage); (ii) PI: critical values based on plug-in estimated moment conditions (this is not uniformly valid); (iii) LF: critical values based on the least favorable model (plug-in 0 for the moment conditions); (iv) 2MS: two-step moment selection; and (v) 2UB: refined moment selection (plug-in upper bound of moment inequalities).

sumData is a low-level function that generates summary statistics, and genMat can be used to construct the constraint matrices. The simulated dataset ramdata is also provided for illustration. For revealed attention analysis, see revealAtte.

Usage

revealPref(
  menu,
  choice,
  pref_list = NULL,
  method = "GMS",
  nCritSimu = 2000,
  BARatio2MS = 0.1,
  BARatio2UB = 0.1,
  MNRatioGMS = NULL,
  RAM = TRUE,
  AOM = TRUE,
  limDataCorr = TRUE,
  attBinary = 1
)

Arguments

menu Numeric matrix of 0s and 1s, the collection of choice problems.
choice Numeric matrix of 0s and 1s, the collection of choices.
pref_list Numeric matrix, each row corresponds to one preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, \ldots), will be used.

method String, the method for constructing critical values. Default is GMS (generalized moment selection). Other available options are LF (least favorable model), PI (plug-in method), 2MS (two-step moment selection), 2UB (two-step moment upper bound), or ALL (report all critical values).

nCritSimu Integer, number of simulations used to construct the critical value. Default is 2000.

BARatio2MS Numeric, beta-to-alpha ratio for two-step moment selection method. Default is 0.1.

BARatio2UB Numeric, beta-to-alpha ratio for two-step moment upper bound method. Default is 0.1.

MNRatioGMS Numeric, shrinkage parameter. Default is $\sqrt{1/\log(N)}$, where N is the sample size.

RAM Boolean, whether the restrictions implied by the RAM of Cattaneo et al. (2020) should be incorporated, that is, their monotonic attention assumption (default is TRUE).

AOM Boolean, whether the restrictions implied by the AOM of Cattaneo et al. (2024) should be incorporated, that is, their attention overload assumption (default is TRUE).

limDataCorr Boolean, whether assuming limited data (default is TRUE). When set to FALSE, will assume all choice problems are observed. This option only applies when RAM is set to TRUE.

attBinary Numeric, between 1/2 and 1 (default is 1), whether additional restrictions (on the attention rule) should be imposed for binary choice problems (i.e., attentive at binaries).

Value

sumStats Summary statistics, generated by sumData.

consstraints Matrices of constraints, generated by genMat.

Tstat Test statistic.

critVal Critical values.

pVal P-values (only available for GMS, LF and PI).

method Method for constructing critical value.

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revealPrefModel

Model Falsification with Random Limited Attention

Description

Given a collection of choice problems and corresponding choice probabilities, revealPrefModel determines if they are compatible with the Random Attention Model (RAM) of Cattaneo, Ma, Masatlioglu, and Suleymanov (2020) and/or the Attention Overload Model (AOM) of Cattaneo, Cheung, Ma, and Masatlioglu (2024).

See revealPref for revealed preference analysis with empirical choice data.

References


Examples

# Load data
data(ramdata)

# Set seed, to replicate simulated critical values
set.seed(42)

# list of preferences
pref_list <- matrix(c(1, 2, 3, 4, 5,
                      2, 1, 3, 4, 5,
                      2, 3, 4, 5, 1,
                      5, 4, 3, 2, 1), ncol=5, byrow=TRUE)

# revealed preference using only RAM restrictions
result1 <- revealPref(menu = ramdata$(menu), choice = ramdata$choice, method = "GMS",
                      pref_list = pref_list, RAM = TRUE, AOM = FALSE)
summary(result1)

# revealed preference using only AOM restrictions
result2 <- revealPref(menu = ramdata$menu, choice = ramdata$choice, method = "GMS",
                      pref_list = pref_list, RAM = FALSE, AOM = TRUE)
summary(result2)

# revealed preference using both RAM and AOM restrictions
result3 <- revealPref(menu = ramdata$menu, choice = ramdata$choice, method = "GMS",
                      pref_list = pref_list, RAM = TRUE, AOM = TRUE)
summary(result3)

# revealed preference employing additional restrictions for binary choice problems
result4 <- revealPref(menu = ramdata$menu, choice = ramdata$choice, method = "GMS",
                      pref_list = pref_list, RAM = TRUE, AOM = TRUE, attBinary = 2/3)
summary(result4)
Usage

revealPrefModel(
  menu,
  prob,
  pref_list = NULL,
  RAM = TRUE,
  AOM = TRUE,
  limDataCorr = TRUE,
  attBinary = 1
)

Arguments

menu Numeric matrix of 0s and 1s, the collection of choice problems.
prob Numeric matrix, the collection of choice probabilities
pref_list Numeric matrix, each row corresponds to one preference. For example, c(2, 3, 1) means 2 is preferred to 3 and to 1. When set to NULL, the default, c(1, 2, 3, ...), will be used.
RAM Boolean, whether the restrictions implied by the RAM of Cattaneo et al. (2020) should be incorporated, that is, their monotonic attention assumption (default is TRUE).
AOM Boolean, whether the restrictions implied by the AOM of Cattaneo et al. (2024) should be incorporated, that is, their attention overload assumption (default is TRUE).
limDataCorr Boolean, whether assuming limited data (default is TRUE). When set to FALSE, will assume all choice problems are observed. This option only applies when RAM is set to TRUE.
attBinary Numeric, between 1/2 and 1 (default is 1), whether additional restrictions (on the attention rule) should be imposed for binary choice problems (i.e., attentive at binaries).

Value

constraints Matrices of constraints, generated by genMat. R: a matrix containing all constraints. ConstN: number of constraints for each preference.
inequalities The moment inequalities. Positive numbers indicate that the RAM/AOM restrictions are rejected by the given choice probabilities. R: a vector containing all moment inequalities. ConstN: number of constraints for each preference.

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sumData

Generate Summary Statistics

Description

sumData generates summary statistics. Given a collection of choice problems and corresponding choices, sumData calculates the number of occurrences of each choice problem, as well as the empirical choice probabilities.

This function is embedded in revealPref.

Usage

sumData(menu, choice)
Arguments

menu: Numeric matrix of 0s and 1s, the collection of choice problems.
choice: Numeric matrix of 0s and 1s, the collection of choices.

Value

sumMenu: Summary of choice problems, with repetitions removed.
sumProb: Estimated choice probabilities as sample averages for different choice problems.
sumN: Effective sample size for each choice problem.
sumMsize: Size of each choice problem.
sumProbVec: Estimated choice probabilities as sample averages, collapsed into a column vector.
Sigma: Estimated variance-covariance matrix for the choice rule, scaled by relative sample sizes.

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References


Examples

```r
# Load data
data(ramdata)

# Generate summary statistics
summaryStats <- sumData(ramdata$choice, ramdata$choice)
nrow(summaryStats$sumMenu)
min(summaryStats$sumN)

summaryStats$sumMenu[1, ]
summaryStats$sumProb[1, ]
summaryStats$sumN[1]
```
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