

SIMPLE-G-Brazil: Users' Guide

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Last updated: September 21, 2026

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Summary

This document provides detailed instructions on how to conduct simulations with the Simplified International Model of agricultural Prices, Land use and the Environment: Gridded version for Brazil (SIMPLE-G-Brazil): version 1 (benchmarked with 2017 data). It is designed as the supplementary material of “Chapter 15: The Role of Transportation Infrastructure Expansion in the Transmission of Global Price Shocks to the Brazilian Economy” from “SIMPLE-G: A Gridded Economic Approach to Sustainability Analysis of the Earth’s Land and Water Resources. Haqiqi and Hertel (eds). Springer Publishing, 2024”.

SIMPLE-G-Brazil is developed and simulated based on the General Equilibrium Modelling PACKage (GEMPACK) (Horridge et al. 2018). Before simulating SIMPLE-G-Brazil, it is suggested to install the GEMPACK software ² on your computer first. For additional information about SIMPLE-G-Brazil and its database, please refer to

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² A free-trail version of GEMPACK is available at <https://www.copsmodels.com/gpeidl.htm>.

Wang et al. (2024).

This users' guide contains three sections. Section 1 provides an overview of files and folders of the SIMPLE-G-Brazil program. Section 2 introduces the procedure of conducting simulations with SIMPLE-G-Brazil. Finally, section 3 lists several frequently asked questions for readers' additional information.

1. Folders and files of SIMPLE-G-Brazil

Under the folder of SIMPLE-G-Brazil, users will find the following folders and files.

1.1 Command files

```
cmf\  
    simpleg_WorldPriceShock.cmf  
    simpleg_WorldPriceShock_High.cmf  
    simpleg_WorldPriceShock_Low.cmf
```

The folder “cmf” contains command files (*.cmf), which contains important information for simulation, including the path of input and output files, parameters for model solving, closure of the current model, and shock (policy levers) to be changed in the experiment. Each experiment is stored in a separate command file.

1.2 Input and output files

```
in\  
    GRIDDATA.har  
    GRIDPARM.har  
    GRIDSETS.har  
    TC2035S1.har  
    TC2035S8.har
```

The folder “in” contains the input data of SIMPLE-G-Brazil, stored as Header Array files (*.har). As their names suggest, GRIDDATA³, GRIDPARM and GRIDSET contain the data, parameters and sets of the model (if users are not familiar with sets in models developed with GEMPACK, please refer to section 3.1). These files provide the key information of conducting any simulations with SIMPLE-G-Brazil (and also other models with the SIMPLE-G framework).

In contrast, the files “TC2035S1.har” and “TC2035S8.har” contain projections about the gridded transportation cost and distance in Brazil by 2035 under different infrastructure expansion scenarios. And they are only used in experiments where we take the development of domestic transportation network into consideration.

```
out\  

```

³ SIMPLE-G-Brazil database (Version 1.1.0; variant: transportation). This version is based on the database used in Chapter 15, with bug fixes and updates to the underlying SIMPLE database. Results reproduced using this updated version may differ slightly from those reported in this chapter, while the overall patterns and conclusions remain unchanged.

The folder “out” is empty now, but after users run the model, its solution files, updated data and log files will be stored in this folder.

1.3 Files for additional analyses

SSA\ simpleg.MDF SSA.CLS SSA.ssd WorldPriceShock.SHF WorldPriceShock_High.SHF WorldPriceShock_Low.SHF Readme Use RunGEM for SSA\ Step1_model_data.jpg Step2_closure.jpg Step3_shocks.jpg Step4_output.jpg Step5_solve.jpg Step6_results.jpg Step7_SSA parameter.jpg Step8_SSA setting.jpg
--

The folder “SSA” contains files for systematic sensitivity analysis (SSA) with respect to parameters’ uncertainty, which will be discussed in section 3.2. Those files are not used during the simulation. The folder “Readme Use RunGEM for SSA” provides instructions on how to conduct SSA with another software (RunGEM), which is installed together with GEMPACK.

Additional files\ GRIDDATA_withoutTC.har simpleg_SSP2.cmf

Besides the experiments described in Chapter 15, users can also conduct alternative simulations with files in the “Additional files” folder. In the current model, we set:

$\text{Gridded farm-gate crop price} = \text{national crop price} - \text{gridded transportation cost}$

If users would like to disable the effect of transportation cost in SIMPLE-G-Brazil, they can rename the file “GRIDDATA.har” in the folder “in” to “GRIDDATA_withTC.har”, copy the file “GRIDDATA_withoutTC.har” from the folder “Additional files” to “in” and rename that file to “GRIDDATA.har”, to create a version of SIMPLE-G-Brazil without domestic transportation cost. With this new version, please do not shock transportation cost and distance anymore with TC2035S1.har or TC2035S8.har to avoid problematic results.

Also, if users would like to project or hindcast the model with socio-economic drivers, they can use the file “simpleg_SSP2.cmf” as a template, which contains shocks to project SIMPLE-G-Brazil from 2017 baseline to 2035 under the Shared Socioeconomic Pathways, scenario 2 “middle of the road”. Details about those projections are available from Wang et al. (2024).

1.4 Script and model

```
do.bat  
gfortran_link_ltg.fig  
LTG.LOG  
parcomp.log  
simpleg-ceqexplen.har  
simpleg.axs  
simpleg.axt  
simpleg.exe  
simpleg.inf  
simpleg.LOG  
simpleg.min  
simpleg.tab  
simpleg.cls
```

Those files are located directly under the folder of SIMPLE-G-Brazil. The file “simpleg.tab” provides the original TABLO code for SIMPLE-G-Brazil for users’ information. Experienced users can further edit the code and compile new model versions. The file “do.bat” is a batch file that manages model simulations, which will be further explained in the next section. Finally, all other files are automatically generated from the compiling of SIMPLE-G-Brazil. Users do not need to further check or edit them.

2. Experiment Design and Simulations

To create their own experiments and conduct simulations, users should follow three steps.

2.1 Create and Edit Command Files

First, we need to create a command file for our experiment. Take the command file “simpleg_WorldPriceShock_High.cmf” as an example, this file contains two types of shocks:

- Global crop price shock: increase by 10%.
- Domestic transportation shock: transportation infrastructure will expand under the high development scenario, which influences the transportation cost and distance (by road and railway) at gridded level.

In this command file, scroll down to the last section “Shocks Section”, users will find how to represent those shocks as commands (Fig. 1).

```

127 automatic accuracy = NO;
128 accuracy figures = 2;
129 accuracy percent = 80;
130 minimum subinterval length = 0.001; ! default is 0.000001 ( 10^-6 )
131 minimum subinterval fails = stop;
132 accuracy criterion = both;
133
134
135 ! ***** !
136 ! Shocks Section !
137 ! ***** !
138 Shock p_PCROP = 10;
139
140 ! Transportationi shock from PNL2035-scenario 8 (scnario high in application)
141 Final_Level TCg = file in\TC2035S8.har header "TCST";
142
143 ! Transportationi shock from PNL2035-scenario 8
144 Final_Level DISTRADg = file in\TC2035S8.har header "TDRO";
145 Final_Level DISTRALg = file in\TC2035S8.har header "TDRA";

```

Fig.1. The screenshot of a command file

The first shock is represented by the command “shock p_PCROP = 10;”. This command means:

- Shock: the command to change an exogenous variable by a certain percentage written in the same line.
- p_PCROP: PCROP is the variable of global crop price, and the prefix “p_” refers to its percentage change. In the original setting, both PCROP and p_PCROP are endogenous. Please refer to section 3.3 on how to shock the value of an endogenous variable.
- = 10: it indicates we would like to increase the global crop price by 10%. Please note that if users would like to shock a variable with multiple components (for example those defined at the set REG) by the same percentage, they should use “= uniform 10;” instead.

The second shock is implemented in a slightly different manner. Instead of using “shock” command and provide the magnitude of change directly, we use the command “Final level” to set the value of variables to equal the data read from a header array file (please note that instead of setting the percentage to be changed, the “Final_level” command provides the value after change directly). This approach is feasible when users need to shock a large number of variables with different values. For further information about the command file, please refer to the manual of GEMPACK (Horridge et al. 2018).

2.2 Edit Batch File

After we have created a command file for our simulation, we need to include it into the batch file “do.bat”. This file can be opened with any text editor. The content of this file is:

```

call simpleg -cmf cmf\simpleg_WorldPriceShock.cmf
call simpleg -cmf cmf\simpleg_WorldPriceShock_Low.cmf
call simpleg -cmf cmf\simpleg_WorldPriceShock_High.cmf

```

pause

Take the third line as example, this command means:

- call: the command to run compiled model as executable file (*.exe)
- simpleg: the name of the executable file under the same folder, here it refers to “simpleg.exe”
- -cmf: it indicates the model should be simulated with command files
- cmf\simpleg_WorldPriceShock_High.cmf: this is the relative path of the command file we just checked.

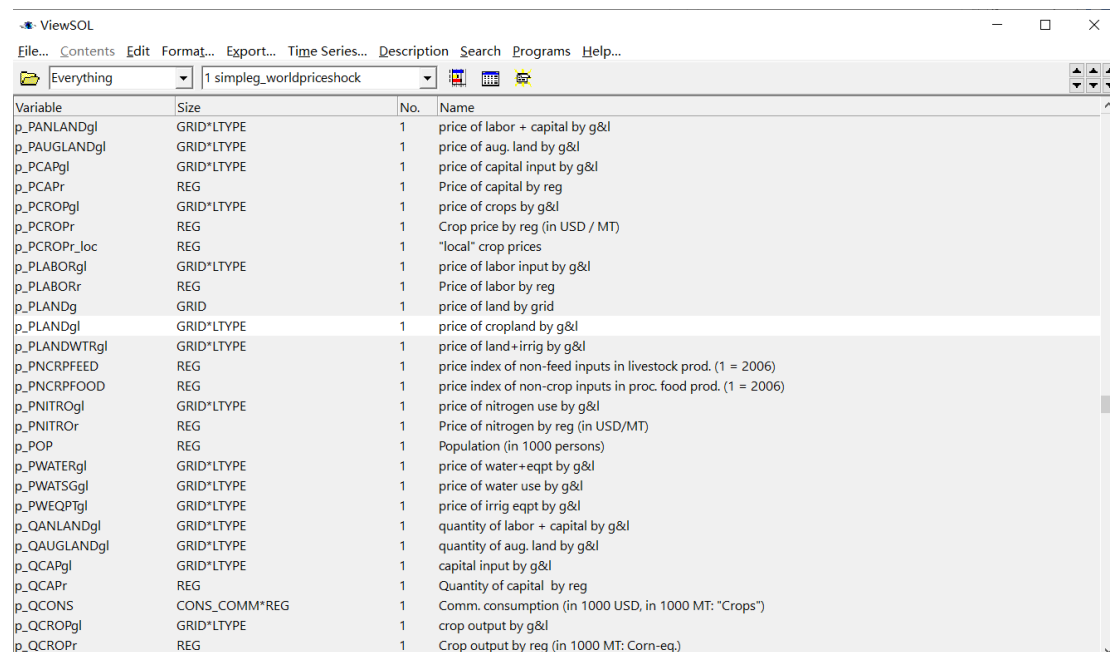
If users need to run multiple simulations, they can create a command file for each simulation, and add the “call ...” commands into the file “do.bat” to run.

The last command “pause” asks the console window to remain open after all simulations, for the convenience of users to check if simulations are conducted successfully or not. Users can also get the same report from log files (*.log) in the folder “out”.

2.3 Run Simulations and Check Results

After the the simulation has been included in to the batch file, users can now double click the “do.bat” file and the model will be simulated with a console (the model is tested on the Windows system. For users with MacOS, please refer to section 3.4). If the console stops with the message “The program has completed without error”, we can further check the results of similtions.

Once the simulation is finished successfully, users should be able to find the solution file (*.sl4) with the same name under the folder “out”. Double-click to open the solution file with ViewSOL (the software installed together with GEMPACK), which will list variables and their descriptions for further check (Fig. 2).



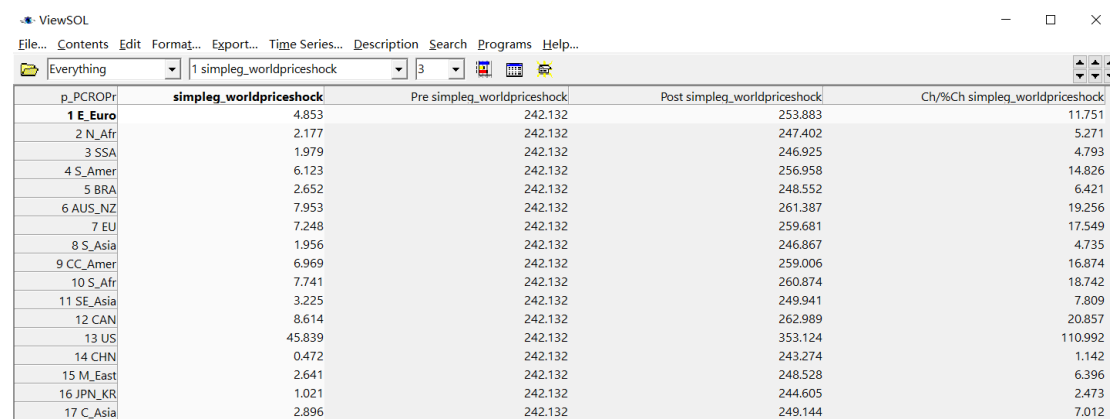
The screenshot shows the ViewSOL application window. The title bar reads "ViewSOL". The menu bar includes "File...", "_Contents", "Edit", "Format...", "Export...", "Time Series...", "Description", "Search", "Programs", and "Help...". The toolbar shows icons for file operations. The main area displays a list of variables with columns for Variable, Size, No., and Name. The list includes variables like p_PANLANDgl, p_PAUGLANDgl, p_PCAPgl, p_PCAPr, p_PCROPgl, p_PCROPr, p_PCROPr_loc, p_PLABORgl, p_PLABORr, p_PLANDg, p_PLANDgl, p_PLANDWTRgl, p_PNCRPFEED, p_PNCRPFOD, p_PNITROgl, p_PNITROr, p_POP, p_PWATERgl, p_PWATSGgl, p_PWEQPTgl, p_QANLANDgl, p_QAUGLANDgl, p_QCAPgl, p_QCAPr, p_QCONS, p_QCROPgl, and p_QCROPr, each with a corresponding size and number, and a detailed description of what each variable represents.

Variable	Size	No.	Name
p_PANLANDgl	GRID*LTYPE	1	price of labor + capital by g&l
p_PAUGLANDgl	GRID*LTYPE	1	price of aug. land by g&l
p_PCAPgl	GRID*LTYPE	1	price of capital input by g&l
p_PCAPr	REG	1	Price of capital by reg
p_PCROPgl	GRID*LTYPE	1	price of crops by g&l
p_PCROPr	REG	1	Crop price by reg (in USD / MT)
p_PCROPr_loc	REG	1	"local" crop prices
p_PLABORgl	GRID*LTYPE	1	price of labor input by g&l
p_PLABORr	REG	1	Price of labor by reg
p_PLANDg	GRID	1	price of land by grid
p_PLANDgl	GRID*LTYPE	1	price of cropland by g&l
p_PLANDWTRgl	GRID*LTYPE	1	price of land+irrig by g&l
p_PNCRPFEED	REG	1	price index of non-feed inputs in livestock prod. (1 = 2006)
p_PNCRPFOD	REG	1	price index of non-crop inputs in proc. food prod. (1 = 2006)
p_PNITROgl	GRID*LTYPE	1	price of nitrogen use by g&l
p_PNITROr	REG	1	Price of nitrogen by reg (in USD/MT)
p_POP	REG	1	Population (in 1000 persons)
p_PWATERgl	GRID*LTYPE	1	price of water+eqpt by g&l
p_PWATSGgl	GRID*LTYPE	1	price of water use by g&l
p_PWEQPTgl	GRID*LTYPE	1	price of irrig eqpt by g&l
p_QANLANDgl	GRID*LTYPE	1	quantity of labor + capital by g&l
p_QAUGLANDgl	GRID*LTYPE	1	quantity of aug. land by g&l
p_QCAPgl	GRID*LTYPE	1	capital input by g&l
p_QCAPr	REG	1	Quantity of capital by reg
p_QCONS	CONS_COMM*REG	1	Comm. consumption (in 1000 USD, in 1000 MT: "Crops")
p_QCROPgl	GRID*LTYPE	1	crop output by g&l
p_QCROPr	REG	1	Crop output by reg (in 1000 MT: Corn-eq.)

Fig.2. The screenshot of a solution file

For the results of each variable in the percentage form (starts with “p_”), the resolution

file will report the percentage of that variable in the first column (here 10 means 10% increase). If the variable also contains the level form (the quantity at base), the solution file will also report its value before the shock (the second column), after shock (the third column), and the difference in net values, not percentage change (the fourth column) (Fig. 3). The easiest way of exporting simulation results is to “Export – Copy” in ViewSOL, which will copy all results of the current variable to clipboard and can be pasted to Excel. Still, a less straightforward but more recommended approach is to access solution file in R using the “HARr” package (Ivanic 2023), which allow users to save simulation results as data frames with scripts for saving or further analysis.



The screenshot shows the ViewSOL application window. The menu bar includes File..., Contents, Edit, Format..., Export..., Time Series..., Description, Search, Programs, and Help... The toolbar shows icons for file operations and viewing. The main window displays a table of simulation results for the variable 'simpleg_worldpriceshock'.

p_PCROPr	simpleg_worldpriceshock	Pre simpleg_worldpriceshock	Post simpleg_worldpriceshock	Ch/%Ch simpleg_worldpriceshock
1 E_Euro	4.853	242.132	253.883	11.751
2 N_Afr	2.177	242.132	247.402	5.271
3 SSA	1.979	242.132	246.925	4.793
4 S_Amer	6.123	242.132	256.958	14.826
5 BRA	2.652	242.132	248.552	6.421
6 AUS_NZ	7.953	242.132	261.387	19.256
7 EU	7.248	242.132	259.681	17.549
8 S_Asia	1.956	242.132	246.867	4.735
9 CC_Amer	6.969	242.132	259.006	16.874
10 S_Afr	7.741	242.132	260.874	18.742
11 SE_Asia	3.225	242.132	249.941	7.809
12 CAN	8.614	242.132	262.989	20.857
13 US	45.839	242.132	353.124	110.992
14 CHN	0.472	242.132	243.274	1.142
15 M_East	2.641	242.132	248.528	6.396
16 JPN_KR	1.021	242.132	244.605	2.473
17 C_Asia	2.896	242.132	249.144	7.012

Fig.3. The screenshot of results

3. Frequently Asked Questions

3.1 What are included in GRIDSETS?

The header array file GRIDSETS contains two types of information, set and mapping. Here “set” refers to domains that a variable or parameter is defined upon, while “mapping” refers to the relationship between two sets.

For example, the set “REG” defines a domain of the regions included in the model:

Table 1. Regions in SIMPLE-G-Brazil

No.	REG	Description
1	E_Euro	Eastern Europe
2	N_Afr	North Africa
3	SSA	Sub Saharan Africa
4	S_Amer	South America (except Brazil)
5	BRA	Brazil
6	AUS_NZ	Oceania
7	EU	European Union
8	S_Asia	South Asia
9	CC_Amer	Central America

10	S_Afr	Southern Africa
11	SE_Asia	Southeast Asia
12	CAN	Canada
13	US	USA
14	CHN	China
15	M_East	Middle East
16	JPN_KR	Japan / Korea
17	C_Asia	Central Asia

where Brazil (“BRA”)’s index is 5. While the set “GID” defines a domain of grid cells (G00001, ... G50614), where the first 50,598 grid cells are disaggregated from Brazil, and the following 16 grid cells refer to 16 non-Brazil regions in set REG.

The mapping MAP1 maps set GID to REG. Each row of MAP1 represents the corresponding grid cell in GID, and it records the region (by its index) that the grid cell is mapped to. That explains why the first 50,598 rows of MAP1 all have the value of 5!

3.2 How to conduct sensitivity analysis with SIMPLE-G-Brazil?

Sensitivity analysis plays an important role in simulations. It includes testing the sensitivity of results with respect to key parameters, model assumptions, uncertainty in scenarios, etc. Here we provide an example to how to conduct the sensitive analysis with respect to parameter values, while users may refer to Wang et al. (2024) for other types of sensitivity analyses. We describe the procedure of sensitivity analysis below, while large-size visual instructions are available in the folder “Readme Use RunGEM for SSA”.

- Step 1. Open RunGEM (installed together with GEMPACK). RunGEM is another approach to simulate models developed with GEMPACK, it provides a built-in function for conduction sensitivity analysis. In RunGEM, set the paths of the complied model and input files.
- Step 2. Load the model closure “SSA.CLS” from the folder “SSA”.
- Step 3. Load the shocks (*.SHF) file from the folder “SSA”. Users may need to change the path of TC2035S1 / TC2035S8 files in the shock file.
- Step 4. Set the path and filename of output files.
- Step 5. Make sure the solution method in RunGEM matches the solution method in the corresponding command files (under “Verbal description and solution method” section). Click “Solve” to start the simulation.
- Step 6. After the simulation is finished, click “Tools – SSA wrt Parameters”.
- Sept 7. In the pop-up window, click “Add to list from file” and load the prepared SSA file “SSA.ssd” from “SSA” folder. In this study, we conduct the SSA with the triangle distribution of parameters (alpha and beta) in cropland supply elasticity estimation. For additional information on the SSA setting, please refers to chapter 15 or Wang et al. (2024).
- Section 8. Select the maximum concurrent SSA solves (on our end, setting the number to be greater than 1 will cause failures, but users can still test for

different values in order to increase the efficiency of SSA), select the quadrature and click OK, RunGEM will automatically conduct SSA and report the mean and standard deviation of model results. For further information about the sensitivity analysis method in RunGEM and how to interpret SSA results, users may further check “Tools – Help on Systemic Sensitivity Analysis”.

3.3 How can I shock the value of an endogenous variable?

Users may notice that in the original setting of SIMPLE-G-Brazil, the variable p_PCROP (the percentage change of global crop price) is an endogenous variable that to be solved with the model, which cannot be shocked exogenously directly.

In order to make p_PCROP exogenous, we need to include an additional command by the end of “closure” section:

swap p_PCROP = p_AOCROPr("US");

which means we will let p_PCROP to be exogenous and make the previously exogenous variable p_AOCROPr("US") (the percentage of efficiency index in crop production in the US, which represents the technological effect on agricultural productivity) to be endogenous.

This command can be interpreted that in order to achieve the exogenously given change in global crop price, we will let the model to select how much the US should adjust its agricultural technology to make it happen. Theoretically, we can swap p_PCROP with another endogenous variable. The reason of selecting p_AOCROPr("US") here is that we would like to keep the impact of swapping outside of Brazil, so its impact only influences Brazil through global crop price.

3.4 How can I conduct simulations on the MacOS?

The simulation of models developed with GEMPACK on the MacOS can be challenging sometime, since there is no official GEMPACK support for the MacOS yet. Instead, users may try to install GEMPACK on MacOS as a container or with a virtual machine with several third-party options:

- CrossOver (<https://www.codeweavers.com/crossover/>)
- Virtual Box (<https://www.virtualbox.org/wiki/Downloads>)
- Parallels Desktop (<http://www.parallels.com/products/desktop/>)
- VMWare Fusion (<http://www.vmware.com/products/fusion.html>)

Reference

Horridge, J.M., M. Jerie, D. Mustakinov, and F. Schiffmann. 2018. *GEMPACK manual*. Victoria University, Centre of Policy Studies/IMPACT Centre.

Ivanic, M. 2023. “GEMPACK simulations in R: A demonstration of running the GTAP model and processing its results entirely in R using packages HARr and tabloToR.” *Journal of Global Economic Analysis* 8(1):1–20.

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of transportation infrastructure in Brazil has implications for the pattern of agricultural production and carbon emissions.” *Science of The Total Environment* 928:172434.