



TECHNICAL

NOTES & MANUALS

User Manual for the DIGNAD Toolkit

Zamid Aligishiev, Cian Ruane, and Azar Sultanov

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CompEcon Toolbox is a set of MATLAB functions for solving a variety of problems in economics and finance. The CompEcon Toolbox was developed to accompany *Applied Computational Economics and Finance*, by Mario J. Miranda and Paul L. Fackler, MIT Press, Cambridge, MA. 2002.

For additional information or to report any problems, please visit [CompEcon Toolbox for MATLAB](#).

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1. Introduction

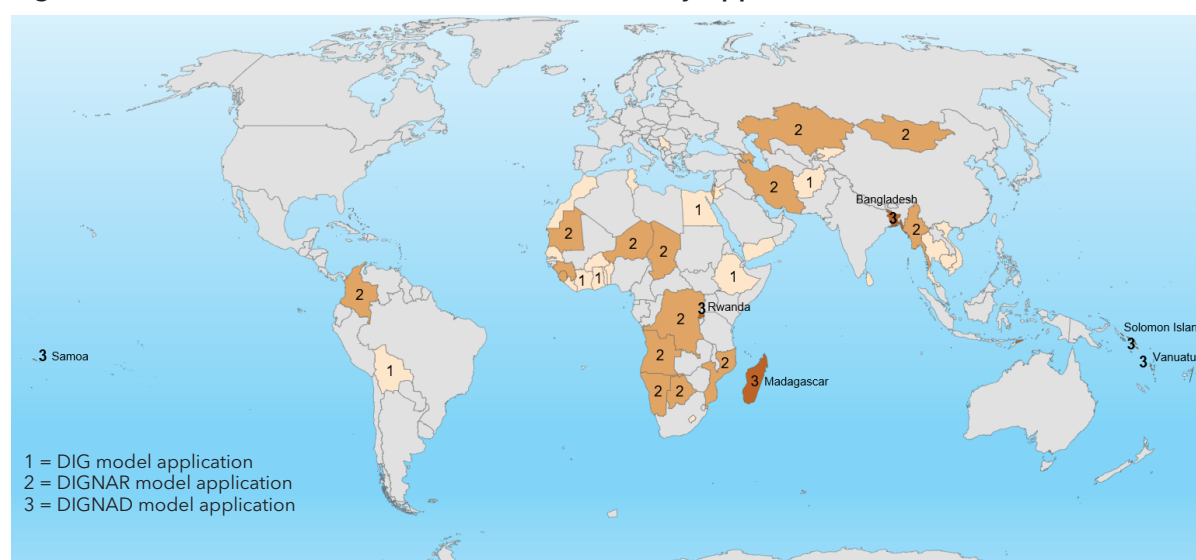
This user guide provides an overview of the Debt-Investment-Growth and Natural Disasters (DIGNAD) toolkit. The toolkit comprises a set of Excel and MATLAB files that allow the DIGNAD model to be run by economists with little to no knowledge of MATLAB and Dynare.

DIGNAD is a dynamic general equilibrium model of a small open economy developed at the IMF. The model can help economists and policymakers with quantitative assessments and policy scenario analysis of the macrofiscal effects of natural disasters and adaptation infrastructure investments in low-income developing countries and emerging markets. DIGNAD is tailored to disaster-prone countries, which typically are small countries or low-income countries that are particularly exposed to large climate shocks—countries where shocks that can disrupt the entire economy are frequent. However, DIGNAD can be relevant also for larger countries that may potentially be exposed to extreme climatic disasters in the future.

The DIGNAD model builds on the underlying framework of the Debt-Investment-Growth (DIG) model of Buffie and others (2012).¹ DIG and its extensions DIGNAR (Debt-Investment-Growth and Natural Resources; Melina, Yang, and Zanna 2014), DIGNAR-19 (extending DIGNAR for policy scenario analysis during the COVID-19 pandemic; Aligishiev, Melina, and Zanna 2021), and DIGNAD have been used in applications for more than 70 low-income countries and emerging markets over the past 10 years, some of which are shown in Figure 1.

This user manual has the following structure: Section II provides a brief overview of the DIGNAD model. Section III describes how to set up the toolkit and describes its structure. Section IV describes how to run the toolkit and provides some example outputs. Section V describes the additional modules contained in the toolkit. Section VI discusses how to calibrate the model parameters. Section VII walks through an example scenario analysis using the DIGNAD toolkit.

Figure 1. Previous DIG, DIGNAR, and DIGNAD Country Applications



Source: Gurara, Melina, and Zanna (2019), updated by IMF staff.

Note: The boundaries, colors, denominations, and any other information shown on the map do not imply, on the part of the International Monetary Fund, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries. DIG = Debt-Investment-Growth; DIGNAR = Debt-Investment-Growth and Natural Resources; DIGNAD = Debt-Investment-Growth and Natural Disasters.

¹ See a summary of applications in Gurara, Melina, and Zanna (2019).

2. A Brief Overview of the DIGNAD Model

This manual provides only a short overview of the main features of the DIGNAD model in this section.²

The Basic Structure of the DIGNAD Model

The core of the model encompasses three blocks.

1. The private demand block contains households' consumption and saving decisions. There are two types of households: savers who have access to financial instruments, and liquidity-constrained households who do not and therefore spend the income they receive each period. Both types of households face an intratemporal decision that determines their supply of labor, whereas savers also face an intertemporal decision that determines savings. Households earn labor income and receive remittances from abroad and direct transfers from the government. They then use this income to consume domestically produced goods and services, as well as goods produced abroad.
2. The private supply block contains firms' decisions on labor and capital demand. There are two sectors: tradable and nontradable, with production undertaken by a representative private firm in each. Output is produced through a Cobb-Douglas aggregate of capital and labor inputs. Firms choose capital and labor to maximize profits. Firm output is also increasing in sectoral total factor productivity, which, in turn, depends on the total stock of public infrastructure. The total stock of public infrastructure is an aggregate of the stock of climate-resilient (or adaptation) infrastructure and the stock of standard infrastructure, which are assumed to be perfectly substitutable.
3. The policy block collects a set of fiscal and debt instruments that covers government investment plans and their financing. These include consumption taxes, labor taxes, and net transfers to households. The government can also issue domestic public debt, private domestic debt, external commercial debt, and external concessional debt. It can also receive grants or other forms of costless external financing from abroad. The government determines how much to invest in standard infrastructure and how much to invest in adaptation infrastructure. There are two ways the model can be used to think about government policy choices. The first is to impose a condition that the government follows fiscal rules, which means taxes adjust automatically to close the fiscal gap and prevent excessive accumulation of debt. Alternatively, the user can impose a condition that no automatic adjustment occurs, but rather the government closes the fiscal gap by adjusting debt levels.

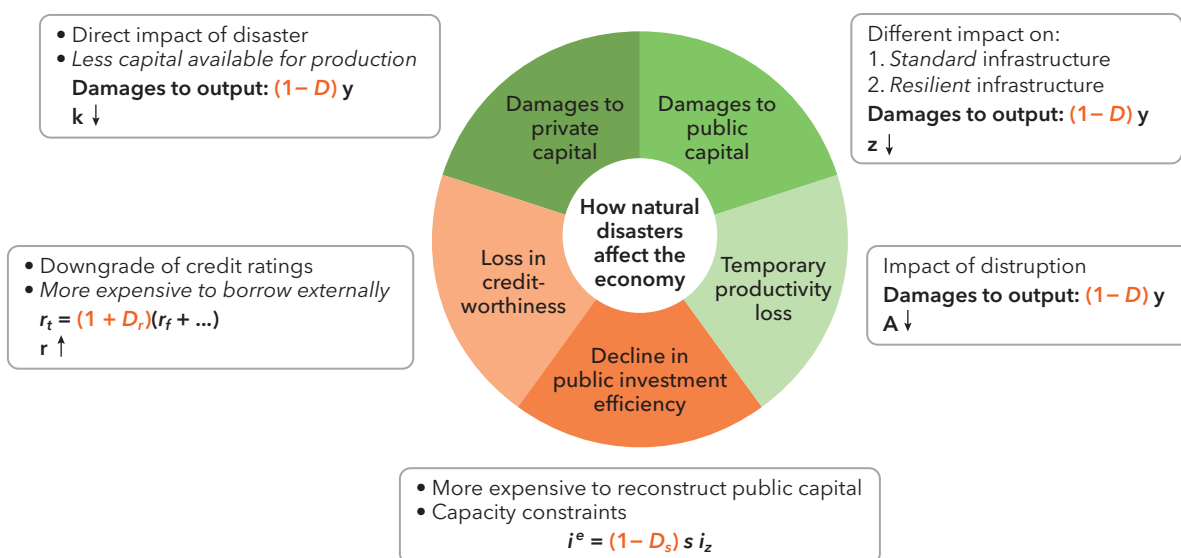
The dynamic general equilibrium nature of the model ensures that these three blocks are interdependent, and macroeconomic outcomes are jointly determined by their interaction.

The Effect of Natural Disasters in DIGNAD

The main novel feature in the DIGNAD model is that it can be used to simulate the effect of a one-off natural disaster in the previously described economic environment. The various channels are shown in Figure 2. The main three channels through which a natural disaster can affect the macroeconomy are (1) destroying the stock of public infrastructure, (2) destroying the stock of private capital, and (3) reducing total factor productivity.

The relative strength of each of these channels can be calibrated by the user in the toolkit. While they all imply that the natural disaster directly reduces output, they have different macrofiscal implications. The stock of public infrastructure can be reconstructed only by the government, which results in fiscal costs that

² For more details, see Buffie and others (2012) and Marto, Papageorgiou, and Klyuev (2018).

Figure 2. Natural Disasters in the DIGNAD Model

Source: IMF staff.

Note: DIGNAD = Debt-Investment-Growth and Natural Disasters.

can be covered by increased taxes, debt, or external funding. The stock of private capital can be rebuilt only through private sector investments, which are subject to adjustment costs. Total factor productivity is assumed to exogenously and gradually recover to its predisaster level; however, the user can determine how slowly this recovery takes place.

A natural disaster can affect the macroeconomy through two additional mechanisms: (1) increasing the risk premium on external commercial debt and (2) reducing the efficiency of government investment in infrastructure.

The increase in the risk premium is a plausible channel if foreign creditors perceive a higher risk of default after a natural disaster. The reduction in the efficiency of government investment is consistent with limited government capacity to manage large-scale reconstruction, especially after a natural disaster. The magnitude of these channels can be determined by the toolkit user, or they can be switched off entirely.

Features of Standard and Adaptation Infrastructure in DIGNAD

The second main novel feature of the DIGNAD model is that it allows for two types of public infrastructure: climate-resilient or climate adaptation infrastructure and standard infrastructure. The baseline assumption in the toolkit is that the total stock of public infrastructure is the sum of these two types of infrastructure; that is, they are perfectly substitutable.³

The main feature of adaptation infrastructure is that it mitigates the output damages from natural disasters. A larger stock of adaptation infrastructure means a larger share of damages are mitigated. A key parameter in the model governs the extent to which a given stock of capital mitigates the damages from natural disasters. In contrast with investing in adaptation infrastructure, investing in standard infrastructure has no mitigating effect on natural disaster damages. However, adaptation infrastructure is often more expensive than standard infrastructure, a feature that can also be captured by the DIGNAD model. The cost of adaptation relative to standard infrastructure can be calibrated by the user.

³ A future expansion of the toolkit is expected to allow the user to make different assumptions about the elasticity of substitution between adaptation and standard infrastructure.

The toolkit allows standard and adaptation infrastructure to differ from each other in two additional ways: (1) standard and adaptation infrastructure may have different rates of depreciation, and (2) standard and adaptation infrastructure may have different rates of returns (that is, different marginal products).

In several situations, it is plausible that adaptation infrastructure has a lower rate of depreciation than standard infrastructure—for example, climate-proofed roads may be more likely to withstand normal seasonal wear and tear. Regarding the marginal product of adaptation infrastructure, its low existing stock in many low-income developing countries suggests that rates of return may be high for initial investments. Individual users should determine the appropriateness of their assumptions regarding these additional features of adaptation infrastructure, based on their specific context.

Saving in an External Contingency Fund

One set of policies that the DIGNAD toolkit can be used to explore is the value of building fiscal buffers in an external natural disaster contingency fund to finance postdisaster reconstruction. One reason to do this is that access to financing (particularly external financing) might be curtailed or become prohibitively expensive exactly when the government needs money to deal with a shock. The downside is that saving in a contingency fund may reduce available resources to invest in climate-resilient infrastructure.

Should a country susceptible to natural disasters invest in a contingency fund? The answer depends on many factors, including the size of the shock it is insuring itself against, the opportunity cost of diverting funds into a contingency fund, and the reaction of the international community in case a natural disaster occurs. Relatively frequent (occurring once every few years) events of manageable proportions are unlikely to elicit a major response from development partners. If the country must deal with the consequences of such events largely on its own, a permanent income hypothesis argument suggests that accumulating resources in a contingency fund during nondisaster years would allow it to avoid large costly adjustments in disaster years, which could be welfare-improving (Marto, Papageorgiou, and Klyuev 2018).

3. The DIGNAD Toolkit

Setting Up the Toolkit

To run the toolkit, users need to have MATLAB installed on their computers. The entire folder containing the DIGNAD toolkit should be downloaded and saved locally on the user's computer.⁴ The toolkit is set up so that the user can run the model while opening only the relevant Excel files—the model is run through MATLAB in the background.

The Excel Interface

The toolkit combines an Excel-based front end and a back end that makes use of MATLAB, Dynare, and CompEcon scripts and functions (Figure 3). The Excel interface consists of three files: the input, run, and output files. User inputs, such as model calibration, shock specifications, external baselines, and so on, should be specified in the "input DIG-ND.xlsx" file. The input file includes the following sheets:

- **Calibration:** Allows users to calibrate the main parameters of the model and to define the steady-state values of key macroeconomic variables.
- **Exogenous series:** Allows users to specify the path of public infrastructure investment, grants, concessional debt, and terms-of-trade shocks for up to 50 periods.
- **Scenario:** Allows users to choose the combination of financing scenarios (that is, whether the government closes the fiscal gap using taxes or allows debt to deviate from its steady-state value) and the exogenous series they want to run.
- **Disasters:** Allows users to define the timing of the natural disaster, the damages and losses caused, and how long it takes the government to rebuild the stock of public infrastructure.
- **Graphs:** Allows users to choose the type of graphs, variables, and number of periods to plot.
- **XLSoutput:** Allows users to choose the variables for which the time series will be exported to Excel.

In addition to the aforementioned sheets, the input file also includes the following additional modules, each in their own separate sheet:

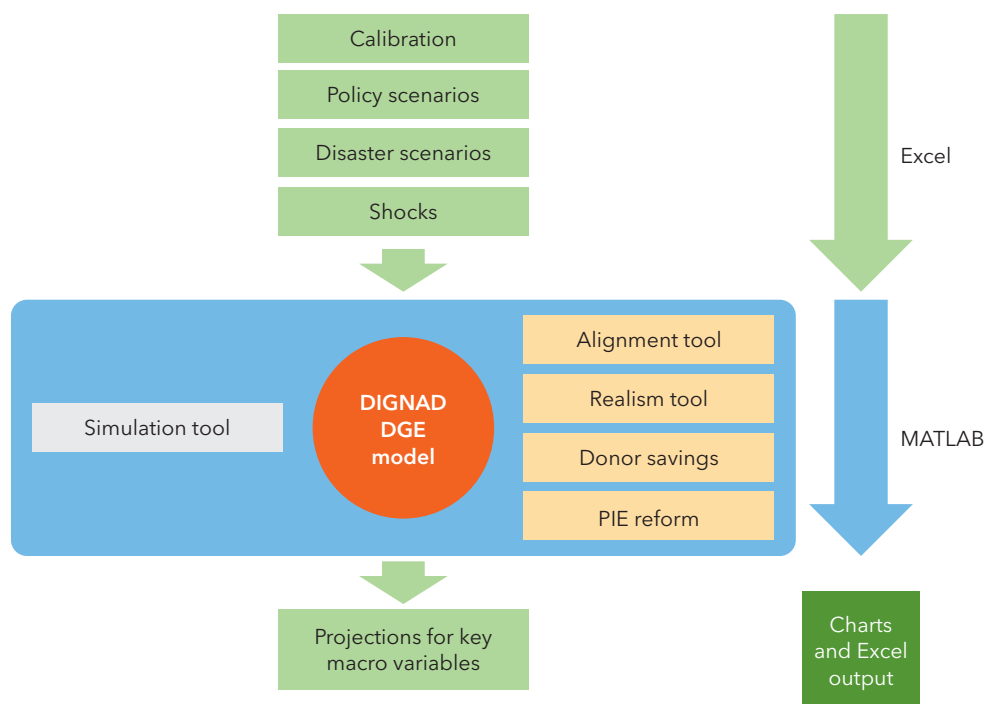
- **Realism:** Allows users to analyze the sensitivity of the model output for different values of the disaster damage mitigation parameter.
- **Public investment efficiency reform:** Allows users to simulate public investment efficiency reform by setting a target level for efficiency of public infrastructure investment.
- **Alignment:** Allows users to make the model match a user-defined trajectory of real GDP after a natural disaster.
- **Donor savings:** Donors may face a trade-off between financially supporting a country in building resilience or financing postdisaster reconstruction. This module allows users to calculate the net savings or losses of donors from ex ante adaptation investments compared with investments in ex post reconstruction.

Calibration

In the Calibration sheet (Figure 4), the user needs to specify the country-specific steady-state values for the model's endogenous variables (for example, the debt-to-GDP ratio), as well as other parameters. Parameters fall into four groups: (1) country-specific parameters and moments, (2) parameters determining

⁴ After downloading the zipped file, users should right-click on the file and choose "Extract all" to a folder of their choice.

Figure 3. DIGNAD Toolkit



Source: IMF staff.

Note: DGE = dynamic general equilibrium; DIGNAD = Debt-Investment-Growth and Natural Disasters; PIE = public investment efficiency.

the main characteristics of standard and adaptation infrastructure, (3) fiscal adjustment parameters, and (4) other structural parameters. Parameters are color coded as follows:

- Green: Parameters that can typically be calibrated based on publicly available information from national accounts.
- Orange: Other parameters that should be calibrated based on country-specific data, if available.
- Yellow: Key parameters determining features of adaptation infrastructure that should be calibrated on a case-by-case basis.
- Blue: Other structural parameters, for advanced users.

Users should populate the green and orange parameters. Sensitivity of model outputs to the assumed values of the yellow parameters should be explored, given that they can depend on the precise types of adaptation investments being considered. Blue parameters can be left unchanged, although advanced users may wish to alter them. More details regarding the baseline parameters in the toolkit and the range of plausible values used in the literature are provided in Section VI.

Exogenous Series

After inputting the calibration, users need to specify the path for the exogenously determined variables. These include deviations of public investment in standard and adaptation infrastructure, grants, concessional debt, and oil revenue from their steady-state levels, as well as changes to the terms of trade and to the contingency fund. These can be changed in the Exogenous series sheet (Figure 5).

In this sheet, users can specify up to three sets of paths for the exogenous variables. For each scenario that they intend to run, each variable needs to have values (that is, cells cannot be empty). Therefore, if users do not want to include changes to a specific exogenous variable, they should simply fill the cells with zeros.

Figure 4. Calibration Table

	Parameter Description	Parameters
Country-specific parameters and moments	Public infrastructure investment-to-GDP ratio	iziy
	Public adaptation infrastructure investment-to-GDP ratio	izay
	Consumption tax rate (VAT)	ho
	Labor income tax rate	hlo
	Public domestic debt-to-GDP ratio	share_b
	Public concessional debt-to-GDP ratio	share_d
	Public external commercial debt-to-GDP ratio	share_dc
	Private external debt-to-GDP ratio	share_bstar
	Real interest rate on public domestic debt	ro
	Real interest rate on public external commercial debt	r_dco
	Grants-to-GDP ratio	share_grants
	Oil revenues-to-GDP ratio	oilro
	Remittances-to-GDP ratio	share_remit
	Imports-to-GDP ratio	Imp2gdp
	Government savings-to-GDP ratio	Savo
	Trend per capita growth rate in absence of natural disasters	g
	Value-added in NT-sector	VA_n
	NS/S - Labor ratio of nonsavers to savers / [S+a_ratio*S = 1]	a_ratio
	Efficiency of public infrastructure investment	s_o
	Cost share of NT-inputs in the production of private capital	alpha_k
Cost share of NT-inputs in the production of public capital	alpha_z	
Capital's share in value added in the T-sector	alpha_x	
Capital's share in value added in the NT-sector	alpha_n	
Parameters determining main characteristics of standard and adaptation infrastructure	Scaling parameter determining ability of adaptation capital to withstand natural disaster (see Realism sheet)	ppi_nd_n
	Cost ratio adaptation vs standard investment [adaptation is % expensive than standard]	a_z
	Initial return standard on infrastructure investment	R_zio
	Initial return on adaptation infrastructure investment	R_zao
	Depreciation rate of public capital (standard infrastructure)	delta_zi
	Depreciation rate of public capital (adaptation)	delta_z
	Speed of reconstruction of public standard infrastructure	pgamma_zi
	Speed of recovery of public investment efficiency	pgamma_s
	Speed of recovery of tradable sector TFP	pgamma_ax
	Speed of recovery of country risk premium	pgamma_rdc
	User fees for infrastructure services (% of recurrent costs)	fo
	Fiscal adjustment parameters	Division of fiscal adjustment parameter - Transfers
Division of fiscal adjustment parameter - Consumption tax		lambda_h
Division of fiscal adjustment parameter - Labor income tax		lambda_hl
Share of public debt adj. between commercial external and domestic (= 1 when only domestic debt is used)		upsilon
Fiscal reaction parameter (policy instrument terms) - Consumption VAT		lambda1
Fiscal reaction parameter (debt terms) - Consumption VAT		lambda2
Fiscal reaction parameter (policy instrument terms) - Transfers		lambda3
Fiscal reaction parameter (debt terms) - Transfers		lambda4
Fiscal reaction parameter (policy instrument terms) - Labor income tax	lambda5	
Fiscal reaction parameter (debt terms) - Labor income tax	lambda6	
Other structural parameters	Risk-free foreign RIR (r^f)	rstar
	Depreciation rate in T-sector	delta_x
	Depreciation rate in NT-sector	delta_n
	Intertemporal elasticity of substitution	tau
	Inverse of Frisch elasticity of labor supply	phfi
	Determines the severity of absorptive capacity constraint in public sector	phi
	Portfolio adjustment costs parameter	eta
	Public debt risk premium (= 0 [the interest rate on public commercial debt is not affected by the total debt level] or = 1)	etag
	Capital learning externalities in NT-sector	xi_n
	Traded T-sector output learning externality	sigma_x
	Non-traded NT-sector output learning externality	sigma_n
	Ratio of [the elasticity of the NT-sector to infrastructure] and [the elast. of the T-sector to infrastructure]. Tobin's q -elasticity of investment spending	nxpsi omega

Source: IMF staff.

Note: adj. = adjusted; NS/S = nonsavers-to-savers; NT = nontradable; TFP = total factor productivity; T = tradable; VAT = value-added tax.

Scenarios

The code takes as given the path of grants and concessional debt specified in the Exogenous series sheet. In the Scenario sheet (Figure 6), users specify how they want the residual fiscal gap (after the Exogenous series specified is accounted for) to be covered. Either debt is allowed to endogenously adjust to cover the fiscal gap ("commercial," "domestic," "all debt"), or debt is held constant and taxes adjust to cover the fiscal gap ("exogenous"). If "commercial" is chosen, public external commercial debt is allowed to adjust to

Figure 5. Exogenous Series Table

Period	Year	Option 1					Terms-of-trade shock			
		Public infrastructure investment (% of initial GDP)	Public adaptation investment (% of initial GDP)	Delta contingency fund (% of initial GDP)	Grants (% of initial GDP)	Concessional debt (% of initial GDP)	Price of exported goods (Index)	Price of imported consumption goods (Index)	Price of imported capital goods (Index)	
1	2022	1.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0	
2	2023	1.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0	
3	2024	1.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0	
4	2025	1.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0	
5	2026	1.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0	
6	2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	2028	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
8	2029	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
9	2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
10	2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
11	2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
12	2033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
13	2034	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14	2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	2036	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16	2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
17	2038	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
18	2039	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
19	2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Source: IMF staff.

cover the fiscal gap, while public domestic debt is held constant. Conversely, if “domestic” is chosen, public domestic debt is allowed to adjust to cover the fiscal gap, while public external commercial debt is held constant. If “all debt” is chosen, public domestic and external commercial debt are both allowed to adjust to cover the fiscal gap. If the user chooses the “exogenous” scenario, then the fiscal gap is closed using taxes and transfers, given the fiscal parameters assumed in the Calibration sheet.

Figure 6. Scenario Tables

Define how financing is achieved in each scenario		Define which Exogenous series (shocks) are used in each scenario	Option	Periods	Define name of shock
Scenario 1	domestic_debt		1	30	Baseline
Scenario 2			2	30	Adaptation 1
Scenario 3			3	30	Adaptation 2

Scenarios	Label	Debt scenarios
	exogenous	The entire fiscal gap is covered by fiscal instruments (labor tax, consumption tax, and cash transfers) conditional on exogenous paths for grants and concessional debt (supplied in the “Exogenous_series” worksheet).
	commercial_debt	Public external commercial debt is allowed to cover the fiscal gap, while public domestic debt and fiscal instruments are held constant.
	domestic_debt	Public domestic debt is allowed to cover the fiscal gap, while public external commercial debt is held constant.
all_debt	Public domestic and external commercial debt are allowed to cover the fiscal gap, in addition to the path for concessional debt and grants specified in the “Exogenous_series” worksheet.	

Source: IMF staff.

Figure 7. Disasters Table: Impact of Natural Disasters

		Period	Year
	Would you like to incorporate a natural disaster?	yes	
	In which period does the natural disaster strike?	6	2027

Impact of natural disaster	Natural disaster scenario	Damages and losses
	Impact of natural disaster on tradable output ? Specify destruction in %.	0.0
	Impact of natural disaster on nontradable output ? Specify destruction in %.	0.0
	Impact of natural disaster on reconstruction efficiency (%)	0.0
	Impact of natural disaster on external public debt risk premium ? (increase in percentage points)	0.0
	Impact of natural disaster on public capital (% of GDP)	0.0
	Impact of natural disaster on private capital (% of GDP)	0.0
	Share of damages to tradable sector capital (% total private capital damages)	0.0

Source: IMF staff.

Disasters

In the Disasters sheet (Figure 7), the user must specify the magnitude of the natural disaster hitting the economy. The user must attach a numerical value to damages and losses to tradable and nontradable output, reconstruction efficiency, the external public debt risk premium, public capital (that is, infrastructure), and private capital. The numbers filled in beside the cells “Impact of natural disaster on tradable (nontradable) output” correspond to the total decline in output (GDP) as a result of the natural disaster, assuming no behavioral responses from households, optimization responses by firms, or policy changes by the government.⁵ The user can also decompose these output losses into the shares attributable to the reductions in public capital, private capital, and total factor productivity. The user does this by filling in how much the natural disaster reduces the stocks of public and private capital relative to GDP. The reduction in total factor productivity as a result of the disaster is then inferred as the residual source of damages. Information on damages from natural disasters is typically available from historical data, although the breakdown across sectors, the effect on reconstruction efficiency, and the external risk premium may not be available in many cases. The user will therefore need to make assumptions on the magnitudes of these effects.

In addition to specifying the year in which the natural disaster occurs, the user must define the year in which reconstruction in public infrastructure begins—this may not be immediate if government capacity is constrained after the disaster. The user must also specify the year by which the government plans to complete the reconstruction of the stock of public infrastructure. Last, the user must specify the year in which total factor productivity in tradable and nontradable sectors, public investment efficiency, and the external debt premium recover (Figure 8).

⁵ However, in the model simulations, the natural disaster will trigger such responses, so GDP decreases on impact may not align with what the user specifies here.

Figure 8. Disasters Table: Recovery Periods

Recovery Periods	Loss of productivity	Traded sector TFP	Nontraded sector TFP
	When does the recovery start?	2027	2027
	Year in which recovery is complete?	2032	2032
	Efficiency for reconstruction		
	When does the recovery start?	2027	
	Year in which recovery is complete?	2032	
	Public capital reconstruction		
	When does the recovery start?	2027	
	Year in which recovery is complete?	2032	
	External debt risk premium		
When does the recovery start?	2027		
Year in which recovery is complete?	2032		

Source: IMF staff.

Note: TFP = total factor productivity.

Graphs and Excel Output

In the Graphs sheet, users can choose which variables they want to include in the figures produced by the model. Users can plot up to 16 variables (Figure 9). The variables available to graph are listed in the same sheet (see Figure 11), with the main macroeconomic variables that are typically of interest colored in red.

Users also need to specify the number of rows and columns for the plots and allow sufficient space for the variables selected. For example, if users select 10 variables, they need to have space for them, with four rows and three columns (or three columns and four rows), such that the number of rows times the number of columns is greater or equal to the number of variables selected.

Similarly, in the XLSoutput sheet, users can specify which variables they want to be exported to Excel (up to 16 variables; see Figure 11).

Figure 9. Variables Available to Graph

Variables available to graph	Label
Public infrastructure investment (% of GDP)	pubinvgdp
Public infrastructure adaptation investment (% of GDP)	pubadapgdp
Real GDP growth (% dev from SS)	rgdp
Private investment growth (% dev from SS)	privinvgr
Domestic public debt (% of GDP)	domdebtgdp
Concessional debt (% of GDP)	concedebt
Total public debt (% of GDP)	totpubdebt
Fiscal deficit (% of GDP)	fiscaldef
Grants (% of GDP)	grantsgdp
Public effective standard capital (level)	zie
Public effective adaptation capital (level)	zae
Real GDP growth (% YoY)	rgdpgryoy
Tradable output (% dev from SS)	rgdpx
Nontradable output (% dev from SS)	rgdpn
TFP in the tradable sector (level)	a_x
TFP in the nontradable sector (level)	a_n
Private consumption growth (% dev from SS)	privconsgr
Current expenditures (% of GDP)	curexpgdp
Oil revenues (% of GDP)	oilrevgdp
External private debt (% of GDP)	extpdebtgdp
External public commercial debt (% of GDP)	commdebtgdp
Current account deficit (% of GDP)	cadef
Real interest rate on domestic debt (%)	rpercent
Real interest rate on external commercial debt (%)	rextgpercent
Real exchange rate (% dev from SS)	rerpercent
Consumption tax (%)	hpercent
Labor income tax (%)	hlpercent
Natural disaster fund (% of GDP)	savgdp
Real wages (% dev from SS)	rwages

Source: IMF staff.

Note: dev = deviation; SS = steady state; TFP = total factor productivity; YoY = year over year.

4. Running the Toolkit

Using the MATLAB Command Window

Users may run the toolkit and modules in two ways. Users who are familiar with MATLAB may want to use the MATLAB interface directly. First, users need to find the folder where the toolkit is saved. The "Current Folder" window will display a MATLAB file "simulate.m," as shown in Figure 10.

To run the model, users should type "simulate" in the command window, press the "Enter" key, and follow the remaining prompts and instructions. Alternatively, users can click the "Run" button under the "EDITOR" ribbon after opening the simulate.m file in editor mode.

The user should follow the same procedure to run any of the modules in the toolkit.

Once the program is completed, two new folders will be created: one includes an Excel spreadsheet with the output of the model, and the other includes MATLAB and PDF figures of the user's plots (Figure 11).

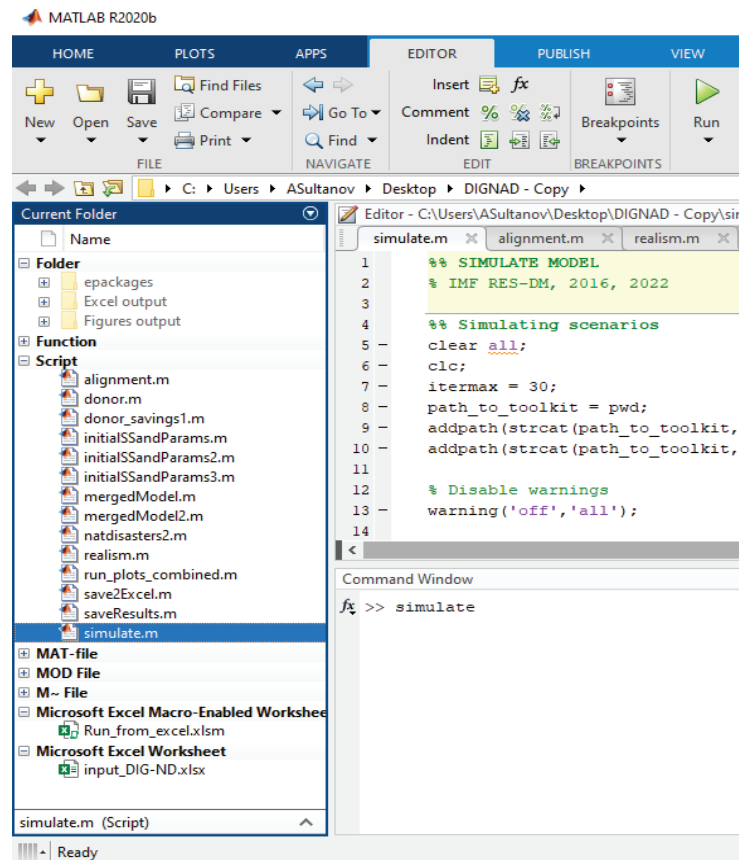
Running the Simulation Tool

To run the toolkit and modules through the Excel interface, users should browse the toolkit folder and open the macro-enabled Microsoft Excel file "Run from excel.xlsm." If prompted by the security warning "Macros have been disabled," users need to click the "Enable Content" button. Figure 12 presents the DIGNAD Toolkit folder structure. The Excel input file and the macro-enabled "Run from excel.xlsm" are shown with green arrows.

To run the model, users should click the selected icon (in Figure 13) and follow the remaining prompts and instructions displayed.

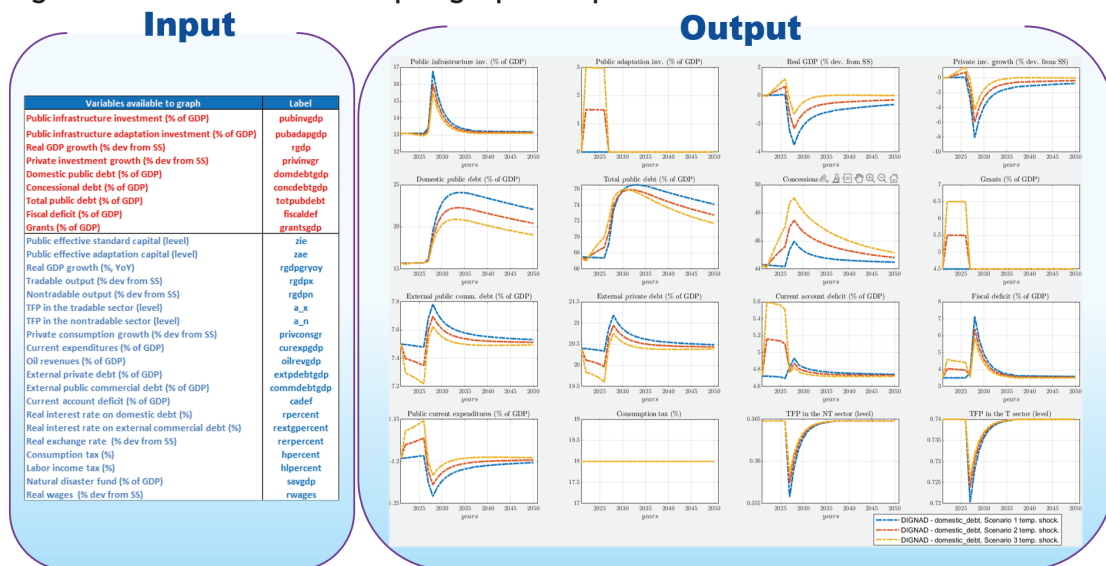
Once the program is completed, two new folders will be created: one includes an Excel spreadsheet with the output of the model, and the other includes PDF figures of the user's plots. These folders and respective files are presented in Figure 12 as Excel output (orange arrow) and figures output saved in a PDF format (blue arrows).

Figure 10. Running the Model from MATLAB



Source: IMF staff.

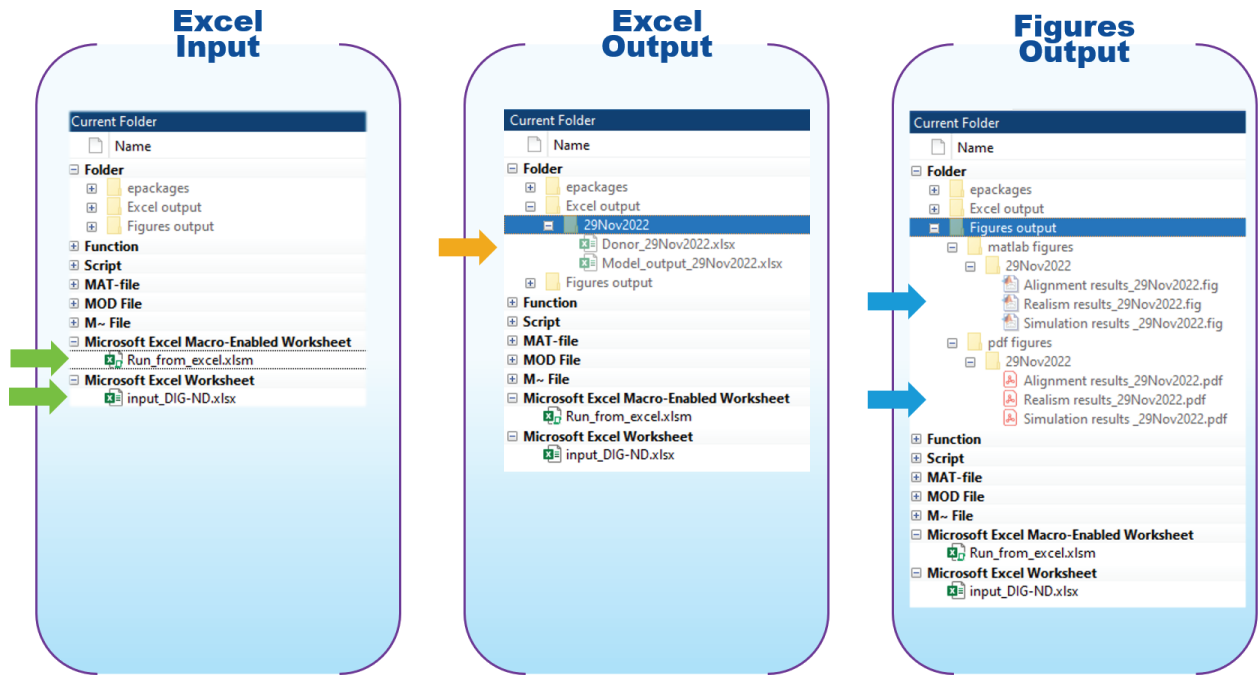
Figure 11. DIGNAD Toolkit: Graphing Input-Output



Source: IMF staff.

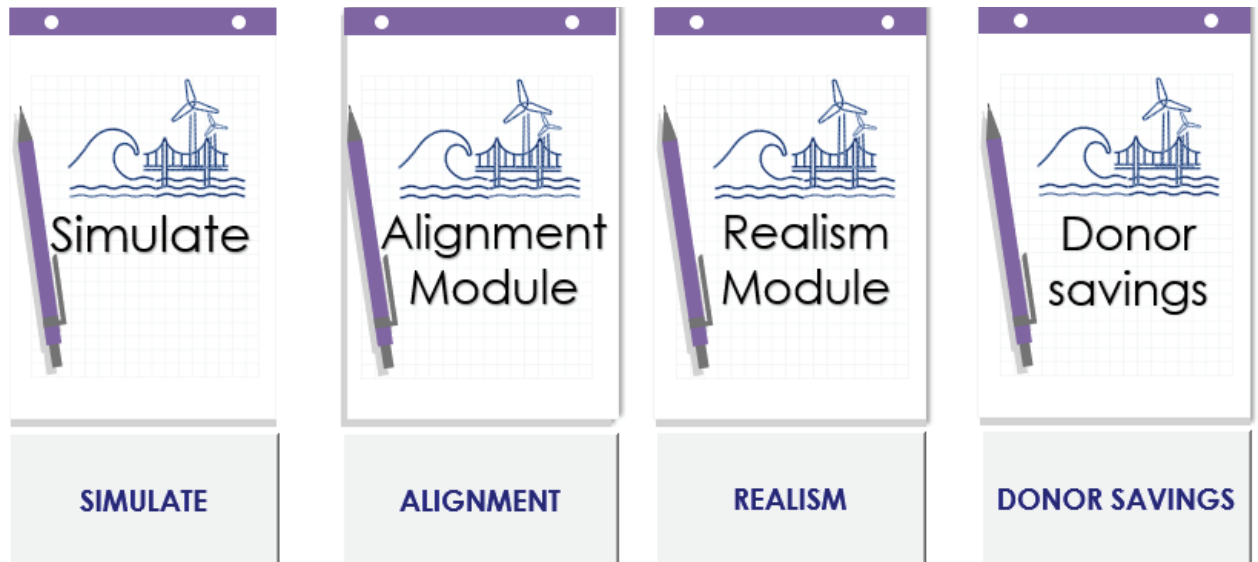
Note: Comm = commercial; dev = deviation; DIGNAD = Debt-Investment-Growth and Natural Disasters; inv. = investment; SS = steady state; NT = nontradable; T = tradable; temp. = temporary; TFP = total factor productivity; YoY = year over year.

Figure 12. DIGNAD Toolkit Folder Structure



Source: IMF staff.

Figure 13. Running the Toolkit from Macro-Enabled Excel File



Source: IMF staff.

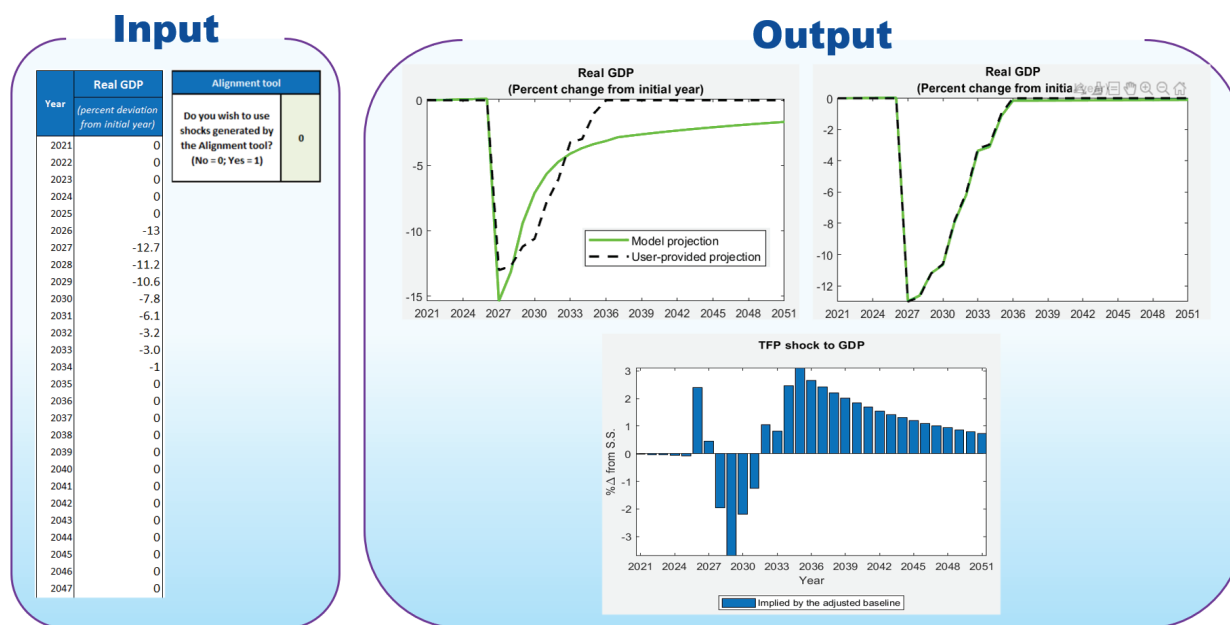
5. The DIGNAD Modules

Alignment

The alignment tool helps the user cross-check the dynamics of GDP projected from the model against an independent series provided by the user (from a separate model-based framework or from empirical studies). Users can choose to align the model projections with their own. In this case, the Realism tool reverse-engineers shock to total factor productivity to achieve this alignment.

To initiate the Alignment tool, users should populate the input file and either submit a command in the MATLAB command window and follow on-screen instructions or click on the Alignment tool on the macro-enabled Excel file (Figure 14).

Figure 14. DIGNAD Toolkit: Alignment Module



Source: IMF staff.

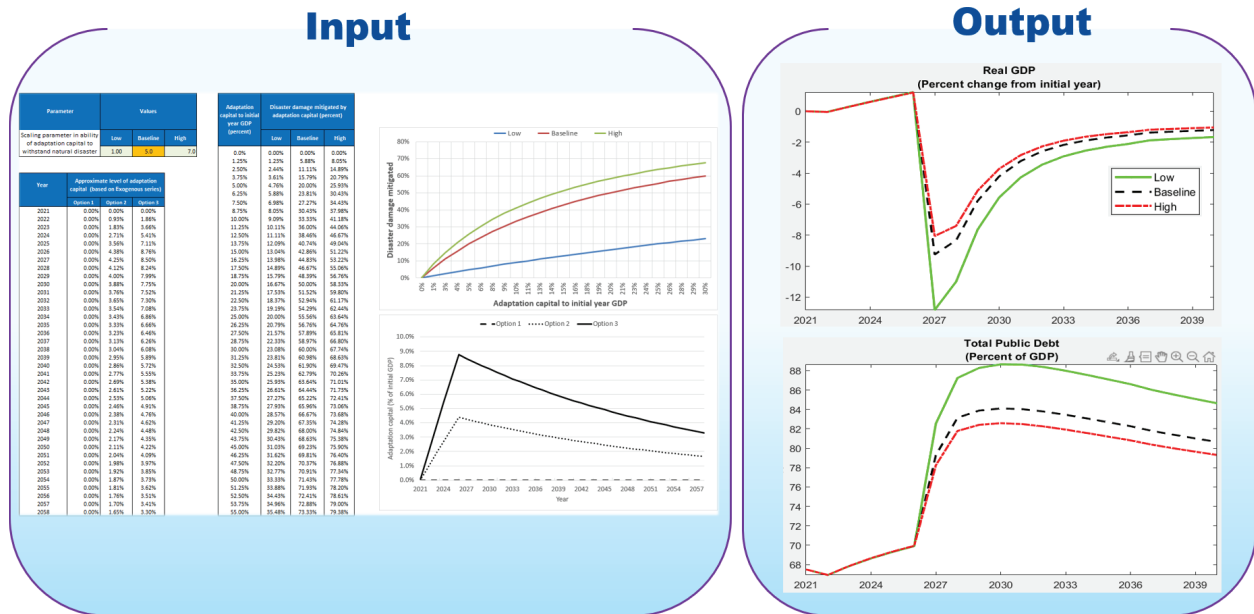
Note: Δ = change; DIGNAD = Debt-Investment-Growth and Natural Disasters; S.S. = steady state; TFP = total factor productivity.

Realism

The Realism module serves two purposes: (1) the charts in the Input sheet (Figure 15, left panel) help the user understand the assumptions being made about the disaster damage mitigation parameter, and (2) the graphs in the Output sheet provide a model-based sensitivity analysis of model results to this parameter (Figure 15, right panel).

The bottom graph in the left panel of Figure 15 plots a back-of-the-envelope approximation of the stock of adaptation capital relative to GDP over time (calculated in Excel rather than in MATLAB for simplicity). This series takes as given the assumed path of adaptation investments (specified in the Exogenous series sheet) and the assumed rate of depreciation (in the Calibration sheet). This graph enables the user to quickly see the size of the stock of adaptation capital in the year the disaster occurs. The top graph in the left panel of Figure 15 plots the percentage of disaster damages mitigated against the stock of adaptation capital relative

Figure 15. DIGNAD Toolkit: Realism Module



Source: IMF staff.
 Note: DIGNAD = Debt-Investment-Growth and Natural Disasters.

to GDP. This is plotted for three different values of the disaster damage mitigation parameter: the baseline value from the Calibration sheet, a high value, and a low value. This enables users to quickly tell what their assumptions imply for the percentage of disaster damages mitigated through adaptation investments.

The Realism module also provides a sensitivity analysis of the model output to the disaster damage mitigation parameter. In the Realism module (either from the Excel interface or from MATLAB), figures such as the ones in the right panel of Figure 15 are produced, showing the dynamics of both real GDP and the total-debt-to-GDP ratio for the low, baseline, and high values of the parameter assumed in the Realism module sheet.

Donor Savings

An important exercise carried out in Marto, Papageorgiou, and Klyuev (2018) and IMF (2022) is a donor net savings calculation. The exercise considers a donor that would fund the entirety of infrastructure reconstruction costs after a natural disaster and asks, "How large would the net savings (or losses) be were the donor to fund investments in adaptation infrastructure ex ante, thereby requiring smaller donations for reconstruction ex post." The Donor savings module allows the user to automate this calculation. Future financing costs are discounted at a rate specified by the user, with the output reported as a percentage of reconstruction costs under no policy change. Users are also required to specify the baseline GDP level and specify if they want to simulate the module before running it from the Excel interface or from MATLAB. The results of the simulation can be seen in the MATLAB command window and are also saved as Excel output.

Figure 16. DIGNAD Toolkit: Public Investment Efficiency Reform Module

Define which Exogenous series are used in each scenario (From Exogenous_series sheet)	Option	Periods	Define name of shock	PIE reform target (%)
Scenario 1	1	20	Baseline	50
Scenario 2	2	20	Adaptation 1	50
Scenario 3	3	20	Adaptation 2 & PIE	70

Source: IMF staff.

Note: PIE = public investment efficiency.

Public Investment Efficiency Reform

The Public Investment Efficiency Reform module (Figure 16) allows the user to perform a scenario analysis in which the government implements reforms raising public investment efficiency to the level specified in the public investment efficiency reform target cell in the Scenario sheet. The public investment efficiency reform considered captures only the efficiency gains for new infrastructure investments, rather than the transition dynamics to a new higher infrastructure stock resulting from the reform. Future versions of the toolkit may be able to incorporate such transition dynamics.

6. Parameter Calibration

The use of judgment is critical to calibrate, construct, and interpret the scenarios using the DIGNAD toolkit. A key step in this process is choosing values for (calibrating) the model parameters. These include both structural parameters and the steady-state values for the model's endogenous variables. Model outputs critically depend on the information inputted by the user in the Calibration sheet. Where possible, it is therefore important to use country-specific parameter values that accurately reflect the scenario considered. When it is difficult to obtain such information, sensitivity analysis can be conducted. The DIGNAD toolkit can be a helpful tool for anchoring policy discussions precisely because it requires users to be explicit about the assumptions underlying projections and scenario analysis.

The values in the toolkit's Calibration sheet are prepopulated to allow users to instantly run the model for a default calibration. Where possible, the default steady-state values for the endogenous variables in the DIGNAD toolkit are set to be broadly representative of the typical sub-Saharan African low-income country. Other parameters are chosen in line with standard values in the literature, as discussed in the next subsection.

Calibrating the Public Infrastructure Parameters

Table 1 provides a list of the parameters in the DIGNAD model related to the characteristics of public infrastructure. Evidence from the literature regarding the calibration of these parameters is discussed in what follows.

Table 1. Public Infrastructure Parameters

PARAMETERS THAT USERS MUST CALIBRATE IN THE CALIBRATION SHEET	NOTATION/ VARIABLE IN MARTO, PAPAGEORGIU, AND KLYUEV (2018)
Public-infrastructure-investment-to-GDP ratio	$i_{zi,o}$
Public-adaptation-infrastructure-investment-to-GDP ratio	$i_{za,o}$
Depreciation rate of public capital (standard infrastructure)	δ_{zi}
Depreciation rate of public capital (adaptation)	δ_{za}
Initial return on standard infrastructure investment	R_o^{zi}
Initial return on adaptation infrastructure investment	R_o^{za}
User fees for infrastructure services (percentage of recurrent costs)	μ
Efficiency of public infrastructure investment	s_o
Scaling parameter determining ability of adaptation capital to withstand natural disaster	π_j
Cost of adaptation relative to standard infrastructure	a_{za}

Source: IMF staff.

Note: See the calibration discussion in the text.

Public-infrastructure-investment-to-GDP ratio: The toolkit follows Buffie and others (2012) and sets the default value of initial infrastructure investment equal to 6 percent of GDP. This includes the net investment associated with trend growth and the outlays on operations and maintenance, which average about 3.4 percent of GDP for low-income countries in sub-Saharan Africa. It is also close to the average for low-income countries in sub-Saharan Africa of 6.09 percent in 2008 (Briceño-Garmendia, Smits, and Foster 2008).

Public-adaptation-infrastructure-investment-to-GDP ratio: Precise data on public expenditures on adaptation infrastructure are frequently not available for low-income countries. Given that stocks of climate-resilient public infrastructure tend to be very low in low-income countries, the toolkit sets the default value equal to 0 percent.

Depreciation rate of public capital (standard infrastructure): As Buffie and others (2012) note, limited data are available on depreciation rates in low-income countries. They assume the same depreciation rate for private capital and public infrastructure, which they set to 5 percent, in line with estimates for advanced economies. Marto, Papageorgiou, and Klyuev (2018) assume a somewhat higher depreciation rate of 7.5 percent for public infrastructure in an application for Vanuatu, similar to the 7 percent in Melina, Yang, and Zanna (2014). Higher values have also been considered, for example, 15 percent in the case of the Solomon Islands (IMF 2018). Given that depreciation rates are likely higher in low-income countries than in advanced economies, the toolkit takes a midrange value from the literature and sets the default depreciation rate for standard public infrastructure to 7.5 percent.

Depreciation rate of public capital (adaptation): There is very little empirical evidence on depreciation rates for climate-resilient infrastructure, especially that in low-income countries. Certain types of climate-resilient infrastructure might be expected to depreciate at lower rates than standard infrastructure, however. For example, weatherproofed roads may be more likely to cope with regular seasonal wear and tear than standard roads. The toolkit therefore follows the literature and sets the default depreciation rate for climate-resilient infrastructure to be 3 percent, in line with the values chosen by Marto, Papageorgiou, and Klyuev (2018) for Vanuatu, IMF (2018) for the Solomon Islands, and IMF (2022) for Samoa. Users should use their judgment when calibrating this parameter, carefully considering the precise features of the adaptation infrastructure investments in the Scenario analysis.

Initial return on standard infrastructure investment: The World Bank estimates the median return on its infrastructure projects in various subcategories to be between 17 percent and 31 percent (Independent Evaluation Group 2010). The median rate of return on World Bank projects circa 2001 was 20 percent in sub-Saharan Africa and 15–29 percent for various subcategories of infrastructure investment (Buffie and others 2012). The toolkit follows Buffie and others (2012) and sets the default value of returns to standard infrastructure investments to be 25 percent at the initial steady state. Values used in the literature have ranged from 15 percent for the Solomon Islands application (IMF 2018) to 30 percent for Vanuatu (Marto, Papageorgiou, and Klyuev 2018) and 25 percent for Samoa (IMF 2022).

Initial return on adaptation infrastructure investment: The little empirical evidence on returns from adaptation infrastructure suggests very high rates of return (discussed in more detail in Box 1). This is unsurprising given that stocks of climate-resilient infrastructure are very low in emerging market and developing economies. Marto, Papageorgiou, and Klyuev (2018) therefore set the return on adaptation infrastructure to 50 percent for Vanuatu, compared with a return on standard infrastructure of 30 percent. In contrast, the initial return on investment in adaptation infrastructure was assumed to be 30 percent for Samoa (IMF 2022) and 40 percent for the Solomon Islands (IMF 2018). The toolkit makes a conservative assumption and sets the default rate of return on adaptation investment to 30 percent, only 5 percentage points higher than the rate of return on standard infrastructure.

User fees for infrastructure services: According to Briceno-Garmendia, Smits, and Foster (2008), on average, user fees recoup 50 percent of recurrent costs in sub-Saharan Africa. Marto, Papageorgiou, and Klyuev (2018) assume that the government charges 50 percent of its costs to households, noting, however, the huge variation across countries. The toolkit follows Buffie and others (2012) and IMF (2018), setting the default value of user fees for infrastructure services to a lower level of 5 percent.

Efficiency of public infrastructure investment: In DIGNAD, high public investment efficiency implies a larger stock of public capital for a given investment rate and hence higher output. Public investment efficiency can

BOX 1. Evidence on the Returns to Adaptation Infrastructure Investments

Estimating adaptation benefits is not an easy task as it is characterized by large uncertainties, however there is growing consensus that the benefits are large, as sectoral studies report high climate adaptation returns (as high as 100 to 900 percent). For instance, long-term savings from investment in resilience and coping mechanisms can reach 300 percent for droughts and 1,200 percent for storms in sub-Saharan Africa, and large benefits of investing in adaptation are also found in other regions. However, as total investment in adaptation increases, adaptation costs are expected to increase faster than benefits, eventually leading to smaller net benefits. See Aligishiev, Bellon, and Masetti 2022 for a detailed review of adaptation benefits and costs.

Source: Aligishiev, Bellon, and Masetti 2022.

be affected by many factors, including poor technologies, waste, or corruption. Public investment efficiency is estimated as 50 percent for sub-Saharan Africa in Melina, Yang, and Zanna (2014). Berg, Yang, and Zanna (2015) assume a slightly lower value of 40 percent in their baseline calibration, based on 2005-12 quarterly data for sub-Saharan African countries, and close to the value of 42 percent for Uganda in IMF (2021). Lower values have also been considered, such as that in IMF (2018), in which the value assumed for the Solomon Islands was 30 percent. In contrast, Buffie and others (2012) assume a somewhat higher level of efficiency of 60 percent. The toolkit sets the default value of public investment efficiency to 50 percent, in the midrange of these estimates and in line with those estimated for sub-Saharan Africa. Box 2 discusses sources of data on public investment efficiency.

Scaling parameter determining ability of adaptation capital to withstand natural disaster: Significant uncertainty exists on the extent to which a higher stock of adaptation infrastructure can mitigate the effect of natural disasters, and few studies provide estimates; it depends on the type of infrastructure and type of disaster risk to which a country is exposed. Users should therefore be clear that the value assigned to this parameter is subject to much uncertainty and should use the Realism tool to explore sensitivity to their assumptions. One of the few studies to provide estimates is Bresch (2014), which finds that adaptation infrastructure investment can help avoid up to 65 percent of projected disaster losses in advanced economies. Bresch (2014) also shows an example of adaptation investment in India, which could avert 50 percent of the loss from a potential drought. The toolkit sets the default value of this parameter in the toolkit such that a stock of adaptation infrastructure equal to 5 percent of GDP would reduce the damages from a natural disaster by roughly one-third.

Cost of adaptation relative to standard infrastructure: An important reason that governments may be less likely to invest in adaptation infrastructure is that it may be more expensive than standard infrastructure projects, requiring more skilled workers or specialized parts and materials. The toolkit therefore sets the default cost of adaptation infrastructure to be 25 percent higher than standard infrastructure, in line with the literature (Cantelmo, Melina, and Papageorgiou 2019; Fernandez-Corugedo, Gonzales-Gomez, and Guerson 2022).

Country-Specific Moments and Parameters Related to Real Economy

Table 2 presents the list of parameters related to the real economy that should be calibrated based on country-specific data.

BOX 2. Where to Find Data to Calibrate the Investment Efficiency Parameter

- The Public Investment Management Index developed by Dabla-Norris and others (2011) is one potential source. Table 1 on page 35 of Dabla-Norris and others (2011) lists the index for several developing countries. To get a proxy for the public investment efficiency parameter, divide the index for the country of interest by 4 to yield a number between 0 and 1, which can be used as the value for the public investment efficiency parameter.
- World Bank studies on infrastructure in Africa are also very useful. These studies cover almost all sub-Saharan African countries. In each country study, the average annual public spending on infrastructure is given as well as the average annual amount that is wasted in the process because of inefficiencies. This information can be used to derive the efficiency parameter (1 minus the ratio of average annual inefficiencies to average annual spending on infrastructure).
- If data on public spending that are misclassified as infrastructure spending are available, for example, transfers to civil servants that are treated as infrastructure spending, then the efficiency parameter can be derived as 1 minus the ratio of misclassified to total spending on infrastructure.

Source: IMF staff.

Trend growth rate: This parameter determines potential growth in the absence of natural disasters or other economic shocks. The toolkit sets the default value of this parameter to 6 percent. This is above typical growth rates observed in sub-Saharan Africa, because DIGNAD abstracts from the many shocks (economic and otherwise) that have held back growth in sub-Saharan African low-income countries.

Table 2. Moments and Parameters Related to Real Economy

PARAMETERS THAT USERS MUST CALIBRATE IN THE CALIBRATION SHEET	NOTATION/ VARIABLE IN MARTO, PAPAGEORGIU, AND KLYUEV (2018)
Steady-State Moments of Endogenous Variables	
Trend per capita growth rate in absence of natural disasters	g
Natural-resources-revenues-to-GDP ratio	N_o
Imports-to-GDP ratio	I_o
NS/S - Labor ratio of nonsavers (NS) to savers (S)	α
Tradable (T) and Nontradable (NT) Sectors	
Cost share of NT inputs in the production of public capital	α_z
Cost share of NT inputs in the production of private capital	α_k
Value added in NT sector	$VA_{n,o}$
Capital's share in value added in T sector	α_x
Capital's share in value added in the NT sector	α_n
Depreciation rate in T sector	δ_x
Depreciation rate in NT sector	δ_n

Source: IMF staff.

Note: See the calibration discussion in the text.

Natural resource revenues: The toolkit sets the default share of natural resource revenues in GDP to 0 percent. This share varies substantially across countries, however, and it should be adjusted by the user in particular for countries with sizable income shares from exports of natural resources.

Imports-to-GDP ratio: The toolkit sets the default share of imports in GDP to 38 percent, based on the average pre-COVID share calculated for sub-Saharan African low-income countries between 2015 and 2019 from the IMF World Economic Outlook database.⁶

Ratio of nonsavers to savers: The toolkit sets the default value of the ratio of nonsavers to savers such that 60 percent of households are liquidity-constrained, following Buffie and others (2012), who note that this is broadly in line with survey findings in low-income countries. This share may vary widely across countries. On the basis of 2011 data, Demirgüç-Kunt and Klapper (2012) report that on average about 24 percent of adults in sub-Saharan Africa have an account in a financial institution, while Marto, Papageorgiou, and Klyuev (2018) calibrate the share of liquidity-constrained households at 12.7 percent for Vanuatu.

Cost share of nontradable inputs in the production of public (private) capital: The toolkit follows Marto, Papageorgiou, and Klyuev (2018) and Buffie and others (2012) and sets the default value of the cost share of nontradable inputs to 50 percent. Buffie and others (2012) show that this value is consistent with data on the ratio of imported machinery and equipment to aggregate investment.

Value added in the nontradable sector: The value-added share in nontradable sectors can be constructed from the sectoral aggregation of nontradable activities in value added from national accounts. Given that these data are available for a large set of sub-Saharan African low-income countries, the toolkit follows Marto, Papageorgiou, and Klyuev (2018) and sets the value-added share in the nontradable sector to 48 percent.

Capital's share in value added: The toolkit sets the default values for the capital share in value added to 40 percent in the tradable sector and 55 percent in the nontradable sector, following Buffie and others (2012), who calculate these as the midrange values for sub-Saharan Africa based on data from version 5 of the Global Trade Analysis Project database.

Depreciation rates for private capital: As Buffie and others (2012) note, limited data are available on depreciation rates in low-income countries, and they therefore set this to 5 percent in line with estimates for advanced economies. The toolkit does the same, setting the default depreciation rate for private capital to 5 percent.

Calibrating Debt and Other Sources of Government Revenues

Table 3 presents the list of parameters related to government debt, other sources of revenue, and interest rates, which should be calibrated based on country-specific data.

Debt-to-GDP ratios: Levels of public debt (domestic, concessional, external commercial, and external private) as a share of GDP should be calibrated on a country-specific basis. Various data sources are available, including, for example, the IMF Global Debt Database.⁷ The toolkit sets the average value of the total-public-debt-to-GDP ratio for sub-Saharan African low-income countries for the pre-COVID-19 period between 2015 and 2019, based on data from the IMF World Economic Outlook database, to 54 percent. Buffie and others (2012) report that the share of concessional loans in total debt for low-income countries is approximately 70 percent; therefore, the toolkit sets the default value for the public-concessional-debt-to-GDP ratio equal to 38 percent, that for the public-domestic-debt-to-GDP to 16 percent, and that for the public-external-commercial-debt-to-GDP ratio to 0 percent. Given limited information about the value of

⁶ To access the IMF World Economic Outlook database, visit <https://IMF.org/en/Publications/SPROLLS/world-economic-outlook-databases#sort%3D%40imfdate%20descending>.

⁷ To access the IMF Global Debt Database, visit <https://IMF.org/external/datamapper/datasets/GDD>.

Table 3. Parameters Related to the Debt and Interest

PARAMETERS THAT USERS MUST CALIBRATE IN THE CALIBRATION SHEET	NOTATION/ VARIABLE IN MARTO, PAPAGEORGIU, AND KLYUEV (2018)
Debt	
Public-domestic-debt-to-GDP ratio	b_o
Public-concessional-debt-to-GDP ratio	d_o
Public-external-commercial-debt-to-GDP ratio	$d_{c,o}$
Private-external-debt-to-GDP ratio	b_o^*
Savings-in-contingency-fund-to-GDP ratio	b_o^*
Other Sources of Government Financing	
Grants-to-GDP ratio	G_o
Remittances-to-GDP ratio	R_o
Interest Rates	
Real interest rate on public domestic debt	r_o
Real interest rate on public external commercial debt	$r_{dc,o}$
Risk-free foreign RIR	r^f

Source: IMF staff.

Note: See the calibration discussion in the text.

private foreign debt in low-income countries, the toolkit also sets the default value for the private-external-debt ratio to 0 percent.

Other sources of government financing: Two other sources of government revenues that the DIGNAD model allows for are external grants and remittances. The toolkit sets the default values to 0 percent, but users should adjust these based on available data.

Interest rates: The toolkit follows Buffie and others (2012) and sets the default value of the real risk-free foreign interest rate to 4 percent, a standard value in the literature, which roughly approximates the average historical real returns on stocks and 3- to 10-year Treasury bills in the United States. There is tremendous variation in domestic real interest rates across countries and time periods. Previous DIGNAD applications therefore calibrated these interest rates to reflect country-specific conditions. The toolkit sets the default real interest rate on domestic debt at 5 percent, a small premium over the foreign risk-free rate, and the real interest rate on public external commercial debt at 6 percent, reflecting a potential additional risk premium charged by foreign private creditors.

Calibrating Fiscal Instruments

Fiscal instruments: The steady-state values of consumption taxes and labor income taxes (shown in Table 4) should be chosen by the user based on country-specific tax rates. The toolkit sets the default values to 15 percent and 20 percent, respectively, which are in the typical range for such taxes. The division of fiscal adjustment parameters determines whether the government closes the fiscal gap using changes in transfers, consumption taxes, or labor taxes. The shares of commercial external and domestic debt in public debt adjustment determine whether the government relies on domestic debt, external commercial debt, or a mix of both when closing the fiscal gap through borrowing. The fiscal reaction parameters determine how responsively the government uses these fiscal tools when a fiscal gap opens. The values chosen for these parameters should all therefore be guided by the policy scenario that users want to simulate, as well as by what they consider feasible as a fiscal adjustment by the government (Melina, Yang, and Zanna 2014).

Table 4. Fiscal Instruments

PARAMETERS THAT USERS MUST CALIBRATE IN THE CALIBRATION SHEET	NOTATION/ VARIABLE IN MARTO, PAPAGEORGIOU, AND KLYUEV (2018)
Taxes¹	
Consumption tax rate (VAT)	h
Labor income tax rate	hl
Fiscal Adjustment Parameters^{2,3}	
Division of fiscal adjustment parameter–Transfers	λ
Division of fiscal adjustment parameter–Consumption tax	λ_h
Division of fiscal adjustment parameter–Labor income tax	λ_{hl}
Share of public debt adjustment between commercial external and domestic	u
Fiscal Reaction Parameters²	
Policy instrument term–Consumption VAT	λ_1
Debt term–Consumption VAT	λ_2
Policy instrument term–Transfers	λ_3
Debt term–Transfers	λ_4
Policy instrument term–Labor income tax	λ_5
Debt term–Labor income tax	λ_6

Source: IMF staff.

Note: See the calibration discussion in the text. VAT = value-added tax.

¹Users should calibrate against country-specific data.

²Total of three must be equal to 1: [$\lambda + \lambda_h + \lambda_{hl} = 1$].

³Users should calibrate depending on the policy scenario that they want to simulate.

7. An Example Using the DIGNAD Toolkit

This section provides an example scenario analysis using the DIGNAD toolkit. To obtain a model-based 20-year projections for a hypothetical small low-income developing country in sub-Saharan Africa, the default calibration in the toolkit is used so that users can replicate the outputs in this example. Three scenarios are compared, with the same natural disaster occurring in each case in year 6. To capture the impetus for a swift recovery, the example assumes that the government intends to rebuild damaged public infrastructure to predisaster levels in roughly five years. Three scenarios are considered:

1. Baseline scenario: The government does not invest in climate-resilient infrastructure; however, it invests 1.5 percent of GDP in standard public infrastructure for each of the five years before the natural disaster. It finances this expenditure through a mix of grants and concessional borrowing.
2. Adaptation 1 scenario: The government invests 1.5 percent of GDP in climate-resilient public infrastructure for each of the five years before the natural disaster. It finances this expenditure with grants and concessional borrowing.
3. Adaptation 2 scenario: The government invests 2 percent of GDP in climate-resilient public infrastructure for each of the five years before the natural disaster. It finances this expenditure with grants and concessional borrowing. The country also undertakes reforms related to climate Public Investment Management Assessment and green public financial management, which raise the efficiency of public investment by 20 percentage points.

Step 1. Setting up infrastructure investments: Figures 17 and 18 present the setup of the Exogenous series worksheet for the baseline and adaptation 1 scenarios, respectively.

Figure 17. Baseline Scenario

Year	Option 1				
	Public infrastructure investment (% of initial GDP)	Public adaptation investment (% of initial GDP)	Delta contingency fund (% of initial GDP)	Grants (% of initial GDP)	Concessional debt (% of initial GDP)
2022	1.5	0.0	0.0	1.0	0.5
2023	1.5	0.0	0.0	1.0	0.5
2024	1.5	0.0	0.0	1.0	0.5
2025	1.5	0.0	0.0	1.0	0.5
2026	1.5	0.0	0.0	1.0	0.5
2027	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0

Source: IMF staff.

Figure 18. Adaptation 1 Scenario

Year	Option 2				
	Public infrastructure investment (% of initial GDP)	Public adaptation investment (% of initial GDP)	Delta contingency fund (% of initial GDP)	Grants (% of initial GDP)	Concessional debt (% of initial GDP)
2022	0.0	1.5	0.0	1.0	0.5
2023	0.0	1.5	0.0	1.0	0.5
2024	0.0	1.5	0.0	1.0	0.5
2025	0.0	1.5	0.0	1.0	0.5
2026	0.0	1.5	0.0	1.0	0.5
2027	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0

Source: IMF staff.

The adaptation 2 scenario's exogenous variables setup includes an additional 0.5 percent of GDP investment in adaptation infrastructure for five consecutive years. This is presented in Figure 19. However, the adaptation 2 scenario also needs to encompass an increase in the efficiency of public investment by 20 percentage points. This increase will be set in the next step, when the financing scenario is defined.

Figure 19. Adaptation 2 Scenario

Year	Option 3				
	Public infrastructure investment (% of initial GDP)	Public adaptation investment (% of initial GDP)	Delta contingency fund (% of Initial GDP)	Grants (% of initial GDP)	Concessional debt (% of initial GDP)
2022	0.0	2.0	0.0	1.5	0.5
2023	0.0	2.0	0.0	1.5	0.5
2024	0.0	2.0	0.0	1.5	0.5
2025	0.0	2.0	0.0	1.5	0.5
2026	0.0	2.0	0.0	1.5	0.5
2027	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0

Source: IMF staff.

Step 2. Financing scenarios: In the Scenario sheet (Figure 20), the users specify how they want the residual fiscal gap (after the Exogenous series specified is accounted for) to be covered. Either debt is allowed to endogenously adjust to cover the fiscal gap ("commercial," "domestic," "all debt"), or debt is held constant and taxes adjust to cover the fiscal gap ("exogenous"). For the example here, the "all debt" option is chosen, and both public domestic and external commercial debt are allowed to adjust to cover the fiscal gap. To impose a condition that the public debt adjustment is split evenly between commercial external and domestic debt, set $u = 50$ percent in the Calibration sheet.

If the user chooses the exogenous financing option, then the fiscal gap would be closed using fiscal instruments, that is, taxes and transfers, given the fiscal parameters assumed in the Calibration sheet. Users can choose "exogenous" as a second financing option (see Financing 2 in the figure), in which case the toolkit will run both financing options ("all debt" and "exogenous") for all three investment scenarios (baseline, adaptation 1, and adaptation 2) and produce two sets of figures.

The exogenous variable series to use for each of the three scenarios is specified in the "Option" column. Users can name the scenarios in the "Define name of shock" column. In the rightmost column, "PIE reform target (%)," the user can define the target level of public investment efficiency from the reform. The baseline and adaptation 1 scenarios assume no change in the efficiency of public investment, so the value remains at 50 percent (identical to what is set in the Calibration sheet). The adaptation 2 scenario assumes that reforms (related to climate Public Investment Management Assessment and green public financial management) raise the efficiency of public investment by 20 percentage points, and the target public investment efficiency is therefore set to 70 percent.

Figure 20. Financing Scenarios

Define how financing is achieved in each scenario		Define which Exogenous series are used in each scenario (From Exogenous_series sheet)	Option	Periods	Define name of shock	PIE reform target (%)
Financing 1	all_debt	Scenario 1	1	20	Baseline	50
Financing 2	exogeneous	Scenario 2	2	20	Adaptation 1	50
Financing 3		Scenario 3	3	20	Adaptation 2 & PIE	70

Source: IMF staff.

Note: PIE = public investment efficiency.

Step 3. Graphing: In the Graphs sheet, the user can choose to produce figures comparing debt financing scenarios for each debt-financing option. The user can plot up to 16 variables. The variables available to graph are listed in the same sheet (see Figure 11).

Step 4. Disasters and recovery: The Disasters sheet specifies when the disaster strikes and the magnitude of the natural disaster hitting the economy, as in Figure 21. The disaster is assumed to inflict damage that would reduce output by 10 percent in each of the tradable and nontradable sectors, with no behavioral or policy responses assumed. Decomposing these effects into the three channels, the example assumes that the natural disaster damages the stock of public infrastructure and the stock of private capital sufficiently to reduce each of them by 10 percentage points of GDP. Note that the effect on aggregate GDP of the reductions in the stock of public infrastructure and private capital depends on their respective marginal returns, which are specified in the Calibration sheet. The remaining disaster damages are assigned to aggregate total factor productivity as a residual. To capture the impetus for a swift recovery, it is assumed that the

Figure 21. Disasters Sheet: Damages and Losses

		Period	Year
	Would you like to incorporate a natural disaster?	Yes	
	In which period does the natural disaster strike?	6	2027

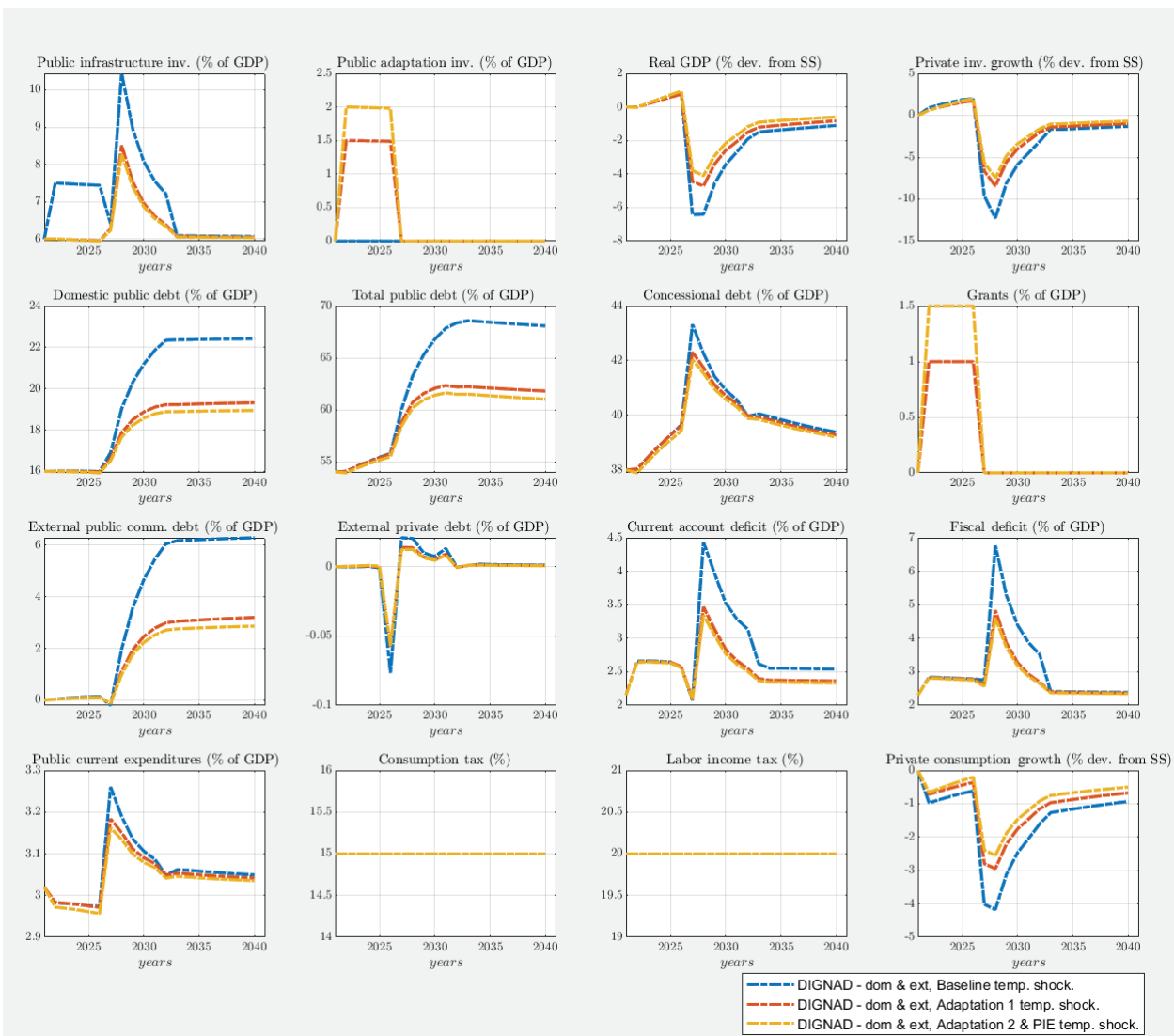
Impact of natural disaster	Natural disaster scenario	Damages and losses
	Impact of natural disaster on tradable output ? Specify destruction in %.	10.0
	Impact of natural disaster on nontradable output ? Specify destruction in %.	10.0
	Impact of natural disaster on reconstruction efficiency (%)	0.0
	Impact of natural disaster on external public debt risk premium ? (increase in percentage points)	0.0
	Impact of natural disaster on public capital (% of GDP)	10.0
	Impact of natural disaster on private capital (% of GDP)	10.0
	Share of damages to tradable sector capital (% total private capital damages)	50.0

Source: IMF staff.

government intends to rebuild its damaged infrastructure to its predisaster level in about five years (also in the Disasters sheet).

Step 5. Simulation: To obtain the model projections, the Simulation tool is run, either from the file "Run from excel.xlsm" or from the MATLAB interface, as described in the first two subsections of Section IV. After some preliminary checks, the simulation starts and automatically generates a graph or set of graphs with projections of major macro indicators. These are stored in the Figures output and Excel output folders. Figures 22 and 23 present the outputs for the "all debt" and "exogenous" (fiscal instruments) financing options. The legends present each investment option (baseline, adaptation 1, and adaptation 2) in different colors.

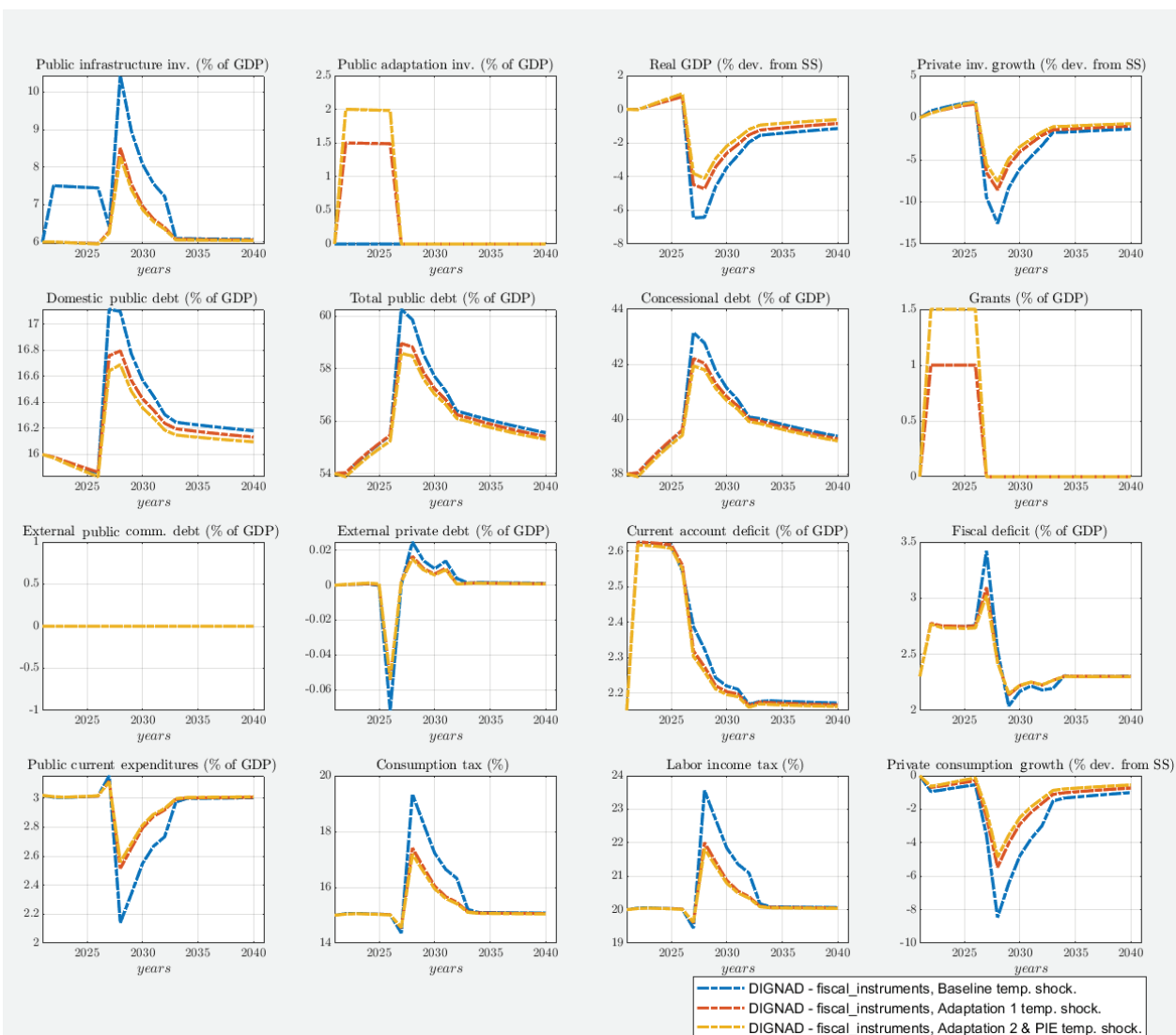
Figure 22. Simulation Results: All Debt Financing



Source: IMF staff.

Note: comm. = commercial; dev. = deviation; DIGNAD = Debt-Investment-Growth and Natural Disasters; dom & ext = domestic and external; inv. = investment; PIE = public investment efficiency; SS = steady state; temp. = temporary.

Figure 23. Simulation Results: Fiscal Instruments (Taxes and Transfers) Financing



Source: IMF staff.

Note: comm. = commercial; dev. = deviation; DIGNAD = Debt-Investment-Growth and Natural Disasters; dom & ext = domestic and external; inv. = investment; PIE = public investment efficiency; SS = steady state; temp. = temporary.

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