GEM-Core User Guide

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1. Introduction

In this document we describe how to implement the GAMS code of GEM-Core, a recursive dynamic small open economy computable general equilibrium (CGE) model developed in the context for the World Bank. The detailed description of the model can be found in Lofgren and Cicowiez (2017). The model is easy to implement through the ISIM version 2 interface (see Cicowiez et al., 2013).

2. GAMS Code Organization

The GEM-Core CGE model was developed as a "standard" model, meaning that the same model can be implemented using various datasets. In other words, the "theory" of the model is completely separated from the data that is used for model calibration. In fact, certain characteristics of the GEM- Core CGE model (e.g., the existence of unemployment) can be active or not depending on the dataset set that is used to make the model operational.

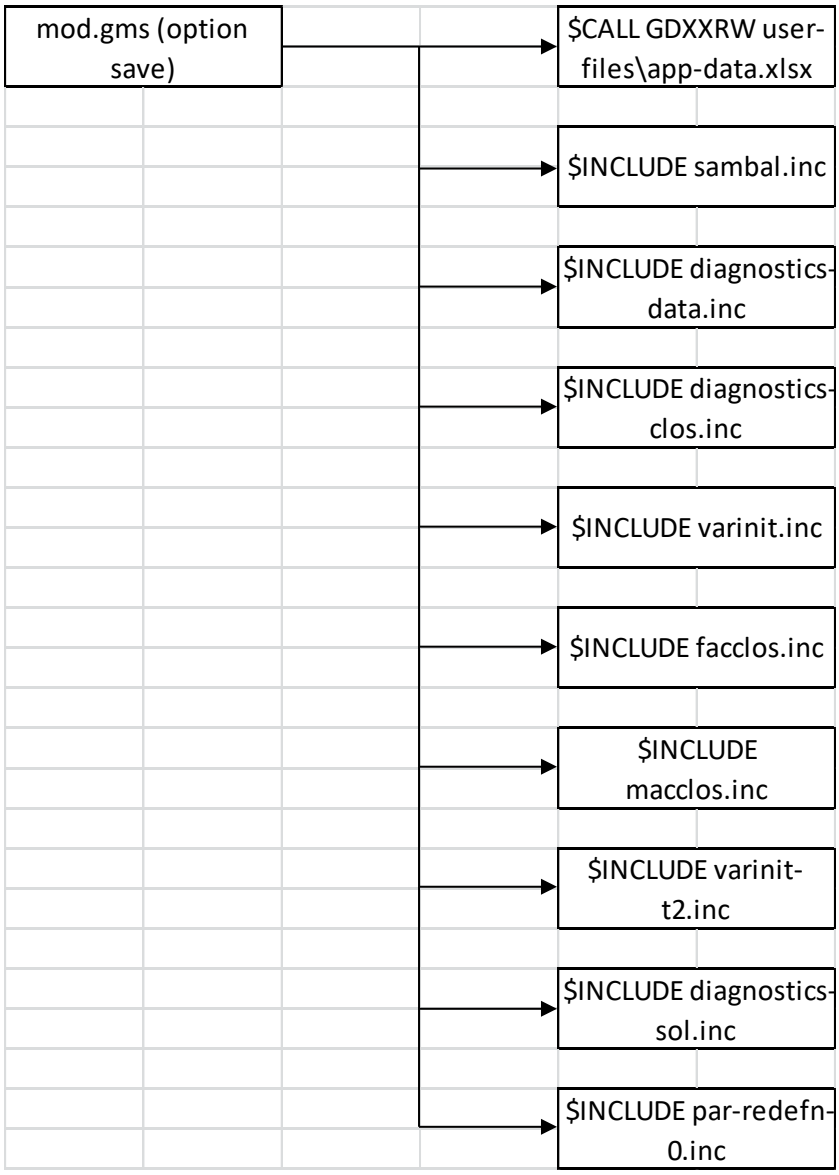
In Figure 2.1 we show how the GAMS files of the model are organized. As can be seen, we use a "modular" approach where some parts of the code are re-utilized. The GAMS model code is organized around three main files: mod.gms, sim.gms, and rep.gms. The file mod.gms defines and calibrates the model, replicating the information in the social accounting matrix (SAM) in order to verify the consistency between data and model, and generate the (dynamic) reference scenario. The data that is used for this first step is saved in an Excel file, typically named app-data.xlsx where app represents the name of the GEM-Core CGE model application (e.g., arm2013-data.xlsx). The file sim.gms runs the user-defined simulation scenarios. The definition of the simulation scenarios is made using another Excel file, typically named app-sim.xlsx (e.g., arm2013-sim.xlsx). Finally, the file rep.gms generates several of the report parameters that show up, at

the end of model execution, in the file rep1-disp-gdx.gdx, which can be inspected using the GAMSIDE or the ISIM own GDX viewer. (In what follows, the scenario that results from running mod.gms is called “reference scenario”. In turn, sim.gms runs the “base scenario”, which usually will be the same as the reference scenario. However, below we explain the reasons for making such a distinction between the reference and the base scenarios.)

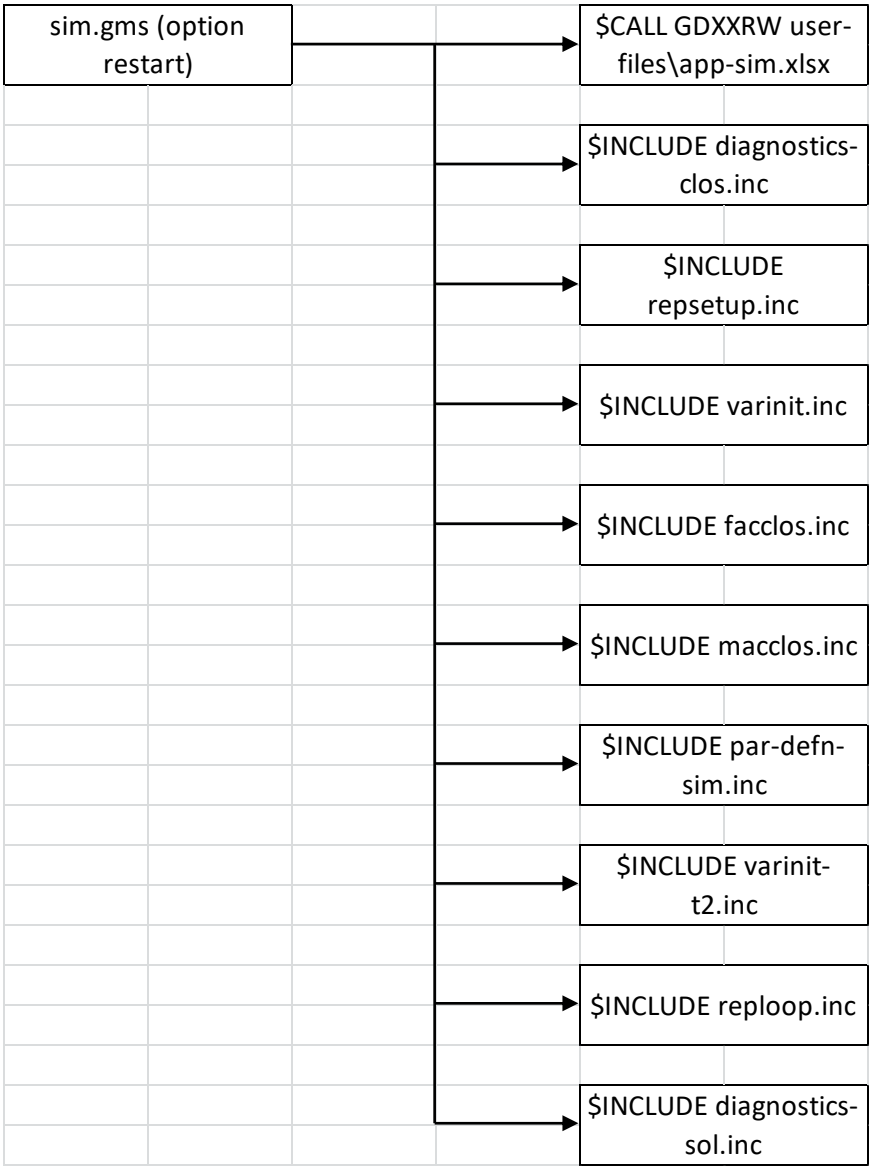
On the other hand, when the GEM-Core CGE model is ran through the ISIM interface, the software takes care of running the three GAMS files mentioned in the previous paragraph. Thus, when using ISIM, the user does not need to worry about knowing the GAMS modeling language.

Figure 2.1: organization of GAMS files for GEM-Core CGE model

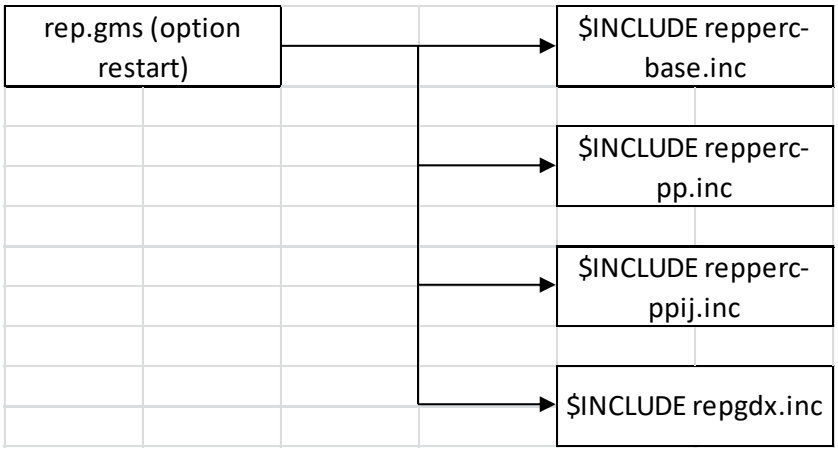
Panel (a) – mod.gms



Panel (b) – sim.gms



Panel (c) – rep.gms



The installation of the GEM-Core CGE model implies unzipping the distributed file (generally, GEM-Core-in-GAMS-yyyy-mm-dd.zip) in a dedicated folder. As was described, the following three files should be executed sequentially in order to run the GEM-Core CGE model:

mod.gms with the command line option s=save\mod

sim.gms with the command line option r=save\mod s=save\sim

rep.gms with the command line option r=save\sim s=save\rep

As an example, Figure 2.2 shows how the GAMSIDE window should look when running mod.gms. The workings of the GAMS interface is described in Help | docs | tools | gamside.pdf. As explained, the steps described are not needed when the model is run through ISIM.[1]

Figure 2.2. Execution of mod.gms

3. Steps to Implement the GEM-Trade

In this section, the steps required to implement the GEM-Core CGE model with a new dataset are described. Generally, we recommend saving the files created by the user in the folder "user-files". In the most common case, the next steps should be followed:

i) create copies of the files demo-data.xlsx and demo-sim.xlsx that are located in the user-files folder;

[1] In the document "Instructions to Add the GEM-Core Model to ISIM" the steps required to add the GEM-Core model to ISIM are explained in detail.

ii) rename the file copies made in the previous step to something like arg2012-data.xlsx and arg2012-sim.xlsx, where arg2012 refers to the name that is given to the new application of the GEM-Core CGE model;

iii) in the file mod.gms, add the sentence $SET app2 arg2012 where it is indicated.

In our case, the distributed model contains, besides the two example datasets (i.e., demo and demo2), another with the data for Armenia with 2013 as its base year.

In case of using the model through ISIM, see Cicowiez et al. (2013). Specifically, see the section that explains how to add a new dataset to an existing model in the interface.

4. Data File

In this section we describe the content of each of the sheets in the Excel that contains the information used to calibrate the model. As section titles, we used the name of each Excel sheet together with the name of the parameter that defines, identifying its set dimensions.

dmod -- dmod

In this sheet the user selects the version of the model that will be used. The valid values for this parameter are

- **dmod=0** to use the model in "static mode"; in this case, the shocks to be simulated should be introduced for the first year in the set t (see below).
- **dmod=1** to use the dynamic version of the model under the assumption that the baseline generation is conducted by imposing an exogenous rate of GDP at factor cost growth, at the same time that total factor productivity is considered an endogenous variable. Besides, the user can specify growth rates and/or GDP shares for other exogenous variables such as labor supply, land supply, government consumption, among others. It is worth mentioning that for the simulation scenarios the rate of GDP growth is always endogenous.
- **dmod=2** to use the dynamic version of the model assuming that the reference scenario is generated under the assumption that the modeled economy is on a balanced growth path; in this case, the growth rate specified in the

sheet/parameter ssgrw (see below) is applied to all quantities in the model – except factor endowments if fprdgrw is not zero (see below) --, at the same time that relative prices stayed unchanged.

time-related-sets

In this dynamic model, we use sets t and tsol(t) (see Table 4.1). The set t refers to all periods for which the model can (potentially) be solved. In turn, set tsol(t) contains the periods for which the model is actually solved. For example, when designing the scenarios, the analyst can run the model for only a few periods using tsol(t) with the aim of speeding up the debugging process.

Tabla 4.1: time sets

set	descripción
t	all periods
tsol(t)	solution periods

global-set

The set ac contains all the accounts in the social accounting matrix, together with additional elements such as reserved keywords that are used to make reference to government consumption (i.e., congov), products not in the SAM but that are defined through the mapaggreg mapping (see below), among others.

sam-related-sets

In Table 4.2 we show the list of sets that are defined in the Excel data file used for model calibration. The remaining model sets are automatically defined in the GAMS model code. The x(y) notation implies that set x is a subset of set y, meaning that all elements of set x should also be elements of set y. It is relevant to note the presence of set r(ac), which contains the trade partners of the modeled country identified in the SAM. In this model we have minimized the number of mandatory names for SAM accounts. For example, the name of the SAM account that refers to direct taxes can be chosen arbitrarily, provided it complies with GAMS restrictions for set elements. Then, that name should be introduced in the set taxdir(actax). On the other hand, an account

named “total” is mandatory, as it is explicitly referenced (i.e., it is hard-coded) in the GAMS model code (see file mod.gms).

Table 4.2: sets for reading the SAM

set	description
a(ac)	activities
c(ac)	commodities
tacd(ac)	domestic trade and transport margin account
tacm(ac)	import trade and transport margin account
tace(ac)	export trade and transport margin account
f(ac)	factors
flab(f)	factors labor
fcap(f)	factors capital
fcapng(fcap)	factors capital non-government
fcapg(fcap)	factors capital government
ins(ac)	institutions
insd(ins)	domestic institutions
insdng(insd)	domestic non-government institutions
h(insdng)	households
insngo(insdng)	non-gov organization institutions
insgov(insd)	enterprises
insrow(ins)	rest of the world
capins(ac)	institutions capital accounts
capinsd(capins)	domestic institutions capital accounts
capgov(capinsd)	government capital account
capfin(ac)	financial institution capital account
actax(ac)	all taxes
taxvatc(actax)	value-added tax
taxcom(actax)	sales tax
taxact(actax)	tax on producer gross output value
taxdir(actax)	direct tax on dom inst ins
taximp(actax)	import tariff
taxexp(actax)	export tax
taxfac(actax)	direct tax on factors (soc sec tax)
subcom(acgovspnd)	commodity demand subsidies
inv(ac)	investment accounts
invng(inv)	non-government investment
invg(inv)	government investment
invginf(invg)	government investment in infrastructure
dstk(ac)	changes in inventories

sam – SAM(ac,acp)

In this sheet, the social accounting matrix that will be used to calibrate the model is stored. Generally speaking, it advisable that no large differences exist between the maximum and the minimum values in the SAM. In addition, it is preferable that values in the SAM do not exceed the number 99999. Doing this, the SOLVE performance when searching for a model solution is improved. To that end, the sheet "scaling" can be used to re-scale the SAM (see below), if necessary.

mapaggreg – mapaggreg(ac,acp)

In this sheet the user can aggregate accounts of the social accounting matrix. Specifically, account ac in SAM and other parts of database is aggregated to acp. For example, Figure 4.1 shows how the tax-vat and sub-com accounts can be excluded from the model by aggregating their content with the tax-com account.

Figure 4.1. Example of mapaggreg

mapaggreg(ac,acp)		**account ac i**
sub-act	tax-act	YES
tax-vat	tax-com	YES
sub-com	tax-com	YES

mcapins -- mcapins(capins,ins)

In this sheet SAM accounts that represent institutional capital accounts (i.e., elements in the set capins) are linked to SAM accounts that represent institutions (e.g., households, government, and rest of the world) (i.e., elements in the set ins). As an example, see Figure 4.2.

Figure 4.2. Example of mapaggreg

mcapins(capins,ins)		
cap-hhd	hhd	YES
cap-gov	gov	YES
cap-row	row	YES

mtfactf -- mtfactf(taxfact,f)

In case the SAM identifies taxes on factor use, this sheet is used to establish a mapping between accounts in the SAM that refer to taxes on factor use by the activities (see rows in Figure 4.3) and the accounts in the SAM that refer to factors (see columns in Figure 4.3). In other words, this mapping is used to identify which is the tax base for each of the taxes on factor use that exist in the SAM. As shown in Figure 4.3, YES is used to establish a relation between elements in rows and columns; each tax account can only be related to one factor.

Figure 4.3. Example of maptfactf

mtfactf(taxfact,f)		
	f-calif-for	f-ncalif-for
tax-calif	YES	
tax-ncalif		YES

mfcapinv -- mfcapinv(fcap,invng)

In this sheet SAM accounts that represent capital factors (i.e., elements in the set fcap) are linked to SAM accounts that represents non-government investments (e.g., those made by private and/or public enterprises) (i.e., elements in the set invng). As an example, see Figure 4.4. It is worth mentioning that each investment account can be linked to one capital account. Similarly, each capital account can be linked to one investment account. Note that the user can use the mapping mapaggreg to overcome those restrictions. In panel b of Figure 4.4 we show the case of a dataset with only one non-government capital and investment accounts.

Figure 4.4a. Example of mfcapinv

mfcapinv(fcap,invng)		
f-cap	invprv-otr	YES
f-capgenterm-g	invg-genterm	YES
f-capgenhidro-g	invg-genhidro	YES
f-capgenterm-ng	invprv-genterm	YES
f-captrnsele	invg-trnele	YES
f-capgengeoterm-ng	invprv-gengeoterm	YES
f-capdistele	invprv-distele	YES

Figure 4.4b. Example mfcapinv

mfcapinv(fcap,invng)		
f-cap	invng	YES

msubcom -- msubcom(c,ac)

In this sheet the user identifies the model agents (i.e., activities, households, government and investment) that receive consumption subsidies. Obviously, the information in msubcom is only relevant when the SAM records consumption subsidies in a dedicated account; i.e., not as net commodity taxes. Figure 4.5 shows an example.

Figure 4.5. Example of msubcom

msubcom(c,ac)	demander ac
	hhd
c-ele	YES
c-wtsn	YES
c-trns	YES
c-comunic	YES
c-otrsvc	YES

dinam – dinam(ac,acp)

In this sheet information relevant for the dynamic version of the model is introduced (see Figure 4.6). Row kappa provides the value of the parameter that refers to the speed with which the new capital can move across sectors. Row netprfrat provides the value of the net profit rate for non-government capital, which is used to estimate the initial capital stocks when dmod=1 (see dmod above).

Figure 4.6. Example of dinam

dinam(ac)	
kappa	0.50
netprfrat	0.15

deprcap -- deprcap(fcap)

In this sheet depreciation rates for public (in the example, row f-capg) and private (in the example, row f-cap) are introduced. Based on available estimates, the former is typically smaller than the last one. As an example, see Figure 4.7.

Figure 4.7. Example of deprcap

deprcap(fcap)	
f-cap	0.04
f-capg	0.025

ssgrw – ssgrw(ac)

In this sheet the user can introduce the GDP growth rate that is imposed when it is assumed that the economy evolves in the baseline according to a balance growth path (i.e., in case dmod=2 is selected; see dmod above). Optionally, the user can also introduce a growth rate for labor factor endowments. In such a case, the labor productivity growth rate (fprdgrw(flab,t)) is computed as

fprdgrw(flab,t) = (1+ssgrw('gdp'))/(1+ssgrw('qlab')) - 1

In other words, when dmod=2, the growth rate in ssgrw is applied to all elements in the model that grow at an exogenous growth rate, except labor endowments if data for ssgrw('qlab') is provided. Thus, it is ensured that the economy is on a balanced growth path. For an example, see Figure 4.8.

Figure 4.8. Example of ssgrw

ssgrw(ac)	
gdp	0.035
qlab	0.0250

gdpgrw -- gdpgrw(t)

In this sheet the user introduces the GDP at factor cost annual growth rate that will be imposed in the baseline when dmod=1; i.e., when the user assumes that the economy is not on a balanced growth path. Typically, a growth rate based on the recent past is used. Besides, this growth rate can be used to replicate the observed behavior of the economy during the period that goes from the base year to the current year. In addition, note that when dmod=2, gdpgrw=ssgrw('gdp'). As an example, see Figure 4.9.

Figure: 4.9. Example of gdpgrw

gdpgrw(t)						
2014	2015	2016	2017	2018	2019	2020
0.03533	0.03005	0.01886	0.025	0.03	0.035	0.035

pop -- pop(h,t)

In this sheet population projections for each representative household identified in the SAM are introduced. Naturally, if the SAM identifies only one representative household, in this sheet the user must introduced data for the total population of the modeled country.

qfacgrw -- qfacgrw(f,t)

In this sheet the user can introduce growth rates for the supply of the factors identified in the model. Note that when the dynamic version of the model is used, the growth rate for the capital factors is ignored, given that its supply is endogenous. In addition, note that when dmod=2, qfacgrw(flab)=ssgrw('qlab') if data is provided (see above).

qfbase – qfbase(f,a)

In this sheet the user can introduce the number of workers in each labor category demanded by each activity. The data must be introduced as a table, with labor categories in its rows and activities in its columns. The number of workers is used in the model code to compute the "distortion factor" that allows factor remunerations to (exogenously) differ across activities. Besides, in case data is introduced in qfbase, the variables that report labor supply and demand will be expressed in "number of workers". To simplify model calibration and results interpretation, the user should use the same units as those used for population.

fprdgrw – fprdgrw (f,t)

In this sheet the user can introduce information of factor productivity growth. For example, in case estimates are available, it can be used to assume that land productivity grows at a given yearly rate.

unemp – unemp(f,ac)

In this sheet information that is used to model the existence of endogenous unemployment for one or more factors in introduced (see Figure 4.10). Column UERAT00 refers to the unemployment rate in the base year. Column eta_wf refers to the elasticity of the wage curve that is used to model endogenous unemployment.

Figure: 4.10. Example unemp

unemp(f,ac)		
	UERAT00	eta_wf
f-lab-unsk	0.157	-0.5
f-lab-sk	0.166	-0.5

prodelas – prodelas(a)

In this sheet the elasticities of substitution between factors are introduced. Note that the value added production function is a CES function. The user must introduce an elasticity value for each activity in the SAM. Figure 4.11 shows an example.

Figure 4.11. Example prodelas

prodelas(a)	
a-agrforfsh	0.25
a-min	0.2
a-mnf	0.7
a-elegaswat	0.7
a-cns	0.7
a-trd	0.7
a-trnscom	0.7
a-hotelrest	0.7
a-fin	0.7
a-bus	0.7
a-pubadm	0.7
a-edu	0.7
a-hlt	0.7
a-othsvc	0.7
a-domest	0.7

leselas -- leselas(c,h)

In this sheet values for the income (expenditure)-elasticities for each commodity demanded by the households in the SAM are introduced. In order to calibrate the

model, Seale et al. (2003) provide comparable estimate for a large number of countries (see <*www.ers.usda.gov/Data/Elasticities*>).[2]

Figure 4.12. Example leselas

leselas(c,h)	
	hhd
c-agrforfsh	0.720
c-min	1.381
c-mnf	1.022
c-elegaswat	1.068
c-cns	1.051
c-trd	1.381
c-trnscom	1.169
c-hotelrest	1.527
c-fin	1.381
c-bus	1.381
c-pubadm	1.381
c-edu	0.924
c-hlt	1.376
c-othsvc	1.381
c-domest	1.381

frisch -- frisch(h)

In this sheet the user should introduce values for the Frisch parameter for each representative household in the SAM. As explained in Dervis et al. (1982), this parameter is used to calibrate the linear expenditure system that can be derived from the assumption of Stone-Geary utility function for households. The value of the Frisch parameter can be computed following Luch et al. (1977), who estimated the following relation:

$$frisch = -36 \cdot ypc^{-0.36}$$

[2] Note that, if necessary, the model code rescales these elasticities in order to meet the Engel aggregation condition; i.e.,

$$\sum_c w_{ch}\eta_{ch} = 1$$

where w_{ch} is the share of commodity c in total consumption of household h, and η_{ch} is the income-elasticity of demand of commodity c for household h.

where *ypc* is the income per capita in US dollars of 1970. Thus, the value of the Frisch parameter can be estimates based on data for the income per capita for the model base year expressed in US dollars of 1970.

mps000 -- MPS000(insdng)

In this sheet the user can introduce the marginal propensity to save of domestic non-government institutions. In case no data is provided, it is assumed that the intercept in the savings functions is zero at the same time that MPS00 is computed using data from the SAM.

tradelas – tradelas(c,ac)

In this sheet values for the trade-related elasticities are introduced. Specifically, the following elasticities are required:

- column sigma_q = Armington elasticities
- sigma_x = CET elasticities
- sigma_md = elasticities of substitution between imports of disaggregated commodities mapped to c
- sigma_ed = elasticities of transformation between exports of disaggregated commodities mapped to c

As can be seen, elasticities can be different among commodities. Figure 4.13 shows an example.

Figure 4.13. Example tradelas

tradeas(c,ac)				
	sigma_q	sigma_x	sigma_md	sigma_ed
c-agrforfsh	2	2.5	4	5
c-min	2	2.5	4	5
c-mnf	0.9	1.15	1.8	2.3

mpcapgov -- mpcapgov(fcapg)

In this sheet the user can introduce a value for the marginal product of government capital of type fcapg. This parameter defines the total change in GDP per unit of extra

government capital fcapg under base-year conditions (ceteris paribus). For more details, see the discussion just below of the parameter mtfp.[3]

Figure 4.14. Example mpcapgov

mpcapgov(fcapg)		marginal pr
f-capg		
0.125		

mtfp -- mtfp(a,fcapg)

In this sheet the user can introduce a mapping indicating the extent to which TFP in activity a is affected by government capital stock fcapg relative to other activities. For this parameter, the relative gain in TFP for all activities a with an identical value -- e.g., 1 -- will be identical. Relative, not absolute mtfp values matter (the outcome is the same of the same set of entries have values of 1 or 2). While the parameter mpcapgov indicates the aggregate effect of one unit more of capital stock fcapg on TFP, the parameter mtfp is used to generate the distribution of this TFP gain across different activities.

These parameters provide a channel for capturing returns from government investments that, unlike investments in health and education, are not captured via other channels. Considering the size of the initial government capital stock of fcapg, mpcapgov and mtfp are used to compute an elasticity parameter – the elasticity of productivity in activity a with respect to capital stock fcapg. The elasticity values that are generated are such that, ceteris paribus (including no changes in prices or factor employment), the sum of the marginal GDP changes across all activities a linked to the capital stock invg (via mtfp) per LCU spent on investments in this capital stock is equal to the value provided for the parameter mpcapgov; for example, if the value is 0.2, then for an investment of 1, the output gain (due to higher productivity) is 0.2.

In GEM-Core, mpcapgov may cover all types of government capital. The value of mpcapgov is likely to vary strongly across countries, time periods, sectors, and capital

[3] For additional details, see Lofgren and Cicowiez (2014).

stocks. Higher values are expected for government capital stocks that directly contribute to production (such as roads and dams) as opposed to broader aggregates of government capital.

taxrate0 -- taxrate0(acgovrec,ac,t)

In this sheet the user can impose changes in the different tax rates for the baseline scenario. For the first row label, the legal entries are the tax accounts in the SAM (also in the set actax). For the second row label, which shows the payer, the legal entries are elements in the sets for institutions (insdng), factors (f), activities (a), and commodities (c) that, according to the SAM, pay the different direct and indirect taxes. In case govrecrule0(actax,t) is 1 (see below), then the specified rates are imposed as

= [base-year rate for tax imposed on ac] * [taxrate0(actax,ac,t)]/[taxrate00(actax,ac)]

In other words, only the relative values provided by the user will matter. If the user-provided base-year figure [taxrate0(actax,ac,tmin)] coincides with the base-year tax rate (according to the SAM; the first term in the numerator), then the exact values provided by the user for non-base years will be imposed; i.e., only taxrate0(actax,ac,t) remains in the above expression.

taxrate20 – taxrate20(acgovrec,ac,t)

In this sheet the user can also impose changes in the different tax rates for the baseline scenario. However, in this case the counterfactual tax rates are introduced as a level, not as deviation relative to the base year.

facclos0 – facclos(f)

In this sheet, the user selects the closure rule (i.e., the mechanism to equilibrate supply and demand) for the factor markets; this model provides four pre-programmed alternatives:

- facclos0(f) = 1 factor is fully employed and perfectly mobile among sectors;
- facclos0(f) = 2 factor is fully employed and sector specific (i.e., immobile);
- facclos0(f) = 3 factor is unemployed with an horizontal supply curve and mobile among sectors; and

- facclos0(f) = 4 factor in unemployed with a wage curve and mobile among sectors.

Typically, the second alternative is used for the capital factor in the context of a short run/medium run simulation, where it is assumed that installed capital cannot move between productive sectors. The third alternative assumes that factor supply is horizontal; in other words, factor supply is perfectly elastic. In model terms, the Table 4.15 summarizes the available options.

Tabla 4.15: facclos0(f)

#	workings of factor markets
1	full employment (fixed UERAT); mobile factor
2	full employment (fixed UERAT); specific factor
3	unemployment assuming exgenous (constant) real wage; mobile factor
4	unemployment assuming wage curve (i.e., negative relation bt real wage and UERAT); mobile factor

numeraire0 – numeraire0

In this sheet the user selects the model numeraire; two pre-programmed alternatives are available: (1) the model numeraire is the consumer price index, and (2) the model numeraire is the index for domestic producer prices. In Table 4.16 we show the available options.

Tabla 4.16: numeraire0

#	numeraire
1	consumer price index
2	producer price index

govclos0 – govclos0

In this sheet the user can select one of the three available (pre-programmed) closures to balance the government budget. In Table 4.17 the available alternatives are shown, together to the endogenous variable that clears the government budget.

Tabla 4.17: govclos0

#	variable that clears the government budget
1	direct (income) tax rate
1	net domestic financing
3	net foreign financing
4	government consumption

siclos0 – siclos0

In this sheet the user can select the clearing variable for the savings-investment balance. Table 4.18 summarizes the pre-programmed alternatives.

Tabla 4.18: siclos0

#	variable that clears the non-government savings-investment balance
1	investment
2	savings rate of insdng; endog invgdp
3	net foreign financings

rowclos0 – rowclos0

In this sheet the user can select the clearing variable for the current account of the balance of payments. In other words, the mechanism for balancing inflows and outflows of foreign exchange is selected. In the only available option, the real exchange rate is the clearing variables that drives exports and imports to be consistent with the exogenous current account balance expressed in FCU (i.e., minus SAVF) (see Table 4.19).

Tabla 4.19: rowclos0

#	variable that clears the current account BoP
1	real exchange rate

govrecrule0 -- govrecrule0(acgovrec)

In this sheet the user selects the behavior for each of the income sources for the government. The available alternatives are two: (1) exogenous growth rate

(determined through govrecgrw0), o (2) exogenous GDP ratio (determined through govrecgdp0) (see Figure 4.20). The government income sources identified in the model are

- 'trgovngov' = transfers from domestic institutions (i.e., households and/or enterprises)
- 'trgovrow' = transfers from the rest of the world (i.e., foreign aid)
- elements of the set actax (i.e., taxes)
- 'netdomfin' = net domestic financing
- 'netforfingov' = net foreign financing government

Figure 4.20. Example govrecrule0

govrecrule0(acgovrec)	
trgovngov	2
trgovrow	2
tax-vat	1
tax-act	1
tax-com	1
tax-imp-CHN	1
tax-imp-USA	1
tax-imp-E_U	1
tax-imp-VNM	1
tax-imp-ROW	1
tax-dir	1
tax-fac	1
netdomfin	2
netforfingov	2

govrecgrw0 -- govrecgrw0(acgovrec,r)

In this sheet the user can introduce growth rates for the government receipts items identified in govrecrule0.

govrecgdp0 -- govrecgrw0(acgovrec,r)

In this sheet the user can introduce GDP ratios for the government receipts items identified in govrecrule0.

govspndrule0 -- govspndrule0(acgovspnd)

In this sheet the user selects the behavior for each of the spending items of the government. The available alternatives are two: (1) exogenous growth rate (determined through govspndgrw0), o (2) exogenous GDP ratio (determined through govspndgdp0) (see Figure 4.21). The government spending items identified in the model are

- 'trngovgov'
- 'trrowgov'
- 'congov'
- Elements of the set subcom (i.e., consumption subsidies)
- elements of the set fcapg (i.e., government capital stocks)

Figure 4.21. Example govspndrule0

govspndrule0(acgovspnd)	
trngovgov	2
trrowgov	2
congov	2
sub-com	2
f-capg-roads	2
f-capg-agr	2
f-capg-ogov	2

govspndgrw0 -- govspndgrw0(acgovspnd,t)

In this sheet the user can introduce growth rates for the government spending items identified in govspndrule0.

govspndgdp0 -- govspndgdp0(acgovspnd,t)

In this sheet the user can introduce GDP ratios for the government spending items identified in govspndrule0.

ngovpayrule0 -- ngovpayrule0(acngovpay)

In this sheet the user selects the behavior for each of the modeled non-government payments (e.g., remittances, factor income from abroad, domestic non-government

savings, among others). The available alternatives are two: (1) exogenous growth rate (determined through ngovpaygrw0), o (2) exogenous GDP ratio (determined through ngovpaygdp0) (see Figure 4.22). The government income sources identified in the model are

- 'trngovrow' = transfers from rest of the world to domestic non-government institutions
- 'trrowngov' = not yet available; currently, fixed share of domestic non-government institutions income
- 'trfacrow' = factor income from abroad
- 'trrowfac' = not yet available; currently, fixed share of factor income
- 'savngov' = savings of domestic non-government institutions
- 'netforfinngov' = net foreign financing domestic non-government institutions
- elements of the set fcapng (i.e., non-government capital stocks)
- 'fdi' = foreign direct investment

Figure 4.22. Example ngovpayrule0

ngovpayrule0(acngovpay)	
trngovrow	2
trrowngov	1
trfacrow	2
trrowfac	2
savngov	2
f-cap	2
netforfinngov	2
fdi	2

ngovpaygrw0 -- ngovpaygrw0(acngovpay,t)

In this sheet the user can introduce growth rates for the non-government payment items identified in ngovpayrule0.

ngovpaygdp0 -- ngovpaygdp0(acngovpay,t)

In this sheet the user can introduce GDP ratios for the non -government payment items identified in ngovpayrule0.

qgc010 -- qgc010(c,t)

In this sheet the user can select which are the elements in the set c that will be considered endogenous in case government consumption is the clearing variable for the government balance. If left empty, qgcj010 is set equal to one for all elements in the set c and in SAM(c,insgov).

iadj010 – iadj010(inv)

In this sheet the user can select which are the elements in the set invng that will be considered endogenous in case non-government investment is the clearing variable for the savings-investment balance. If left empty, iadj010 is set equal to one for all elements in the set inv.

debt00 -- debt00(ins,insp)

In this sheet values for the base-year debts of institution (column) "insp" to institution (row) "ins" are introduced. It is expressed in the same units as SAM. Figure 4.23 shows an example.

Figure 4.23. Example debt00

debt00(ins,insp)		**base-year de**
	hhd	gov
hhd		683,346
row	1,890,875	1,844,748

gintrat0 -- gintrat0(t)

In this sheet values for the real interest rate on domestic government debt are introduced.

fintrat0 -- fintrat0(insd,t)

In this sheet values for the real interest rate on foreign debt are introduced. Figure 4.24 shows an example.

Figure 4.24. Example fintrat0

fintrat0(insd,t)	real interest rate on foreign debt				
	2013	2014	2015	2016	2017
hhd	0.015	0.015	0.015	0.015	0.015
gov	0.015	0.015	0.015	0.015	0.015

scaling – scaling(ac)

In this sheet the user can introduce scaling values for the SAM and for information related to the number of workers and the population (i.e., see qfbase0 and pop). The number one means that no scaling is made.

layout

In this sheet, we define how the information in the Excel file is organized. In general, the user should not modify this sheet.

5. Simulations File

In this section we describe the content of each element in the ISIM application Excel file; for example, app-sim.xlsx, where app refers to a particular application; for example, demo-sim.xlsx. As we will see, the simulation scenarios can combine different shocks; i.e., the same scenario name can appear in more than one of the simulation parameters that are described next. For example, we can define a scenario that combines a reduction in the import tariff rate of a specific commodity with an increase in the world import price of that same (or other) commodity.

sim – sim

In this element, defined with the Scenario Manager when using ISIM, the user gives a name to each of the simulation scenarios that will be defined; the “base” simulation should not be deleted – it corresponds to the reference scenario that is used to calibrate the model. Alternatively, it is the starting point for the non-base simulations. If using ISIM, the simulation names should be entered through the Scenario Manager. Figure 5.1 shows an example; besides the base simulation, we have created various additional simulations.

Figure 5.1. Example sim

sim	
base	base scenario
num-dupli	double numeraire
govcon-dupli	double gov consumption
remesas-inc	remittances increase
tfpagr	tfp agr
pweagr	world export price agr
pwmagr	world import price agr
pwagr	world price agr
pwemin	world export price min
pwmmin	world import price min
pwmin	world price min

simcur -- simcur(sim)

In this sheet the user selects which are the simulation scenarios that should be run. Thus, the set of simulations simcur is a subset of the simulations in sim. If using ISIM, the selection is made through the Scenario Manager.

facclossim – facclossim(sim,f)

In this simulation parameter the user can select the closure rule for the factor markets in each of the scenarios; the available alternatives are the same as those presented above for facclos0. By default (i.e., when no selection is made), all simulations assume the same closure rule that was selected in facclos0 (i.e., the value used in the pre-programmed reference scenario). However, that default is overwritten if a selection is made for the base scenario. Table 4.15 (facclos0) shows the available options.

numerairesim -- numerairesim(sim)

In this simulation parameter the user can select the numeraire for each simulation. The selection made for the calibration/reference scenario is the default for all non-base simulations. In case no selection is made for the base scenario, the value for numeraire0 (i.e., for the reference scenario) is used as the default for all non-base simulations. Table 4.16 (numeraire0) shows the available (pre-programmed) options.

govclossim – govclossim(sim)

In this sheet the user can select the government closure rule for each scenario. The available options are the same as the ones described for the calibration/reference scenario (see govclos0). This is an optional parameter; by default, it is assumed that all non-base simulations implement the closure selected for the base scenario. In case no selection is made for the base scenario, the selection from the model calibration/setup is used. Table 4.17 (govclos0) shows the available (pre-programmed) options.

siclossim – siclossim(sim)

In this sheet the user can select the savings-investment closure rule for each scenario. The available options are the same as the ones described for the calibration/reference scenario (see siclos0). This is an optional parameter; by default, it is assumed that all non-base simulations implement the closure selected for the base scenario. In case no selection is made for the base scenario, the selection from the model calibration/setup is used. Table 4.18 (siclos0) shows the available (pre-programmed) options.

rowclossim – rowclossim(sim)

In this simulation parameter the user can select the variable that balances the inflows and outflows of foreign exchange in each simulation. The selection made for the calibration/reference scenario is the default for all non-base simulations. In case no selection is made for the base scenario, the value for rowclos0 (i.e., for the reference scenario) is used as the default for all non-base simulations. Table 4.19 (rowclos0) shows the available (pre-programmed) options.

govrecrulesim -- govrecrulesim(sim,acgovrec)

The working of govrecrulesim is the same as the one described above for govrecrule0, although adding the “sim” dimension (i.e., one or more of the elements of set sim). The selection made for the “base” scenario is the default for the non-base simulations. In case no value is specified for the “base” scenario, the value assigned to govrecrule0 in the data file (i.e., for generating the reference scenario) is used as default.

govrecgrwsim -- govrecgrwsim(sim,acgovrec,t)

The working of the govrecgrwsim is the same as the one described above for the govrecgrw0, although adding the "sim" dimension (i.e., one or more of the elements of set sim).

govrecgdpsim -- govrecgdpsim(sim,acgovrec,t)

The working of the govrecgdpsim is the same as the one described above for the govrecgdp0, although adding the "sim" dimension (i.e., one or more of the elements of set sim).

govspndrulesim -- govspndrulesim(sim,acgovspnd)

The working of govspndrulesim is the same as the one described above for govspndrule0, although adding the "sim" dimension (i.e., one or more of the elements of set sim). The selection made for the "base" scenario is the default for the non-base simulations. In case no value is specified for the "base" scenario, the value assigned to govspndrule0 in the data file (i.e., for generating the reference scenario) is used as default.

govspndgrwsim -- govspndgrwsim(sim,acgovspnd,t)

The working of the govspndgrwsim is the same as the one described above for the govspndgrw0, although adding the "sim" dimension (i.e., one or more of the elements of set sim).

govspndgdpsim -- govspndgdpsim(sim,acgovspnd,t)

The working of the govspndgdpsim is the same as the one described above for the govspndgdp0, although adding the "sim" dimension (i.e., one or more of the elements of set sim).

ngovpayrulesim -- ngovpayrulesim(sim,acngovpay)

The working of ngovpayrulesim is the same as the one described above for ngovpayrule0, although adding the "sim" dimension (i.e., one or more of the elements of set sim). The selection made for the "base" scenario is the default for the non-base

simulations. In case no value is specified for the “base” scenario, the value assigned to ngovpayrule0 in the data file (i.e., for generating the reference scenario) is used as default.

ngovpaygrwsim -- ngovpaygrwsim(sim,acngovpay,t)

The working of the ngovpaygrwsim is the same as the one described above for the ngovpaygrw0, although adding the “sim” dimension (i.e., one or more of the elements of set sim).

ngovpaygdpsim -- ngovpaygdpsim(sim,acngovpay,t)

The working of the gngovpaygdpsim is the same as the one described above for the ngovpaygdp0, although adding the “sim” dimension (i.e., one or more of the elements of set sim).

cpisim – cpisim(sim,t)

In this sheet scenarios in which the value of the numeraire is changed can be defined. In our case, the model numeraire is the consumer price index – see variable CPI. In general, this sheet can be used to check that the model is homogenous of degree zero in prices. In other words, if the numeraire is doubled, all nominal variables (i.e., prices and incomes) should be doubled and quantities remain constant. The counterfactual CPI is defined as

CPI(t) = CPI0(t) if CPISIM(sim,t) = 0

CPI(t) = CPI0(t) * CPISIM(sim,t) if CPISIM(sim,t) <> 0

That is to say, shocks are introduced as deviations with respect to the base scenario value; for example, 2 implies a 100% increase. Besides, when no values are introduced for cpisim, the values from the reference scenario are used. As we will see, the same applies to the other parameters that are used to define simulation scenarios. Of course, one can only simulate changes in the CPI provided it is considered an exogenous variable. In any case, GEM-TRADE has, as default, the CPI selected as the model numeraire.

pwesim -- pwesim(sim,c,t)

In this sheet the user can define shocks to the world price of exports. The counterfactual value for pwe for commodity c in period t in simulation sim is computed as

pwe(c,t) = pwe0(c,t)	if pwesim(sim,c,t) = 0
pwe(c,t) = pwe0(c,t)*pwesim(sim,c,t)	if pwesim(sim,c,t) <> 0

pwmsim -- pwmsim(sim,c,t)

In this sheet the user can define shocks to the world price of imports. The counterfactual value for pwm for commodity c in simulation sim in period t is computed as

pwm(c,t) = pwm0(c,t)	if pwmsim(sim,c,t) = 0
pwm(c,t) = pwm0(c,t)*pwmsim(sim,c,t)	if pwmsim(sim,c,t) <> 0

taxratesim -- taxratesim(sim,actax,ac,t)

In this sheet the user can define scenarios in which changes to the rate for tax type actax imposed on ac in t. To simplify, apart from the addition of the initial sim entry, the explanation for taxrate0 applies. If no value is provided for a given simulation, then the value for the base simulation is used.

taxrate2sim – taxrate2sim(acgovrec,ac,t)

In this sheet the user can also define scenarios in which changes to the rate for tax type actax imposed on ac in t. However, in this case the counterfactual tax rates are introduced as a level, not as deviation relative to the base year. To simplify, apart from the addition of the initial sim entry, the explanation for taxrate20 applies. If no value is provided for a given simulation, then the value for the base simulation is used.

subcbsim -- subcbsim(sim,c,ac,t)

In this sheet the user can define scenarios in which changes to – intermediate and/or final -- consumption subsidy rates are changed. The counterfactual consumption subsidy rates are defined as deviation with respect to the base scenario, as in previous

cases. For example, 0.25 is equivalent to a 75% reduction in the consumption subsidy rate for the baseline scenario. Figure 5.3 shows how to eliminate the consumption subsidy on product cc-ele received by five representative urban households during the period 2012-2012.

Figure 5.3. Example subcbsim

gammacsim(sim,c,ac,t)					
			2010	2011	2012
subelecut	cc-ele	h-urb-q1	1	0.25	0.75
subelecut	cc-ele	h-urb-q2	1	0.25	0.75
subelecut	cc-ele	h-urb-q3	1	0.25	0.75
subelecut	cc-ele	h-urb-q4	1	0.25	0.75
subelecut	cc-ele	h-urb-q5	1	0.25	0.75

qgbsim – qgbsim(sim,c,t)

In this sheet scenarios in which the government consumption/provision of goods and services is changed can be defined. The shocks are introduced as previously explained for other simulation parameters. Thus, shocks are defined as deviation with respect to the government consumption recorded for the same period in the base scenario.

qinvdestbsim – qinvdestbsim(sim,inv,t)

In this sheet the user can define scenarios that change government and/or non-government investment. In the first case, we refer to investment by the general government in those sectors identified in the SAM; i.e., those included in the set invg. In the second case, we refer to private investment and/or investment by public enterprises; specifically, see sectors included in the set invng. Thus, a value of 1.5 for a sim-invng-t combination implies a 50% increase in the simulation sim for the sector invng in period t relative to the base scenario. For example, Figure 5.4 shows how to define the scenario inf-dir, in which we increment by 20% the government investment in the sector “invg-trnsinf”, which in the example refers to transport public infrastructure.

Figure 5.4. Example rgfcfbarsim

rgfcfbarsim(sim,inv,t)						
		2010	2011	2012	2013	2014
inf-tdir	invg-trnsinf	1	1.2	1.2	1.2	1.2

qinvdestb2sim – qinvdestb2sim(sim,inv,t)

In this simulation parameter the user can also define scenarios in which government and/or non-government (i.e., private investment and/or investment by public enterprises) is changed; specifically, see sectors included in the set inv. However, shocks are defined as level, not as deviation with respect to the base scenario for the same year. For example, a value of 500 for a sim-inv-t combination implies an increase of $500 in the simulation sim for the sector inv in period t relative to the base scenario. In this case, qinvgbar2sim is expressed in the same units as the SAM.

iadj01sim -- iadj01sim(sim,invng)

In this sheet the user can select which are the elements in the set invng that will be considered endogenous in case private investment is the clearing variable for the savings-investment balance. By default, model parameter iadj01(invng) is equal to one for all elements in the set invng.

trnsfrbsim -- trnsfrbsim(sim,ac,ins)

In his sheet the user can define shocks in which the one or more of the following transfers are modified: (a) from the rest of the world to domestic institutions, (b) from the rest of the world to factors, and (c) from the government to the other (non-government) institutions. On the other hand, note that transfers from domestic non-government institutions are a fixed shared of their respective incomes. The counterfactual transfer from institution ins to institution/factor ac in period t is computed as

trnsfrbar(ac,ins,t) = trnsfrbar0(ac,ins,t) if trnsfrbarsim(sim,ac,ins,t)) = 0

trnsfrbar(ac,ins,t) = trnsfrbar0(ac,ins,t) * trnsfrbarsim(sim,ac,ins,t) if trnsfrbarsim(sim,ac,ins,t)) <> 0

where ac can include institutions and/or factors of production.

qfacgrwsim -- qfacgrwsim(sim,f,t)

In this sheet the user can define scenarios that change the growth rate for (exogenous) factor supplies. In case the dynamic version of the model is being used, the user cannot impose an exogenous growth rate for physical capital. Again, the shocks are defined as deviation with respect to the base scenario for the same year. The next two examples show how to implement shocks for mobile and sector-specific factors.

In order to implement a shock for a mobile factor,

QFS(f,t) = QFS0(f,t)	if qfacgrwsim(sim,f,t)) = 0
QFS(f,t) = QFS0(f,t)*qfacgrwsim(sim,f,t)	if qfacgrwsim(sim,f,t)) <> 0

(In this case, all institutional factor endowments of factor f will be increased by the same percentage change; see variable ENDOW(ins,f,t) in the model mathematical statement.)

In order to implement a shock for a specific factor,

QF(f,a,t) = QF0(f,a,t)	if qfacgrwsim(sim,f,t)) = 0
QF(f,a,t) = QF0(f,a,t)*qfacgrwsim(sim,f,t)	if qfacgrwsim(sim,f,t)) <> 0

tfpexogsim -- tfpexogsim(sim,a,t)

In this simulation parameter, the user can define scenarios in which the sectoral total factor productivity (TFP) is changed. In practice, the scale/shift parameter of the value added production functions is modified. The counterfactual TFP for activity a is computed as

tfpexog(a,t) = tfpexog0(a,t)	if tfpexogsim (sim,a,t) = 0
tfpexog(a,t) = tfpexog0(a,t) * tfpexogsim (sim,a,t)	if tfpexogsim (sim,a,t) <> 0

layout

In this sheet, we define how the information in the Excel file is organized. In general, the user should not modify this sheet.

6. Report Files

The report file (i.e., report.gdx) is generated after executing the file rep.gms. Specifically, the reporting file contains (1) all endogenous variables (variable name + X), (2) the percentage change relative to the base for all endogenous variables (variable name + XP), (3) the annual average growth rate for all endogenous variables (variable name + XPP), (4) parameters used to define counterfactual scenarios (parameter name + X), and (5) additional report parameters computed based on model results that are described next.

- modsolstat(solcol,t,sim): status of solver and model; given that the model is solved as a MCP (mixed complementarity problem) problem, the solver and model status should be 1 and 1, respectively. Otherwise, an error has occurred.
- SIMSAM(ac,acp,t,sim): is a collection of SAMs defined using results from each of the simulations contained in the simcur set.
- simsambalchk(ac,t,sim): is a report parameter that allows checking if the SIMSAM accounts are balanced.
- MACROSAM(ac2,ac2p,t,sim): contains an aggregated (macro) SAM for each of the simulation scenarios.
- macrosambalchk(ac2,t,sim): is a report parameter that allows checking if the MACROSAM accounts are balanced.
- gdpindic(igdp,kgdp,t,sim): summary table with GDP and its components, both in nominal and real terms; in absolute values and as shares of GDP.
- gdpindicXP(igdp,kgdp,t,sim): similar to the previous one but shows percentage changes relative to the base scenario.
- sectorstruc(ac,sectorcol,t,sim): this report parameter described the sectoral structure of the economy, both in terms of production and foreign trade. For example, it contains the share of each commodity in total exports, the share of each commodity in total, the share of imports in total consumption, and the share of exports in the total output.

- sectorindic(ac,sectorcol2,kgdp,t,sim): this report parameter also describes the sectoral structure of the economy, both in terms of production and foreign trade; unlike the previous one, it presents information in absolute values. In turn, the sectorindicXP parameter presents the results as percentage changes from the base scenario.
- fiscalindic(fiscalcol,t,sim): this report parameter shows the government budget. For example, it shows the ratio between government savings and GDP, the ratio between tax collection and GDP, among others.
- taxstruc(ac,taxcol,t,sim): this report parameter shows information regarding the tax collection, in values, as a share of total tax collection, and as a share of GDP.
- bopindic(bopcol,kgdp,t,sim): this report parameter shows the current account of the balance of payments, in domestic currency, as a share of GDP, and in foreign currency.
- actvashr(a,t,sim): this report shows the share of each activity in total value added.
- ev(h,t,sim): is the equivalent variation.
- cv(h,t,sim): is the compensatory variation.
- demstruc(kgdp,ac,demcol,t,sim): this report shows the demand structure (i.e., intermediate/final) for each commodity in the SAM.
- incomestruc (incdistcol,ac,ac,t,sim): this report shows the sources of income by institution, including taxes for government and imports for rest of the world.
- incomedist(incdistcol,ac,ac,t,sim): this report summarizes the income distribution across representative households.

The reports that are expressed in the local currency unit are scaled – using the information in the scaling sheet -- to the original units in the SAM. The model can be used through ISIM, in which case some Excel reports are generated.

References

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