TECHNICAL NOTES AND MANUALS

DIGNAR-19 Toolkit Manual

Zamid Aligishiev, Giovanni Melina, and Luis-Felipe Zanna

Research Department and Institute for Capacity Development

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Prepared by Zamid Aligishiev, Giovanni Melina, and Luis-Felipe Zanna

Authorized for distribution by Antonio Spilimbergo and Paul Cashin

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Authors' E-Mail Addresses:	zaligishiev@IMF.org gmelina@IMF.org fzanna@IMF.org

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Prepared by Zamid Aligishiev, Giovanni Melina, and Luis-Felipe Zanna

This note is a user's manual for the DIGNAR-19 toolkit, an application aimed at facilitating the use of the DIGNAR-19 model by economists with no to little knowledge of Matlab and Dynare via a user-friendly Excel-based interface. DIGNAR-19 is a Dynamic General Equilibrium (DGE) model of a real small open economy developed at the International Monetary Fund to strengthen quantitative macroeconomic assessments and policy scenario analysis in Low-Income Developing Countries (LIDCs) and Emerging Markets (EMs) during the COVID-19 pandemic. It allows incorporating shocks associated with the pandemic and producing macroeconomic scenarios (with an emphasis on GDP growth and government debt), conditional on domestic and supranational policy responses, while benefiting from an internally consistent framework delivered by the general equilibrium approach.

The toolkit comprises three tools—the simulation tool, the graphing tool, and the realism tool—that translate the contents of an Excel input file into instructions for Matlab/Dynare programs. These programs are executed behind the scenes. Outputs are saved in a separate Excel file and can also be visualized in customizable charts.

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I. DIGNAR-19 TOOLKIT

This user guide provides an overview of the DIGNAR-19[1] toolkit – an application written to facilitate the use of the DIGNAR-19 model by economists with little to no knowledge of Matlab and Dynare (see Aligishiev and others, 2021).[2]

DIGNAR-19 is a Dynamic General Equilibrium (DGE) model of a real small open economy developed at the International Monetary Fund to help country teams with quantitative macroeconomic assessments and policy scenario analysis in Low-Income Developing Countries (LIDCs) and Emerging Markets (EMs) during the COVID-19 pandemic. It is an extension of the DIGNAR model[3] (which itself is an extension of the DIG model by Buffie and others, 2012; Zanna and others, 2019) that accommodates the effects of the COVID-19 pandemic.[4]

The toolkit helps users do policy scenario analysis. It allows incorporating shocks associated with the pandemic and producing macroeconomic projections (with an emphasis on GDP growth and government debt) conditional on domestic and supranational policy responses, while benefiting from an internally consistent framework delivered by the general equilibrium approach. Despite the advantages of the DGE framework for macroeconomic analysis, its use may be constrained by the need of knowing Matlab and Dynare programming. The DIGNAR-19 toolkit aims to relax this constraint by providing a user-friendly Excel-based interface.

The Excel-based interface consists of two files: input and output. The input file consists of five worksheets that must be populated by the user according to the exercise in mind. The toolkit translates the contents of the input file into instructions for Matlab/Dynare programs; these programs are then executed behind the scenes. Depending on the task at hand, the toolkit can present the output in a file where simulated time series are stored, in customized graphs, or both.

Figure 1 presents a graphical representation of the toolkit. It is composed of the following three tools: the simulation tool, the graphing tool, and the realism tool. The simulation tool leverages the DIGNAR-19 model to calculate the dynamic path of key macroeconomic variables conditional on information supplied by the user. Such information includes the description of the economy under scope, as well as assumptions regarding future paths of pandemic-related variables and policy instruments. The graphing tool helps compare these paths graphically. For instance, users can compare the debt-to-GDP dynamic paths under alternative policy formulations (i.e., policy scenarios). The realism tool provides a framework for consistency and realism checks. It reverse-engineers shocks required to align the model-based GDP and debt-to-GDP paths to projections obtained by alternative macro frameworks such as those generated by country teams.

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1 DIGNAR-19 is an acronym that stands for **D**ebt, **I**nvestment, **G**rowth, **NA**tural **R**esources and COVID-**19.**

2 A working paper by Aligishiev and others (2021) will provide technical details and an application of the model to fiscal consolidations.

3 See Melina, Yang and Zanna (2014, 2016).

4 Both DIGNAR and DIG models have gained a wide measure of acceptance for policy work. Over the past eight years, they have complemented the IMF and World Bank Debt Sustainability Framework (DSF) analysis, with over 65 country applications, in the context of Fund programs and surveillance work, and are now part of the IMF-WB Multipronged Approach for addressing debt vulnerabilities. These models helped inform policy analysis, based on qualitative and quantitative scenario analysis, on issues such as public investment surges, fiscal consolidations, and the collapse of commodity prices, among others. See Gurara, Melina and Zanna (2019) for an overview of DIG and DIGNAR applications.

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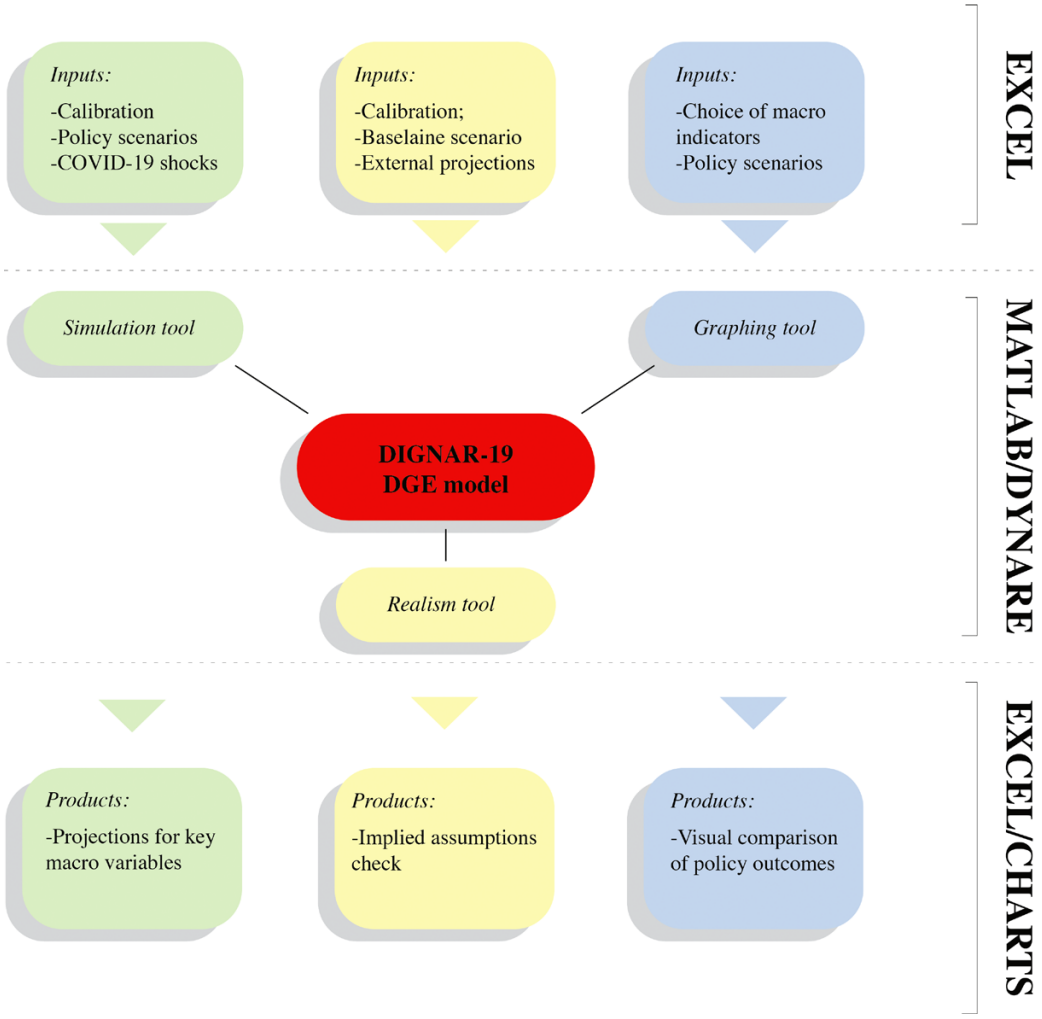
To do this, for instance, the tool computes the improvement in TFP necessary to match an optimistic projection of GDP, or it computes the improvement in the fiscal balance required to match more optimistic debt projections. To use the DIGNAR-19 toolkit, download the zip archive and extract its contents into a working folder of your choosing. Excel, Matlab, and Dynare must be installed on your computer.[5]

FIGURE 1: DIGNAR-19 toolkit



The manual proceeds as follows. Section 2 describes the Excel interface in detail, focusing on the structure of the input and output files. Section 3, 4, and 5 provide an overview of the simulation, graphing, and realism tools, respectively; these sections are accompanied by examples that go through selected toolkit applications.

[5] The toolkit was designed to operate on Matlab version 2019b and Dynare version 4.5.6. Dynare is freely available from www.dynare.org

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II. THE EXCEL INTERFACE

A. Overview

The toolkit combines an Excel-based frontend and a backend that makes use of Matlab and Dynare scripts and functions. At most, the required knowledge of Matlab is limited to opening the application, navigating to the working folder and submitting inputs using the command window. Guidance on performing these actions is provided in this manual, in the sections that describe the application of the three tools.

The Excel interface consists of two files. User inputs, such as model calibration, shock specifications, external baselines, etc., should be specified in the *'input.xlsx'* file. This *'Input.xlsx'* file contains five worksheets: *'Calibration'*, *'Exogenous series'*, *'Scenarios'*, *'Customized graphs'*, and *'External baseline'*. Each of these worksheets contains a template that can be filled by users. Detailed guidance on filling these worksheets is discussed below; its summary (containing most important rules and hints) is also noted in the respective worksheets for convenience of users.

The second Excel file stores the results of the model simulations performed by users. Each worksheet of the *'outputs.xls'* file contains the macroeconomic projections based on a single scenario. By way of example, if the user were to specify five scenarios in the 'Scenario' worksheet, the simulation tool would save projections for these scenarios in five separate worksheets, which would be named using the respective scenario number.

B. Calibration

The first bit of information that needs to be supplied by users includes the calibration of major macroeconomic indicators and structural parameters. Some examples include, among others, the GDP growth rate, fiscal ratios to GDP, depreciation rates, and share of non-savers in the total population. The *'Calibration'* worksheet contains the information necessary to tune the DIGNAR-19 model to a specific country application. The toolkit identifies five calibration groups and four cell types.

The calibration groups (*'National accounting'*, *'Interest rates'*, *'Structural parameters'*, *'Natural resource sector'*, and *'Fiscal policy'*) assist users in navigating the worksheet more effectively by classifying information according to some economic criteria.

The cell types (green, red, blue, and hidden) assist users in populating the template by highlighting the relative importance of filling certain cells. The green cells contain highly country-specific information. Users should aim at populating all the green cells. The blue cells contain information that is often unavailable or difficult to come by for some country applications. By default, these contain LIDC averages that should provide the second best when data is scarce. Users should try to populate the blue cells if such information is available but, if it is not, they may also rely on the default values. The red cells contain information on parameters governing fiscal adjustment rules. These parameters do not affect the simulation results but may need adjustment if the toolkit fails to converge to a stable and unique solution. This is particularly important when calibrating the labor supply implications of the pandemic and using the realism tool to match the paths for GDP and debt-to-GDP ratios.[6] Users should not update the red cells unless the toolkit

[6] The relevance of the red cells is further discussed in section 5.1.

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fails to find a solution for the DGE model. Last, the hidden cells govern additional model features that are not aligned with the purpose of the DIGNAR-19 toolkit. These are left in the Excel file for the convenience of the advanced users who may wish to modify the underlying DGE model, if they have the expertise.

None of the colored cells should be left blank. Ultimately, the choice of the cells to be updated and the values to be inputted in them relies on the users' good judgment.

FIGURE 2: Excerpt from the 'Calibration' worksheet of the 'input.xlsx' file

4. Natural resource sector	4.a Share of government natural resource revenues in total government revenues (in percent)	10
5. Fiscal policy	5.a Share of labour taxes in total public revenue (in percent)	25
	5.b Share of consumption taxes in total public revenue (in percent)	25
	5.c User fees of public infrastructure (in percent of recurrent costs)	0
	5.d Elasticity of sovereign risk	1.4
	Percent of fiscal adjustment via consumption tax'	25
	Percent of fiscal adjustment via labour income tax'	25
	Percent of fiscal adjustment via government consumption'	25
	Percent of fiscal adjustment via transfers'	25
	Speed of adjustment of cosumption tax rate to target rate (to close the fiscal gap)'	0.5
	Responsiveness of consumption tax rate to public debt/GDP deviations'	0.1
	Speed of adjustment of labour income tax rate to target rate (to close the fiscal gap)'	0.5
	Responsiveness of labour income tax rate to public debt/GDP deviations'	0.1
	Speed of adjustment of government spending to target level (to close the fiscal gap)'	0.5
	Responsiveness of governemnt consumption to public debt/GDP deviations'	0.1
	Speed of adjustment of transfers to target level (to close the fiscal gap)'	0.5
	Responsiveness of transfers to public debt/GDP deviations'	0.1

C. Exogenous series

The toolkit provides users with a possibility of imposing assumptions regarding the projected paths of some pandemic-related indicators and policy instruments. The '*Exogenous series*' worksheet accommodates fourteen of those series that are divided into five categories listed below.

1. Natural resource sector:
   a. Natural resource output (YoY growth)
   b. Natural resource price (level)
2. Fiscal instruments:
   a. Public investment (% of GDP)
   b. Public investment efficiency (%)
   c. Public consumption (% of GDP)
   d. Transfers (% of GDP)
   e. Change in the consumption tax rate (percentage points)
   f. Change in the labor tax rate (percentage points)
3. Indicators related to the financing of the public sector:
   a. Grants (% of GDP)
   b. Concessional debt (% of GDP)
   c. Sovereign risk premium (% of GDP)
4. Indicators affecting balance of payments:
   a. Remittances (% of GDP)
   b. Exports (% of GDP)
5. Labor markets:
   a. Labor supply change induced by the pandemic (percentage points)

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Apart from the labor supply change, all of the above series are purely exogenous and are determined by the user's input. As can be seen in Figure 3, there are three options available per each of them, all or some of these options can be populated. Such a setup allows for an effortless combination of multiple assumptions regarding future paths of the same exogenous indicator.

FIGURE 3: Excerpt from the 'Exogenous series' worksheet of the 'input.xlsx' file

Year	Horizon	A Natural Resources					
		A.1 Natural resource output growth (YoY %)			A.2 Natural resource price (level)		
		Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
2019	0	0	0	0	64.03191707	0	0
2020	1	-1.374074519			42.76852154		
2021	2	-0.298641745			47.96734592		
2022	3	0.864526633			49.57496125		
2023	4	1.38424258			50.85151225		
2024	5	2.181526472			51.96020233		
2025	6						

In the case of the labor supply change, the toolkit inverts the DGE model to determine a sequence of labor supply shocks that would, in the absence of other disturbances, deliver the target change in the labor supply. This target is decided by users, and ideally guided by an external framework aimed at evaluating the effect of the COVID-19 pandemic on the country's labor supply. Keep in mind that the target labor supply change specified in the *'Exogenous Series'* worksheet will not coincide with the final labor supply projection delivered by the model.[7] The final labor supply projection will be a product of all assumptions specified in the *'Exogenous series'* worksheet.

The model simulations rely on the initial values of these exogenous series. These values are located on the row corresponding to horizon zero (see Figure 3). The red and green cells should not be modified; the former values are endogenized while the latter ones are brought over from the *'Calibration'* worksheet. Only the blue cells contain initial values that must be specified by users.

D. Scenarios

The toolkit allows for the design and simulation of up to thirty scenarios, by selecting the appropriate options in the *'Scenario'* worksheet. Users can pick which scenarios are to be simulated by updating the *'Simulate scenario'* row. All selected scenarios are simulated and saved in a single run of the toolkit. The cells corresponding to the *'Simulation horizon'* and *'Starting year'* determine the initial and final year of the proposed simulation.

In the toolkit, scenarios can be customized through seventeen options. Fourteen of them are related to the choice of the exogenous series (recall that there are fourteen exogenous series in DIGNAR-19 model). For each of the exogenous series, users can pick one of the three options provided in the *'Exogenous Series'* worksheet (see Figure 3) or choose to keep the variable constant throughout the simulation horizon. In the case of the labor supply change, the last option assumes no labor supply shocks due to the pandemic, but only an endogenous response of the labor supply to other shocks as standard in DGE models.

[7] Unless all the exogenous series apart from the labor supply change are set to remain constant.

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FIGURE 4: Excerpt from the 'Scenarios' worksheet of the 'input.xlsx' file

Options					
Starting (base) year (YY)		2019			
Simulation horizons (# of years)		6			
		Model-based baseline	Scenarios		
Scenarios		1	2	3	4
Simulate scenario	(0=No; 1=Yes)	0	1	0	0
A. Natural Resources					
A.1 Natural resource output growth	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1		
A.2 Natural resource price	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1		

Besides specifying the exogenous series, users can choose to allow for accumulation of commercial borrowing or not. If it is allowed, the composition of the accumulation of new debt during the projection horizon must be declared by specifying the share of debt denominated in foreign currency over total commercial debt. These options should be used with care. Both foreign and domestic commercial debt are determined endogenously in the model. The DGE framework will not produce explosive debt projections, and will only deliver outputs, if the supplied debt options and fiscal experiments imply a non-explosive debt path.[8]

Finally, users can choose to correct the model projections by feeding in the implied shocks produced by the realism tool. This option is available for Scenarios 2 – 30, since Scenario 1 (the model-based baseline) is used by the realism tool as a benchmark.

E. Customized graphs

The *'Customized graphs'* worksheet allows users to leverage Excel in configuring plots that are generated by the graphing tool. The setup of the template is straight forward. Users can plot up to thirty-two graphs by filling in information under the respective rows.

For each graph, users must choose the scenarios (to be plotted) under the *'Scenarios'* column; the template accommodates up to four scenario choices. These scenarios will be overlaid on a single graph to facilitate their comparison. Custom legends can be assigned to these scenarios for clarity.

FIGURE 5: Excerpt from the 'Customized graphs' worksheet of the 'input.xlsx' file (fragment 1)

Graph #	Produce graph? (0=No; 1=Yes)	Scenarios				Legend 1	Legend 2	Legend 3	Legend 4
1	1	1	2			Scenario 1: Adverse NAR	Scenario 2: Adverse NAR + Pub. Inv. Increase		
2	0								
3	0								
4	0								
5	0								
6	0								
7	0								
8	0								
9	0								

Each graph can accommodate up to 12 variables that are presented as individual subplots. Theaselection of variables is executed by inputting codes assigned to the variables of interest under the *'Variables'* column. Users are encouraged to use the codebook (available in the worksheet) to search for the desired codes.

[8] Please note that, in the DGE framework debt is non-explosive if it returns to its steady-state value (long-run trend). It should not be confused with debt sustainability definitions adopted at the IMF for operational work.

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Finally, users can specify the dimensions of the graph by selecting the desired number of rows and columns. By way of example, six subplots can be fitted in a three-by-two or a six-by-one graph, and so on.

FIGURE 6: Excerpt from the 'Customized graphs' worksheet of the 'input.xlsx' file (fragment 2)

Graph #	Produce graph? (0=No; 1=Yes)	Variables												# of rows	# of columns
1	1	9	13	25	26									2	2
2	0														
3	0														
4	0														
5	0														
6	0														
7	0														
8	0														
9	0														

F. External baseline

The 'External baseline' worksheet contains the user-provided baseline of the debt-to-GDP and GDP growth. These are used by the realism tool to perform a realism check of the projections produced by alternative macro frameworks. Base year values (marked green in Figure 7) are brought over from the *'Calibration'* worksheet. This makes sure that all the baseline scenarios, both model-based and user-provided, are initialized at the same values. Other values must be provided by users. Note that the horizon of the user-provided baseline should coincide with the horizon of the model simulation defined in the *'Scenarios'* worksheet.

FIGURE 7: Excerpt from the 'External baseline' worksheet of the 'input.xlsx' file

Year	Horizon	Total public debt (in percent of GDP)	GDP growth (YoY %)
2019	0	25.201	3.7
2020	1	26	-0.5
2021	2	26.5	5.5
2022	3	27	4.5
2023	4	27.5	4.6
2024	5	27	4.7
2025	6	0	0
2026	7	0	0

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G. Output.xls

The simulation tool produces macroeconomic projections based on the user inputs described above. These projections are automatically saved in the *'output.xls'* file for users' convenience. As the output of each simulated scenario is stored in a separate worksheet, the worksheet names correspond to the scenario numbers (see Figure 8). By default, the toolkit stores the projections of the following twenty-five macro indicators:

- Total GDP growth (YoY %)
- Resource output growth (YoY %)
- Resource price (level)
- Resource revenue (% of tot. rev.)
- Public investment to GDP (Δ from by, pp)
- Public investment efficiency (%)
- Public consumption to GDP (Δ from by, pp)
- Transfers to GDP (Δ from by, pp)
- Consumption tax rate (Δ from by, pp)
- Labor income tax rate (Δ from by, pp)
- Grants to GDP (Δ from by, pp)
- Total public debt to GDP (Δ from by, pp)
- Domestic debt to GDP (Δ from by, pp)
- Foreign debt to GDP (Δ from by, pp)
- Concessional debt to GDP (Δ from by, pp)
- Net real interest rate (Δ from by, pp)
- Sovereign risk premium (%)
- Real exchange rate (%Δ from by)
- Remittances to GDP (Δ from by, pp)
- Exports to GDP (Δ from by, pp)
- Current account deficit to GDP (Δ from by, pp)
- Real wage (%Δ from by)
- Labor (%Δ from by)
- Private investment to GDP (Δ from by, pp)
- Private consumption to GDP (Δ from by, pp)

Advanced users can update the composition of the automatically reported and stored projections, but this requires knowledge of the Matlab interface and its syntaxis.

FIGURE 8: Excerpt from the 'output.xls' file

	A	B	C	D	E
1	Years	Total GDP growth (YoY %)	Resource output growth (YoY %)	Resource price (level)	Resource revenue (% of tot. rev.)
2	2019	3.7	0	1	10
3	2020	-2.126743738	-1.374074519	0.667925052	7.271267508
4	2021	4.940891819	-0.298641745	0.749116192	7.962364741
5	2022	4.155875772	0.864526633	0.774222661	8.223315769
6	2023	4.162995416	1.38424258	0.794158828	8.468581364
7	2024	4.281201398	2.181526472	0.811473476	8.734811935
8					
9					
10					

Scenario1 +

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III. THE SIMULATION TOOL

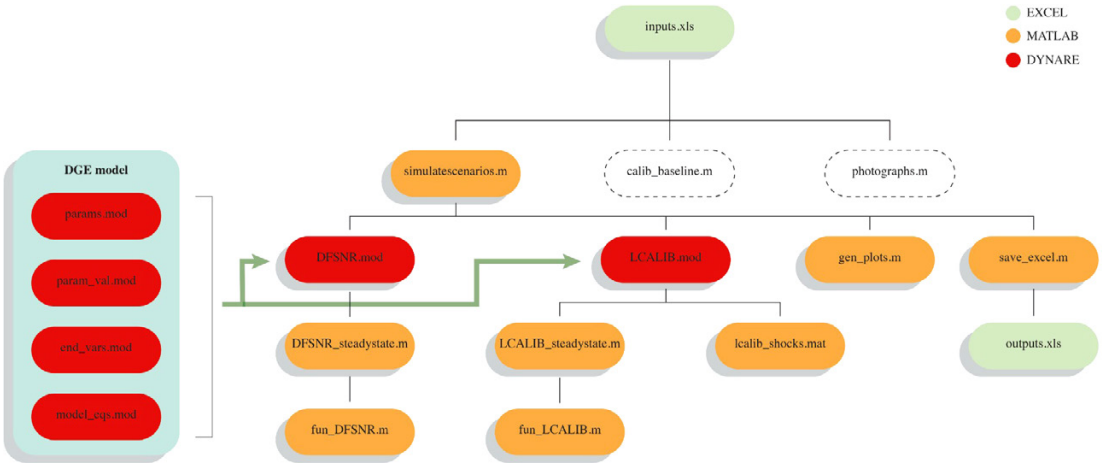
A. Overview

The simulation tool produces the dynamic paths of key macro indicators using the DIGNAR-19 model. As can be seen in Figure 9, the tool is a collection of Matlab and Dynare programs that read user inputs from the *'input.xlsx'* file, simulate the model, and store the results in the *'output.xls'* spreadsheet. The tool also presents the simulation results visually by plotting the main macro indicators on the screen for an on-the-spot inspection by users.

To generate the paths using the simulation tool, users need to populate the *'input.xlsx'* file, initiate the simulation by submitting a command in the Matlab command window, and follow on-screen instructions. Further details are available in the next section.

The tool is user-oriented, accommodating a variety of cross-checks that run behind the scenes and automatize most of the mechanic tasks users would typically perform manually. By way of example, the tool searches for potential violations, inconsistencies, or omissions in the *'input.xlsx'* before initiating simulations. If present, it guides users to the source of the problem by on-screen messaging.

FIGURE 9: File structure of the simulation tool



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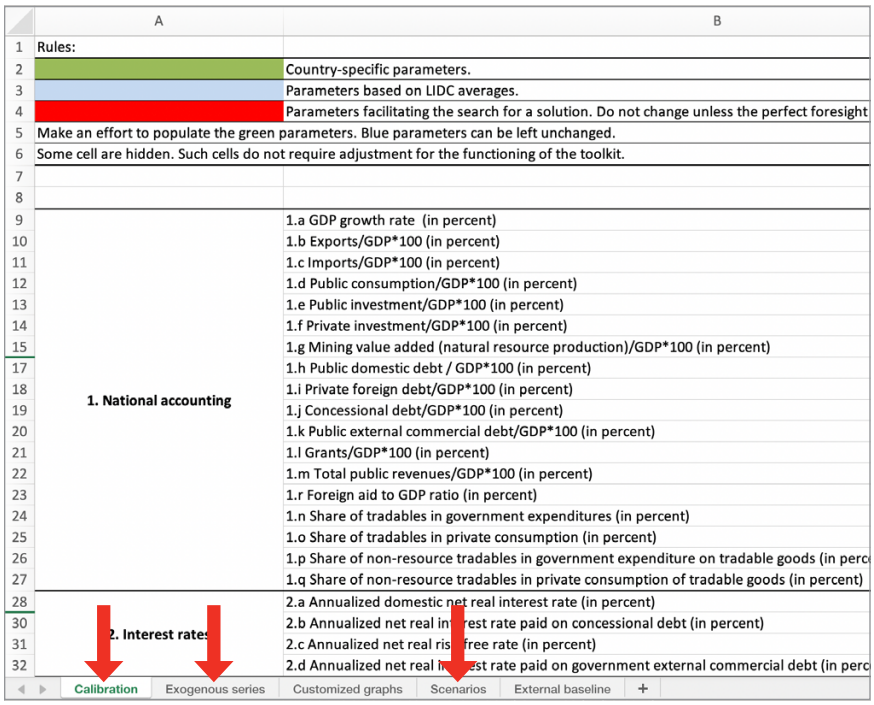
B. Running the simulation tool

There are five steps necessary to run this tool:

STEP 1: Populate the *'input.xlsx'* spreadsheet (worksheets: *'Calibration'*, *'Exogenous series'*, and *'Scenarios'*).

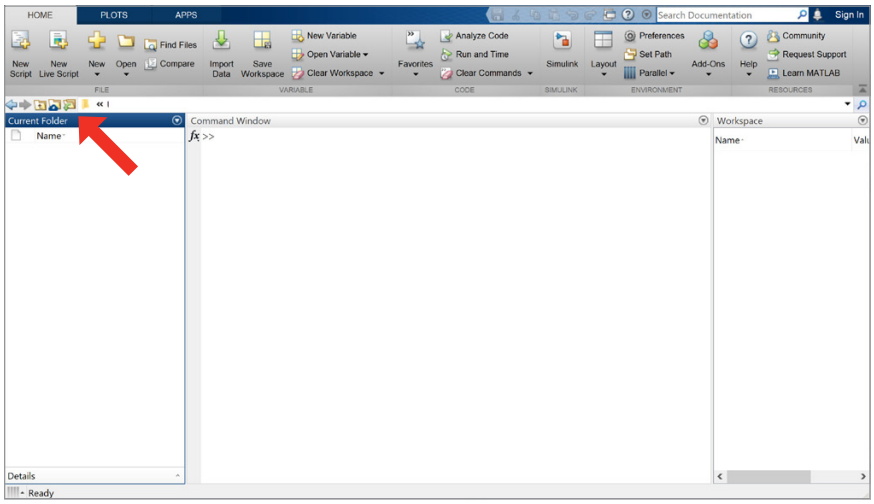
FIGURE 10: Running the simulation tool: step 1



STEP 2: Save changes to the *'input.xlsx'* spreadsheet.

STEP 3: Open Matlab on your computer and navigate to the working folder. To do so, click on the *'Browse for folder'* icon, find the folder containing toolkit files and click the *'Select Folder'* button.

FIGURE 11: Running the simulation tool: step 3



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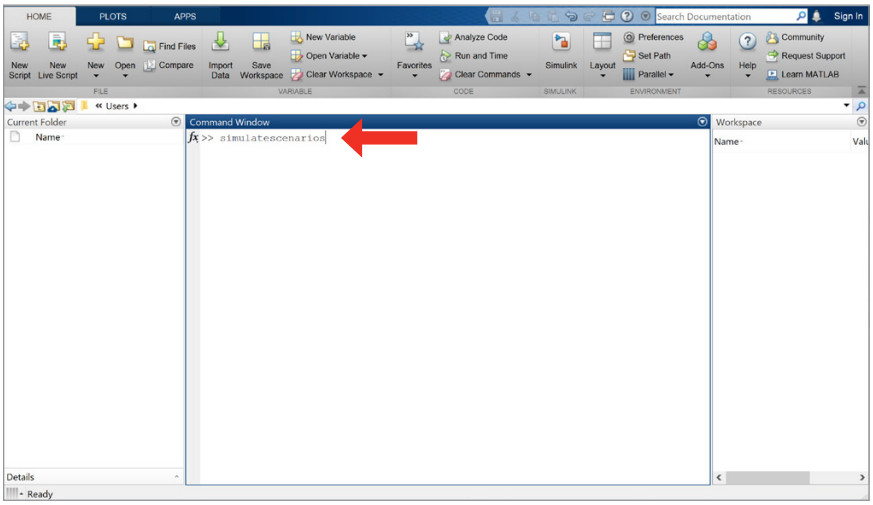
STEP 4: Run the '*simulatescenarios.m*' script. To run a Matlab script simply type its name (without the file extension) in the Matlab command window and hit enter.

FIGURE 12: Running the simulation tool: step 4



STEP 5: Follow on-screen instructions. The toolkit will ask the user to confirm that the '*input.xlsx*' file was saved after the last modification. Then it will evaluate the '*input.xlsx*' file and advise the user if it needs corrections.

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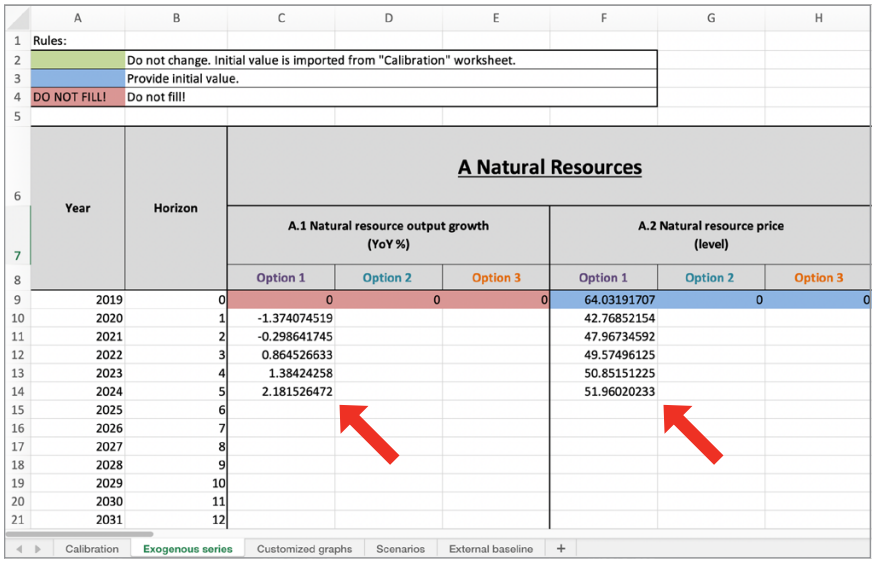
C. Example 1: Simulating a single scenario

In this example, we consider simulating a single scenario (Scenario 1). We are interested in obtaining model-based projections (dynamic paths) for 5 years ahead (starting in 2019) for a scenario characterized by:

- A negative natural resource outlook—a fall in both prices and output of oil.
- All other exogenous series remaining constant at base year levels.
- Allowing for commercial borrowing, where 50% of debt is denominated in foreign currency.

We assume the default calibration and proceed to specify the exogenous series.[9] Figure 13 presents the setup of the *'Exogenous series'* worksheet of the *'input.xlsx'* file. The paths for the output of the natural resource sector and price of oil are supplied as first options.

FIGURE 13: Example 1, a fall in the price and output of oil



Rules:	
	Do not change. Initial value is imported from "Calibration" worksheet.
	Provide initial value.
DO NOT FILL!	Do not fill!

Year	Horizon	A Natural Resources					
		A.1 Natural resource output growth (YoY %)			A.2 Natural resource price (level)		
		Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
2019	0	0	0	0	64.03191707	0	0
2020	1	-1.374074519			42.76852154		
2021	2	-0.298641745			47.96734592		
2022	3	0.864526633			49.57496125		
2023	4	1.38424258			50.85151225		
2024	5	2.181526472			51.96020233		
2025	6						
2026	7						
2027	8						
2028	9						
2029	10						
2030	11						
2031	12						

Calibration | Exogenous series | Customized graphs | Scenarios | External baseline

There is no need to explicitly specify other exogenous series. Since they are assumed to remain constant, we can account for that in the *'Scenarios'* worksheet. Figure 14 presents the setup of the *'Scenario'* worksheet. Since both variables characterizing the natural resource sector were inputted in the *'Exogenous series'* worksheet under columns denoted *'Option 1'*, the user must make sure to reflect this choice in the *'Scenarios'* worksheet (see cells B14 and B15 in Figure 14).

[9] The toolkit is accompanied by the *'Examples'* folder containing files necessary to replicate results of all six examples discussed in the manual.

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FIGURE 14: Example 1, 'Scenarios' worksheet of the 'input.xlsx' file

	A	B	C	D	E	F
4	**Options**					
5	Starting (base) year (YY)	2019				
6	Simulation horizons (# of years)	6				
7						
8		Model-based baseline	Scenarios			
9	***Scenarios***	1	2	3	4	5
10						
11	**Simulate scenario** (0=No; 1=Yes)	1	0	0	0	0
12						
13	**A. Natural Resources**					
14	A.1 Natural resource output growth (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
15	A.2 Natural resource price (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
16						
17	**B. Fiscal instruments**					
18	B.1 Public Investment (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	1			
19	B.1.1 Public investment efficiency (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
20	B.2 Public consumption (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
21	B.3 Transfers (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
22	B.4 Change in Consumption Tax rate (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
23	B.5 Change in Labour Tax rate (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
24						
25	**C. Financing options**					
26	C.1 Concessional debt (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
27	C.2 Grants (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
28	C.3 Commercial borrowing allowed? (0=No; 1=Yes)	1	1			
29	C.3.1 If yes, % external debt over tot. comm. debt accumulation (remaining is domestic)	50	50			
30	C.4 Sovereign risk premium (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
31						
32	**D. Balance of Payments**					
33	D.1 Remittances (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
34	D.2 Exports (0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
35						
36	**E. Calibrations**					
37	E.1 Calibrate the labour supply? (0=No, 1=Option 1, 2=Option 2, 3=Option 3)	0	0			
	E.2 Use shocks consistent with the external baseline (0=No; 1=Yes)					
	Warning: Use "calib_baseline.m" routine to obtain shocks before selecting this option. Scenario 1 is always used	0				
38	as a model-based baseline, i.e. is left uncalibrated.		1			

Calibration | Exogenous series | Customized graphs | Scenarios | External baseline | +

To obtain the projections (dynamic paths), we run the simulation tool as described in section 3.2. As can be seen in Figure 15, the toolkit requests the user to confirm that changes to the *'input.xlsx'* file were saved. Type *'1'* and hit enter.

FIGURE 15: Example 1, internal checks (part 1)

```
Command Window
##########################################################################################
Initializing DIGNAR-19...


Have you saved your INPUT spreadsheet, and closed your OUTPUT spreadsheet if it already exists? (1=yes; 0=no): 1
OK

Importing inputs...

You have chosen to simulate the following scenarios: 1.

Checking INPUT spreadsheet...

Scenario 1:
CHECK: Required options have been selected.
CHECK: Exogenous series have been provided.

Preprocessing completed!

##########################################################################################
##########################################################################################
Starting DIGNAR-19 simulations...


####################
fx Simulating scenario 1.
```

Next, the toolkit presents the results of the preliminary checks of the 'input.xlsx' file. As can be seen in Figure 16, there are no violations, inconsistencies, or omissions.

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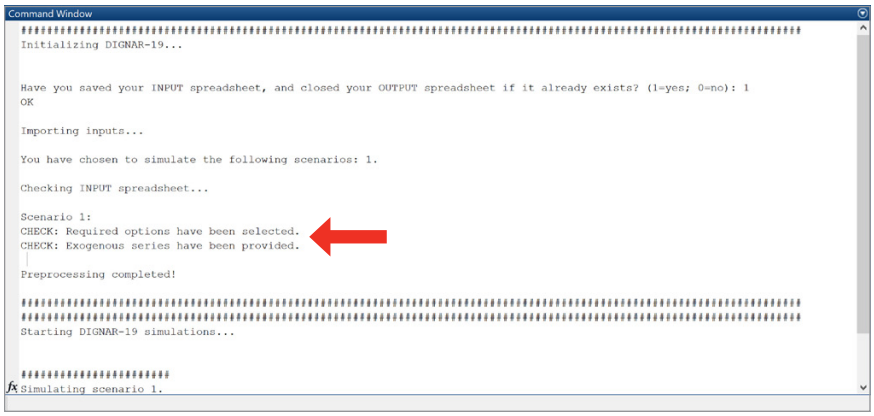
FIGURE 16: Example 1, internal checks (part 2)



After these preliminary checks, the simulation starts. It will automatically generate a graph with projections of major macro indicators and store them in the *'output.xls'* file. Figures 17 and 18 present these outputs.

FIGURE 17: Example 1, output of the simulation tool, graph containing projections of main macro indicators

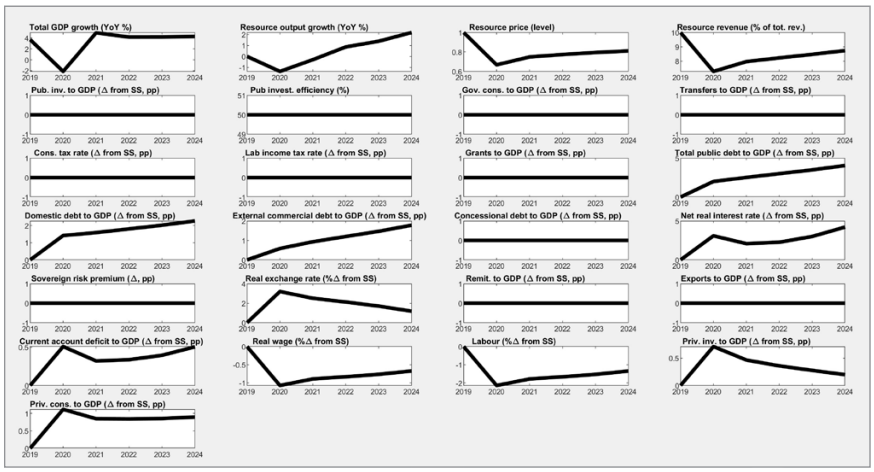


FIGURE 18: Example 1, output of the simulation tool, projections stored in the 'output.xls' file

	A	B	C	D	E	F	G	H	I	J	K	L
1	Years	Total GDP growth	Resource output	Resource price	Resource revenue	Pub. inv. to GDP	Pub invest.	Gov. cons. to GDP	Transfers to GDP	Cons. tax	Lab income	Grants
2	2019	3.7	0	1	10	0	50	0	0	0	0	0
3	2020	-2.126743738	-1.374074519	0.667925052	7.271267508	1.97811E-26	50	-7.99426E-27	1.17901E-25	0	0	0
4	2021	4.940891819	-0.298641745	0.749116192	7.962364741	2.24836E-26	50	1.93365E-25	2.01304E-24	0	0	0
5	2022	4.155875772	0.864526633	0.774222661	8.223315769	4.08136E-27	50	-2.27161E-26	8.26741E-24	0	0	0
6	2023	4.162995416	1.38424258	0.794158828	8.468581364	2.99074E-27	50	1.11194E-26	6.60746E-26	0	0	0
7	2024	4.281201398	2.181526472	0.811473476	8.734811935	1.13976E-26	50	-2.30897E-26	-6.33939E-25	0	0	0
8												
9												
10												

Scenario1 +

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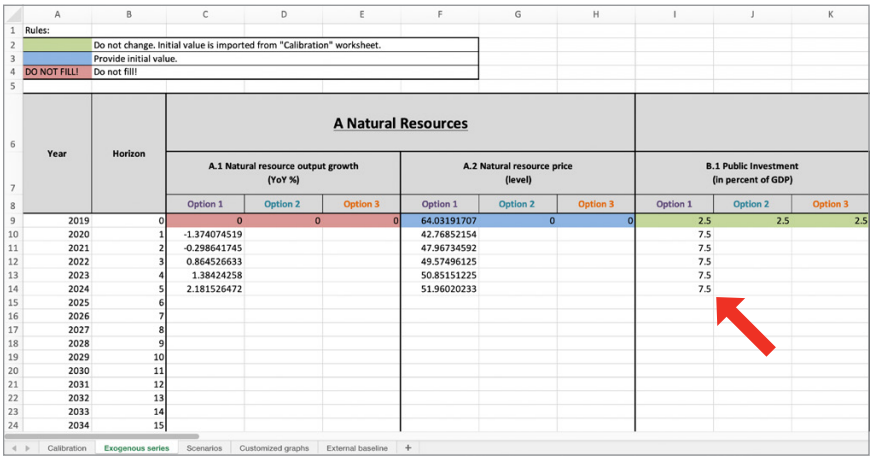
D. Example 2: Simulating multiple scenarios

Now consider a comparative scenario case: simulating two scenarios. The first one replicates the scenario considered in Example 1. The second one assumes, in addition, a 5% increase in the public investment to GDP ratio during the next five years. Figure 19 presents the new setup of the *'Exogenous series'* worksheet.

FIGURE 19: Example 2, a fall in the price and output of oil, accompanied by an increase in public investment



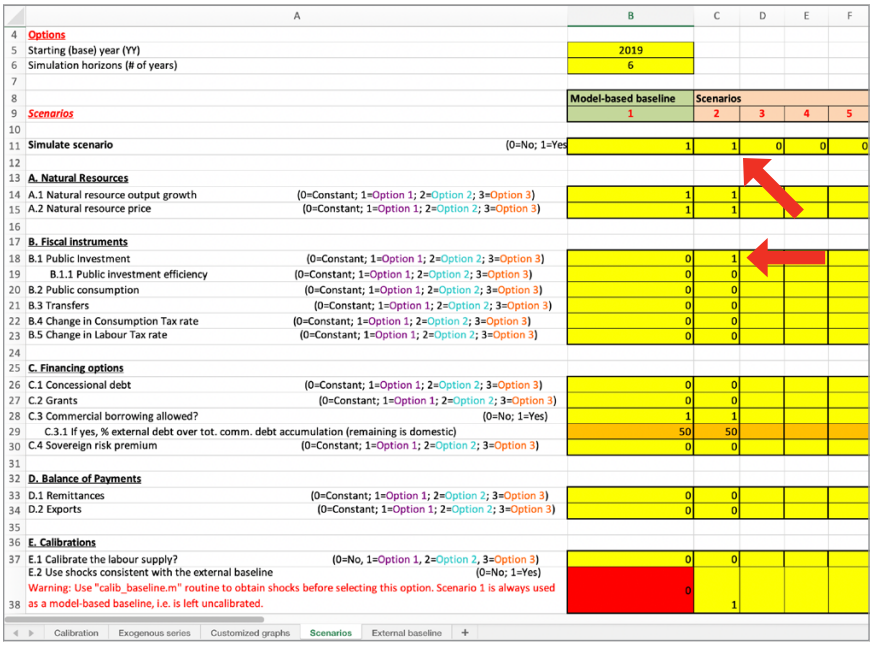
Rules:	
	Do not change. Initial value is imported from "Calibration" worksheet.
	Provide initial value.
DO NOT FILL!	Do not fill!

Year	Horizon	A Natural Resources								
		A.1 Natural resource output growth (YoY %)			A.2 Natural resource price (level)			B.1 Public Investment (in percent of GDP)		
		Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
2019	0	0	0	0	64.03191707	0	0	2.5	2.5	2.5
2020	1	-1.374074519			42.76852154			7.5		
2021	2	-0.298641745			47.96734592			7.5		
2022	3	0.864526633			49.57496125			7.5		
2023	4	1.384242258			50.85151225			7.5		
2024	5	2.181526472			51.96020233			7.5		
2025	6									
2026	7									
2027	8									
2028	9									
2029	10									
2030	11									
2031	12									
2032	13									
2033	14									
2034	15									

Calibration | Exogenous series | Scenarios | Customized graphs | External baseline | +

The *'Scenarios'* worksheet must be updated as well. We must reflect the fact that we are interested in simulating two scenarios (Scenario 1 and 2) and that the second scenario assumes that public investment series is no longer constant, in fact, it increases as per *'Option 1'* in the *'Exogenous series'* worksheet. Figure 20 presents the setup of the *'Scenarios'* worksheet.

FIGURE 20: Example 2, 'Scenarios' worksheet of the 'input.xlsx' file



		Model-based baseline	Scenarios			
Options						
Starting (base) year (YY)		2019				
Simulation horizons (# of years)		6				
Scenarios		1	2	3	4	5
Simulate scenario	(0=No; 1=Yes	1	1	0	0	0
A. Natural Resources						
A.1 Natural resource output growth	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
A.2 Natural resource price	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
B. Fiscal instruments						
B.1 Public Investment	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	1			
B.1.1 Public investment efficiency	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
B.2 Public consumption	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
B.3 Transfers	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
B.4 Change in Consumption Tax rate	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
B.5 Change in Labour Tax rate	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
C. Financing options						
C.1 Concessional debt	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
C.2 Grants	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
C.3 Commercial borrowing allowed?	(0=No; 1=Yes)	1	1			
C.3.1 If yes, % external debt over tot. comm. debt accumulation (remaining is domestic)		50	50			
C.4 Sovereign risk premium	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
D. Balance of Payments						
D.1 Remittances	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
D.2 Exports	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
E. Calibrations						
E.1 Calibrate the labour supply?	(0=No, 1=Option 1, 2=Option 2, 3=Option 3)	0	0			
E.2 Use shocks consistent with the external baseline	(0=No; 1=Yes)					
Warning: Use "calib_baseline.m" routine to obtain shocks before selecting this option. Scenario 1 is always used as a model-based baseline, i.e. is left uncalibrated.		0	1			

Calibration | Exogenous series | Customized graphs | Scenarios | External baseline | +

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The simulation tool will iterate through the two simulations and produce two graphs, one per each scenario of interest. These can be seen in Figures 21 and 22 below.

FIGURE 21: Example 2, output of the simulation tool, Scenario 1

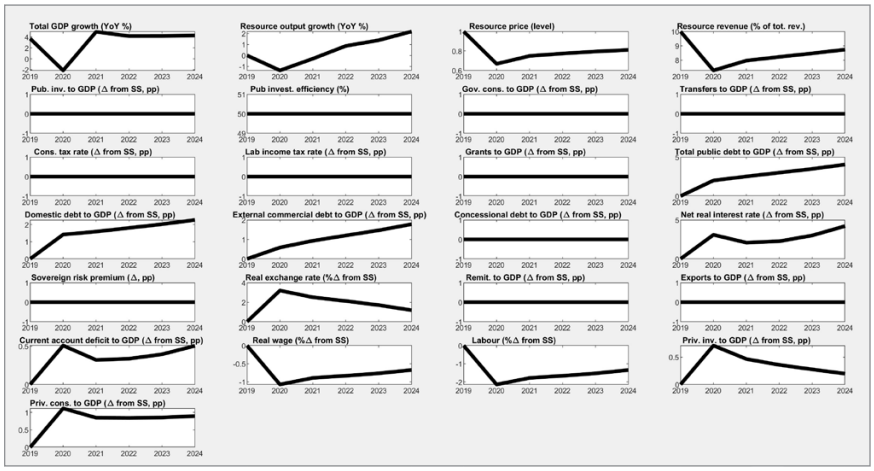
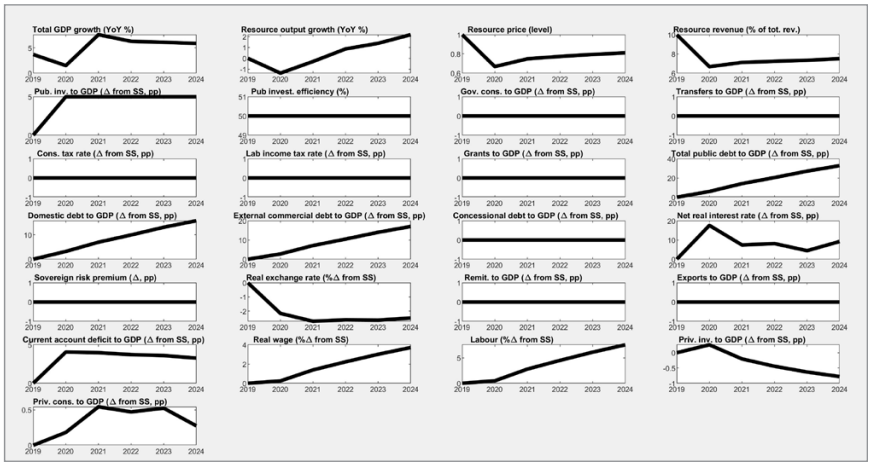


FIGURE 22: Example 2, output of the simulation tool, Scenario 2



Additionally, the DIGNAR-19 toolkit will save the results of both model simulations in separate worksheets of the output file (Figure 23). The simulation of more scenarios follows the same logic.

FIGURE 23: Example 2, output of the simulation tool, projections stored in the 'output.xls' file

	A	B	C	D	E	F	G	H	I
1	Years	Total GDP growth	Resource output	Resource price	Resource revenue	Pub. inv.	Pub invest.	Gov. cons. to GDP	Transfers to GDP
2	2019	3.7	0	1	10	0	50	0	0
3	2020	1.498002852	-1.374074519	0.667925052	6.66759804	5	50	1.25401E-27	6.46689E-26
4	2021	7.624169678	-0.298641745	0.749116192	7.113167046	5	50	6.94411E-26	-8.56734E-24
5	2022	6.309526207	0.864526633	0.774222661	7.232971672	5	50	5.75255E-28	-1.03274E-23
6	2023	6.117925176	1.38424258	0.794158828	7.338435769	5	50	-3.26291E-26	-1.30382E-23
7	2024	5.889913517	2.181526472	0.811473476	7.510317191	5	50	2.49208E-25	1.05699E-23
8									
9									
10									

Sheet1 Scenario1 Scenario2 +

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IV. THE GRAPHING TOOL

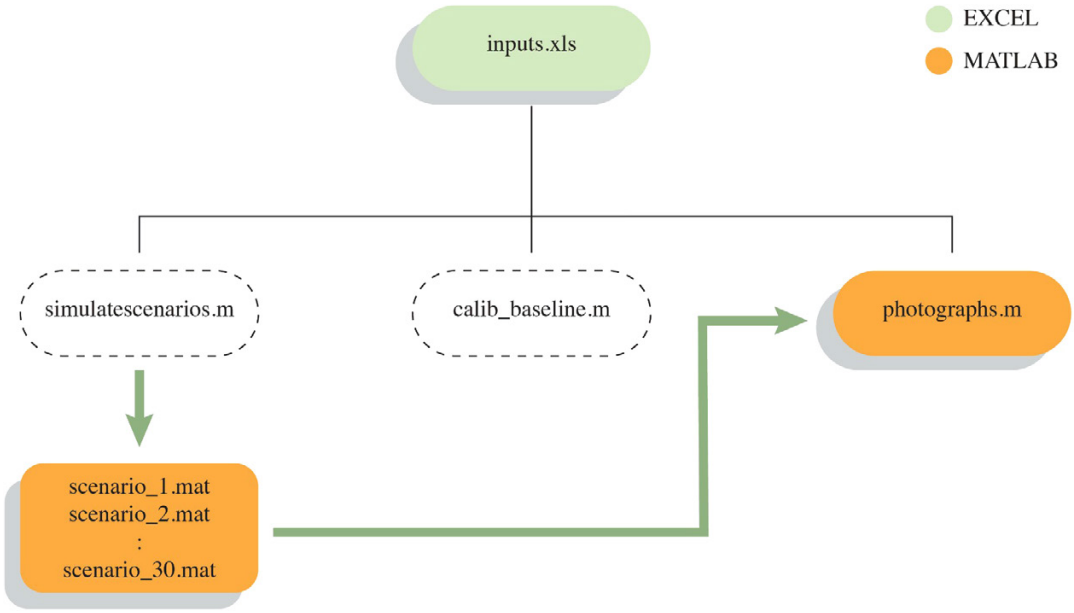
A. Overview

The graphing tool allows users to plot and compare projections of macro indicators obtained using the simulation tool. It delivers a user-friendly way to generate Matlab graphs using an Excel-based interface.[10] As can be seen in Figure 24, the graphing tool consists of a single Matlab script that takes the simulation results as an input. Therefore, all the scenarios of interest should be first simulated using the simulation tool.

The graphing tool can be used in multiple ways. It can produce figures with a customized set of subplots; users can select macro indicators to be plotted in the *'Customized graphs'* worksheet of the *'input.xlsx'* file. The tool can be also leveraged to produce scenario comparisons by presenting simultaneously projections implied by different scenarios. The tool allows to combine up to four scenarios and up to thirty-two variables in a single graph.

To generate visual comparisons using the simulation tool, users need to populate the *'input.xlsx'* file, simulate the scenarios of interest, initiate the graphing tool by submitting a command in the Matlab command window, and follow on-screen instructions. Further details are available in the next section.

FIGURE 24: File structure of the graphing tool



[10] The graphing tool is an option to visualize the simulations obtained using the DIGNAR-19 toolkit. Country teams, however, can construct their own graphs, using the simulation results that are stored in *'output.xls'*.

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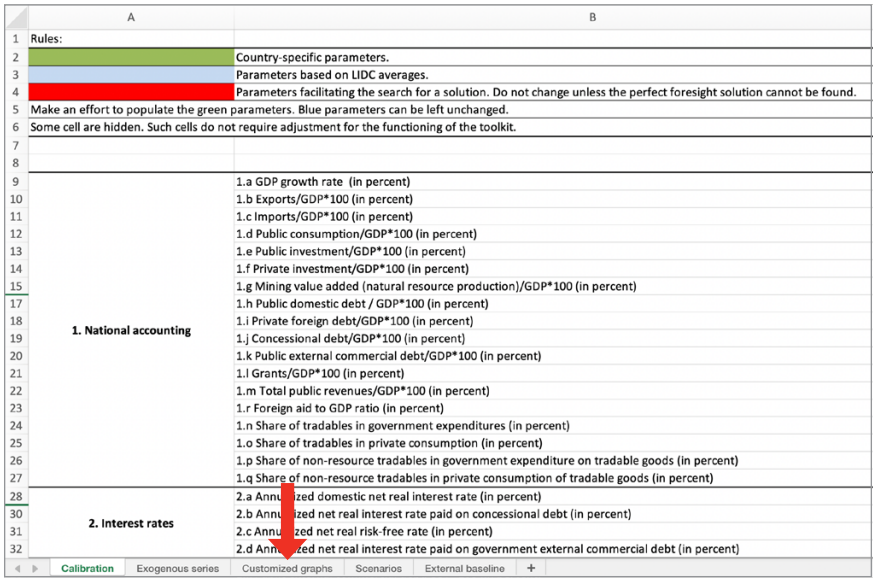
B. Running the graphing tool

There are six steps necessary to run the tool:

STEP 1: Run the simulation tool to produce the projections for those scenarios of interest. Refer to Section 3.2 for the instructions on running the simulation tool.

STEP 2: Populate the *'input.xlsx'* spreadsheet (worksheets: *'Customized graphs'*).

FIGURE 25: Running the graphing tool: step 2



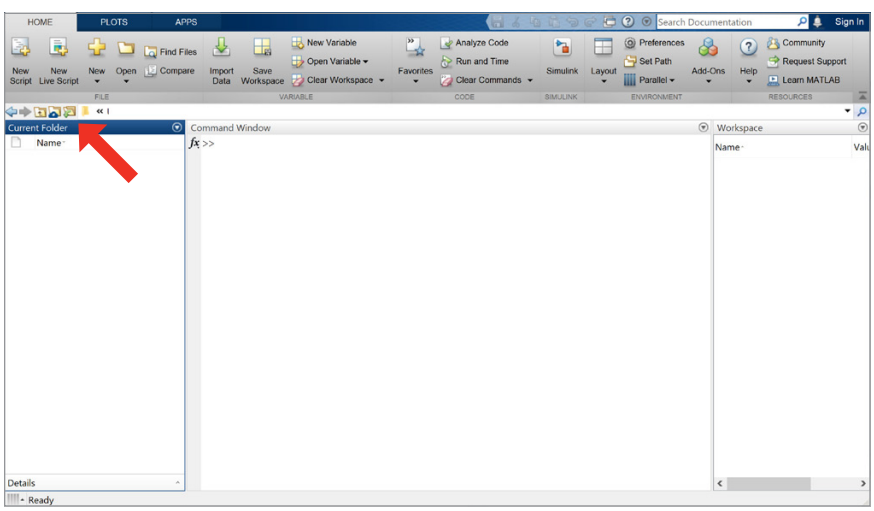
	A	B
1	Rules:	
2		Country-specific parameters.
3		Parameters based on LIDC averages.
4		Parameters facilitating the search for a solution. Do not change unless the perfect foresight solution cannot be found.
5	Make an effort to populate the green parameters. Blue parameters can be left unchanged.	
6	Some cell are hidden. Such cells do not require adjustment for the functioning of the toolkit.	
7		
8		
9	1. National accounting	1.a GDP growth rate (in percent)
10		1.b Exports/GDP*100 (in percent)
11		1.c Imports/GDP*100 (in percent)
12		1.d Public consumption/GDP*100 (in percent)
13		1.e Public investment/GDP*100 (in percent)
14		1.f Private investment/GDP*100 (in percent)
15		1.g Mining value added (natural resource production)/GDP*100 (in percent)
17		1.h Public domestic debt / GDP*100 (in percent)
18		1.i Private foreign debt/GDP*100 (in percent)
19		1.j Concessional debt/GDP*100 (in percent)
20		1.k Public external commercial debt/GDP*100 (in percent)
21		1.l Grants/GDP*100 (in percent)
22		1.m Total public revenues/GDP*100 (in percent)
23		1.r Foreign aid to GDP ratio (in percent)
24		1.n Share of tradables in government expenditures (in percent)
25		1.o Share of tradables in private consumption (in percent)
26		1.p Share of non-resource tradables in government expenditure on tradable goods (in percent)
27		1.q Share of non-resource tradables in private consumption of tradable goods (in percent)
28	2. Interest rates	2.a Annualized domestic net real interest rate (in percent)
30		2.b Annualized net real interest rate paid on concessional debt (in percent)
31		2.c Annualized net real risk-free rate (in percent)
32		2.d Annualized net real interest rate paid on government external commercial debt (in percent)

Calibration | Exogenous series | Customized graphs | Scenarios | External baseline

STEP 3: Save changes to the *'input.xlsx'* spreadsheet.

STEP 4: Open Matlab on your computer and navigate to the working folder. To do so, click on the *'Browse for folder'* icon, find the folder containing toolkit files, and click the *'Select Folder'* button.

FIGURE 26: Running the graphing tool: step 4



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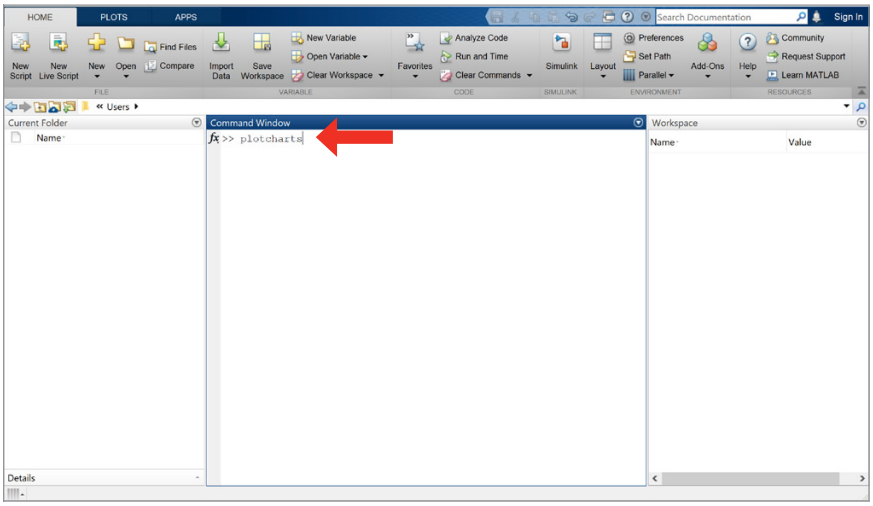
STEP 5: Run '*plotgraphs.m*' script. To run a Matlab script simply type its name (without the file extension) in the Matlab command window and hit enter.

FIGURE 27: Running the graphing tool: step 5



STEP 6: Follow on-screen instructions. The toolkit will ask the user to confirm that the '*input.xlsx*' file was saved.

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C. Example 3: Plotting select macro variables

In this example, we will consider generating a customized graph of projections produced by the simulation in Example 1. Assume that the objective is to generate a 2 by 2 graph that plots total GDP growth, total debt-to-GDP, labor supply, and real wage over time.

To produce such a graph, the *'Customized graphs'* worksheet must reflect the fact that we are interested in Scenario 1 and the variable codes 9,13, 25, 26. Codes can be found in the codebook which is available in the *'input.xlsx'* file (see Figure 28 below).

FIGURE 28: Variable codebook

2	Var #	Label	Description
3	1	'resoutlev'	Resource output (level)
4	2	'respricelev'	Resource price (level)
5	3	'taxo'	Resource revenue (% of tot. rev.)
6	4	'grants'	Grants to GDP (\Delta from SS, pp)
7	5	'd'	Concessional debt to GDP (\Delta from SS, pp)
8	6	pubinv'	Public investment to GDP (\Delta from SS, pp)
9	7	govcons'	Public consumption to GDP (\Delta from SS, pp)
10	8	'espilon'	Public investment efficiency (%)
11	9	gdp'	Total GDP growth (YoY)
12	10	'pubcap'	Public capital (%\Delta)
13	11	'dc'	External commercial debt to GDP (\Delta from SS, pp)
14	12	'b'	Domestic debt to GDP (\Delta from SS, pp)
15	13	'totdebt'	Total public debt to GDP (\Delta from SS, pp)
16	14	'sovriskprem'	Sovereign risk premium (\Delta, pp)
17	15	'tauc'	Consumption tax rate (\Delta, pp)
18	16	'taul'	Lab income tax rate (\Delta, pp)
19	17	transfers'	Transfers to GDP (\Delta from SS, pp)
20	18	'yt'	Tradable output (%\Delta)
21	19	'yn'	Nontradable output (%\Delta)
22	20	'ynon'	Non-resouce output (%\Delta)
23	21	'privcons'	Private consumption to GDP (\Delta from SS, pp)
24	22	'privinv'	Private investment to GDP (\Delta from SS, pp)
25	23	'ynongrowth'	Non-resource GDP growth (%)
26	24	'intrate'	Net real interest rate (\Delta, pp)
27	25	'labour'	Labour (%\Delta)
28	26	'wage'	Real wage (%\Delta)
29	27	'rer'	Real exchange rate (%\Delta)
30	28	totrev'	Total government revenue to GDP (\Delta from SS, pp)
31	29	'cad'	Current Account deficit to GDP (\Delta from SS, pp)
32	30	'crot'	Private cons of rule-of-thumb to GDP (\Delta from SS, pp)
33	31	'copt'	Private cons of optimisers to GDP (\Delta from SS, pp)
34	32	'remit'	Remittances to GDP (\Delta from SS, pp)
35	33	'export'	Exports to GDP (\Delta from SS, pp)

The simulation results should be obtained first using the simulation tool. Assuming that all the instructions described in Example 1 were executed beforehand, we can trigger the graphing tool. Figure 29 presents the setup of the *'Customized graphs'* worksheet that will deliver the desired graphs, while Figure 30 presents the graph itself. Note that legends are not available in the case of a single scenario—even if the user specifies a legend, it will not be added to the graph.

FIGURE 29: Example 3, 'Customized graphs' worksheet of the 'input.xlsx' file

Graph #	Produce graph? (0=No; 1=Yes)	Scenarios				Legend 1	Legend 2	Legend 3	Legend 4	Variables										# of rows	# of columns
1	1	1				Scenario 1: Adverse NAR	Scenario 2: Adverse NAR + Pub. Inv. Increase			9	13	25	26							2	2
2	0																				
3	0																				
4	0																				
5	0																				
6	0																				
7	0																				
8	0																				
9	0																				
10	0																				

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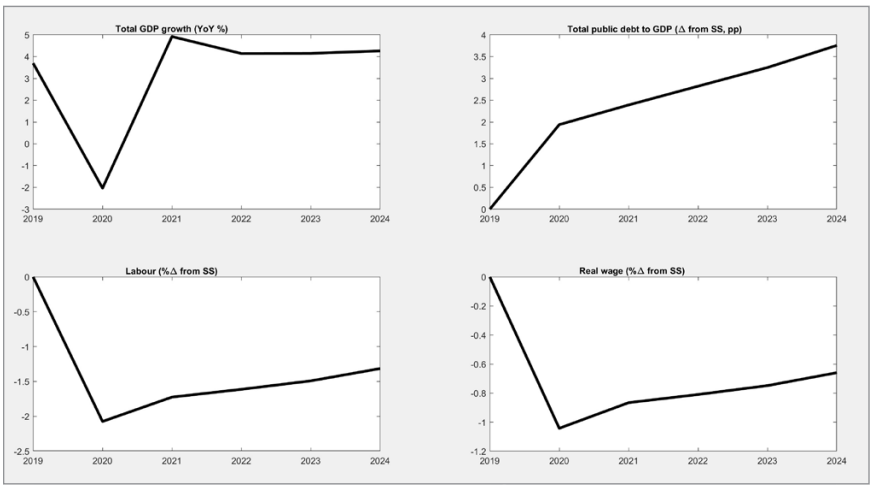
FIGURE 30: Example 3, graph produced by the graphing tool



The user can save this figure in multiple formats. To do so, use the Matlab's graphical user interface and follow these steps:

STEP 1: Click on the '*File*' button.

STEP 2: Select option '*Save as*'.

STEP 3: Type a name and choose the format for the graph.

STEP 4: Click on the '*Save*' button.

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D. Example 4: Scenario comparison

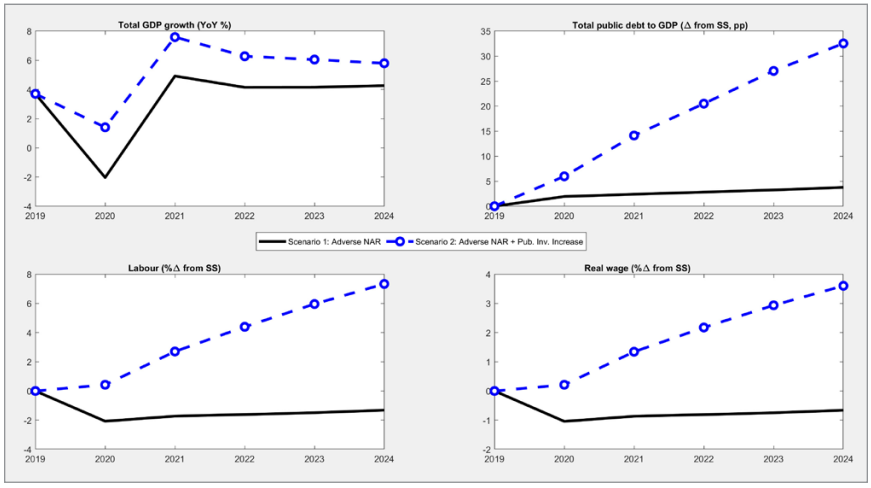
Now turn to scenario comparisons. This example generates a graph that overlays simulation results of both scenarios discussed in Example 2. To recall, Scenario 1 assumes a fall in both price of oil and output of the natural resource sector, the remaining exogenous series are set constant. Scenario 2 corresponds to Scenario 1, and additionally assumes an increase in public investment—a 5% increase in the public investment to GDP ratio for five years. Assuming the same format of the graph and the list of variables of the previous example, the *'Customized graphs'* worksheet takes the following form (see Figure 31).

FIGURE 31: Example 4, 'Customized graphs' worksheet of the 'input.xlsx' file

Graph #	Produce graph? (0=No; 1=Yes)	Scenarios				Legend 1	Legend 2	Legend 3	Legend 4	Variables										# of rows	# of columns
1	1	1	2			Scenario 1: Adverse NAR	Scenario 2: Adverse NAR + Pub. Inv. Increase			9	13	25	26							2	2
2	0																				
3	0																				
4	0																				
5	0																				
6	0																				
7	0																				
8	0																				
9	0																				
10	0																				

In addition, assuming that actions described in Example 2 were executed beforehand, we can trigger the graphing tool. Figure 32 presents the resulting graph. The black bold line corresponds to Scenario 1 and the blue dashed line corresponds to Scenario 2. We can clearly see that the public investment stimulus improves the economic outlook but also substantially increases total public debt.

FIGURE 32: Example 4, graph produced by the graphing tool



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V. THE REALISM TOOL

A. Overview

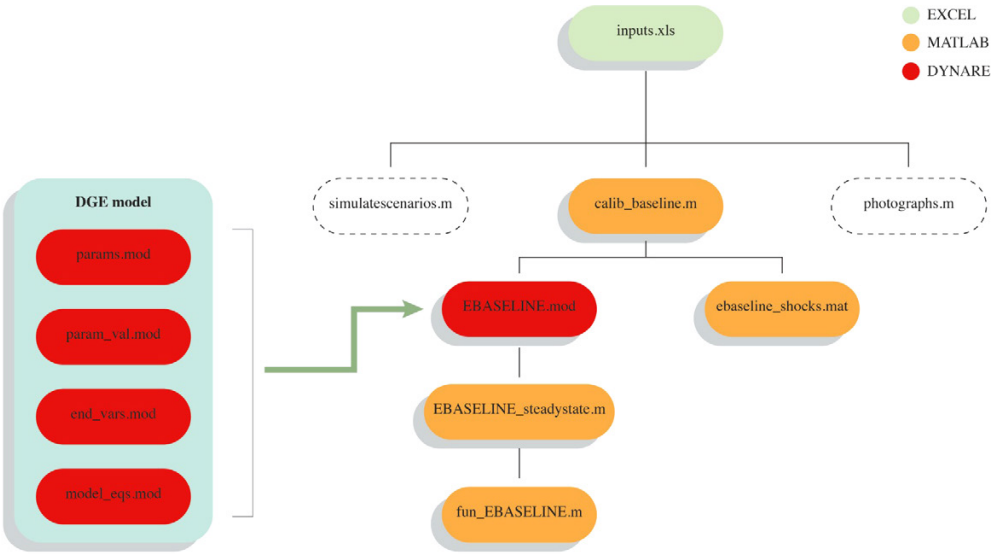
The realism tool helps cross-check the projections of GDP growth and debt from other macro frameworks (for example, those coming from the area department team's macro framework) against the model-based ones. Users can choose to align these projections. In this case, the realism tool reverse-engineers shocks to Total Factor Productivity (TFP) and the fiscal balance to achieve this alignment.

The application of the realism tool is useful for at least two reasons. On the one hand, such a comparison can uncover the implicit assumptions embedded in the macro framework that is used by country teams to produce assessments of debt sustainability and to project economic growth. Users may check their frameworks for realism (e.g. are their assumptions too optimistic by implying unrealistic shocks to TFP and the fiscal balance?) and adjust their projections if the implied assumptions are deemed unreasonable.

On the other hand, due to the nature of the DGE model, which accommodates a large yet limited number of shocks, the analysis may point to shocks or mechanisms considered by country teams that are not embedded in the model. That is, projections obtained using other macro frameworks may be conditional on realizations of shocks that are not included in the DIGNAR-19 model. In this case, the calculated shocks to TFP and the fiscal balance act as limited proxies for such omitted shocks.[11] But this still encourages the country team to understand and verify the implications of their own assumptions for their projections.

To initiate the realism tool, users need to populate the *'input.xlsx'* file, submit a command in the Matlab command window, and follow on-screen instructions. Further details are available in the next section.

FIGURE 33: File structure of the realism tool



[11] We chose these two shocks as they affect directly debt and growth helping with the aforementioned alignment of their projections.

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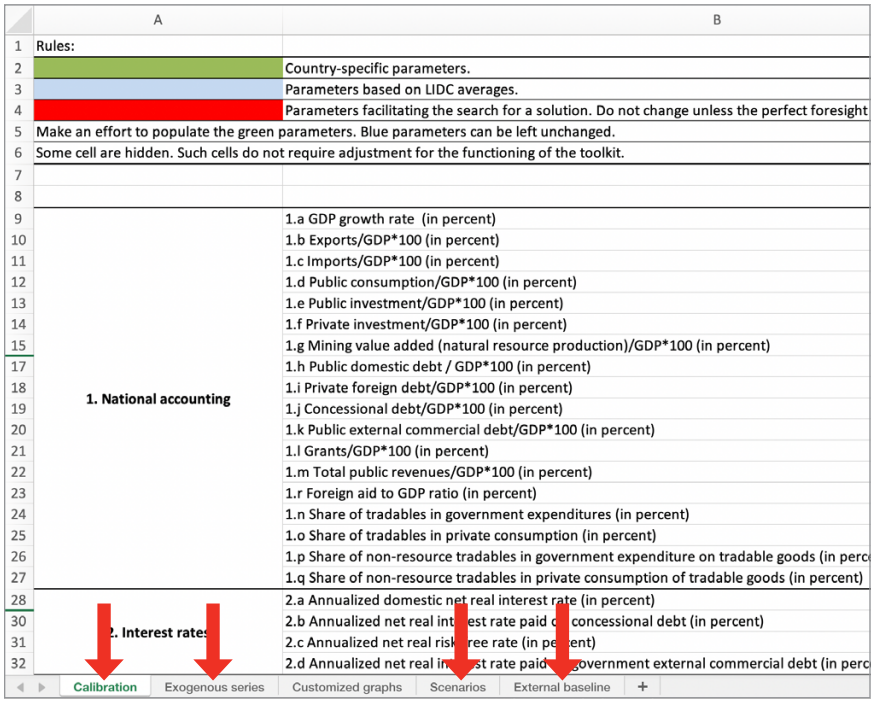
B. Running the realism tool

There are five steps necessary to run the tool:

STEP 1: Populate the *'input.xlsx'* spreadsheet (worksheets: *'Calibration'*, *'Exogenous series'*, *'Scenarios'*, *and 'External baseline'*).

FIGURE 34: Running the realism tool: step 1

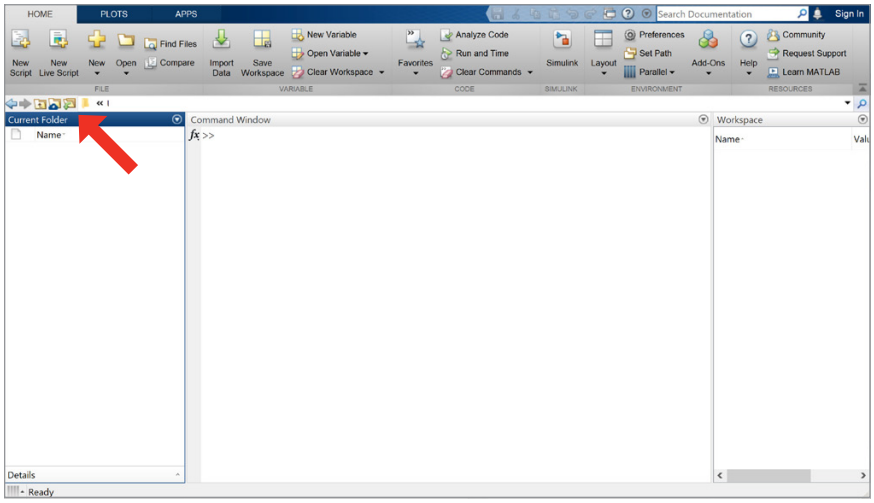


	A	B
1	Rules:	
2		Country-specific parameters.
3		Parameters based on LIDC averages.
4		Parameters facilitating the search for a solution. Do not change unless the perfect foresight
5	Make an effort to populate the green parameters. Blue parameters can be left unchanged.	
6	Some cell are hidden. Such cells do not require adjustment for the functioning of the toolkit.	
7		
8		
9	1. National accounting	1.a GDP growth rate (in percent)
10		1.b Exports/GDP*100 (in percent)
11		1.c Imports/GDP*100 (in percent)
12		1.d Public consumption/GDP*100 (in percent)
13		1.e Public investment/GDP*100 (in percent)
14		1.f Private investment/GDP*100 (in percent)
15		1.g Mining value added (natural resource production)/GDP*100 (in percent)
17		1.h Public domestic debt / GDP*100 (in percent)
18		1.i Private foreign debt/GDP*100 (in percent)
19		1.j Concessional debt/GDP*100 (in percent)
20		1.k Public external commercial debt/GDP*100 (in percent)
21		1.l Grants/GDP*100 (in percent)
22		1.m Total public revenues/GDP*100 (in percent)
23		1.r Foreign aid to GDP ratio (in percent)
24		1.n Share of tradables in government expenditures (in percent)
25		1.o Share of tradables in private consumption (in percent)
26		1.p Share of non-resource tradables in government expenditure on tradable goods (in perc
27		1.q Share of non-resource tradables in private consumption of tradable goods (in percent)
28	2. Interest rates	2.a Annualized domestic net real interest rate (in percent)
30		2.b Annualized net real interest rate paid on concessional debt (in percent)
31		2.c Annualized net real risk-free rate (in percent)
32		2.d Annualized net real interest rate paid on government external commercial debt (in perc

STEP 2: Save changes to the *'input.xlsx'* spreadsheet.

STEP 3: Open Matlab on your computer and navigate to the working folder. To do so, click on the *'Browse for folder'* icon, find the folder containing toolkit files, and click the *'Select Folder'* button.

FIGURE 35: Running the realism tool: step 3



Source: IMF staff.

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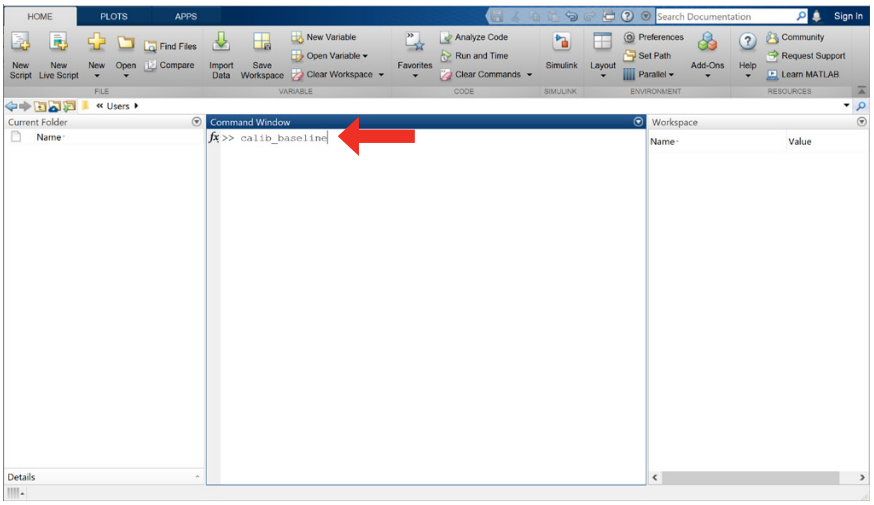
STEP 4: Run '*calib_baseline.m*' script. To run a Matlab script simply type its name (without the file extension) in the Matlab command window and hit enter.

FIGURE 36: Running the realism tool: step 4



Step 5: Follow on-screen instructions. The toolkit will ask the user to confirm that the '*input.xlsx*' file was saved. Then it will evaluate the '*input.xlsx*' file and advise the user if it needs corrections.

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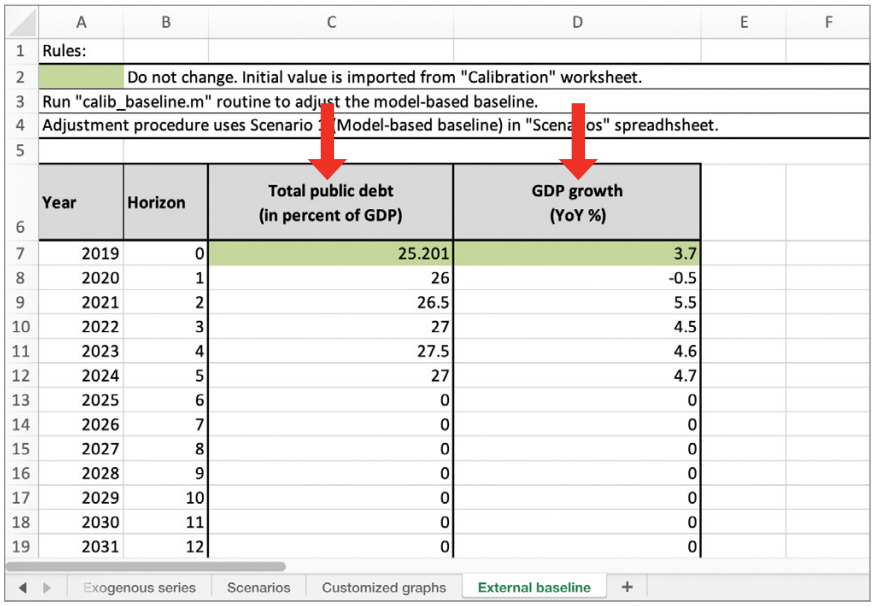
C. Example 5: Uncovering implicit assumptions

In this example, we will consider using the realism tool to compare the model-based projections of debt-to-GDP and GDP growth with those produced by an alternative macro framework.[12] We will attempt to align the model-based projections to those given by the alternative framework, uncovering the implicit assumptions of the latter along the way. These assumptions are quantified as shocks to TFP and the fiscal balance.

Consider Scenario 1 from Example 1 that assumes a fall in oil price and output of the natural resource sector. It is important to be sure that the scenario of interest is inputted as Scenario 1, which is identified as the *'Model-based baseline'* in the *'Scenarios'* worksheet. We will compare it with a more optimistic user-provided projections. As can be seen in Figure 37, these projections should be inputted into the *'External baseline'* worksheet of the *'input.xlsx'* file.

FIGURE 37: Example 5, 'External baseline' worksheet of the 'input.xlsx' file



	A	B	C	D	E	F
1	Rules:					
2		Do not change. Initial value is imported from "Calibration" worksheet.				
3	Run "calib_baseline.m" routine to adjust the model-based baseline.					
4	Adjustment procedure uses Scenario 1 (Model-based baseline) in "Scenarios" spreadhsheet.					
5						
6	Year	Horizon	Total public debt (in percent of GDP)	GDP growth (YoY %)		
7	2019	0	25.201	3.7		
8	2020	1	26	-0.5		
9	2021	2	26.5	5.5		
10	2022	3	27	4.5		
11	2023	4	27.5	4.6		
12	2024	5	27	4.7		
13	2025	6	0	0		
14	2026	7	0	0		
15	2027	8	0	0		
16	2028	9	0	0		
17	2029	10	0	0		
18	2030	11	0	0		
19	2031	12	0	0		

Exogenous series | Scenarios | Customized graphs | External baseline

The *'Calibration'*, *'Exogenous series'*, and *'Scenarios'* worksheets remain the same as in Example 1 (see Figures 13 and 14). Once initiated, the realism tool produces a graph that compares the two types of projections. Figure 38 presents this graph. The black bold line plots the more optimistic user-provided projections of higher GDP growth and lower debt-to-GDP ratios, while the green bold line shows the paths for the same variables as generated by the DIGNAR-19 model.

[12] Data used for the purposes of this exercise (as well as other exercises described in the manual) is arbitrary, handpicked to illustrate the DIGNAR-19 toolkit.

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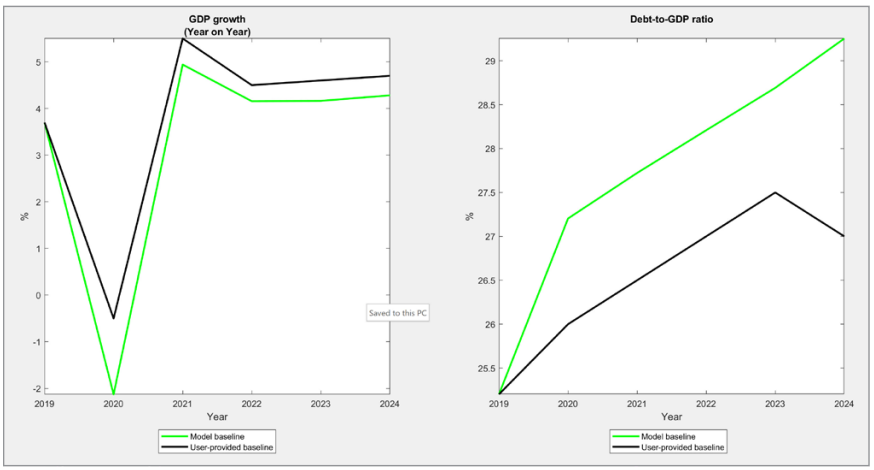
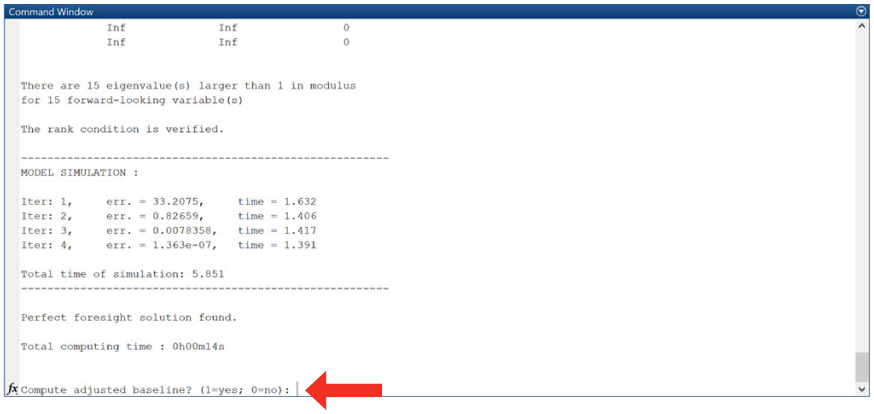
FIGURE 38: Example 5, visual comparison of the two baselines by the realism tool



The interface then provides the user with a choice to perform the alignment or abort the realism tool (Figure 39). If the alignment option is selected, the tool inverts the DGE model to solve for sequences of TFP and fiscal balance shocks that bring the model-based projection to the user-provided one.

FIGURE 39: Example 5, alignment initialization



Note that the realism and simulation tools are not fully automated. The ability of these tools to operate is conditional on the right set of fiscal policy reaction parameters and exogenous shock magnitudes. Although the former do not affect the simulated series over the plotted projection horizon, they play an important role in solving the model (i.e., solving for the perfect foresight paths). The convergence of the algorithm is not always guaranteed. Nonetheless, increasing the size of the fiscal reaction parameters (highlighted in red in the *'Calibration'* worksheet of the *'input.xlsx'* file) or decreasing the magnitudes of the swings in exogenous series often solves the problem.[13]

[13] This approach should not be used as a substitute for a thorough scenario design. The specified combination of exogenous series must deliver a consistent (and realistic) macroeconomic scenario for the model to be solvable. By way of example, if public expenditure is assumed to increase in the future, the scenario should also allow for an accumulation of government debt or an increase in government revenues (or both) that are necessary to finance such an increase in expenditure.

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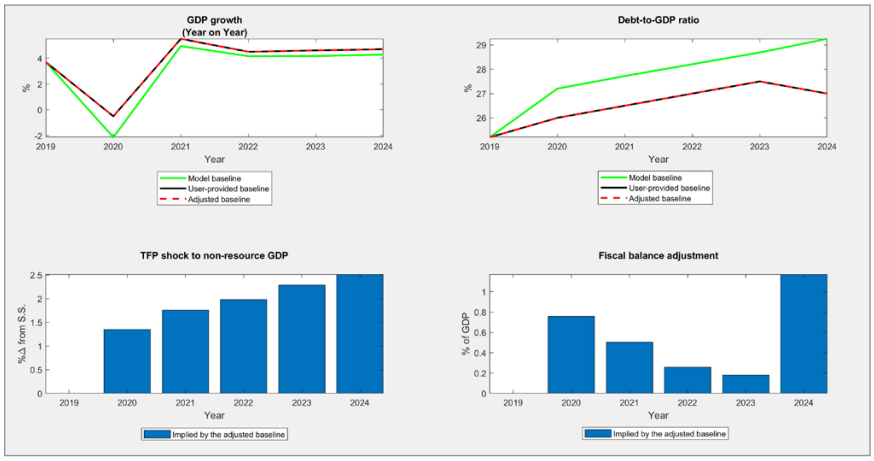
If successful, the toolkit produces a graph with aligned projections and implied shocks (see Figure 40). At this stage, the user can evaluate the implicit assumptions embedded in the user-provided baseline. If these assumptions are deemed unreasonable, the alternative macro framework may need to be adjusted. If they are justified, the tool allows using these shocks in simulating other model-based scenarios. We consider the latter case in the next example.

FIGURE 40: Example 5, results of the alignment, produced by the realism tool



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D. Example 6: Using the shocks stored by the realism tool

The implied shocks that are computed by the realism tool are automatically saved by the toolkit. Users can choose to introduce them in their simulations (performed by the simulation tool) by selecting an appropriate option in the *'Scenarios'* worksheet. The realism tool should be used first to compute and save the shocks. Only after that, the simulation tool can utilize them.

Scenarios 2-30 can accommodate these shocks in the simulations. Here the specification of Scenario 1 (the Model-based baseline) must remain the same as when the realism tool was used to compute the shocks. If the calibration of the model or the specification of Scenario 1 change, the toolkit will acknowledge that the setup used to compute the saved shock sequences is no longer valid. In this case, the simulation will be aborted, and the user will be asked to use the realism tool again to come up with the updated shock sequences.

In this example, we will use the shock sequences computed in Example 5 to supplement Scenario 2 from Example 2. If the steps described in Example 5 were executed beforehand (i.e., the toolkit has computed and stored the desired shock sequences), we can use the simulation tool to produce "aligned" projections. Figure 32 presents the setup of the *'Scenarios'* worksheet used to perform such simulation.

FIGURE 41: Example 6, 'Scenarios' worksheet of the 'input.xlsx' file

	A		B	C	D	E	F
4	Options						
5	Starting (base) year (YY)		2019				
6	Simulation horizons (# of years)		6				
7							
8			Model-based baseline	Scenarios			
9	Scenarios		1	2	3	4	5
10							
11	Simulate scenario	(0=No; 1=Yes)	0	1	0	0	0
12							
13	A. Natural Resources						
14	A.1 Natural resource output growth	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
15	A.2 Natural resource price	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	1	1			
16							
17	B. Fiscal instruments						
18	B.1 Public Investment	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	1			
19	B.1.1 Public investment efficiency	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
20	B.2 Public consumption	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
21	B.3 Transfers	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
22	B.4 Change in Consumption Tax rate	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
23	B.5 Change in Labour Tax rate	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
24							
25	C. Financing options						
26	C.1 Concessional debt	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
27	C.2 Grants	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
28	C.3 Commercial borrowing allowed?	(0=No; 1=Yes)	1	1			
29	C.3.1 If yes, % external debt over tot. comm. debt accumulation (remaining is domestic)		50	50			
30	C.4 Sovereign risk premium	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
31							
32	D. Balance of Payments						
33	D.1 Remittances	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
34	D.2 Exports	(0=Constant; 1=Option 1; 2=Option 2; 3=Option 3)	0	0			
35							
36	E. Calibrations						
37	E.1 Calibrate the labour supply?	(0=No, 1=Option 1, 2=Option 2, 3=Option 3)	0	0			
	E.2 Use shocks consistent with the external baseline	(0=No; 1=Yes)					
	Warning: Use "calib_baseline.m" routine to obtain shocks before selecting this option. Scenario 1 is always used		0				
38	as a model-based baseline, i.e. is left uncalibrated.			1			

Calibration | Exogenous series | Customized graphs | Scenarios | External baseline | +

The only difference between the specification of Scenario 2 in Figure 20 and Figure 41 is the choice of option E.2, which in the latter case instructs the toolkit to use the saved shocks in the simulation. Triggering the simulation tool will produce the projections for Scenario 2, making use of the implied shocks computed using the realism tool.

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International Monetary Fund
Research Department and
Institute for Capacity Development
700 19th Street NW
Washington, DC 20431
USA
T. +(1) 202.623.8554
F. +(1) 202.623.6073

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