Public Investment and Debt Sustainability in Low-Income Countries

Hands-on Session

Ricardo Marto
Research Department

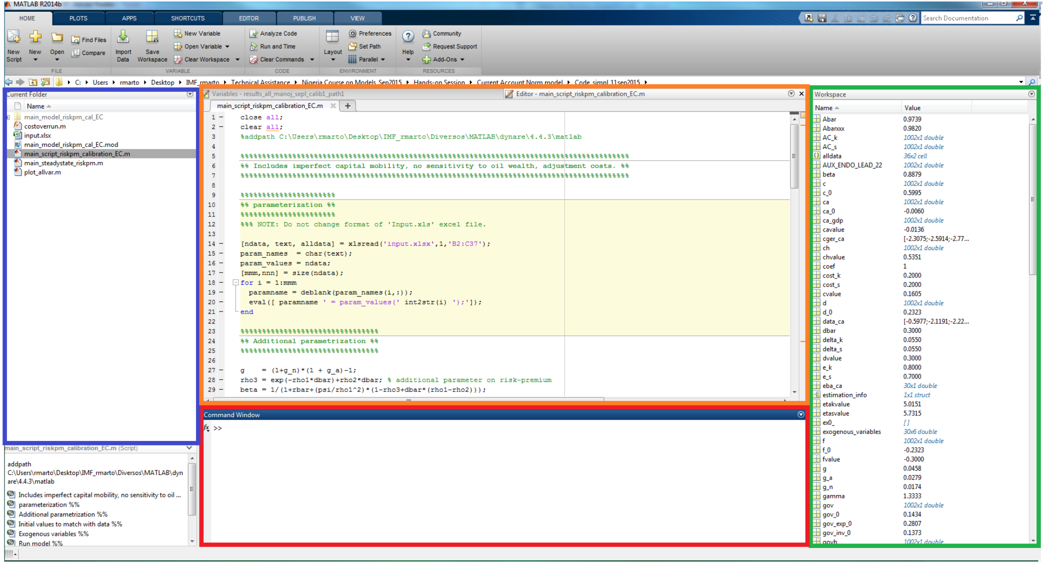
This work benefitted from financial support of the U.K.'s Department for International Development (DFID). The views expressed in this presentation are those of the authors and should not be attributed to the IMF, its Executive Board or its Management, nor to DFID.

Naivasha, Kenya
May 19, 2016

Outline

1. **A brief introduction to Matlab programming**
2. **The Debt, Public Investment, and Growth (DIG) Model in practice**
   - A Matlab-Excel template
   - Running scenarios
   - Do-it-yourself I

What you will face...



What you will face...

- Current folder: Shows the files contained in your current folder.
- Editor: Shows a file containing a series of commands (usually with the extension .m). The code written in the Editor can be run by pressing the F5 key or clicking on the green triangle icon in the Editor tab above.
- Command Window: Allows you to type in any input (commands with instructions) and shows the output of any requested operation.
- Workspace: Stores the objects created by your code (e.g. variables).They can be accessed by double-clicking on their icons or by typing the object's name in the Command Window.

A few examples of code...

Type the following on your Command Window:

```
% Creating your first variables
x = 4+7;
y = x^2;

% Creating your first matrix
M = [x 1/x; y 1];
N = M .* eye(2); % is a 2x2 diagonal matrix
[rows columns] = size(M);
```

```
% Creating your first figure
X = randn(30,1);
figure
plot((1986:2015)',X)
title('Kenya''s GDP growth')
legend('GDP growth')
xlabel('years')
ylabel('%')
close all;
```

A few examples of code...

```
% Creating your first if statement
P = [rand(5,1) rand(5,1)];
for i = 1:length(P)
    if P(i,1)>P(i,2)
        disp 'Portugal won the football match!'
    elseif P(i,1)==P(i,2)
        disp 'Kenya draw against Portugal!'
    else 'Kenya won the football match!'
    end
end
```

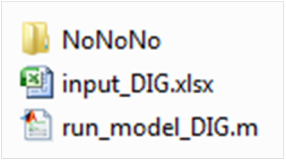
Setting up the toolboxes

- We need first to install (or better "set path") to Dynare and the CompEcon Toolbox.

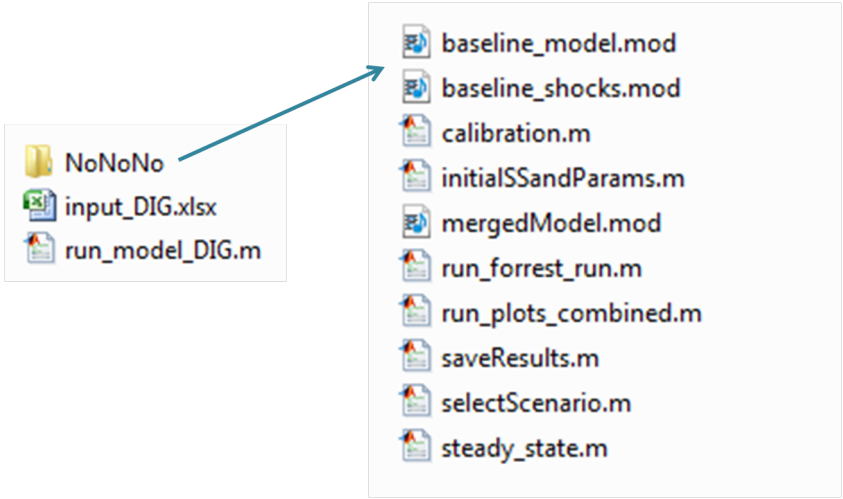
```
% Create a startup.m file, where you have the path to these toolboxes

addpath C:\Users\rmarto\Desktop\IMF_rmarto\Diversos\MATLAB\dynare\4.4.3\matlab

addpath C:\Users\rmarto\Desktop\IMF_rmarto\Diversos\MATLAB\COMPECON\CEtools
```

- Then save your `startup.m` file where you installed Matlab.

What you have in your DIG Model folder...

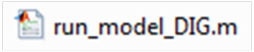


What you have in your DIG Model folder...

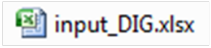


What you have in your DIG Model folder...

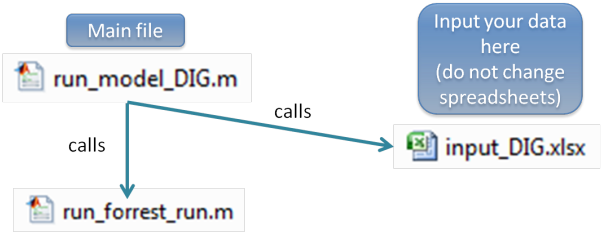
Main file



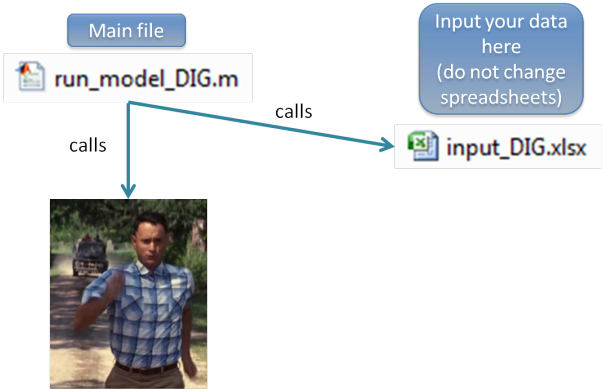
Input your data here (do not change spreadsheets)



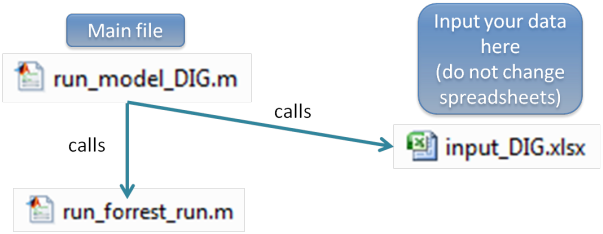
What you have in your DIG Model folder...



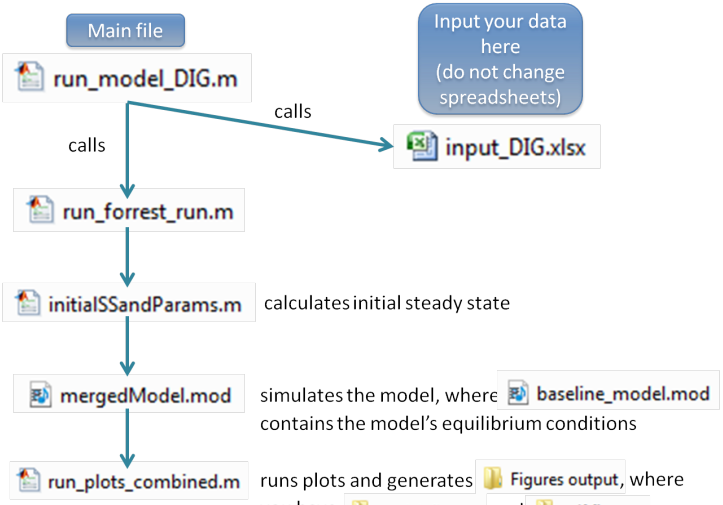
What you have in your DIG Model folder...



What you have in your DIG Model folder...



What you have in your DIG Model folder...



In Dynare...

- Dynare is a powerful toolbox to solve models in Matlab.
  - `dynare` yourfilename.mod `noclearall` (`noclearall` keeps the variables in the Workspace)

After some magic happens (i.e. Matlab/Dynare routines numerically solved your model), you will find in your Workspace:

- The results of your simulation, i.e. the time series for `y, c, i, ...`
- The Matlab structure `M_` containing variable names, parameter values, etc.
- The structure `oo_` containing the simulation output (endogenous variables, steady states, etc.)
- The structure `options_` containing specific options used for the computation (algorithms used, etc.)

You will also find in your Current folder:

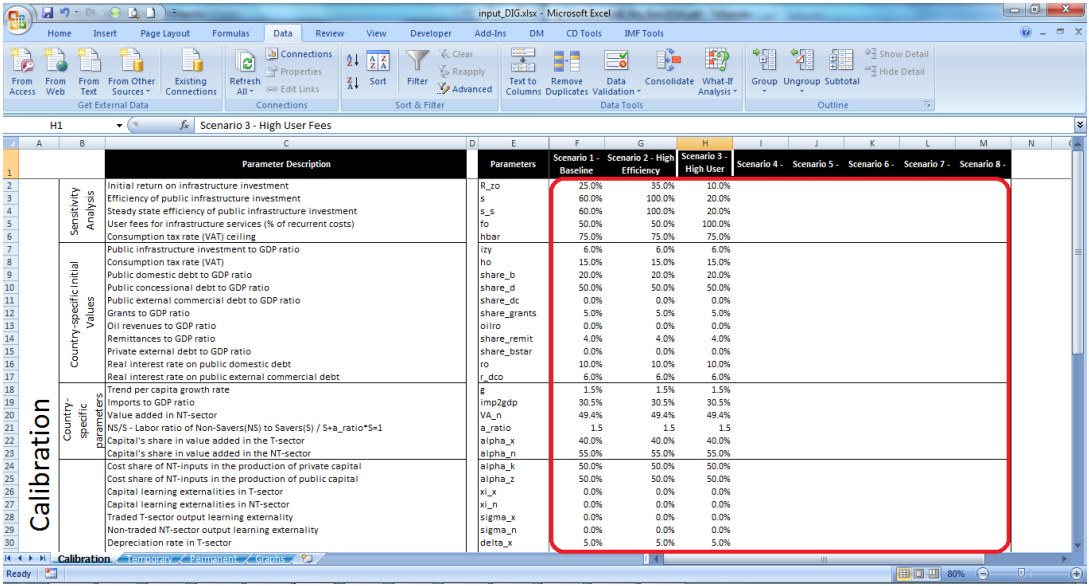
- A few m.files (e.g. yourfilename.m), containing the commands solving your model
  - Very useful when you made a mistake in the steady state / initial values for your model

In Excel...

- Calibration: Allows you to define your particular calibration for parameters and initial values.
- Temporary: Allows you to specify the path of public investment, grants, concessional debt, or terms of trade shocks for up to 50 periods.
- Scenario: Allows you to choose the combination of scenarios you want to run (different financing mechanisms, calibration, and shocks).
- Graphs: Allows you to choose what type of graphs you want, what variables to plot, etc.
- XLSoutput: Allows you to choose what variables to export to Excel.

Don't forget to close your Excel file.

Calibrate your parameters and initial values



input_DIG.xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer Add-Ins DM CD Tools IMF Tools

From Access | From Web | From Text | From Other Sources | Existing Connections | Refresh All | Connections | Properties | Edit Links | Sort | Filter | Clear | Reapply | Advanced | Text to Columns | Remove Duplicates | Data Validation | Consolidate | What-If Analysis | Group | Ungroup | Subtotal | Show Detail | Hide Detail

Get External Data | Connections | Sort & Filter | Data Tools | Outline

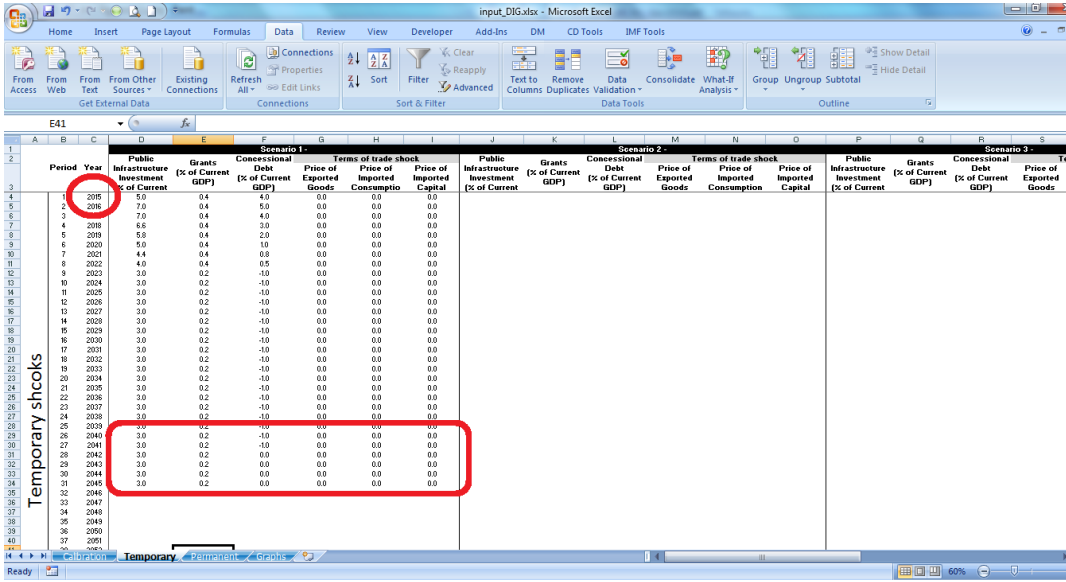
H1 — Scenario 3 - High User Fees

		Parameter Description	Parameters	Scenario 1 - Baseline	Scenario 2 - High Efficiency	Scenario 3 - High User	Scenario 4 -	Scenario 5 -	Scenario 6 -	Scenario 7 -	Scenario 8 -
Calibration	Sensitivity Analysis	Initial return on infrastructure investment	R_zo	25.0%	35.0%	10.0%					
		Efficiency of public infrastructure investment	s	60.0%	100.0%	20.0%					
		Steady state efficiency of public infrastructure investment	s_s	60.0%	100.0%	20.0%					
		User fees for infrastructure services (% of recurrent costs)	fo	50.0%	50.0%	100.0%					
		Consumption tax rate (VAT) ceiling	hbar	75.0%	75.0%	75.0%					
	Country-specific Initial Values	Public infrastructure investment to GDP ratio	izy	6.0%	6.0%	6.0%					
		Consumption tax rate (VAT)	ho	15.0%	15.0%	15.0%					
		Public domestic debt to GDP ratio	share_b	20.0%	20.0%	20.0%					
		Public concessional debt to GDP ratio	share_d	50.0%	50.0%	50.0%					
		Public external commercial debt to GDP ratio	share_dc	0.0%	0.0%	0.0%					
		Grants to GDP ratio	share_grants	5.0%	5.0%	5.0%					
		Oil revenues to GDP ratio	oilro	0.0%	0.0%	0.0%					
		Remittances to GDP ratio	share_remit	4.0%	4.0%	4.0%					
		Private external debt to GDP ratio	share_bstar	0.0%	0.0%	0.0%					
		Real interest rate on public domestic debt	ro	10.0%	10.0%	10.0%					
		Real interest rate on public external commercial debt	r_dco	6.0%	6.0%	6.0%					
	Country-specific parameters	Trend per capita growth rate	g	1.5%	1.5%	1.5%					
		Imports to GDP ratio	imp2gdp	30.5%	30.5%	30.5%					
		Value added in NT-sector	VA_n	49.4%	49.4%	49.4%					
		NS/S - Labor ratio of Non-Savers(NS) to Savers(S) / S+a_ratio*S=1	a_ratio	1.5	1.5	1.5					
		Capital's share in value added in the T-sector	alpha_x	40.0%	40.0%	40.0%					
		Capital's share in value added in the NT-sector	alpha_n	55.0%	55.0%	55.0%					
		Cost share of NT-inputs in the production of private capital	alpha_k	50.0%	50.0%	50.0%					
		Cost share of NT-inputs in the production of public capital	alpha_z	50.0%	50.0%	50.0%					
		Capital learning externalities in T-sector	xi_x	0.0%	0.0%	0.0%					
		Capital learning externalities in NT-sector	xi_n	0.0%	0.0%	0.0%					
		Traded T-sector output learning externality	sigma_x	0.0%	0.0%	0.0%					
		Non-traded NT-sector output learning externality	sigma_n	0.0%	0.0%	0.0%					
		Depreciation rate in T-sector	delta_x	5.0%	5.0%	5.0%					

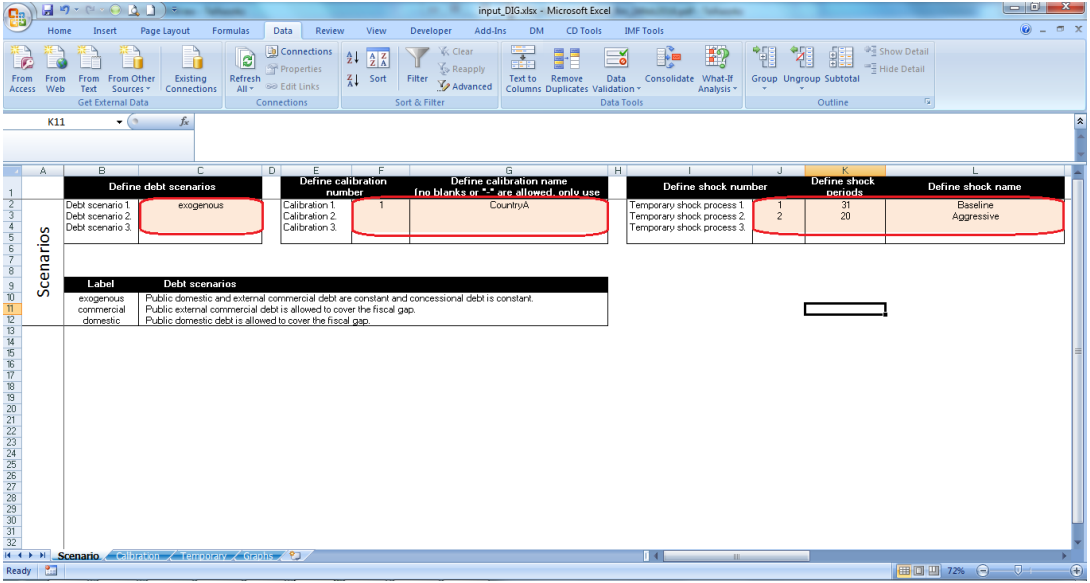
Calibration | Economy | Population | Grids

Ready — 80%

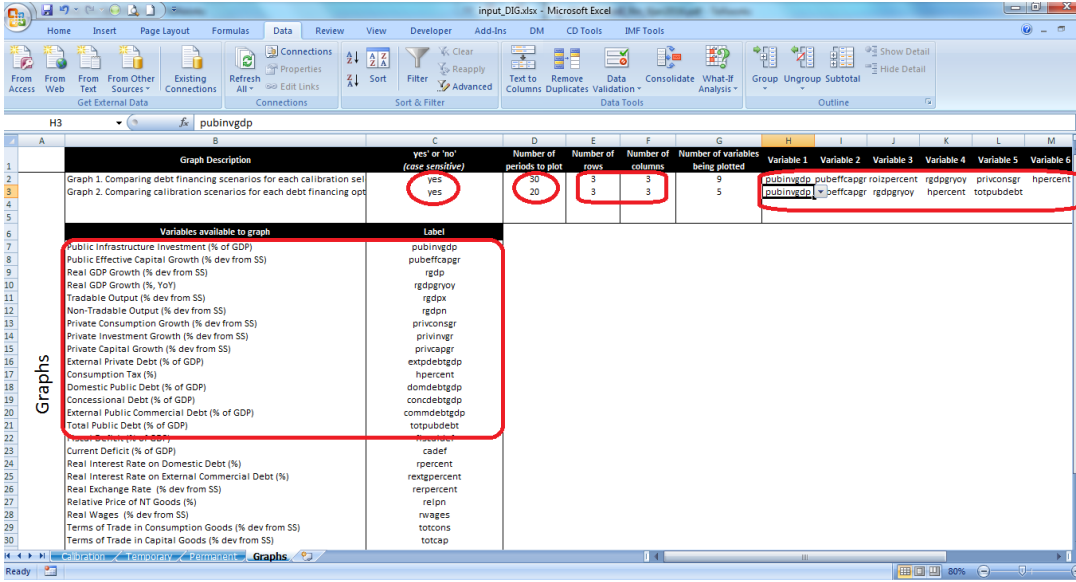
Define the path for your exogenous variables (up to 50 periods)



Select the scenarios you want to run



Define your graph options



input_DIG.xlsx - Microsoft Excel

Home | Insert | Page Layout | Formulas | Data | Review | View | Developer | Add-Ins | DM | CD Tools | IMF Tools

Get External Data | Connections | Sort & Filter | Data Tools | Outline

H3: pubinvgdp

	Graph Description	yes' or 'no' (case sensitive)	Number of periods to plot	Number of rows	Number of columns	Number of variables being plotted	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6
2	Graph 1. Comparing debt financing scenarios for each calibration sel	yes	30	3	3	9	pubinvgdp	pubeffcapgr	rolzpercent	rgdpgryoy	privconsgr	hpercent
3	Graph 2. Comparing calibration scenarios for each debt financing opt	yes	20	3	3	5	pubinvgdp	beffcapgr	rgdpgryoy	hpercent	totpubdebt	

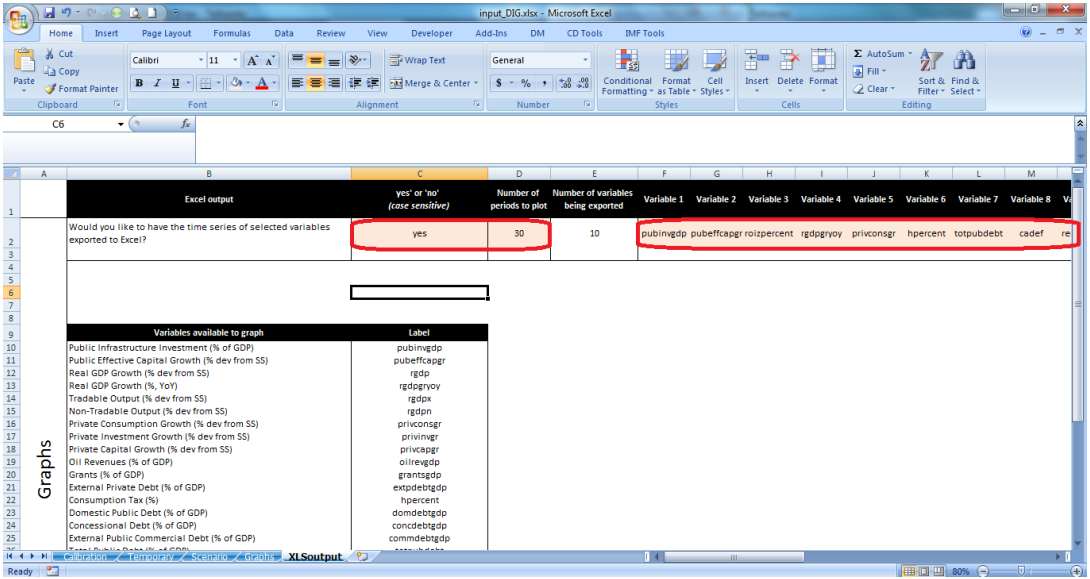
Graphs

Variables available to graph	Label
Public Infrastructure Investment (% of GDP)	pubinvgdp
Public Effective Capital Growth (% dev from SS)	pubeffcapgr
Real GDP Growth (% dev from SS)	rgdp
Real GDP Growth (%, YoY)	rgdpgryoy
Tradable Output (% dev from SS)	rgdpx
Non-Tradable Output (% dev from SS)	rgdpn
Private Consumption Growth (% dev from SS)	privconsgr
Private Investment Growth (% dev from SS)	privinvgr
Private Capital Growth (% dev from SS)	privcapgr
External Private Debt (% of GDP)	extpdebtgdp
Consumption Tax (%)	hpercent
Domestic Public Debt (% of GDP)	domdebtgdp
Concessional Debt (% of GDP)	concdebtgdp
External Public Commercial Debt (% of GDP)	commdebtgdp
Total Public Debt (% of GDP)	totpubdebt
Public Deficit (% of GDP)	pubdef
Current 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
Relative Price of NT Goods (%)	relpn
Real Wages (% dev from SS)	rwages
Terms of Trade in Consumption Goods (% dev from SS)	totcons
Terms of Trade in Capital Goods (% dev from SS)	totcap

Calibration | Temporary | Permanent | Graphs

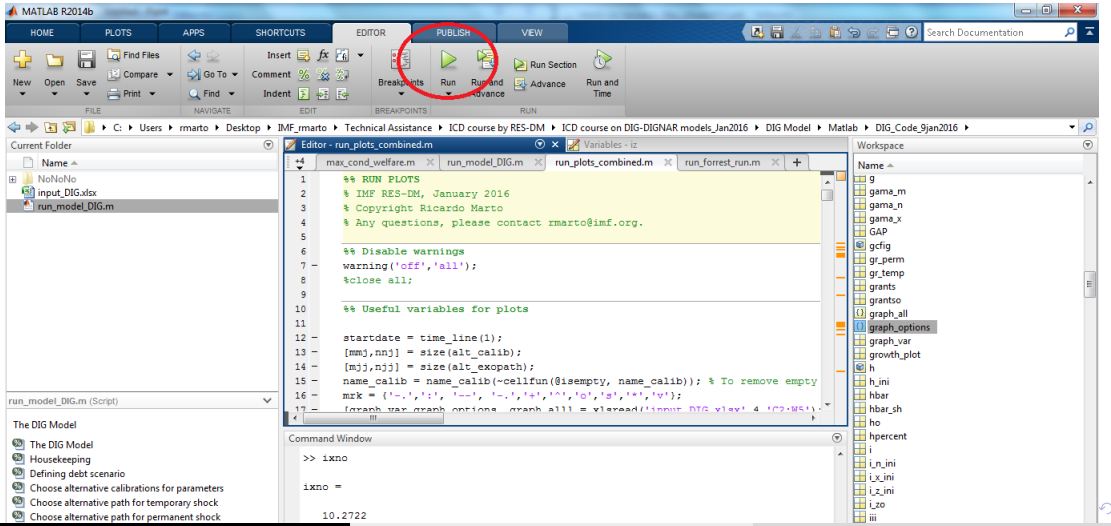
Ready | 80%

Export the path for selected variables



And once you are ready, run your model

- Run your Matlab file: Press `F5` in the Editor Window or type `run_model_DIG` in the Command Window.



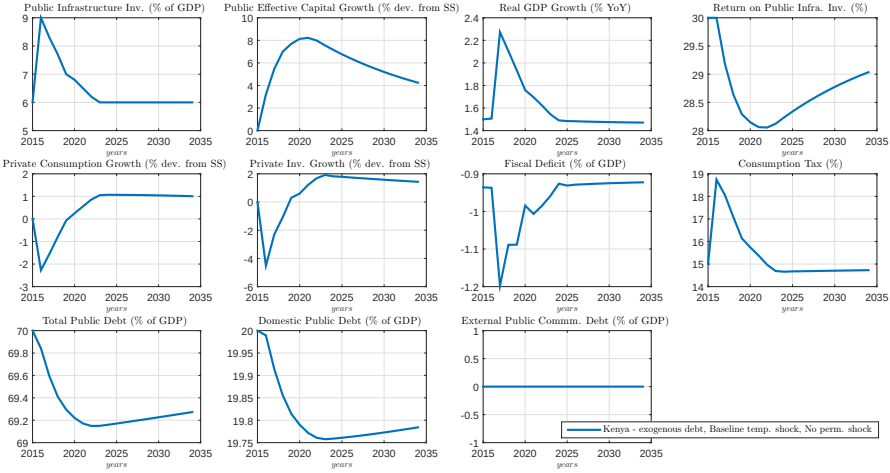
Example 1.a. Baseline calibration with public investment shock and no debt

Let's run the baseline scenario with an increase in public infrastructure investment.

- In Excel:
  - Keep baseline calibration and shock
  - Debt scenario: exogenous
  - Calibration: 1; and give it a name
  - Temporary shock: 1 for 7 periods, and give it a name
  - Choose graph and variables to plot (pubinvgdp, pubeffcapgr, rgdpgryoy, roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, domdebtgdp, commdebtgdp)
  - Choose same variables to export to excel

Example 1.a. Baseline calibration with public investment shock and no debt

You should have obtained the following figure:



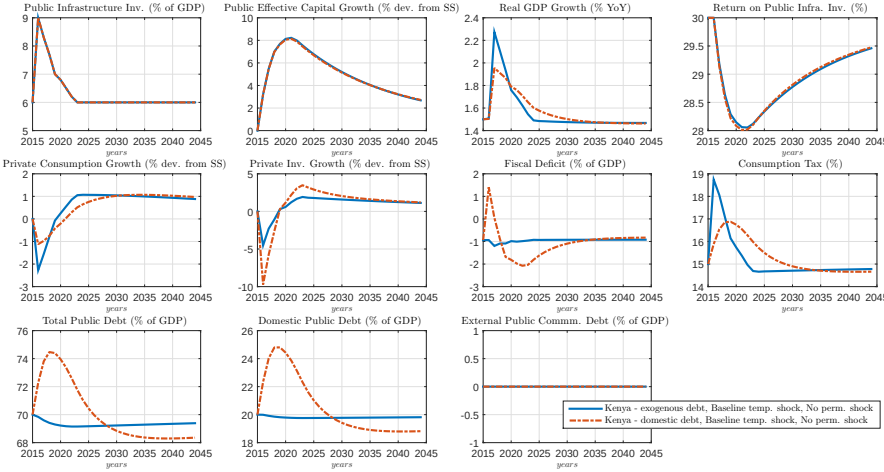
Example 1.b. Baseline calibration with public investment shock and domestic debt adjustments

Comapre the previous example with the same baseline scenario with an increase in public investment but with endogenous domestic debt.

- In Excel:
  - Keep baseline calibration and shock
  - Debt scenario: (i) exogenous and (ii) domestic
  - Calibration: 1; and give it a name
  - Temporary shock: 1 for 7 periods, and give it a name
  - Choose graph and variables to plot (pubinvgdp, pubeffcapgr, rgdpgryoy, roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, domdebtgdp, commdebtgdp)
  - Choose same variables to export to excel

Example 1.b. Baseline calibration with public investment shock and domestic debt adjustments

You should have obtained the following figure:



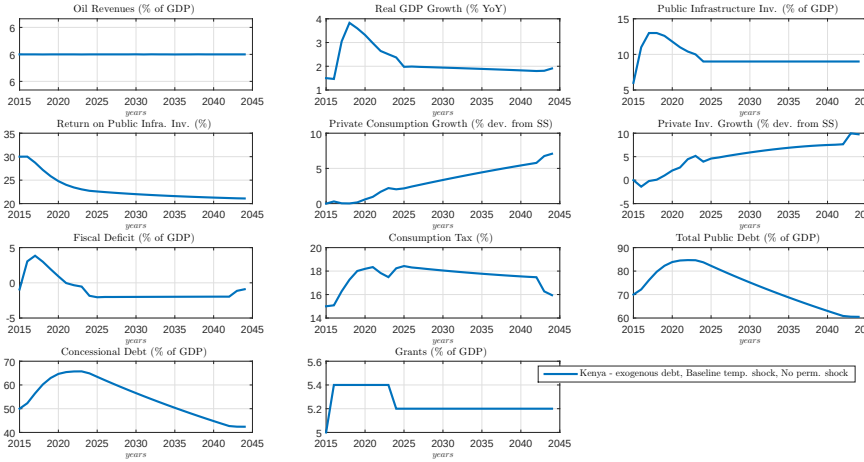
Example 2.a. Baseline scenario with public investment scaling up and concessional debt

Let's run the baseline scenario with unconstrained consumption tax and exogenous debt (only concessional debt), and with public investment and grants increase.

- In Excel:
  - No need to adjust your calibration and shocks
  - Debt scenario: exogenous
  - Calibration: 1; and give it a name
  - Temporary shock: 2 for 31 periods, and give it a name
  - Choose graph and variables to plot (oilrevgdp, rgdpgryoy, pubinvgdp,roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, concdebtgdp, grantsgdp)
  - Choose same variables to export to excel

Example 2.a. Baseline scenario with public investment scaling up and concessional debt

You should have obtained the following figure:



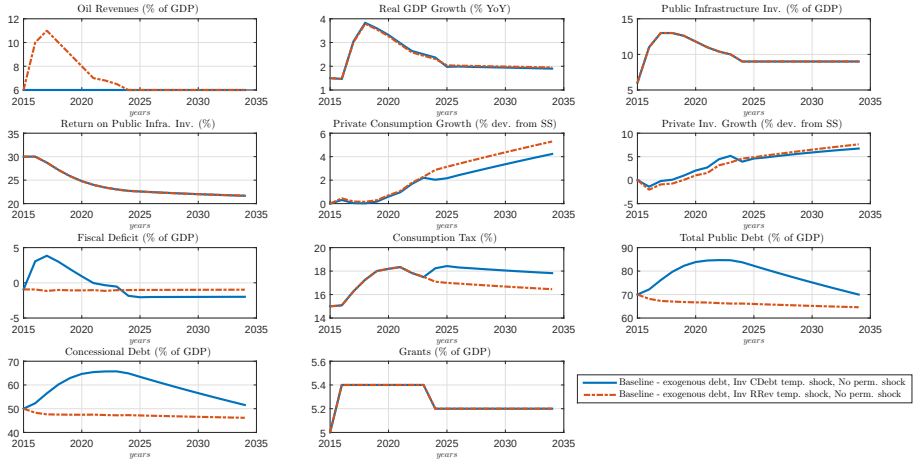
Example 2.b. Baseline scenario with public investment scaling up and natural resource revenue shock

Compare the previous scenario with unconstrained consumption tax and exogenous debt, and with public investment, natural resource revenue, and grants increase.

- In Excel:
  - No need to adjust your calibration and shocks
  - Debt scenario: exogenous
  - Calibration: 1; and give it a name
  - Temporary shock: 2 and 3, both for 31 periods, and give them names
  - Choose graph and variables to plot (oilrevgdp, rgdpgryoy, pubinvgdp,roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, concdebtgdp, grantsgdp)
  - Choose same variables to export to excel

Example 2.b. Baseline scenario with public investment scaling up and natural resource revenue shock

You should have obtained the following figure:



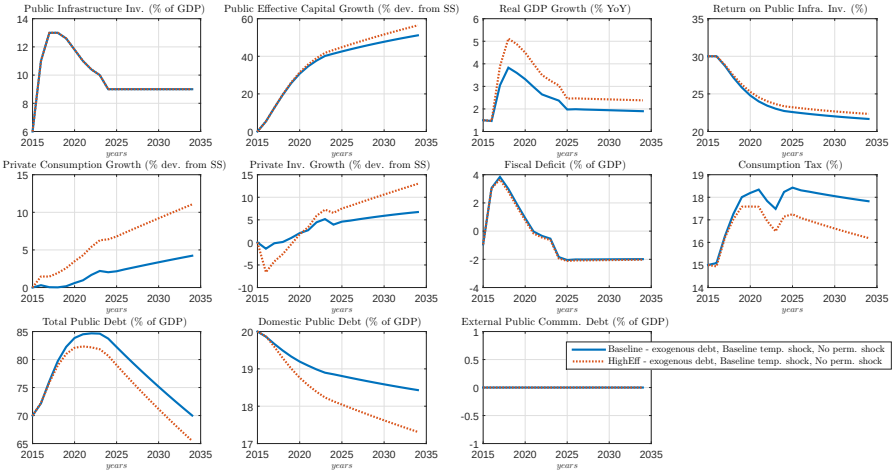
Example 3.a. Baseline scenario vs. High efficiency scenario

Compare the previous scenario (2.a) with one where efficiency is 100% and same return on public infrastructure (still unconstrained consumption tax and exogenous debt).

- In Excel:
  - Copy/paste calibration 1 in calibration 2 and adjust efficiency
  - No need to adjust your shocks
  - Debt scenario: exogenous
  - Calibration: 1 and 2; give them names
  - Temporary shock: 2 for 31 periods, and give it a name
  - Choose graph and variables to plot (pubinvgdp, pubeffcapgr, rgdpgryoy, roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, domdebtgdp, commdebtgdp)
  - Choose same variables to export to excel

Example 3.a. Baseline scenario vs. High efficiency scenario

You should have obtained the following figure:



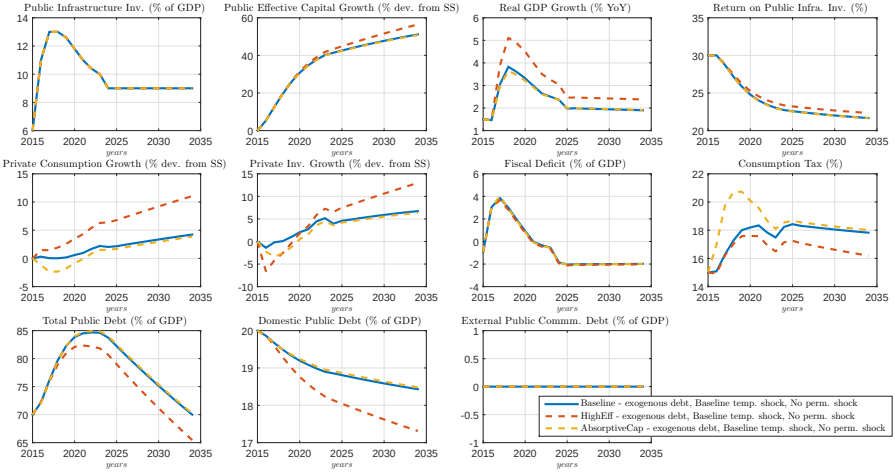
Example 3.b. Baseline scenario vs. Absorptive capacity constraints

Compare the previous scenario (3.a) with one where absorptive capacity constraints are high (i.e. $\phi = 5$) and same return on public infrastructure (still unconstrained consumption tax and exogenous debt).

- In Excel:
  - Copy/paste calibration 1 in calibration 3 and adjust the severity of absorptive capacity constraints
  - No need to adjust your shocks
  - Debt scenario: exogenous
  - Calibration: 1 and 2; give them names
  - Temporary shock: 2 for 31 periods, and give it a name
  - Choose graph and variables to plot (pubinvgdp, pubeffcapgr, rgdpgryoy, roizpercent, privconsgr, privinvgr, fiscaldef, hpercent, totpubdebt, domdebtgdp, commdebtgdp)
  - Choose same variables to export to excel

Example 3.b. Baseline scenario vs. Absorptive capacity constraints

You should have obtained the following figure:

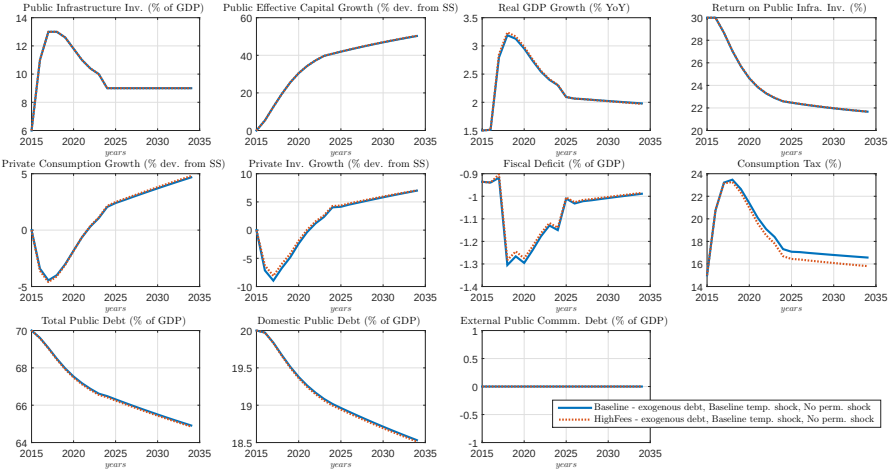


Exercises

- Run the following scenarios:
  1. Suppose the government wants to increase user fees for public infrastructure to 100% and intends to finance its public investment plan solely with grants.
     Simulate your scenarios, comparing this assumption with the baseline calibration.
  2. Suppose the government wants to compare the effects of financing their public investment scaling up with either commercial or domestic debt financing (for baseline calibration and unconstrained taxes).
     Simulate your scenarios, using the exogenous shock processes provided in example 2.a.
  3. Suppose the government wants to compare the effects of financing their public investment scaling up with a cap on the VAT rate at 17% with commercial debt financing (for baseline calibration).
     Simulate your scenarios, using the exogenous shock processes provided in example 2.a.
  4. Suppose the goverment expects terms of trade to deteriorate from period 6 to 25, with the price index of exported goods decreasing 10% and of imported consumption and capital goods increasing 20% (with external commercial debt and unconstrained taxes).
     Simulate your scenarios, using the exogenous shock processes provided in example 2.b.

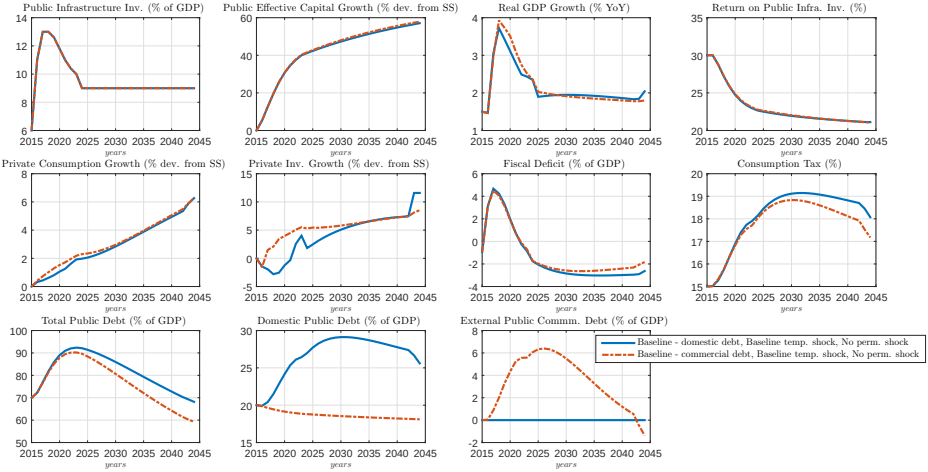
Exercise 1

You should have obtained the following figure:



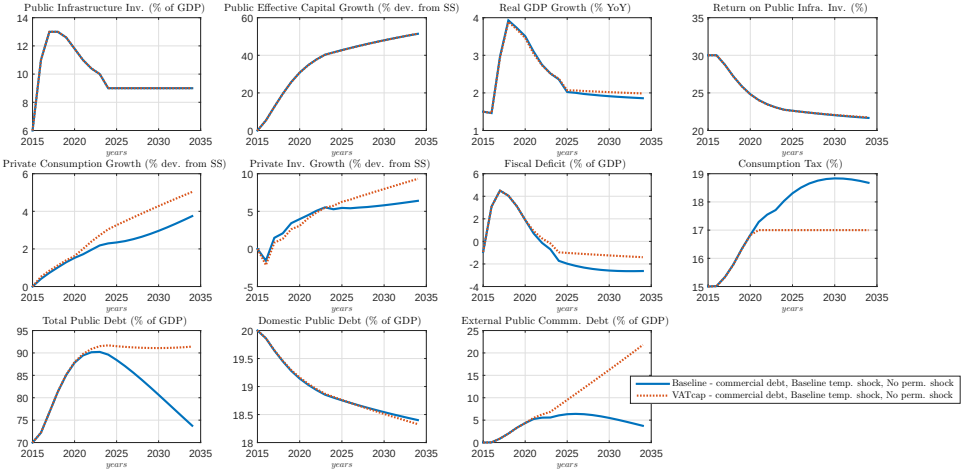
Exercise 2

You should have obtained the following figure:



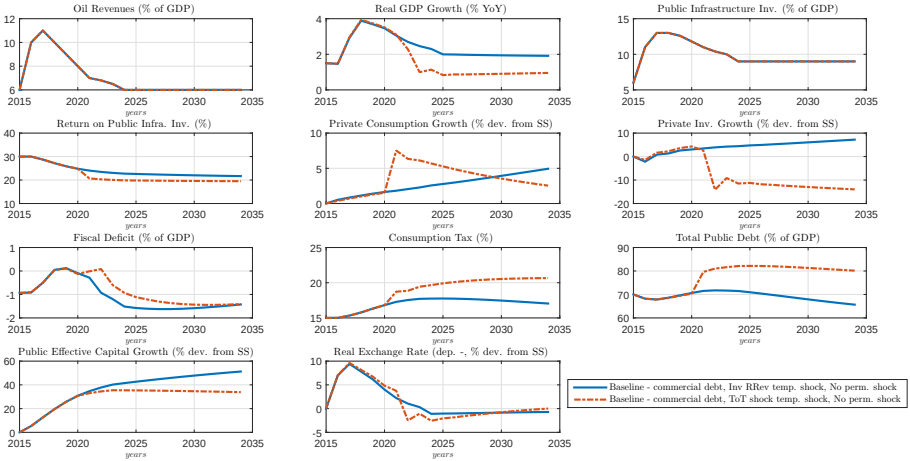
Exercise 3

You should have obtained the following figure:



Exercise 4

You should have obtained the following figure:



Asante sana!