User Manual for Gorica.R

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In this appendix, we discuss how to evaluate (in)equality constrained hypotheses using the R script Gorica.R. Note that the evaluation process can be executed as long as the estimates of (standardized) structural parameters and their covariance matrix are obtained. Users only need an input file called input.txt to be able to execute the code in Gorica.R. The script Gorica.R and the file Input.txt are available on the website **http://informative-hypotheses.sites.uu.nl/software** in the folder called GORICA. The entries of the input file for the three examples in this paper are also provided in this folder. The input file for the logistic regression example is displayed below and elaborated on next:

```
#K        Seed      Iterations
6         111       100000
#Estimates of structural parameters
0.4765    0.2759    0.8670    -0.4430    0.8066    -0.2463
#Covariance matrix of the estimates of structural parameters
 0.1736   -0.1736    0.0000    0.0000    0.0000    0.0000
-0.1736    0.6326    0.0000    0.0000    0.0000    0.0000
 0.0000    0.0000    0.2094   -0.2094    0.0000    0.0000
 0.0000    0.0000   -0.2094    0.3741    0.0000    0.0000
 0.0000    0.0000    0.0000    0.0000    0.1352   -0.1352
 0.0000    0.0000    0.0000    0.0000   -0.1352    0.1830
#Number of models to be compared
3
#Number of equality and inequality constraints per model
3    3
4    2
0    0
```

```
#Hypothesis H1
#Restriction matrix
1 1 0 0 0 0
0 0 1 1 0 0
0 0 0 0 0 1
1 0 0 0 0 0
0 0 1 0 0 0
0 0 0 0 1 0
#Constants
0 0 0 0 0 0
#Hypothesis H2
#Restriction matrix
1 1 0 0 0 0
0 0 1 0 0 0
0 0 0 1 0 0
0 0 0 0 0 1
1 0 0 0 0 0
0 0 0 0 1 0
#Constants
0 0 0 0 0 0
#Hypothesis H3
#Restriction matrix
0 0 0 0 0 0
#Constants
0
```

One has to use "#" in order to specify the lines for comments. The first line consists of three labels: label K for the number of structural parameters in H_m, label Seed for the index number used in the random number generator, and label Iterations for the number of the iterations when calculating the penalty term. The third and fifth lines label the estimates of (standardized) structural parameters and their covariance matrix, respectively. The input file is specified based on the whole set of hypotheses under evaluation, namely, the hypotheses H_1, H_2, and the unconstrained hypothesis H_3 in **(16)**. The line below the fourth line with "#" indicates the number of these three hypotheses, that is, $M = 3$. The

fifth line with "#" labels the numbers of the equality and inequality restrictions in the hypotheses under evaluation. There are three sets of numbers below this line, that is, "3 3"; "4 2"; and "0 0"; each representing the number of equality and inequality restrictions for the corresponding hypothesis, respectively. For example, "3 3" means that there are 3 equality restrictions and 3 inequality restrictions in hypothesis H_1. Note that "0 and 0" means that there are not any restriction on the structural model parameters for the unconstrained hypothesis H_3. Both matrices S_m and R_m in (4), representing the equality and inequality constraints in hypothesis H_m, are reflected by label Restriction matrix, while both vectors s_m and r_m in (4), representing constants in hypothesis H_m are reflected by label Constants. The script Gorica.R always considers equality constraints first. Therefore, equality constraints must be specified before any of the inequality constraints. Both the number of the rows below label Restriction matrix and the length of the vector below label Constants are equal to the total number of constraints. To illustrate how to specify the restriction matrix and constants, consider the following example with $K = 5$ structural parameters:

Hypotheses	Restriction matrix	Constants
• $\theta_1 - \theta_2 + \theta_4 = 0$	1 -1 0 1 0	0,
• $\theta_4 - \theta_5 = 0$	0 0 0 1 -1	0,
• $\theta_1 - \theta_2 + \theta_3 - \theta_5 > 0$	1 -1 1 0 -1	0,
• $\theta_2 - \theta_4 > 0$	0 1 0 -1 0	0,
• $\theta_3 - \theta_5 > 0$	0 0 1 0 -1	0.

In general, for equality constraints,

• $a\theta_1 + b\theta_2 + c\theta_3 + d\theta_4 + e\theta_5 = 0$	$a\ b\ c\ d\ e$	0,

and for inequality constraints

• $a\theta_1 + b\theta_2 + c\theta_3 + d\theta_4 + e\theta_5 > 0$	$a\ b\ c\ d\ e$	0.

Each row corresponds to only one equality or inequality constraint. Therefore, for example, $H_1 : \theta_1 = \theta_2 > \theta_3$ has two rows:

Hypothesis H_1	Restriction matrix	Constants
• $\theta_1 - \theta_2 = 0$	1 -1 0 0 0	0,
• $\theta_2 - \theta_3 > 0$	0 1 -1 0 0	0.

The script Gorica.R for the input file can easily be executed in R. The execution procedure consists of the following basic steps:

- Install the packages "matrixcalc", "MASS", "quadprog", and "FRACTION" in R.
- Change the working directory to folder GORICA with the "setwd()" function in R.

  For example, setwd("C:/Users/(Username)/Desktop/GORICA"), if the GORICA file is saved on the desktop of computer and make sure to use the forward slash.
- Specify the entries in the input file.
- Save the changes (CTRL+S).
- Apply the "source()" function in R:

  source("Gorica.R").

Executing the script Gorica.R based on the input file displayed above renders the following results in R:

```
$MLEs
0.4765    0.2759    0.8670    -0.4430    0.8066    -0.2463
$Covariance_matrix
 0.1736   -0.1736    0.0000    0.0000    0.0000    0.0000
-0.1736    0.6326    0.0000    0.0000    0.0000    0.0000
 0.0000    0.0000    0.2094   -0.2094    0.0000    0.0000
 0.0000    0.0000   -0.2094    0.3741    0.0000    0.0000
 0.0000    0.0000    0.0000    0.0000    0.1352   -0.1352
 0.0000    0.0000    0.0000    0.0000   -0.1352    0.1830
```

$Restricted_MLEs

H_1	0.4765	-0.4765	0.8670	-0.8670	0.6247	0.0000
H_2	0.4765	-0.4765	0.0000	0.0000	0.6247	0.0000
H_3	0.4765	0.2759	0.8670	-0.4430	0.8066	-0.2463

	LogLikelihood	Penalty	GORICA_value	GORICA_weight
H_1	-1.3729	1.4985	5.7428	0.7608
H_2	-3.1676	1.0038	8.3428	0.2073
H_3	-0.0446	6.0000	12.0891	0.0319

Note that we utilized the input file introduced above (together with the script Gorica.R) to obtain the results presented for the logistic regression example in **Tables 7**, **8**, and **9** using one single R function, that is, source("Gorica.R"). To be able to execute the R function in the script Gorica.R, this script and Input.txt file must be in the same folder and the working directory of R must be set to this folder.