CGE Integrated Economic-Environmental Modelling (IEEM): User Guide

Martín Cicowiez and Onil Banerjee

this version: February 3, 2017

1. Introduction

In this document we describe how to implement the GAMS code of the environmentally-extended recursive dynamic small open economy computable general equilibrium (CGE) model developed in the context of the IDB project to develop an "Integrated Economic-Environmental Modelling (IEEM)" to analyze environment-related issues. Of course, the model can also be used to analyze other issues, not related to the energy sector. The detailed description of the model can be found in Banerjee et al (2016). The model is easy to implement through the ISIM interface (see Cicowiez et al., 2013). (In a companion package, we show how the environmentally-extended SAM for Guatemala was built.)

2. GAMS Code Organization

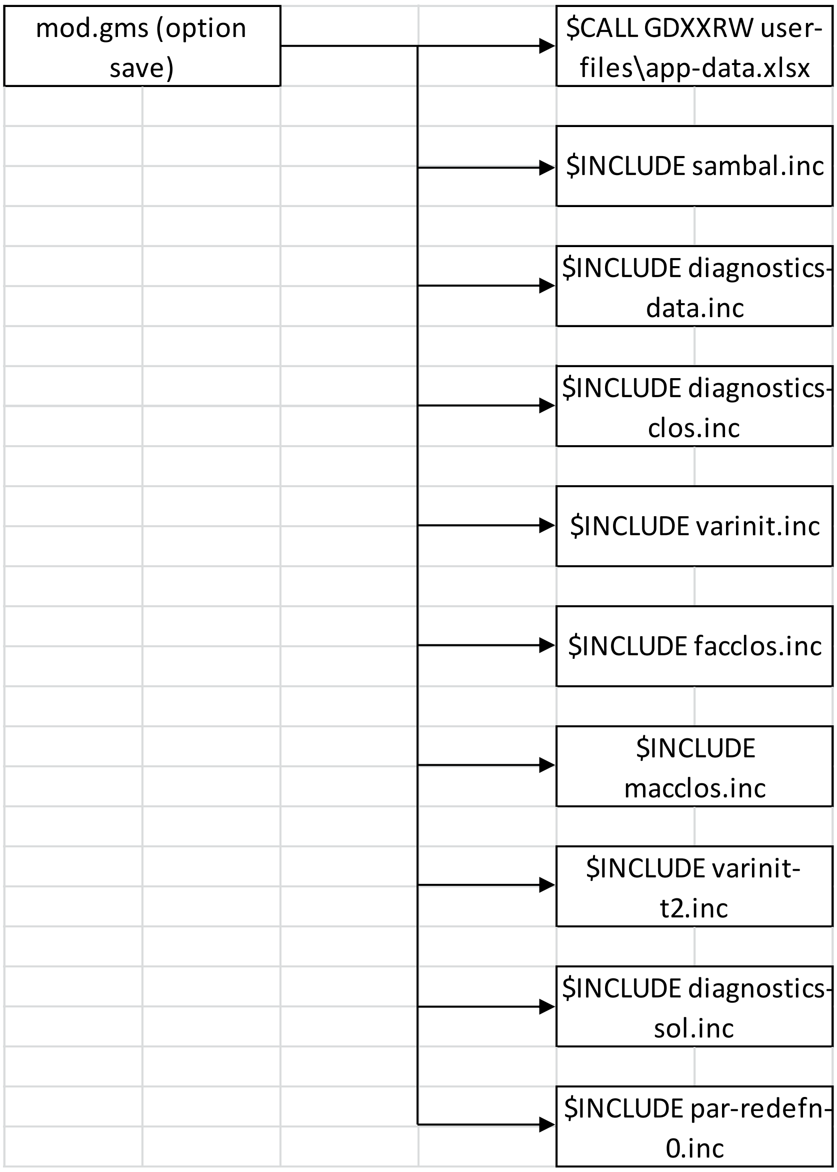
The IEEM CGE model was developed as a "standard" model, meaning that the same model can be implemented using various datasets. In other words, the "theory" of the model is completely separated from the data that is used for model calibration. In fact, certain characteristics of the IEEM CGE model (e.g., the tracking of CO_2 emissions) 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) and satellite environmental accounts 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 IEEM CGE model application (e.g., gtm2010-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., gtm2010-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 report.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.)

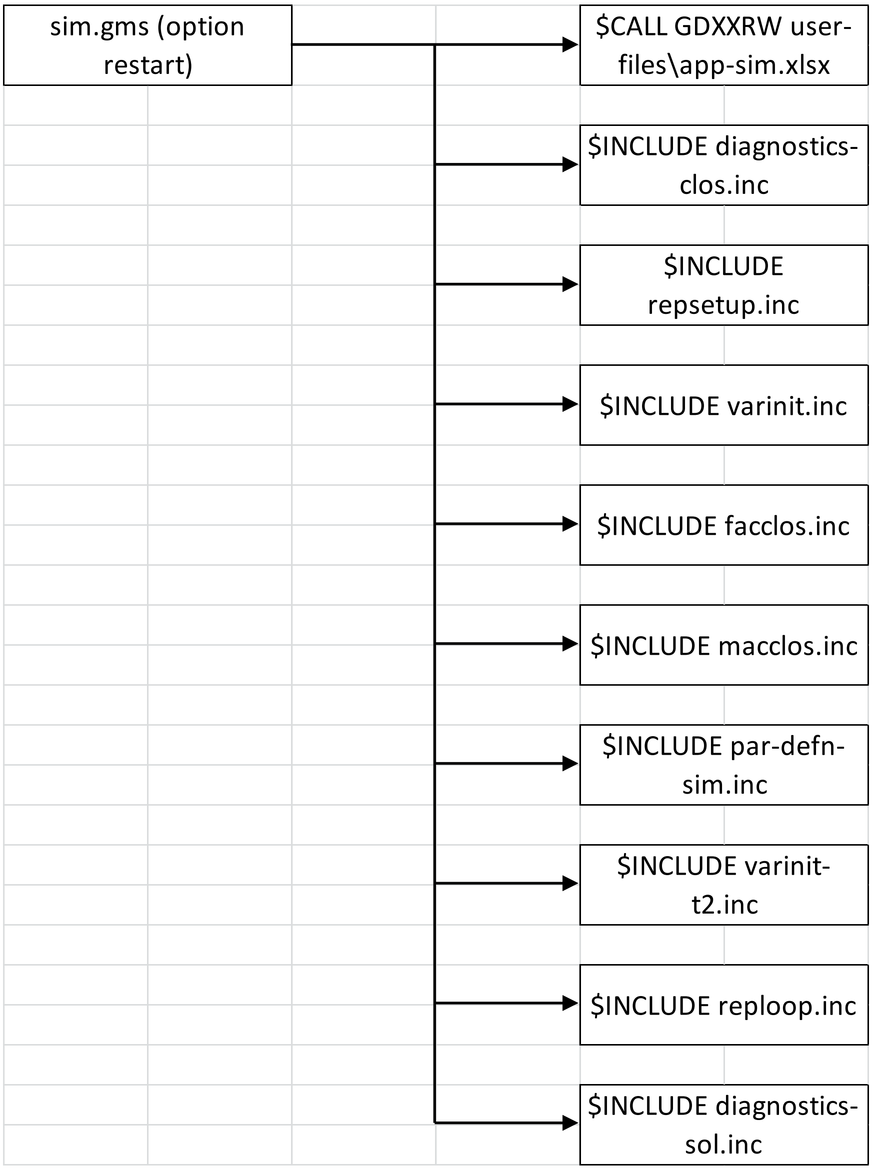
On the other hand, when the IEEM CGE model is ran through the ISIM interface, the software takes care of running the three GAMS files mentioned in the previous paragraph. Thus, when using ISIM, the user does not need to worry about knowing the GAMS modeling language.

Figure 2.1: organization of GAMS files for IEEM CGE model

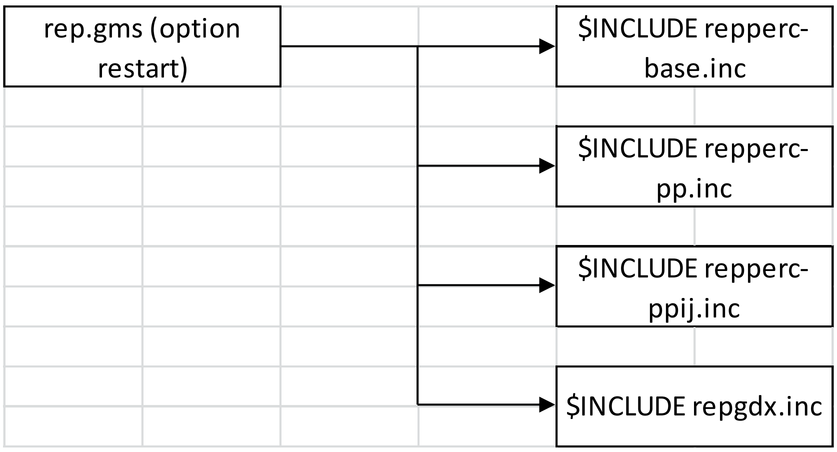
Panel (a) – mod.gms



Panel (b) – sim.gms



Panel (c) – rep.gms



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

mod.gms with the command line option s=save\mod --NonIMv2=1

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

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

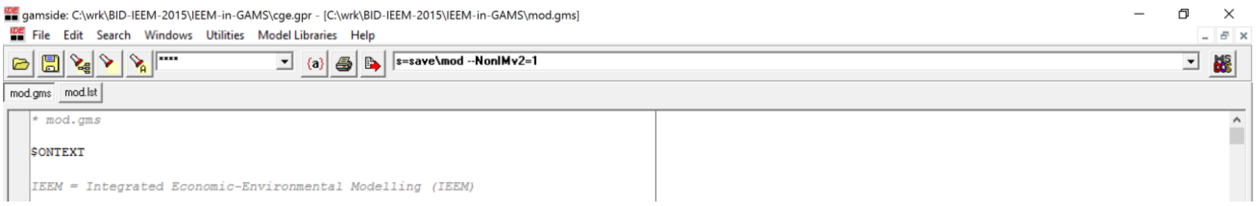
repmacro.gms with the command line option r=save\ repbaseyr s=save\repmacro

repmeso.gms with the command line option r=save\repmacro s=save\repmeso

repenviro.gms with the command line option r=save\repmeso s=save\repenviro

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] In addition, note that the command line option --NonIMv2=1 used when running mod.gms indicates that the model is not being run through ISIM.

Figure 2.2: execution of mod.gms



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

3. Steps to Implement IEEM in GAMS

In this section, the steps required to implement the IEEM 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;

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 IEEM;

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 Guatemala with 2010 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 variant 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 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. 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, for example, file mod.gms). As shown, the last group of sets is used to implement the environmental module of our IEEM CGE model. Thus, if one or more of those sets is left empty, the corresponding model feature will be inactive.

Table 4.2: sets for reading the SAM

set	descripción
ac	global set (SAM accounts and other items)
a(ac)	activities
aagr(a)	agricultural activities
afor(a)	forestry activities
amin(a)	mining activities
c(ac)	commodities
cfor(c)	forestry commodities
cfsh(c)	fishing commodities
cwat(c)	water commodities
cen(c)	energy commodities (in energy composite)
v(ac)	consumed commodities (for households)
vwat(v)	consumed water commodities (for households)
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
fland(f)	factors land
ins(ac)	institutions
insd(ins)	domestic institutions
insdng(insd)	domestic non-government institutions
h(insdng)	households
insgov(insd)	enterprises
insrow(ins)	rest of the world
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
taxfact(itax)	tax on factor use (alt soc sec tax)
taxfac(actax)	direct tax on factors (soc sec tax)
subcom(ac)	commodity demand subsidies
sav(ac)	savings
inv(ac)	investment accounts
invng(inv)	non-government investment
invg(inv)	government investment
invginf(invg)	government investment in infrastructure
dstk(ac)	changes in inventories
wat(ac)	water categories
acwatret(ac)	water return categories
watnreg(wat)	non-registered water categories
watagr(watnreg)	agriculture water categories
watnagr(watnreg)	non-agriculture water categories
watreg(wat)	registered water categories
ext(ac)	extractive resources accounts
emi(ac)	emissions accounts
resid(ac)	waste and residuals accounts

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, he sheet "scaling" can be used to re-scale the SAM and other elements in the IEEM dataset (see below), if necessary.

mapaggreg – mapaggreg(ac,acp)

In this sheet the user can aggregate accounts of the social accounting matrix and other parts of the IEEM dataset. 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 mapaggreg

mapaggreg(ac,acp)		**account ac i**
sub-act	tax-act	YES
tax-vat	tax-com	YES
sub-com	tax-com	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 first column in Figure 4.2) and the accounts in the SAM that refer to factors (see second column in Figure 4.2). 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 4.2, YES is used to establish a relation between elements in the first and second columns; each tax account can only be related to one factor. As can be seen, this mapping is not needed to implement the IEEM CGE model.

Figure 4.2: example maptfactf

mtfactf(taxfact,f)		
cssoc-unsk	f-lab-asal-unsk	YES
cssoc-sk	f-lab-asal-sk	YES

mfcapinv -- mfcapinv(fcap,invng)

In this sheet SAM accounts that represents 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 4.3. It is worth mentioning that each investment account must be linked to one capital account. Similarly, each capital account must be linked to one investment account. Note that the user can use the mapping mapaggreg to, in a sense, overcome those restrictions. In panel b of Figure 4.3 we show the case of a dataset with only one non-government capital and investment accounts.

Figure 4.3a: example 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 4.3b: example mfcapinv

mfcapinv(fcap,invng)		
f-cap	invng	YES

mapcv -- mapcv(c,v)

In this sheet the user can link produced (see set c) and consumed commodities by the households (see set v). For example, mapcv could be used to link the commodities fuelwood, petroleum goods, and electricity to the consumed/composite commodity "energy". In fact, depending on data availability, the energy commodity may or may not appear in the SAM. Alternatively, this mapping could be used to allow for a different classification of consumer and producer goods and services. In fact, a "make matrix" is used where each consumed good can be composed of one or more supplied goods, combined using a Constant Elasticity of Substitution (CES) function. As an example, see Figure 4.4; commodities in the first (second) column c (v) are disaggregated (composite) commodities. Incidentally, note that the model allows simulating an increase in (household) consumption efficiency; i.e., same amount of commodity c in Figure 4.4 "produces" more of composite commodity v in Figure 4.4. Finally, note that there is no need to use mapcv(c,v) if a make matrix to "transform" produced commodity into consumed commodity is available and is part of the SAM.

Figure 4.4: example mapcd(c,v)

mapcv(c,v)		
cc-coffee	ch-coffee	YES
cc-banana	ch-banana	YES
cc-cereals	ch-cereals	YES
cc-othagr	ch-othagr	YES
cc-ctl	ch-ctl	YES
cc-othfor	ch-othfor	YES
cc-fuelwood	ch-energ	YES
cc-fsh	ch-fsh	YES
cc-min	ch-min	YES
cc-food	ch-food	YES
cc-bevtob	ch-bevtob	YES
cc-tex	ch-tex	YES
cc-wood	ch-wood	YES
cc-paper	ch-paper	YES
cc-petprod	ch-energ	YES
cc-chem	ch-chem	YES
cc-rubplast	ch-rubplast	YES
cc-nmetminpı	ch-nmetminpı	YES
cc-met	ch-met	YES
cc-mach	ch-mach	YES
cc-othmnf	ch-othmnf	YES
cc-waste	ch-waste	YES
cc-ele	ch-energ	YES
cc-wat	ch-wat	YES
cc-cns	ch-cns	YES
cc-trade	ch-trade	YES
cc-hotelrest	ch-hotelrest	YES
cc-trns	ch-trns	YES
cc-othsvc	ch-othsvc	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 msubcom

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

mapwatret -- mapwatret(wat,acwatret)

In this sheet the user should link water return accounts with water accounts; see also watbas data parameter. Figure 4.6 shows an example.

Figure 4.6: example mapwatret

mapwatret(wat,acwatret)		
sprinkler-irrig	sprinkler-irrig-ret	YES
drip-irrig	drip-irrig-ret	YES
wat-gravity-use	wat-gravity-ret	YES
wat-oth-use	wat-oth-ret	YES

dinam – dinam(ac)

In this sheet information relevant for the dynamic variant of the model is introduced (see Figure 4.7). 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: 4.7: example dinam

dinam(ac)	
kappa	0.50
netprfrat	0.15

deprcap -- deprcap(ac)

In this sheet depreciation rates for public (row govz) and private (rows fcap) are introduced; note that fcap refers to the set that identifies one or more non-government capital stocks. Based on available estimates, the former is smaller than the last one. As an example, see Figure 4.8.

Figure 4.8: example deprcap

deprcap(ac)	
f-cap	0.05
govz	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. Optionally, the user can also introduce a growth rate for labor factor endowments. In case dmod=2 is selected (see dmod above), 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. Figure 4.9 shows an example, where annual growth rates of 3.5 and 2.5 percent for GDP and labor endowments are introduced, respectively.

Figure 4.9: example 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 for all time periods is automatically set equal to ssgrw('gdp'). Figure 4.10 shows an example

Figure: 4.10: example gdpgrw

gdpgrw(t)						
2011	2012	2013	2014	2015	2016	2017
0.06245	0.05001	0.04446	0.04538	0.046	0.043	0.04

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 rate 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) is automatically set equal to ssgrw('qlab') in case 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 "distorsion factor" that allows factor remunerations to (exogenously) differ across activities. Besides, in case of introducing data in qfbase, the variables that report labor supply and demand will be expressed in "number of workers". To simplify model calibration and interpretation of results, the user should use the same units as those used for population.

In addition, qfbase(f,a) can be used to introduced data on land use, with one or more land types. Of course, the different land types should be identified in the SAM and in the set f.

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. Column UERAT00 refers to the unemployment rate in the base year. Column phillips refers to the elasticity of the wage curve that is use to model endogenous unemployment. As an example, see Figure 4.11.

Figure: 4.11: example unemp

unemp(f,ac)		
	UERAT00	phillips
f-lab-asal-unsk	0.15	-0.5
f-lab-asal-sk	0.15	-0.5
f-lab-noasal-unsk	0.15	-0.5
f-lab-noasal-sk	0.15	-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 4.12 shows an example.

Figure 4.12: example prodelas

prodelas(a)	
aa-agr	0.25
aa-ctl	0.25
aa-for	0.20
aa-fsh	0.20
aa-min	0.20
aa-food	1.15
aa-bevtob	1.15

tradelas – tradelas(c,ac)

In this sheet values for the trade-related elasticities are introduced. Specifically, in column sigma_q (sigma_x) Armington (CET) elasticities are introduced. 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
cc-agr	2	4
cc-ctl	2	4
cc-othfor	2	4
cc-fuelwood	2	4
cc-fsh	2	4
cc-min	2	4
cc-food	2	4
cc-bevtob	2	4

tfpelas -- tfpelas(a,ac)

In this sheet the user can introduce elasticities for the sectoral total factor productivity (TFP) with respect to the different infrastructure capital stocks identified in the model dataset; in other words, those in the set invginf (see above). The model allows the said set to be empty, in which case it is assumed that there is no nexus between sectoral TFP and the size of the infrastructure capital stock(s).

In turn, for mining activities, tfpelas(a,ext) refers to the elasticity of sectoral TFP with respect to the remaining resource stock, where ext refers to specific extractive natural resource; i.e., the smaller the remaining stock, the higher is the marginal cost of extraction, or lower the sectoral TFP. Figure 4.14 shows an example.

Figure 4.14: example tfpelas

tfpelas(a,ac)		
	invg-inf	min
aa-agr	0.05	
aa-ctl	0.05	
aa-for	0.05	
aa-fsh	0.05	
aa-min	0.05	0.75

f_elas – f_elas(f,ac)

In this sheet the use should introduce

(a) column sigma_f = the elasticity of "transformation" for factors modeled as imperfectly mobile between sectors – see option 5 under facclos0 and facclossim, and

(b) column eta_f = the supply-price elasticity for factors with endogenous supply – i.e., with eta_f(f) not equal to zero.

As an example, see Figure 4.15.

Figure 4.15: example f_elas

f_elas(f,ac)		
	sigma_f	eta_f
f-land	1.25	0.5

mps000 -- MPS000(insdng)

In this sheet the user can introduce the marginal propensity to save of domestic non-government institutions such as households and enterprises. 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.

leselas -- leselas(v,h)

In this sheet values for the income (expenditure)-elasticities for each commodity demanded by the households in the SAM are introduced; note the use of set v (consumed commodities), not c (see above). 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 4.16 shows an example.

Figure 4.16: example leselas

leselas(v,h)					
	h-rur-q1	h-rur-q2	h-rur-q3	h-rur-q4	h-rur-q5
ch-coffee	0.877	0.877	0.877	0.877	0.877
ch-banana	0.877	0.877	0.877	0.877	0.877
ch-cereals	0.877	0.877	0.877	0.877	0.877
ch-othagr	0.877	0.877	0.877	0.877	0.877
ch-ctl	0.877	0.877	0.877	0.877	0.877
ch-othfor	1.069	1.069	1.069	1.069	1.069
ch-fsh	0.877	0.877	0.877	0.877	0.877
ch-min	1.069	1.069	1.069	1.069	1.069
ch-food	0.877	0.877	0.877	0.877	0.877
ch-bevtob	0.877	0.877	0.877	0.877	0.877

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:

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

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.

---

[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.

c_elas -- c_elas(v,h)

In this sheet the user should introduce the elasticity of substitution between the individual commodities that, through the make matrix/mapcd(c,v) mapping were linked together to a composite consumed commodity (see above). As said before, a CES function is used to combine the disaggregated commodities into the composite demand commodity. As an example, see Figure 4.17.

Figure 4.17: example c_elas

c_elas(v,h)					
	h-rur-q1	h-rur-q2	h-rur-q3	h-rur-q4	h-rur-q5
ch-energ	0.2	0.2	0.2	0.2	0.2

mkmatqh -- mkmatqh(c,v,h)

In this sheet the user can optionally introduce a make matrix to transform producer commodities into consumer commodities. In fact, the model allows implementing household-specific consumer composite commodities (i.e., one make matrix per household). In Figure 4.18 we show how an expanded SAM would look like. In case no such matrix exist, the code will automatically create a make matrix based on the contents of the SAM and the mapping mapcv(c,v) (see above).

Figure 4.18: simplified SAM to show make matrix for consumer goods

	a-fuelwood	a-petprod	a-ele	a-oth	c-fuelwood	c-petprod	c-ele	c-oth	v-energy	v-oth	hh
a-fuelwood					150						
a-petprod						25					
a-ele							200				
a-oth								5500			
c-fuelwood									150		
c-petprod									25		
c-ele									200		
c-oth										5500	
v-energy											375
v-oth											5500
hhd											

where a- are activities, c- are produced commodities, v- are consumed commodities, and hhd are the households.

taxrate0 -- taxrate0(actax,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 domestic non-government 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.

qxbase – qxbase(c)

In this sheet the user can introduce information on physical units for the supply of selected commodities. Then, the prices PX, PDS, PE, and PXAC will be initialized accordingly. Similarly to qfbase, if physical units are used, the user should select the unit (e.g., tons vs. '000 tons) so that initial price and quantity variables are reasonably scaled (for example between 0.01 and 1000) -- bad scaling may cause solver problems. Figure 4.30 provides an example. In our case, the information provided for forestbas is, by default, automatically used in qxbase.

forclos0 – forclos0

In this sheet the user selects the closure rule for the determination of deforestation; IEEM provides two pre-programmed alternatives:

- forclos0 = 1 is exogenous deforestation with endogenous growth rate for forest
- forclos0 = 2 is endogenous deforestation with exogenous growth rate for forest

deforest0 – deforest0(t)

In this sheet the user can introduce a baseline projection for the deforested area, which used when forclos0 = 1; units should be the same as those used for forest land area in landbas (see below).

forgrw – forgrw(t)

In this sheet the user introduces the natural growth rate of the forest resources. Here, forest resources growth rate is expressed as land here, but should be interpreted in a broader sense. Of course, forest resources can grow even if forest land is constant. Note: data is required for the base-year in order to estimate the initial area cut.

watclos0 – watclos0(wat)

In this sheet the user selects the closure rule for the different types of (non-registered) water singled out in the dataset; IEEM provides two pre-programmed alternatives:

- watclos0(wat) = 1 water supply is unconstrained
- watclos0(wat) = 2 water supply is constrained

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 five 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;
- facclos0(f) = 4 factor is unemployed with a wage curve and mobile among sectors; and

- facclos0(f) = 5 factor is fully employed and imperfectly mobile among sectors (see also facelas(f) elasticity parameter).

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 4.19 shows the endogenous and exogenous variables in each of the four alternatives.

Tabla 4.19: 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
5	full employment (fixed UERAT); imperfectly 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 4.20 we show the endogenous and exogenous variables in each case.

Tabla 4.20: numeraire0

#	numeraire	CPI	DPI
1	consumer price index	fix	flex
2	producer price index	flex	fix

govclos0 – govclos0

In this sheet the user can select one of the three available (pre-programmed) closures to balance the government budget. In Table 4.21 the available alternatives are shown, together to the endogenous and exogenous variables corresponding to each case.

Tabla 4.21: govclos0

#	**variable that clears the government budget**
1	direct (income) tax rate
2	government real savings (domestic financing)
3	foreign financing
4	government (current) consumption

siclos0 – siclos0

In this sheet the user can select the clearing variable for the savings-investment balance. In Table 4.22 the available alternatives are shown, together to the endogenous and exogenous variables corresponding to each case.

Tabla 4.22: siclos0

#	**variable that clears the savings-investment balance**
1	investment
2	savings rate of insdng; endog invgdp

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 first case, 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 FSAV). In the second case, the real exchange rate is assumed exogenous at the same time that the foreign savings are the clearing variable. Table 4.23 shows the selection of endogenous and exogenous variable in each case.

Tabla 4.23: rowclos0

#	**variable that clears the current account BoP**
1	real exchange rate
2	foreign savings

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 4.24). 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)
- 'trgovfac' = factor income
- elements of the set actax (i.e., taxes)

Figure 4.24: example govrecrule0

govrecrule0(acgovrec)	
trgovngov	2
trgovrow	2
tax-dir	1
tax-com	1
tax-imp	1
tax-act	1
tax-vat	1

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 4.25). The government spending items identified in the model are

- ‘trngovgov’
- ‘trrowgov’
- ‘savgov’
- ‘congov’
- elements of the set subcom (i.e., consumption subsidies)
- elements of the set invg (i.e., government investment))

Figure 4.25: example govspndrule0

govspndrule0(acgovspnd)	
trngovgov	2
trrowgov	2
savgov	2
congov	2
sub-com	1
invg-inf	2
invg-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 4.26). The non-government payments 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
- 'savrow'= foreign savings
- elements of the set invng (i.e., non-government investment)

Figure 4.26: example ngovpayrule0

ngovpayrule0(acngovpay)	
trngovrow	2
trrowngov	1
trfacrow	2
trrowfac	1
savngov	2
savrow	2
invng	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.

watbase -- watbase(ac,acp)

In this sheet the user can provide data on water use by activities and households. In addition, note that water can be disaggregated between registered (i.e., provided by the water company) and non-registered (i.e., provided by the environment). Of course, the water input for the water company is sourced by the environment. For the case of Guatemala, we provide a GAMS code that processes and aggregates the original supply and use table and environmental data so that it can be used to calibrate our IEEM CGE model. To facilitate the workings of the reporting system, we recommend using m3 as units. For an example, see Figure 4.27.

Figure 4.27: example watbase

watbase(ac,acp)	**water (m3)**			
	aa-agr	aa-ctl	aa-for	aa-fsh
water-sup-registered				
water-sup-nregistered				
water-use-registered	8,904,872			
water-use-nregistered	21,142,764,815	26,566,248	501,516,456	514,618,007

irrigothbase – irrigothbas(ac,acp,acpp)

In this sheet the user can provide physical data on the irrigation, other agricultural uses of water resources, and water returns from each type of irrigation. For example, in the case of Guatemala, the following elements are singled out: rainfed, sprinkler irrigation, drip irrigation, gravity use, and other use (see Figure 4.28). Also, for all of them except the first one, returns estimates are provided (see also mapwatret). To facilitate the workings of the reporting system, we recommend using m3 as units.

Figure 4.28: example irrigothbas

irrigothbas(ac,acp,acp)		irrigation and other uses of water (m3)		
		aa-coffee	aa-banana	aa-cereals
rainfed	cc-coffee	2,569,739,260		
rainfed	cc-banana		535,828,530	
rainfed	cc-cereals			5,035,556,804
rainfed	cc-othagr			
rainfed	rainfed-tot	2,569,739,260	535,828,530	5,035,556,804
sprinkler-irrig	cc-banana		341,077,072	
sprinkler-irrig	cc-othagr			
sprinkler-irrig	sprinkler-irrig-tot		341,077,072	
drip-irrig	cc-othagr			
drip-irrig	drip-irrig-tot			

extbase -- extbase(ac,acp,acpp)

In this sheet the user can provide data on (a) the supply of extractive resources, (b) the use of extractive resources, and (c) the initial stock of extractive resources. In this case, the data will likely be provided in physical units (e.g., tons). In this data parameter, only flows with corresponding stocks should be considered. In its current version, and following the Guatemalan environmental accounts, the model assumes that extractive resources follow a specific classification – i.e., different from the supply and use table. Figure 4.29 provides an example. In Guatemala, the sources of extractive resources are two: activities and the rest of the world (i.e., imports). To facilitate the workings of the reporting system, we recommend using tons as units.

Figure 4.29 example extbas

extbas(ac,acp,acpp)		extractive resources (ton)		
		aa-min	aa-food	aa-bevtob
ext-res-sup	ext-total	37069837.8		
ext-res-use	ext-total	2342.05992	7676.77899	15.7695761

forestbase -- forestbase(ac,acp,acpp)

In this sheet the user can provide data on the supply and use of extractive resources. In this case, the data will likely be provided in physical units (e.g., m3). In the case of Guatemalan environmental accounts, forest products correspond to commodities in the supply and use table. Thus, the user can choose initialize the price of forest products using the information provided in forestbas in qxbase discussed above. For an example, see Figure 4.30.

Figure 4:30: example forestbas

forestbas(ac,acp,acpp)		forestry products	m3	
		aa-agr	aa-ctl	aa-for
for-prod-sup	cc-agr	371,354		
for-prod-sup	cc-othfor			8,319,869
for-prod-sup	cc-fuelwood			26,313,376
for-prod-sup	cc-wood			
for-prod-sup	cc-paper			
for-prod-sup	cc-othmnf			

enerbase -- enerbase(ac,acp,acpp)

In this sheet the user can introduce energy supply and use by energy commodity and energy supplier/demander. For example, in Figure 4.31 we can see that the forestry activity supplied 247,382 terajoules through the fuelwood commodity. In the model, this information can be used, for example, to simulate scenarios in which energy supply/use is exogenously determined. To facilitate the workings of the reporting system, we recommend using terajoules as units.

Figure 4.31: example enerbase

enerbas(ac,acp,acpp)		energy (terajoules)					
		aa-agr	aa-ctl	aa-for	aa-fsh	aa-min	aa-food
ener-sup	cc-fuelwood			247,382			
ener-sup	cc-min					25,402	
ener-sup	cc-petprod						
ener-sup	cc-othmnf						40,980
ener-sup	cc-ele						4,586
ener-sup	ener-sup-tot			247,382		25,402	45,566
ener-use	cc-fuelwood						33,462
ener-use	cc-min					149	698
ener-use	cc-petprod	3,994	1,076	1,019	177	1,403	10,222
ener-use	cc-othmnf						
ener-use	cc-ele	142	273			279	2,028
ener-use	ener-use-tot	4,136	1,349	1,019	177	1,831	46,410

emibase -- emibase(ac,acp,acpp)

In this sheet the user can introduce data on emissions by pollutant, commodity, and polluter. For pollutants, see the contents of set emi defined above (e.g., carbon dioxide, Nitrous oxide, and methane). For polluters, the model/data currently considers activities and/or households in the case of Guatemala. For an example, see Figure 4.33. Of course, the model allows considering additional pollutants. To facilitate the workings of the reporting system, we recommend using CO2 tons/CO2 equivalent tons as units.

Figure 4.33: example emibas

emibas(ac,acp,acpp)		**emissions (CO2 ton - CO2 equivalent ton)**				
		aa-agr	aa-ctl	aa-for	aa-fsh	aa-min
carbon-diox-sup	cc-fuelwood					
carbon-diox-sup	cc-min					14831.4109
carbon-diox-sup	cc-petprod	292013.12	79469.4091	74913.3922	12755.0028	100178.276
carbon-diox-sup	cc-othmnf					
nitrous-oxide-sup	cc-fuelwood					
nitrous-oxide-sup	cc-min					69.1735812
nitrous-oxide-sup	cc-petprod	742.89479	200.148576	189.60573	32.9129374	260.880568
nitrous-oxide-sup	cc-othmnf					
methane-sup	cc-fuelwood					
methane-sup	cc-min					32.1322442
methane-sup	cc-petprod	2875.72177	774.768682	733.957663	127.404919	302.958078
methane-sup	cc-othmnf					

wastebase – wastebas(ac,acp,acpp)

In this sheet the user can introduce data related to the supply and use of waste and residuals. In Guatemalan data, the suppliers and users of waste are activities, households, and the rest of the world. In the last case, imports from the rest of the world provide waste related to sawdust, hydrocarbons, metallic minerals, and non-metallic minerals. In Figure 4.34 we show an example of the required data. To facilitate the workings of the reporting system, we recommend using tons as units.

Figure 4.34: example wastebase

wastebas(ac,acp,acpp)		**waste (ton)**				
		aa-agr	aa-ctl	aa-for	aa-min	aa-food
resid-sup	resid-sup-tot	19,429,782	835,666	951,341	33,167	53,640,984
resid-sup	resid-animals-organs					813,353
resid-sup	resid-hospital-waste					
resid-sup	resid-metal					
resid-sup	resid-paper-waste					
resid-sup	resid-glass-waste					
resid-sup	resid-rubber-waste					
resid-sup	resid-plastic-waste					
resid-sup	resid-textile-waste					
resid-sup	resid-accumulators					
resid-sup	resid-manure		835,666			
resid-sup	resid-pulp	19,407,452				51,803,441

fshbase – fshbase(ac,ac,acpp)

In this sheet the user can introduce (physical) data on the supply and use of fishing resources. Thus, depending on the model (activities and commodities) disaggregation selected for a specific application, it is possible to track changes in the stocks of one or more fishing resources. To facilitate the workings of the reporting system, we recommend using tons as units. In Figure 4.35 we show an example of the required data.

Figure 4.35: example fshbase

fshbas(ac,acp,acpp)		**fishing resources (ton)**			
		aa-fsh	aa-food	aa-paper	aa-hotelrest
fish-sup	cc-fsh	44,609			
fish-sup	cc-food		12,499		
fish-sup	fish-sup-tot	44,609	12,499		
fish-use	cc-fsh	1,110	5,407	0	2,331
fish-use	cc-food		0		192
fish-use	fish-use-tot	1,110	5,407	0	2,524

landbase – landbase(ac,acp)

In this sheet the user can provide data on the use of land by agricultural product (see Figure 4.36). Of course, the data in this data point should be consistent with the data provided in qfbase(f,a) for the land use by activity. Note: forest land (land-for) is for end of period; deduct deforestation to compute beginning of period

Figure 4.36: example landbase

landbas(ac,acp)	
land-agr	3,071,482
land-bushes	2,703,067
land-past	1,058,952
land-for	3,722,595
land-oth	332,803
land-total	10,888,900

scaling

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), water use, extractive (mineral) resources, fishing resources, forest resources, and energy. Finally, column to1 indicates the units of the SAM data; i.e., 1,000,000 means that SAM is expressed in million LCU. The number one means that no scaling is made.

Figure 4.25: example scaling

scaling(ac)				
sam	qlab	wat	ext	forest
100	1,000	1,000,000	1,000	10,000

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 IEEM CGE model application Excel file; typically, app-sim.xlsx, where app refers to a particular application; for example, gtm2010-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 the numeraire
eff-fuelwood	increase fuelwood efficiency
tfpagr	increase TFP in agriculture

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.

forclossim – forclossim(sim)

In this simulation parameter the user can select the closure rule for the evolution of forest land; the available options are the same as those presented above for forclos0. By default, (i.e., when no selection is made), all simulations assume the same closure rule that was selected in forclos0 (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.

watclossim – watclossim(sim,wat)

In this simulation parameter the user can select the closure rule for the different types of (non-registered) water in each of the scenarios; the available alternatives are the same as those presented above for watclos0. By default (i.e., when no selection is made), all simulations assume the same closure rule that was selected in watclos0 (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.

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 4.19 (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 4.20 (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 4.21 (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 4.22 (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 4.23 (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. By default, 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, IEEM CGE has, as default, the CPI selected as the model numeraire.

tmbarsim -- tmbarsim(sim,c,t)

In this sheet the user can define scenarios in which changes in the import tariff rates are simulated. The counterfactual import tariff rate for commodity c in simulation sim in period t is computed as

tmbar (c,t) = tmbar0(c,t) if tmbarsim(sim,c,t) = 0

tmbar (c,t) = tmbar0(c,t) * tmbarsim(sim,c,t) if tmbarsim(sim,c,t) <> 0

Thus, shocks are introduced as deviations relative to the base scenario. For example, 1.25 implies a 25% increase. Figure 5.2 shows an example; specifically, the taximp scenario simulates a unilateral elimination of import tariffs during the period 2011-2012 for the primary and food commodities in the SAM for Guatemala.

Figure 5.2: example tmbarsim

tmbarsim(sim,c,t)		tm = tm0 x tmsim		
		2010	2011	2012
taximp-cut	cc-agr	1	0.5	0.5
taximp-cut	cc-ctl	1	0.5	0.5
taximp-cut	cc-othfor	1	0.5	0.5
taximp-cut	cc-fuelwood	1	0.5	0.5
taximp-cut	cc-fsh	1	0.5	0.5
taximp-cut	cc-min	1	0.5	0.5
taximp-cut	cc-food	1	0.5	0.5
taximp-cut	cc-bevtob	1	0.5	0.5

tmbar2sim – tmbarsim(sim,c,t)

In this sheet the user can also define scenarios in which changes in the import tariffs rates are simulated. However, in this case the counterfactual import tariff rate is introduced as a level, not as deviation relative to the base scenario. Thus, the simulated import tariff rate is computed as

tmbar (c,t) = tmbar0(c,t) si tmbar2sim(sim,c,t) = 0

tmbar (c,t) = tmbar2sim(sim,c,t) si tmbar2sim(sim,c,t) <> 0

Thus, as opposed to tmbarsim(sim,c), this simulation parameter can be used to introduce import tariffs in cases where there are no such taxes in the SAM; i.e., the reference scenario does not show the existence of import tariffs for all or selected commodities.

tebarsim -- tebarsim(sim,c,t)

In this sheet the user can define scenarios in which changes in (existing) export tax rates are simulated. The counterfactual export tax rate for commodity c in simulation sim in period t is computed as

tebar (c,t) = tebar0(c,t) if tebarsim(sim,c,t) = 0

tebar (c,t) = tebar0(c,t) * tebarsim(sim,c,t) if tebarsim(sim,c,t) <> 0

tebar2sim -- tebarsim(sim,c,t)

In this sheet the user can also define scenarios in which changes in the export tax rates are simulated. However, in this case the counterfactual export tax rate is introduced as a level, not as deviation relative to the base scenario. Thus, the simulated export tax rate is computed as

tebar (c,t) = tebar0(c,t) if tebar2sim(sim,c,t) = 0

tebar (c,t) = tebar2sim(sim,c,t) if tebar2sim(sim,c,t) <> 0

Note that this simulation parameter can be used to introduce export taxes/subsidies in cases where there are no such taxes in the SAM; i.e., the reference scenario does not show the existence of export taxes.

tqbarsim – tqbarsim(sim,c,t)

In this sheet the user can define scenarios in which changes in sales tax rates are simulated. The counterfactual sales tax rates are defined as deviation with respect to the base scenario, as in previous cases.

tabarsim – tabarsim(sim,a,t)

In this sheet the user can define scenarios in which changes in activity tax rates are simulated. The counterfactual activity tax rates are defined as deviation with respect to the base scenario, as in previous cases.

tabar2sim -- tabar2sim(sim,a,t)

In this sheet the user can also define scenarios in which changes in the activity tax rates are simulated. However, in this case the counterfactual activity tax rate is introduced as a level, not as deviation relative to the base scenario.

tfactbar2sim(sim,f,a,t)

In this sheet the user can define scenarios in which changes in the factor use tax rates are simulated (e.g., social security contributions). In this case, the counterfactual tax rate is introduced as a level, not as deviation relative to the base scenario.

gammacbarsim -- gammacbarsim(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 gammacbarsim

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

shqfminsim – shqfminsim(sim,ac)

In this sheet the user can select the institution and/or factor that collect the subsidy required to impose the lower bound (qfminsim) on sectoral factor demands.

qfmin01sim -- qfmin01sim(sim,f,a)

In this sheet the user can select the factor-activity pairs that are subject to a minimum level of employment.

qfminsim – qfminsim(sim,f,a)

In this sheet the user can impose lower bounds on sectoral factor demands. By default, this is equal to the reference scenario (real) values.

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

fprdbarsim -- fprdbarsim(sim,f,t)

In this sheet the user can define shocks to factor productivity, by shocking the constant in definition of productivity of factor f. For example, it can be used to simulate an increase in land productivity. The counterfactual value for fprd for factor f in simulation sim is computed as

fprdbar(f) = fprdbar0(f) if fprdbarsim(sim,f) = 0

fprdbar(f) = fprdbar0(f)*fprdbarsim(sim,f) if fprdbarsim(sim,f) <> 0

fprdabarsim -- fprdabarsim(sim,f,a,t)

In this sheet the user can define shocks to activity-specific factor productivity, by shocking the constant in definition of productivity of factor f used in activity a. For example, it can be used to simulate an increase in land productivity used for a specific crop. The counterfactual value for fprdabar for factor f used in activity a in simulation sim is computed similarly to the previous case.

qgbarsim – qgbarsim(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.

rgfcfbarsim – rgfcfbarsim(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

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.

rgfcfbar2sim – rgfcfbar2sim(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.

trnsfrbarsim -- trnsfrbarsim (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 non-household 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.

In turn, counterfactual transfer per capita from institution ins to household institution h in period t is computed as

trnsfrpcbar(h,ins,t) = trnsfrpcbar0(h,ins,t) if trnsfrbarsim(sim,h,ins,t)) = 0

trnsfrpcbar(h,ins,t) = trnsfrpcbar0(h,ins,t) * trnsfrbarsim(sim,h,ins,t) if trnsfrbarsim(sim,ac,ins,t)) <> 0

FSAVSIM -- FSAVSIM(sim,t)

In this sheet the user can define shocks to the savings from the rest of the world. Of course, the information introduced here is only used if, for the same simulation scenario, the value of rowclossim is 1; i.e., FSAV is an exogenous variable. The counterfactual value for FSAV is computed as deviation from the base scenario, similar to other simulation parameters.

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.

qebarsim -- qebarsim(sim,c,t)

In this sheet the user can define shocks to the exogenous volume of sectoral exports; it applies to commodities in the set cedexog(c) (see see cedexog). The counterfactual value for qebar for commodity c in simulation sim in period t is computed as

qebar(c,r,t) = qebar0(c,r,t) if qebarsim(sim,c,r,t) = 0

qebar (c,r,t) = qebar0(c,r,t)*qebar2sim(sim,c,r,t) if qebarsim(sim,c,r,t) <> 0

qebar2sim -- qebar2sim(sim,c,t)

In this sheet the user can also define shocks to the exogenous volume of sectoral exports. However, in this case the counterfactual volume of sectoral exports is introduced as a level, not as deviation relative to the base scenario. The counterfactual value for qebar for commodity c in simulation sim in period t is computed as

qebar(c,r,t) = qebar0(c,r,t) if qebar2sim(sim,c,r,t) = 0

qebar (c,r,t) = qebar2sim(sim,c,r,t) if qebar2sim(sim,c,r,t) <> 0

In this case, qebar2sim is expressed in the same units as the SAM.

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

qheffbarsim -- qheffbarsim(sim,c,h,t)

In this simulation parameter, the user can define scenarios in which the household consumption efficiency of one or more commodities is increased. For example, it can be used to simulate a scenario in which the volume of energy obtained from a u unit of fuelwood is increased. Again, a value of 1.5 for a sim-c-h-t combination implies a 50% increase in the simulation sim for the commodity c consumed by the household h in period t relative to the base scenario.

qfexogsim – qfexogsim(sim,f,a)

In this sheet the user can define scenarios in which the – otherwise endogenous -- sectoral factor demand is changed. For example, the analyst might be interesting in simulating a policy that imposes a lower bound to the number of hectares of land destined to forestry. To that end, the model implement “phantom taxes/subsidies” that provide the incentives to change the behavior of land users; for example, by introducing a “self-financed tax/subsidy” to the forestry activity.

extdiscsim – extdiscsim(sim,ext,t)

In this sheet the user can define scenarios in which the discoveries of extractive resources change relative to the base scenario.

watsbarsim – watsbarsim(sim,wat,t)

In this sheet the user can define scenarios in which the supply of water changes relative to the base scenario. Again, the shocks are introduced as previously explained for other simulation parameters. Hence, shocks are defined as deviation with respect to the water supply recorded for the same period in the base scenario.

iwatbarsim – iwatbarsim(sim,wat,ac,t)

In the model, the parameter iwatbar refers to the (exogenous) volume of (registered and unregistered) water consumed per unit of output for activities and per capita for households. In this sheet the user can define scenarios in which iwatbar is changed, for example reflecting an increase in the water use efficiency by the activities.

iemisim – iemisim(sim,emi,c,ac,t)

In this sheet the user can define scenarios in which the volume of emissions per unit of intermediate and/or final consumption is changed. Again, a value of 0.95 for a sim-emi-c-ac-t combination implies a 5% decrease in the simulation sim for the volume of pollutant emi generated from the consumption of commodity c by demander ac (i.e., activities/households) in period t relative to the base scenario.

shqdeformaxsim -- shqdeformaxsim(sim,ac)

In this sheet the user can select the institution and/or factor that collect the implicit tax required to impose an upper bound (qdeformaxsim) on deforestation.

qdeformax01sim -- qdeformax01sim(sim)

In this sheet the user can select to impose (qdeformax01sim=1) or to not impose (qdeformax01sim=0) an upper bound on deforestation.

qdeformaxsim -- qdeformaxsim(sim,t)

In this sheet the user can impose an upper bound for the deforested area, which is used when forclossim = 1; units should be the same as those used for forest land area in landbas (see below).

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 describes 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.

- 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.
- facdemstruc(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 shows summarizes the income distribution across representative households.
- enerindic(enercol,ac,ac,t,sim): this report shows energy-related indicators, such as energy intensity (i.e., terajoules per unit of value added).

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

Cicowiez, Martín, Fernando Consigli y Enrique Gallego, 2013, ISIM-MAMS: An Interface for MAMS: User Guide, DECPG Banco Mundial, Mimeo.

Banerjee, Onil, Martin Cicowiez, Renato Vargas y Mark Horridge, 2016, The SEEA-Based Integrated Economic-Environmental Modelling Framework: An Illustration with Guatemala's Forest and Fuelwood Sector, Mimeo.