

Guidelines to reproduction of results

Risk caused by the propagation of earthquake losses through the economy

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All results presented in the paper can be reproduce by using the files and pieces of software available in the supplementary material <https://github.com/JALeonTorres/RAPELE->

Installing Software

Before being able to reproduce the results, please, install the next programs:

- 1) Customized RunGEM
- 2) GEMPACK
- 3) DIRAS

1) The Customized RunGEM is an environment for running CGE models built with GEMPACK software. In our case, we make use of Customized RunGEM to run the BMCH model. Please, download Customized RunGEM from <https://www.copsmodels.com/crungem.htm>. The install procedure tells you how much free hard disk space you will need. You might have to clean up your hard drive before proceeding. It is best to install into a folder named C:\CRUNGEM. Avoid directory names that contain spaces, commas or Asian characters or are more than 8 letters long. Customized RunGEM assumes that the user has his own copy of the program on his own hard drive. The program cannot be installed on a network drive and used by several people at once.

2) In Addition, you must install the GEMPACK software, which provide a temporary license allowing the operation of RunGEM. Find the link for downloading GEMAPCK at <https://www.copsmodels.com/gpeidl.htm>. Download the file *gpei-12.1.004-install.exe* (If you are not allowed to download EXE files then download the ZIP file instead). Start the installation. When Installation process asks you for a GEMPACK license, just click next and automatically the installer will generate a temporary license. One last dialog box asks you for selecting addition tasks, uncheck all boxes and click next, and wait the installation to be completed. If you require a more detailed install instructions of GEMPACK, download the gpinstall.pdf file at <https://www.copsmodels.com/gpeidl.htm>.

Once installed Customized RunGEM and GEMPACK, please follow the 2 next steps: 1) Unzip the files contained in BMCH.part1 and BMCH.part2 (available in supplementary material in <https://github.com/JALeonTorres/RAPELE->) in a single folder named BMCH. 2). Copy the BMCH folder into the folder where Customised RunGEM was installed ("C:\CRUNGEM").

3) DIRAS's installer is available in supplementary material and the install procedure tells you how much free hard disk space you will need. DIRAS (Apache License Version 2.0) allows to reproduce all the results presented in the paper. For a successful installation, please, follow the sequence of instructions given by the DIRAS's installer. When installation wizard asks you for selecting the installation folder, it is suggested: "C:\DIRAS2020\". Avoid to install DIRAS in the following paths: "C:\Program Files\" or "C:\Program Files (x86)\".

DIRAS is a piece of software builds over the Visual.net environment to compute the economic consequence of the natural disaster occurrences. The program is able to compute the economic losses in each sector/region of an economy and also the standard risk metrics used in the risk analysis field, the average annual loss (AAL) and the loss exceedance curve (LEC), regarding to different components of the economy. Before running DIRAS, be sure Customized RunGEM and

BMCH model have been successfully installed and loaded. DIRAS is able to interact with Customized RunGEM software allowing part of its control from DIRAS's interface.

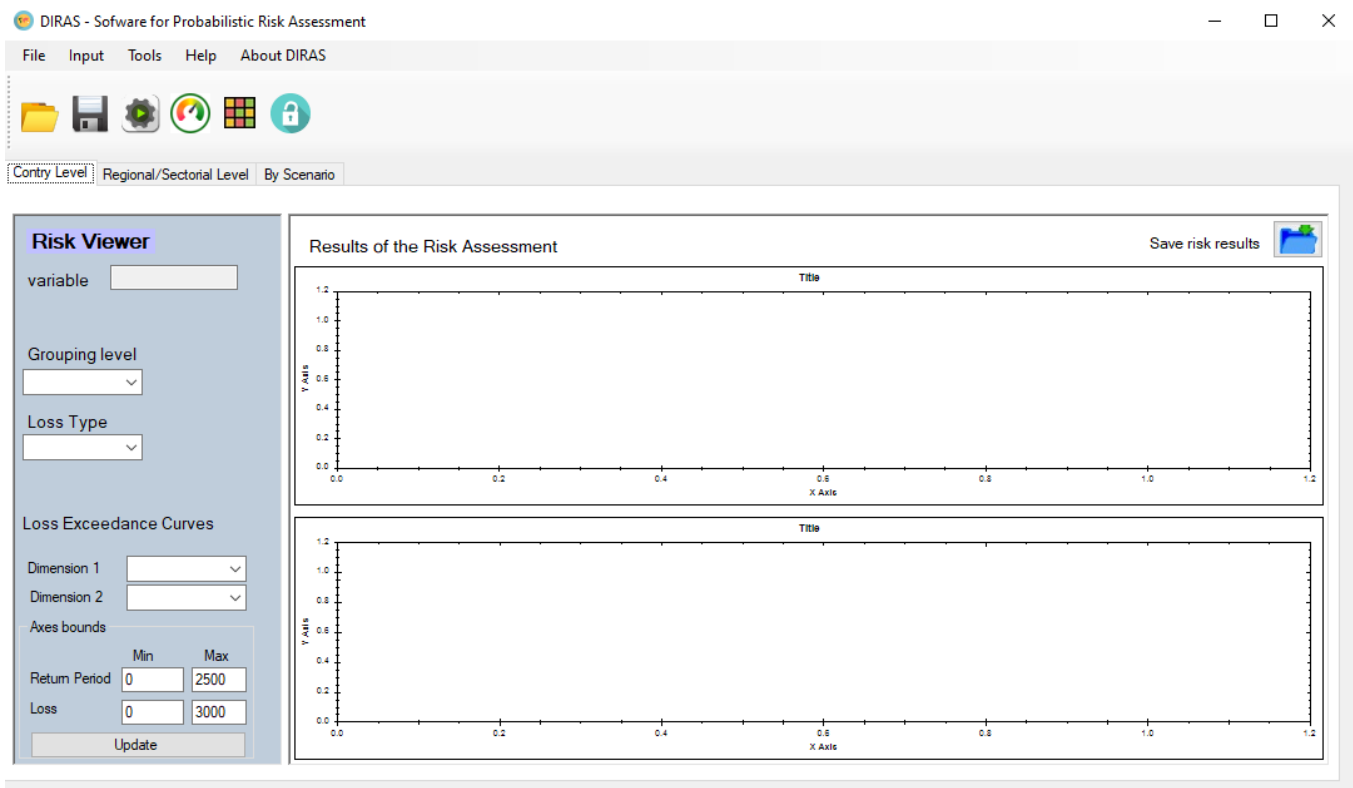


Figure 1: DIRAS's interface

Reproduction of Results

To reproduce the results presented in this study, please follow the bellow steps.

- 1) Download the files contained in the folder *DIRAS-files* available in <https://github.com/JALeonTorres/RAPELE->
- 1) Open DIRAS and create a new project: Input - (e.g., project name: ChileModel). Avoid using “_”, “_” or “.” in the project name.

Figure 2: Project data window

- 2) Go to Input – Load Data. Using the respective button, load the next files:
 - a. SectorsRegions.dat - option Sectors and Regions File.

- b. CAPRA_DirectLossesbyscenarioInd.res - option Losses_CAPRA_file (.res)
- c. InitialConditionsJanuary2022.dat - option Initial economic conditions file
- d. BMCH.exe - option GEMPACK.exe file
- e. ShortRunClosureGEMPACK.cmf - option GEMPACK run settings (.cmf file)

For selecting BMCH.exe file, go to the path where BMCH.exe is located (e.g. C:\CRUNGEM\BMCH\BMCH.exe).

- 3) Click OK to close and save the input data.

Figure 3: Load Data window



- 4) Click the button  “Run Computation” and after click RUN. Depending of the computational power of your computer, for the case of Chile, the total simulations and computations will likely take you between 2 and 5 days.

Figure 4: Compute Indirect Losses window

- 5) Once all simulations and calculations are done, click  “Risk Analysis”.
- 6) In the window “Risk Analysis”, select the economic variable of which you want to carry out the risk analysis using the option “Economic variable” and after click the button “Compute”.

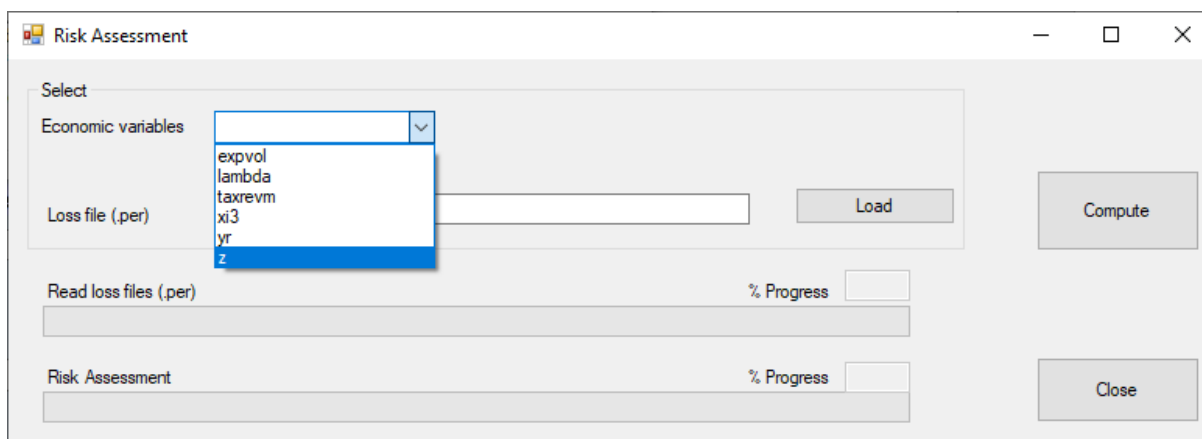


Figure 5: Risk Assessment window

Variable “z” presents results regarding to production losses.
 Variable “expvol” presents results regarding to export volume losses.
 Variable “lambda” presents results regarding to employment losses.
 Variable “taxrevm” presents results regarding to tariff revue losses
 Variable “xi3” presents results regarding to CPI change
 Variable “yr” presents results regarding to GDP and GRP losses

- 7) Once risk computations are done, results are plotted in the main window of the program. You have some interactive options to watch the results with different aggregation levels. Results are given in terms of the average annual loss (AAL) and the loss exceedance curves (LEC).

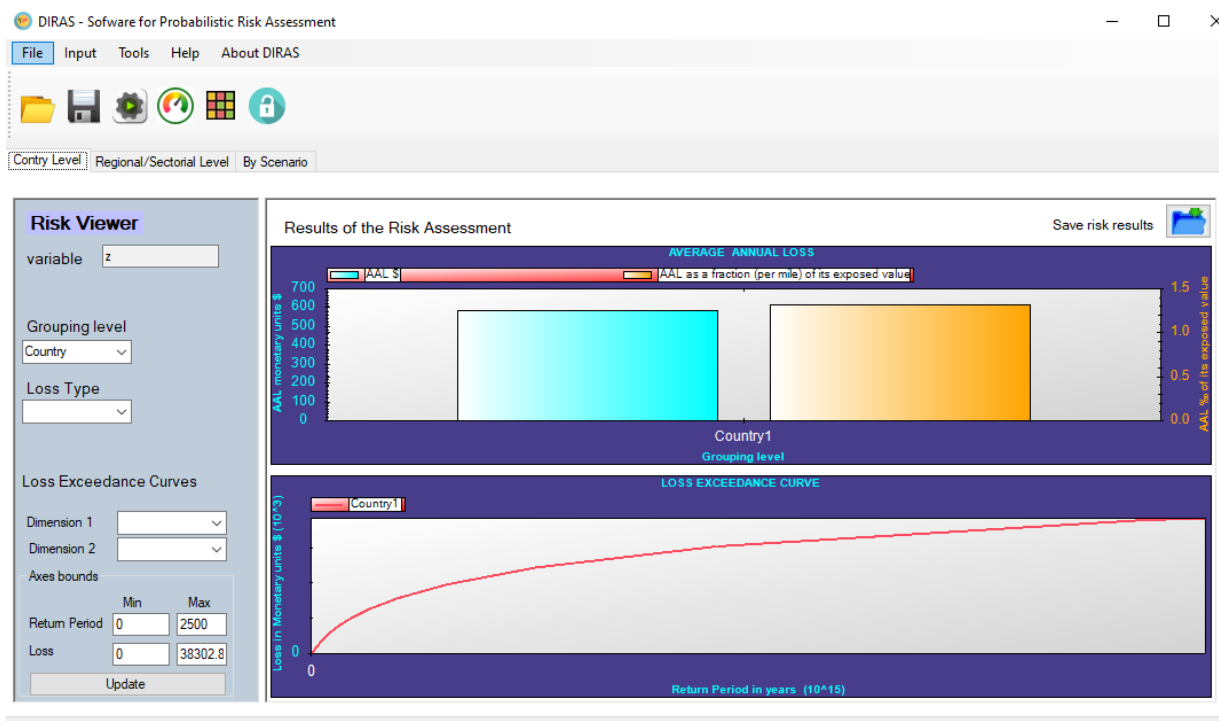



Figure 6: Risk results window

- 8) To export risk results to .dat file, click the button  “save risk results”. A new .dat file will be generated in the same location of the project with the name of the economic variable for which we carried out the risk analysis.
- 9) To develop a risk analysis for a different economic variable, go to step 5.

Reproduction of Results for Individual Simulated Earthquakes

To reproduce the results for the simulated individual events: Simulation 1960 Earthquake Mw9.5, Simulation 1985 Earthquake Mw8.0 Mw8.8 and Simulation 2010 Earthquake Mw8.8, repeat all the steps mentioned before with the following differences. At step 1: create a new project with a different name (e.g., project name: Chile_Mw8_8) and at the step 2, literal b, replace CAPRA_DirectLossesbyscenario.res by CAPRA_losses_M9_5_Valdivia1960.res or CAPRA_losses_M8_valparaiso1985.res or CAPRA_losses_M9_5_Valdivia1960.res according to the event to be analyzed.

Reproduction of Results for Long Run Simulations

To reproduce the results for long run simulations, please follow the bellow steps.

- 2) Open DIRAS and create a new project: Input - (e.g., project name: ChileModelLongRun). Avoid using “_”, “_” or “.” in the project name.
- 3) Go to Input – Load Data. Using the respective button, load the next files:

a. SectorsRegions.dat	- option Sectors and Regions File.
b. CAPRA_DirectLossesbyscenarioInd.res	- option Losses_CAPRA_file (.res)
c. InitialConditionsJanuary2022.dat	- option Initial economic conditions file
d. BMCH.exe	- option GEMPACK.exe file

For selecting BMCH.exe file, go to the path where BMCH.exe is located (e.g. C:\CRUNGEM\BMCH\BMCH.exe).

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|---|---|
| e. LongRunClosureGEMPACK.cmf | - option GEMPACK run settings (.cmf file) |
| f. In the CGE closure type box, select “Lon-run closure. | |
| g. Load the file “Matrix_BETA_R.dat” in the option “Rate of return on capital Matrix” | |
- 4) Click OK to close and save the input data.

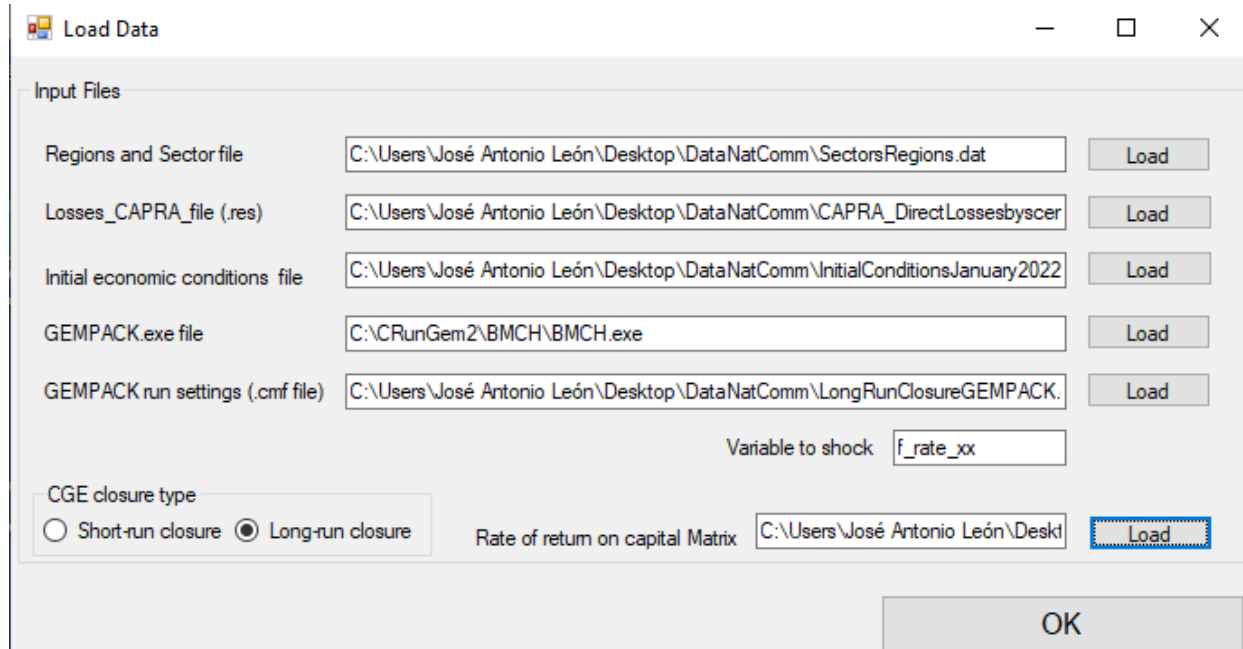





Figure 7: Load Data, long run simulations

- 5) Click the button  “Run Computation” and after click RUN. Depending of the computational power of your computer, for the case of Chile, the total simulations and computations will likely take you between 2 and 5 days.
- 6) Once all simulations and calculations are done, click  “Risk Analysis”.
- 7) In the window “Risk Analysis”, select the economic variable of which you want to carry out the risk analysis using the option “Economic variable” and after click the button “Compute”.
- 8) Once risk computations are done, results are plotted in the main window of the program. You have some interactive options to watch the results with different aggregation levels. Results are given in terms of the average annual loss (AAL) and the loss exceedance curves (LEC).
- 9) To export risk results to .dat file, click the button  “save risk results”. A new .dat file will be generated in the same location of the project with the name of the economic variable for which we carried out the risk analysis. To develop a risk analysis for a different economic variable, go to step 5.

Brief description of input files

SectorsRegions.dat: This file matches the names of sectors and regions in the CGE model (BMCH) with the corresponding name of the physical loss model (DirectLossesbyscenario.res file).

CAPRA_DirectLossesbyscenario.res: This file contains the collection of the physical losses suffered by the assets that made up the database of the place under study (Non-residential buildings of Chile in our case) after the occurrence of a great number of events that collectively describe the seismic hazard of Chile. Each event is associated to a certain frequency of occurrence that is included in the DirectLossesbyscenario.res file. Given that losses are considered as random variables, the direct loss suffered by an asset is given in terms of the expected value of the loss and its standard deviation. Although this study is not focused on showing how direct losses are computed, a very brief description of the process is presented at the end of this document.

CAPRA_losses_M9_5_Valdivia1960.res: This file contains the collection of the physical losses suffered by the assets that made up the database of the place under study (Non-residential buildings of Chile in our case) after the occurrence of a simulated Mw9.5 earthquake with similar characteristics of the 1960 Valdivia Earthquake. Given that losses are considered as random variables, the direct loss suffered by an asset is given in terms of the expected value of the loss and its standard deviation.

CAPRA_losses_M8_Valparaiso1985.res: This file contains the collection of the physical losses suffered by the assets that made up the database of the place under study (Non-residential buildings of Chile in our case) after the occurrence of a simulated Mw8.0 earthquake with similar characteristics of the 1985 Valparaiso Earthquake. Given that losses are considered as random variables, the direct loss suffered by an asset is given in terms of the expected value of the loss and its standard deviation.

CAPRA_losses_M8_8_BioBio2010.res: This file contains the collection of the physical losses suffered by the assets that made up the database of the place under study (Non-residential buildings of Chile in our case) after the occurrence of a simulated Mw8.8 earthquake with similar characteristics of the 2010 Maule Earthquake. Given that losses are considered as random variables, the direct loss suffered by an asset is given in terms of the expected value of the loss and its standard deviation.

InitialConditionsJanuary2022.dat: This file contained the initial level of all economic variables for which we want to develop the risk analysis. These values are commonly taken from the CGE model. Depending of the economic variable, it can have one, two, etc. dimensions. The dimensions refer to the grouping level of the variable, for instance, a one-dimensional variable can group values at sectorial or at regional level, while a two-dimensional variable groups the values at sectorial/regional level.

BMCH.exe: This is the executable file of the Chilean CGE model.

ShortRunClosureGEMPACK.cmf: This file sets up the short-run closure of the BMCH model and some configurations required by GEMPACK. Detailed information of .cfm files can be found at <https://www.copsmodels.com/gpmanual>.

LongRunClosureGEMPACK.cmf: This file sets up the long-run closure of the BMCH model and some configurations required by GEMPACK. Detailed information of .cfm files can be found at <https://www.copsmodels.com/gpmanual>.

Extra-information. Physical Damage – direct loss of assets (*DirectLossesbyscenario.res* file)

The physical losses of non-residential buildings of Chile were computed by using a modified version of CAPRA-GIS software <https://ecapra.org/es/topics/capra-gis>. To reproduce the results, once installed, open CAPRA-GIS, create a new project (you choose the name) and upload the following files: SeismicHazardChile.ame, Exposure-Chile.shp, and VF_Chile_CAPRA.fvu available in the folder “*DirectLossesFiles.zip*”. Run the program and once computation has been completed, you obtained the risk results files (.res) which will be located in the project folder. The file whose name ends with “Total.res” contain the risk results related to physical losses of non-residential buildings in terms of the annual average loss (AAL) and the loss exceedance curve (LEC). The file whose name ends with “Ind.res” contains the results of the individual losses of each asset, in our case, each non-residential building that made up the exposure data base of Chilean’s buildings. Each loss is given in terms of the expected value of the loss and its standard deviation, and it is associated to same frequency of occurrence of the event which gave rise it. A detailed guidelines about CAPRA-GIS is available at:

<https://ecapra.org/sites/default/files/user-manual/User%20Manual%20CAPRA-GIS%20-%20%28eng%29.pdf>.

The computation of “Ind.res” files require to load and extra file to CAPRA-GIS, the file “GroupingFileCAPRA.dat” available in the folder “*DirectLossesFiles.zip*” which is only compatible with the modified version of CAPRA-GIS (available subject to request).