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AGEFIS:
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Abstract

AGEFIS (Applied General Equilibrium model for FIScal Policy Analysis) is a Computable General Equilibrium (CGE) model designed specifically, but not limited, to analyze various aspects of fiscal policies in Indonesia. It is yet, the first Indonesian fully-SAM-based CGE model solved by Gempack. This paper describes the structure of the model and illustrates its application.

Keywords: AGEFIS, CGE, Fiscal Policy, Indonesia
JEL Codes: C68, D58, H30

1. Background

This paper introduces AGEFIS (Applied General Equilibrium model for FIScal Policy Analysis). It starts by introducing the motivation behind building the model, followed by describing the process of constructing the model, and then the theoretical structure and the model's database. A relevant application of the model is illustrated for demonstration purpose.

AGEFIS was built under the capacity building activity carried out by the CGE Modeling Unit (CCMU), Center for Economics and Development Studies (CEDS)[3], Faculty of Economics, Padjadjaran University, for Fiscal Policy Agency (Badan Kebijakan Fiskal/BKF), The Ministry of Finance Republic of Indonesia. It was developed to anticipate the need of the Ministry of Finance to analyze the impact of various fiscal policies on the economy, as well as the impact of various economic shocks to the fiscal position of the budget of the Indonesian government[4].

AGEFIS was built from scratch in the sense that it was created from a 'blank' TABLO[5] code. The process took the following stages:

1. Building the idea of the model's theoretical structure.

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[1] Address for correspondence: Dr. Arief Anshory Yusuf, email: arief.yusuf@fe.unpad.ac.id

[2] Readers who are interested to use the model can visit CEDS website, download and fill in the application form and send it by email to arief.yusuf@fe.unpad.ac.id. The purpose of filling the form is to maintain network of the AGEFIS users.

[3] CEDS website: http://ceds.fe.unpad.ac.id, CCMU website: http://ceds.fe.unpad.ac.id/unit/ccmu.html

[4] AGEFIS is open for public use and can be downloaded from CEDS website, http://ceds.fe.unpad.ac.id

[5] Tablo is a text editor, where all the equations of the model are written. It is part of GEMPACK a General Equilibrium Modeling Package developed by Center of Policy Studies (CoPS), Monash University.

2. Writing down the structural equations of the model i.e. both linear and non-linear equation in level.
3. Linearizing the level equations into percentage change form (as required by Gempack).
4. Writing down the linearized equations into TABLO file.
5. Building the database of the model from the 2003 Indonesian Social Accounting Matrix.

Unlike most Indonesian CGE models solved by GEMPACK which use Input-Output (I-O) table as its basic database (such as INDORANI, WAYANG, INDOCEEM), AGEFIS uses Social Accounting Matrix as its core database. The use of the SAM is necessary if fiscal aspect will be the focus application. Information from an I-O table would be far from sufficient.

To analyze the fiscal aspects, we need information of transaction flow on the source of each item of government income and how they are spent. This information is unavailable from an I-O table. Hence, the only way is to build a model which is based on a SAM. AGEFIS is yet the first Indonesian fully-SAM-based CGE model solved by GEMPACK i.e., the structure of the SAM is in line with the structure of the CGE model, similar to most GAMS[6]-based model.

Although in structure, the AGEFIS Model resembles the other SAM-based models, AGEFIS' interface is designed to abridge the fiscal analyses. Users, for example, can run the exogenous shocks on the component of the government budget and observe easily those impacts on the fiscal position of the budget.

AGEFIS Model may be far from perfection and need various modification and extension to be complete. For example, the number of sectors in AGEFIS which is only 23 commodities offers less flexibility. Besides, it has no theoretical link between government revenue with government spending for investment (capital expenditure). In the future, those weaknesses can be improved.

2. Summary of the Structure and Database of AGEFIS

As an overview (the details would be in the next section), the theoretical structure of the model can be summarized as follows:

1. The production structure of 23 economic sectors is based on nested Leontief production function for intermediate input and value added, while the value added production function is specified as a CES (constant elasticity of substitution). There are two primary production factors in the model, i.e. capital and labor.
2. The optimization of import and domestic goods composition is conducted by an economic agent via Armington specification.
3. The household sector maximizes a Cobb-Douglas utility function.
4. The household receives income from the ownership of production factors, as well as from transfers from a range of other institutions (government, companies and foreign).
5. The government receives their income from indirect tax, direct tax, returns to factor ownership and transfer from other institution such as the rest of the world. Government spends the budget for consumption, to subsidize commodities and to send transfer to other institution such as households.
6. The closure of AGEFIS is flexible, below is some examples:
   a. Long term closure: full employment of factor; capital and labor mobile among sectors.
   b. Short term closure: capital is mobile among sectors; aggregate employment can change (unemployment of factors is possible).

[6] General Algebraic Modeling System, a popular software to solve CGE modeling. See http://www.gams.com for more detail.

c. Short term closure with full employment that capital can not make a move among sectors, but the labor always in full employment.
d. Different closure from fiscal side, such as government saving (for government investment also) is exogenous, or no surplus/deficit but automatically increase the government spending for consumption, etc.

List of Sectors of production in AGEFIS model:

1. CROPS Agricultural food crops
2. OCROP Other agricultural food crops
3. LIVEST Livestock and the products
4. FOREST Forestry and hunting
5. FISHR Fishery
6. MINE Mining and other quarrying
7. QUARY Quarrying of coal & metal ores, oil and natural gas
8. FOOD Manufacture of food, beverage and tobacco
9. TEXT Manufacture of spinning, textile, and leather
10. WOOD Manufacture of wood and wood-based product
11. PAPER Manufacture of paper, printing, metal-based transportation and other industries
12. CHEM Manufacture of chemical, fertilizer, cement and fabricated metal product
13. ELEC Electricity, gas and water supply
14. CONST Construction
15. TRADE Wholesale trade and retail, transportation support service and wear house
16. REST Restaurant
17. HOTEL Hotel
18. LNDTR Land transportation
19. AIRTR Air transport and water transport, communication
20. BANK Bank and insurance
21. REAL Real estate and corporate service
22. GOVSR Government and defense, education, health, other social service
23. SERV Personal service, household and other service

The above sector classification follows the classification in the official Social Accounting Matrix.

The SAM that constitutes the core database of AGEFIS is summarized on Table 1 as follows:

Table 1. Summary of Social Accounting Matrix of AGEFIS (SAM 2003, Rp Trillion)

	FAC	HH	COR	GOV	AGR	MAN	SER	SAV	ITX	SUB	ROW	TOTAL
FAC					509	666	796				9	1,980
HH	1,448	90	48	42							10	1,638
COR	403		58								7	468
GOV	62	18	124	48					132	-5	0	379
AGR		205		0	68	312	57	-4			132	770
MAN		608		16	47	670	229	294			442	2,305
SER		468		142	115	357	271	4			112	1,469
SAV		109	226	105								441
ITX					7	55	37				33	132
SUB						-5	0					-5
ROW	67	140	11	27	25	251	79	145			473	1,217
TOTAL	1,980	1,638	468	379	770	2,305	1,469	441	132	-5	1,217	10,793

Note: FAC = primary factor of production; HH = household; COR = corporate sector; GOV = government sector; AGR = agriculture; MAN = manufacturing; SER = services; SAV = saving-investment; ITX = indirect tax; SUB = subsidy; ROW = rest of the world.

3. The use of AGEFIS

Table 2 shows how AGEFIS model can be applied to various aspects of fiscal policies.

Table 2. The Use of Model AGEFIS

	Instrument/Scenario	**Example Case**
The impact of fiscal policy (revenue side)	Indirect tax for various commodity	To reform indirect taxation (e.g. reduce or increase the indirect tax rate) to find the most optimal (in terms of GDP and employment generation or composition of sectors) indirect tax structure.
	Income tax (household/ individual)	Intensification (increasing direct tax rate) or extensification (direct tax object), the impact to economic
	Corporate tax (transfer for corporate)	Intensification and extensification of tax/transfer from corporate sector and its economic impact
	Foreign aid	The impact of the foreign aid or foreign loan
The impact of fiscal policy (expenditure side)	Subsidy for various commodity	The impact of increasing, decreasing, or even removing subsidy of commodity, e.g. electricity subsidy, etc toward economic, employment, and sector side.
	Government consumption	The impact of increase or decrease the overall government consumption on specific sector on economic, employment, and sectoral side.
	Transfers for various institution	The impact of changing transfer from government to other institution e.g. household, corporate, or foreign toward

		economic, employment and sector side.
combination of income – expenditure side	Combination of various instrument either from income side or expenditure side	The impact of electricity subsidy reduction, and to look for alternative expenditure reallocation: to subsidize other sectors, to transfer the households, or spend for specific sector (which is the most optimum)
The impact on fiscal position	The impact of exogenous various economic shocks on fiscal position	1. The impact of international commodities price shock 2. The impact of supply shock in certain sector, such as dryness in agriculture 3. The impact of the increase of productivity towards government income from tax, and how the most optimum fiscal response. 4. The impact of investment in certain sector towards fiscal position.

4. Illustration of Simulation using AGEFIS

This section will illustrate the case of electricity subsidy removal[7]. To remove the subsidy, we need to know first how much the initial rate of the subsidy (in proportion to its basic price) and then use those numbers for calculating the amount of shock statement. We can find this information from the data AGEFIS.HAR[8]. The data contains a header called 'indirect tax instrument by sector'.

[7] This does not reflect accurately the removal of subsidy on electricity sector because the sectors represent also, gas and water supply sector.

[8] At the Model/Data menu in RUNGEM, right-click data and view with viewhar.

agefis.har in F:\WORK\UNPAD\DEPKEU\CGE\AGEFIS\agefis

File Contents Edit Sets Export Import History Search Aggregation Programs

None 6

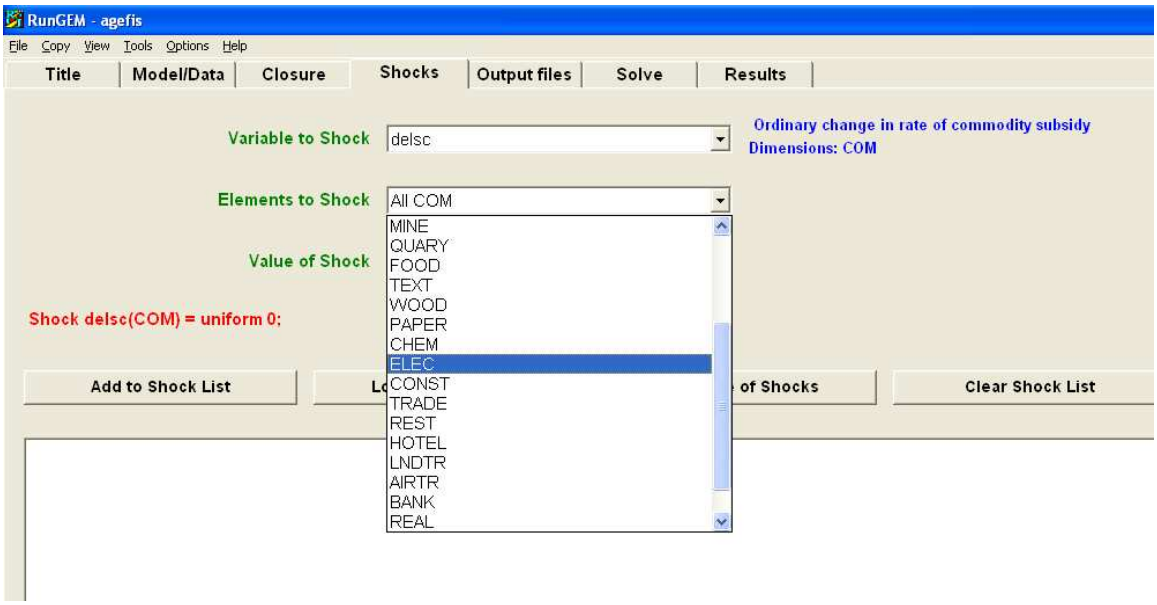
INSTSEC	1 INDTAX	2 SUBSIDY	3 TARIFF	Total
1 CROPS	0.008880	0.000000	0.056468	0.065348
2 OCROP	0.012536	0.000000	0.092101	0.104637
3 LIVEST	0.006143	0.000000	0.073668	0.079811
4 FOREST	0.014075	0.000000	0.090136	0.104211
5 FISHR	0.010905	0.000000	0.062346	0.073251
6 MINE	0.007847	0.000000	0.104842	0.112689
7 QUARY	0.021347	0.000000	0.098269	0.119616
8 FOOD	0.051481	0.000000	0.088443	0.139924
9 TEXT	0.014256	0.000000	0.109346	0.123602
10 WOOD	0.007650	0.000000	0.091647	0.099297
11 PAPER	0.019419	0.000000	0.060594	0.080013
12 CHEM	0.019761	0.001139	0.091799	0.112700
13 ELEC	0.013964	0.063941	0	0.077905
14 CONST	0.015565	0.000000	0	0.015565
15 TRADE	0.045249	0.000000	0	0.045249
16 REST	0.036379	0.000000	0	0.036379
17 HOTEL	0.051128	0.000000	0	0.051128
18 LNDTR	0.015465	0.000599	0	0.016065
19 AIRTR	0.014910	0.000000	0	0.014910
20 BANK	0.008557	0.000000	0	0.008557
21 REAL	0.038137	0.000000	0	0.038137
22 GOVSR	0.005346	0.000000	0	0.005346
23 SERV	0.024038	0.000000	0	0.024038
Total	0.463038	0.065679	1.019660	1.548377

Electricity subsidy rate is 6.4%.

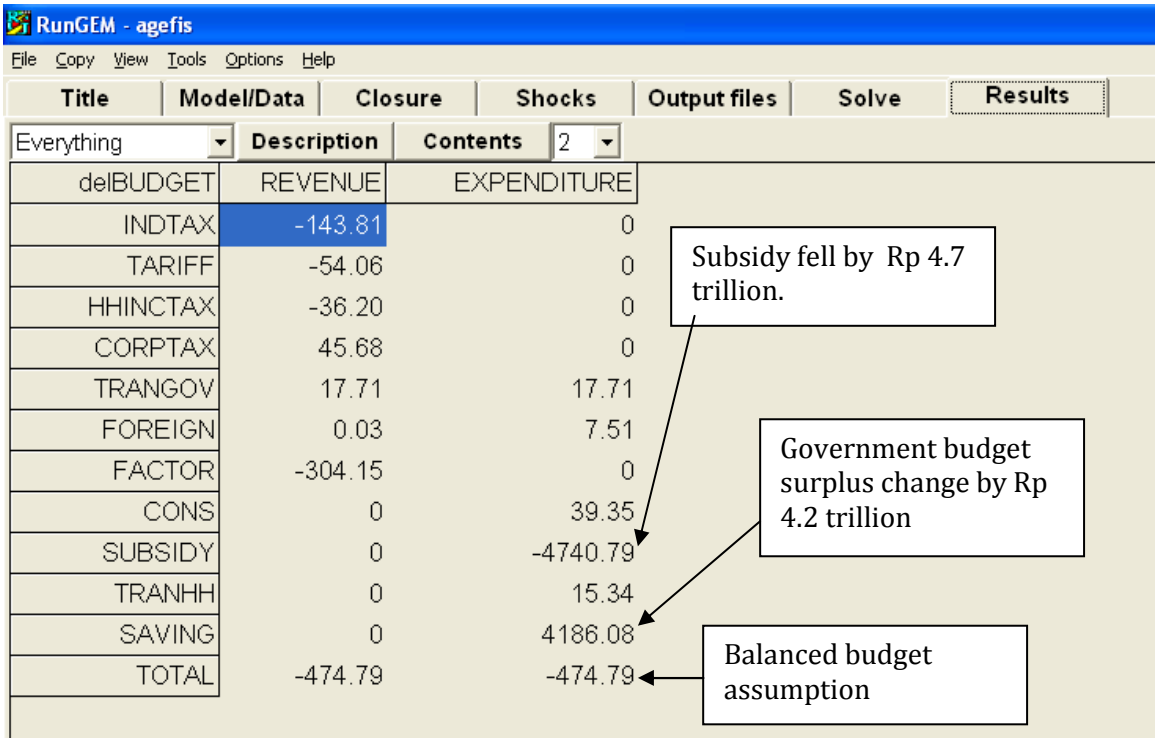
AGEFIS is run using the user-friendly RUNGEM[9] interface. To implement the shock, we only need to go to the shock menu and choose which variable to be shocked. In this case, the variable is subsidy rate i.e, delSC. We then choose the commodity and the amount of the shock, in this case -0.63941. The shock statement is:

shock delSC("ELEC") = -0.63941;

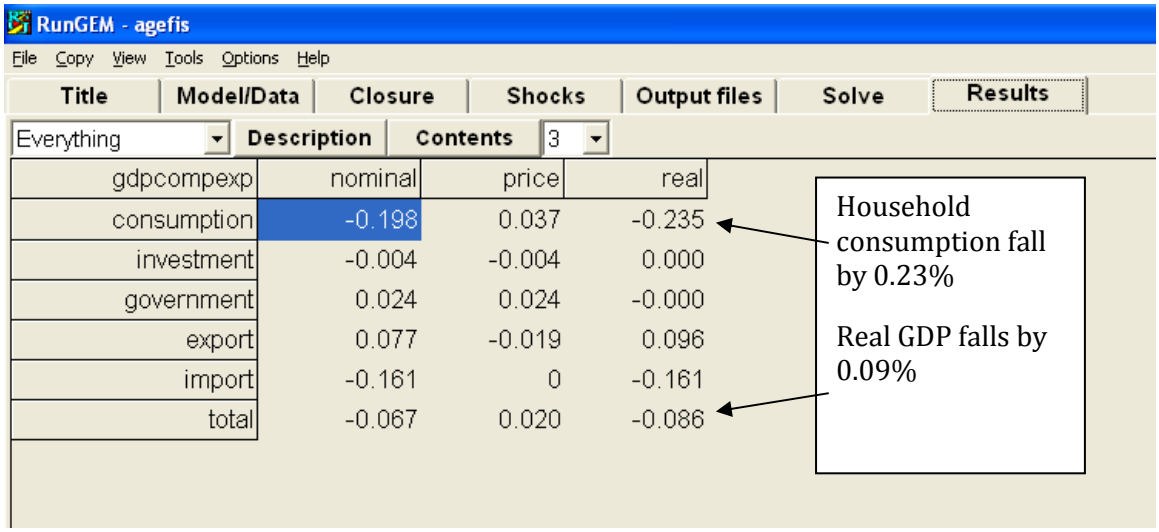
[9] RUNGEM is free to download. The url address for downloading RUNGEM is: http://www.monash.edu.au/policy/gprgem.htm

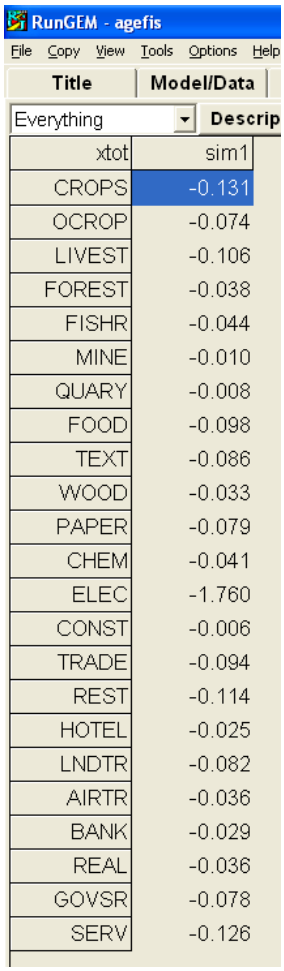


The fiscal impact can be seen from variable delBUDGET (nominal change in billion rupiahs) as illustrated below.



The impact on GDP and its components (from expenditure side) can be seen from variable gdpcompexp (in percentage of change), as illustrated below:





The impact on output by sector can be viewed from variable xtot, as illustrated on the left figure:

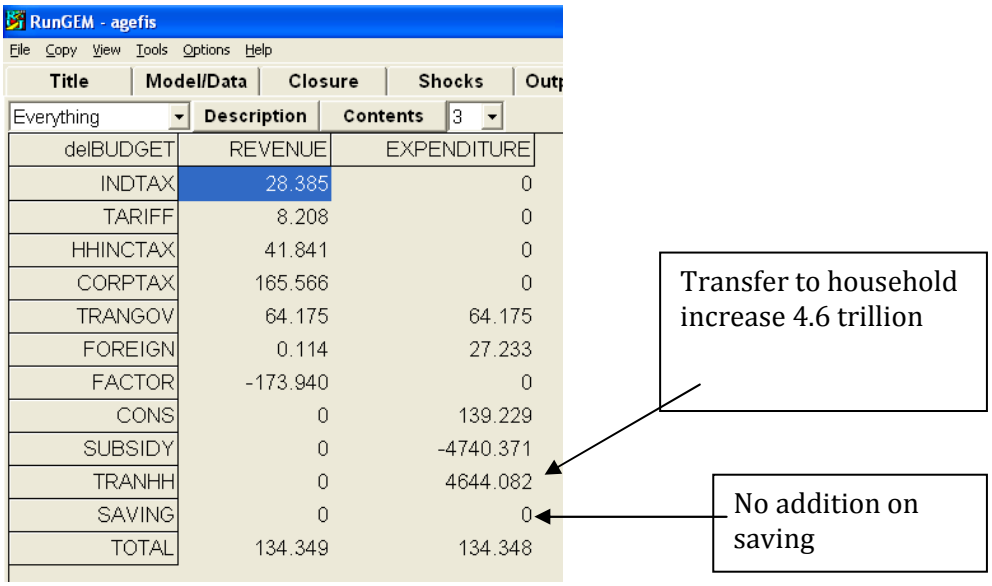
The output of electricity sector falls for by 1.76%. The other sector's outputs generally decline.

The aggregate employment (see variable xfacsup) falls by 0.15%.

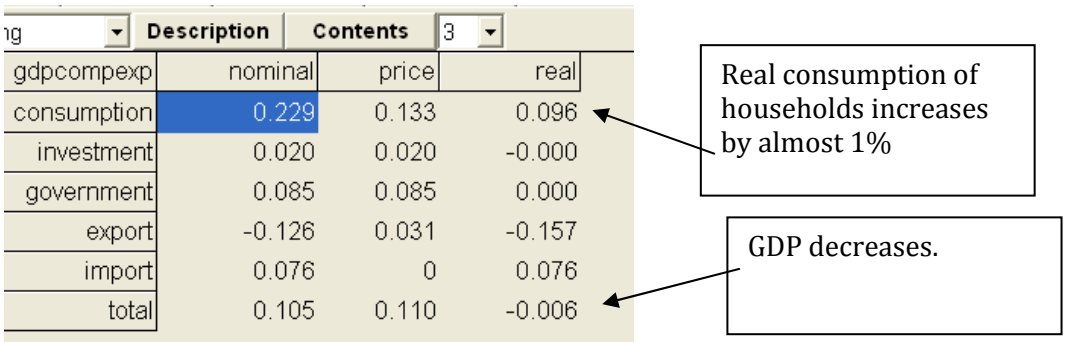
If we want to know the impact of reallocating the money saved from reducing this subsidy to other posts in the budget, we can change that in the closure specification. Suppose that we want to allocate that to households as transfers, then we need only add the following statement in the closure:

swap delSG = delTRHOGO;

The budgetary impact using that closure will be the following:



The impact on GDP as follows:



Other than the above scenarios, we can also do a variety of scenarios which changes the budget items, e.g. allocation to the government consumption expenditure, decrease indirect tax of other goods, or decrease overall indirect tax rate. All things can be done conveniently using RUNGEM interface of AGEFIS model.

5. The Structure of AGEFIS Database

The database of AGEFIS model is stored in the file agefis.har which consists of a range of coefficients recording the transaction values among economic agents, some parameters, and also other information such as the fiscal instruments. The following table summarizes the agefis.har.

Table 3. List of coefficients in AGEFIS databse

Coefficient	Dimension	Value (million rupiahs)	Remark
DEMAND			
VXINT_S	COM*IND	2,478,376	Transaction value of intermediate demand
VXHOU_S	COM	1,416,045	Transaction value of house holds consumption demand
VXINV_S	COM	364,116	Transaction value of investment goods
VXG_S	COM	163,701	Transaction value of government consumption demand
VXEXP	COM	685,851	Transaction value of export
VXD	COM*SRC	4,422,238	Transaction value by source (domestic or import)
PRIMARY PRODUCTION FACTORS			
VXFAC	FAC*IND	1,971,180	Payment of primary production factors by industry
VXFACRO	FAC	8,579	Payment of production factors by rest of the world
VXFG	FAC	61,565	Payment of production factors that owned by government
VXFCO	FAC	402,604	Payment of production factors that owned by corporation
VXFRO	FAC	67,400	Revenue of production factors income that owned by rest of the world
VXFACSH	FAC	1,448,190	Revenue of production factors income that owned by household
TRANSACTION RELATED TO FISCAL INSTRUMENT			
VTX	COM	99,270	Government income from indirect tax
VSC	COM	5,448	Government expenditure to subsidize goods and services
VTM	COM	32,927	Government income from import excise tax
VYTAX	1	18,246	Government income from household' income tax
VCORTAX	1	124,183	Government income from corporate tax
INSTSEC	IND*INST01	1.55	Indirect tax rate and subsidy rate
DIRECTTAX	INST02	0.28	Direct tax rate (household and corporate)

TRANSFERS BETWEEN INSTITUTIONS[10]			
SAVH	1	109,148	Saving of households
VTRROHO	1	4,258	Transfer from households to rest of the world
VTRHOHO	1	90,400	Transfer from households to other households
VTRROGO	1	20,426	Transfer from government to rest of the world
VTRHOGO	1	41,709	Transfer from government to household
VTRGOGO	1	48,135	Transfer from government to other government
VTRHOCO	1	48,192	Transfer from corporate to household
VTRCOCO	1	57,518	Transfer from corporate to corporate
VTRROCO	1	11,260	Transfer from corporate to rest of the world
VTRGORO	1	86	Transfer from rest of the world to government
VTRCORO	1	7,445	Transfer from rest of the world to corporate
VTRHORO	1	9,604	Transfer from rest of the world to household
VTRRORO	1	472,998	Transfer from rest of the world to rest of the world

PARAMETER			
SIGARM	COM	46	Armington Elasticities
SIGMAPRIM	IND	11.5	Elasticities of Factor Production
EXPELAS	COM	115	Export elasticity of demand

The database agefis.har come from Indonesian Social Accounting Matrix 2003.

7. Understanding the Tablo File of AGEFIS

This section will explain the statements in file tablo agefis.tab, especially the structural equations and identities.

Tablo file agefis.tab can be divided into the following parts.

1. **File statement**. In file statement, logical filename (here is 'database') is defined. The physical file is agefis.har. In agefis.tab, file statement is written as:

   ```
   file database # database model agefis #;
   ```

   [note: statement between # is a comment]

2. **Set statement.** In set statement, the name of set and elements from each sets are declared. In tablo agefis.tab, set statement is written as follows:

   ```
   set
   ```

[10] To be easier to remember, the coefficient of inter institution transfer is initiated with VTR (the value of transfer), then followed by XX and then YY or VTRXXYY. XX imply the institution who receives the transfer, while YY represent the institution who gives the transfer. Those institutions are as follows: HO = household; GO = government; CO = Corporate; RO =Rest of The World. So the coefficient VTRHOCO, means the value of transfer received by households from corporate sector or the value of transfer given by corporate sector to households.

```
COM # commodity # (CROPS, OCROP, LIVEST, FOREST, FISHR, MINE,
 QUARY, FOOD, TEXT, WOOD, PAPER, CHEM, ELEC, CONST, TRADE, REST,
 HOTEL, LNDTR, AIRTR, BANK, REAL, GOVSR, SERV);
FAC # factor # (labor, capital);
SRC (dom, imp);
IND = COM;
```

3. **Coefficient declaration.** Coefficients is distinguished from variables. Coefficient is the representation of data read from the model database. In the coefficient declaration, all of the coefficients are declared, and those values would be read from database or calculated using formulas. In general, coefficients can be divided into two types: (1) coefficients of which their value must be read directly from the headers in database, these are called basic coefficients; and (2) coefficients of which their value are calculated based on the basic coefficient in formula statements. Coefficients are written in uppercase.

4. **Read statement.** Read statement is a statement to fill the values of basic coefficient by reading it from database.

5. **Formula statement.** Formula statement is a statement to calculate the coefficients not read from the database, but as a function of other coefficients (such as basic coefficients).

6. **Variable declaration.** A variable essentially is the unknown in the model the value of which is to be solved when the model is solved. Almost all variable in AGEFIS model are in percentage change. Some exception is when the variable is in nominal ordinary change. In this part of the Tablo file, those variables are declared.

7. **Update statement.** Update statement is a statement to update the basic coefficient using their corresponding and relevant variables after the simulations.

8. **Equation statement.** Equation statement is essentially the core of the Tablo file of AGEFIS. Here the structural equations of the model are written.

7.1 Conventions

In AGEFIS model, there are two kinds of variables: scalar variables and a vector or matrices variables. Vector or matrix variable has subscript. To make it easy to remember the following convention for subscript will be used.

- c for commodity
- i for industry
- f for factor of production, i.e., labor and capital
- s for source i.e., where the commodity come from i.e., domestic or foreign

Almost all variables in AGEFIS are in percentage change. They are written in lowercase. There are also ordinary change variables. The name of these variables start with ‘del’. The rest of the convention for naming the variable is as follows:

1. Variables with lowercase means that variable are in percentage change.
2. Variable that starts with ‘del’, such as delXX, delTX or delSC are ordinary change.

3. Coefficients are written with uppercase and are in level
4. Variables or coefficients that start with letter V (or w) are value.
5. Variables or coefficients that start with letter P (or p) are price.
6. Variables or coefficients that start with letter X (or x) are quantity or real variables.

Underline in a variable name means something in AGEFIS. A variable that has underline is usually a result of aggregation (we call it composite variable, sometimes).

1. _c is aggregate or average over commodities (over COM (commodities))
2. _s c is aggregate or average over source (over SRC (dom+imp))
3. _i c is aggregate or average over industries (over IND (Industries))

7.2 Coefficient declaration

In this part of Tablo file, the coefficients are declared as follows: [note: underlined rows indicate basic coefficient]

```
coefficient

 (all,c,COM) VXD_S(c) # Value of Demand Composite Import Domestic #;
 (all,c,COM)(all,s,SRC) VXD(c,s) # Value of Demand by sources #;
 (all,c,COM) VTX(c) # Indirect Taxes Revenue #;
 (all,c,COM) VXCIF(c) # Value of Import at CIF  #;
 (parameter) (all,c,COM) SIGARM(c) # Armingtong Elasticities #;
 (all,c,COM)(all,i,IND) VXINT_S(c,i) # Value of Intermediate Demand #;
 (all,c,COM) VXHOU_S(c) # Value of Household Consumption #;
 (all,c,COM) VXINV_S(c) # Value of Investment #;
 (all,c,COM) VXG_S(c) # Value of Government Consumption by Commodities #;
 (parameter) (all,i,IND) SIGMAPRIM(i) # Elasticities of Factor Production  #;
 (all,f,FAC)(all,i,IND) SFAC(f,i) # Factor cost share #;
 (all,f,FAC) VXFACRO(f) # Value of Demand for Factor from Rest of The World #;
 (all,f,FAC)(all,i,IND) VXFAC(f,i) # Value of Demand for factor #;
 (all,f,FAC) VXFG(f) # Value of factor supply  from government sector #;
 (all,f,FAC) VXFCO(f) # Value of factor supply  from corporate sector #;
 (all,f,FAC) VXFRO(f) # Value of factor supply  from Rest of The World  #;
 (all,i,IND) VTOT(i) # Total value of output (Supply) #;
 (all,i,IND) VXPRIM(i) # Value of demand for factor of production #;
 (all,c,COM) VXEXP(c) # Value of total export by commodities #;
  VYH # Value of household income #;
 (all,f,FAC) VXFACSH(f) # Value of factor pof production by household  #;
  VTRHOGO # Value of transfer from government to household #;
  VTRHOCO # Value of transfer from corporate to household #;
  VTRHOHO # Value of transfer from household to household #;
  VYTAX # Household income tax revenue #;
  SAVH # Saving from household #;
  VYGC # Value Government Revenue #;
 (all,c,COM) VTM(c) # Value of import tarrif by commodities #;
  VCORTAX # Value of transfer from corporate to government #;
```

```
  VTRGORO # Value of transfer from ROW to government #;
  VTRGOGO # Value of transfer from government to government #;
  VTRROGO # Value of transfer from Gov't to ROW #;
 (all,c,COM) VSC(c) # Value of subsidies by commodities #;
  VEGC # Value of Government Expenditure #;
  VYCO # Value of income by corporate sector #;
  VTRCORO # Value of transfer from ROW to corporate #;
  VTRCOCO # Value of transfer from corporate to Corporate #;
  VECO # Value of Corporate Expenditure #;
  VYRO # Value of income from Rest of The World #;
  VTRROHO # Value of transfer from HH to Rest of The World #;
  VTRHORO # Value of transfer from ROW to Household #;
  VERO # Value of expenditure by Rest of The World #;
  VTRRORO # Value of transfer from ROW to ROW #;
  VTRROCO # Value of transfer from corporate to ROW #;
 (parameter) (all,c,COM) EXPELAS(c) # Expenditure elas by commodities #;
  (all,c,COM) VXIMP(c) # Value of Import including tarrif #;
 (all,f,FAC) VXFACSUP(f) # Value of all factor supply #;
 (all,f,FAC) SXFACSH(f) # share of factor owned by household #;
 (all,f,FAC) SXFG(f) # share of factor owned by government #;
 (all,f,FAC) SXFCO(f) # share of factor owned by corporate #;
 (all,f,FAC) SXFRO(f) # share of factor owned by rest of the world #;
 VCORFINC # corporate factor income #;
```

7.3 Read statement

In a read statement, all the value of basic coefficient will be read from the database. It refers to a certain header in file database agefis.har.

```
read
 SIGARM from file database header "SIGA";
 SIGMAPRIM from file database header "SIGP";
 EXPELAS from file database header "EELA";
 VXD from file database header "VXD";
 VTX from file database header "VTX";
 VTM from file database header "VTM";
 VXINT_S from file database header "VINT";
 VXHOU_S from file database header "VHOU";
 VXINV_S from file database header "VINV";
 VXG_S from file database header "VXG";
 VXFAC from file database header "VFAC";
 VXFACRO from file database header "VFAR";
 VXFG from file database header "VFG";
 VXFCO from file database header "VFCO";
 VXFRO from file database header "VFRO";
 VXEXP from file database header "VEXP";
 VXFACSH from file database header "VFHO";
 VTRHOGO from file database header "VRHG";
 VTRHOCO from file database header "VRHC";
 VTRHOHO from file database header "VRHH";
 VYTAX from file database header "VYTX";
```

```
 SAVH from file database header "VSAV";
 VCORTAX from file database header "VRGC";
 VTRGORO from file database header "VRGR";
 VTRROGO from file database header "VRRG";
 VSC from file database header "VSC";
 VTRCORO from file database header "VRCR";
 VTRCOCO from file database header "VRCC";
 VTRROHO from file database header "VRRH";
 VTRHORO from file database header "VRHR";
 VTRGOGO from file database header "VRGG";
 VTRRORO from file database header "VRRR";
 VTRROCO from file database header "VRRC";
```

7.4 Formula statement

In the formula statement, the coefficients that have been declared but not one of the basic coefficients are calculated. Each of the coefficient is a function of those basic coefficients.

```
formula
 (all,c,COM)
 VXD_S(c) = SUM{i,IND,VXINT_S(c,i)} + VXHOU_S(c) + VXG_S(c)+ VXINV_S(c);
 (all,c,COM) VXIMP(c) = VXD(c,"IMP");
 (all,c,COM) VXCIF(c) = VXIMP(c) - VTM(c);
 (all,i,IND) VXPRIM(i) = SUM{f,FAC,VXFAC(f,i)};
 (all,f,FAC)(all,i,IND) SFAC(f,i) = VXFAC(f,i) / ID01[VXPRIM(i)];
 (all,i,IND) VTOT(i) = VXPRIM(i)+ SUM{c,COM, VXINT_S(c,i)};
  VYGC = SUM{i,IND,VTX(i)} + SUM{c,COM,VTM(c)} + VYTAX + VCORTAX
         + VTRGORO + SUM{f, FAC,VXFG(f)} + VTRGOGO;
  VYH = SUM{f,FAC,VXFACSH(f)} + VTRHOGO + VTRHOCO + VTRHORO + VTRHOHO;
  VECO = VTRROCO + VTRHOCO + VTRCOCO;
  VEGC = SUM{c, COM,VXG_S(c)} + VTRHOGO + VTRROGO + SUM{c,COM,VSC(c)} +
       VTRGOGO;
  VYCO = SUM{f,FAC,VXFCO(f)} - VCORTAX + VTRCORO + VTRCOCO;
  VERO = SUM{c,COM,VXEXP(c)} + VTRCORO + VTRGORO + VTRHORO
       + VTRRORO + SUM{f,FAC,VXFACRO(f)};
  VYRO = SUM{f,FAC,VXFRO(f)} + VTRROGO + VTRROHO + SUM{c,COM,VXCIF(c)}
       + VTRRORO + VTRROCO;
 (all,f,FAC) VXFACSUP(f) =  VXFACSH(f) + VXFG(f) + VXFCO(f) + VXFRO(f);
 (all,f,FAC) SXFACSH(f) = VXFACSH(f)/VXFACSUP(f);
 (all,f,FAC) SXFG(f) = VXFG(f)/VXFACSUP(f);
 (all,f,FAC) SXFCO(f) = VXFCO(f)/VXFACSUP(f);
 (all,f,FAC) SXFRO(f) = VXFRO(f)/VXFACSUP(f);
 VCORFINC = SUM{f,FAC,SXFCO(f)*VXFACSUP(f)};
```

7.5 Variable declaration

In this part of the tablo file, all the variables which are part of the of structural model equation are declared.

```
variable
 (all,c,COM)(all,s,SRC) pq(c,s) # Consumer price for commodity c, source s #;
 (all,c,COM)(all,s,SRC) xd(c,s) # Demand for commodity c, source s #;
 (all,c,COM) pq_s(c ) # Consumer price of composite good c #;
 (all,c,COM) xd_s(c ) # Demand for commodity composites #;
 (all,c,COM)(all,i,IND) xint_s(c,i) # Demand for commodity by industry #;
 (all,c,COM) xhou_s(c) # Demand for commodity by household #;
 (all,c,COM) xinv_s(c ) # Demand for commodity for investment #;
 (all,c,COM) xg_s(c ) # Demand for commodity by government #;
```

```
(all,i,IND) xprim(i) # Industry demand for primary-factor composite #;
(all,f,FAC)(all,i,IND) xfac(f,i) # Demand for primary factor by industry i #;
(all,f,FAC) xfacro(f) # Supply of factor f by rest of the world #;
(all,i,IND) pprim(i) # Price of Primary factor composite #;
(all,c,COM) xtot(c ) # Output or supply commodity #;
(all,i,IND) ptot(i)  # Producer's price or unit cost of production #;
 yh # Household income #;
 trhogo # Transfer to household from central government #;
 trhoco # Transfer to household from coorporate #;
 trhoro # Transfer to household from rest of the world #;
 trhoho # Transfer to household from inter household #;
 eh # Household expenditure #;
 ygc #  govenrment income #;
 trgoco # Transfer to cental government from coorporate #;
 trgoro # Transfer to cental government from rest of the world #;
 trgogo  # transfer from government to government #;
 trrogo # Transfer to rest of the world from  government #;
 (change) delSG # govenrment saving #;
 egc #  govenrment expenditure #;
 yco # Coorporate income #;
 trcoro # Transfer to coorporate from rest of the world #;
 trcoco # Transfer to coorporate from cental government  #;
 eco # Coorporate expenditure #;
 trroco # Transfer to rest of the world from corporate #;
 (change) delSCO # Coorporate saving #;
 (all,c,COM) ximp(c ) # Demand for commodity by import #;
 yro # Rest of the world income #;
 (all,f,FAC) pfac(f) # Price of factor f #;
 trroho # Transfer to rest of the world from household #;
 exr # Exchange rate #;
 (all,c,COM) pfimp(c ) # International price of commodity #;
 (all,c,COM) xexp(c ) # Total export for commodity #;
 (all,c,COM) fxexp(c) # q-shifter of export demand #;
 (change) delSRO # Rest of the world saving #;
 ero # Rest of the world expenditure #;
 trroro # transfer from ROW to ROW #;
 (change)(all,c,COM) delTX(c) # Ordinary change in rate of  commodity tax  #;
 (change)(all,c,COM) delSC(c) # Ordinary change in rate of comm. subsidy #;
 (change)(all,c,COM) delTM(c) # Ordinary change in rate of import tarrif #;
 (change)delTAXH # Ordinary change in rate of household tax #;
 (change)delMPSH # Ordinary change in rate of household saving #;
 (all,i,IND) atot(i) # all factors technical change #;
 (all,i,IND) aprim(i) # neutral technical change #;
 (all,f,FAC)(all,i,IND) afac(f,i) # factor saving technical change #;
 (all,f,FAC)(all,i,IND) wdist(f,i) # factor price distortion #;
 (all,f,FAC) xfacsup(f) # total factor supply #;
 (all,f,FAC) yfac(f) # factor income #;
 (all,c,COM) fxg_s(c) # government expenditure shifter by commodity #;
 fxg_sc # overall government expenditure shifter #;
 (change) delCORTAX # corporate tax rate #;
 (change) delCORFINC # change in corporate factor income #;
```

The details of those variables above would be discussed on the next section.

7.6 Update statement

In update statement, basic coefficients read from the database will be updated by using the change in their relevant variables.

```
update
 (all,c,COM)(all,s,SRC) VXD(c,s) = pq(c,s)*xd(c,s);
 (change) (all,i,IND) VTX(i) =
       0.01*VTX(i)*[100*(VTOT(i)/ID01[VTX(i)])*delTX(i)
                              + ptot(i) + xtot(i)];
 (all,c,COM)(all,i,IND) VXINT_S(c,i) = pq_s(c)*xint_s(c,i);
 (all,c,COM) VXHOU_S(c) = pq_s(c)*xhou_s(c);
 (all,c,COM) VXINV_S(c) = pq_s(c)*xinv_s(c);
 (all,c,COM) VXG_S(c) = pq_s(c)*xg_s(c);
 (all,f,FAC) VXFACRO(f) = pfac(f)*xfacro(f);
 (all,f,FAC)(all,i,IND) VXFAC(f,i) = pfac(f)*wdist(f,i)*xfac(f,i);
 (change)(all,f,FAC) VXFG(f) = 0.01*SXFG(f)*VXFACSUP(f)*yfac(f);
 (change)(all,f,FAC) VXFCO(f) = 0.01*SXFCO(f)*VXFACSUP(f)*yfac(f);
 (change) (all,f,FAC) VXFRO(f) = 0.01*SXFRO(f)*VXFACSUP(f)*yfac(f);
 (change) (all,f,FAC) VXFACSH(f) = 0.01*SXFACSH(f)*VXFACSUP(f)*yfac(f);
 (all,c,COM) VXEXP(c) = pq_s(c)*xexp(c);
 VTRHOGO  = trhogo;
 VTRHOCO  = trhoco;
 VTRHOHO  = trhoho;
 (change) VYTAX  = 0.01*VYTAX*[100*(VYH/VYTAX)*delTAXH + yh];
 (change) SAVH = (VYH-VYTAX)*delMPSH + [SAVH/(VYH-VYTAX)]
              * [0.01*VYH*yh - delTAXH*VYH - 0.01*VYTAX*yh];
 (change) (all,c,COM) VTM(c) =
      0.01*VTM(c)*[100*(VXCIF(c)/ID01[VTM(c)])*delTM(c)
                              + exr + pfimp(c) + ximp(c)];
 VCORTAX = trgoco;
 VTRGORO = trgoro;
 VTRROGO = trrogo;
 VTRGOGO = trgogo;
 (change) (all,i,IND) VSC(i) =
     0.01*VSC(i)*[100*(VTOT(i)/ID01[VSC(i)])*delSC(i)
                              + ptot(i) + xtot(i)];
 VTRCORO = trcoro;
 VTRCOCO = trcoco;
 VTRROCO = trroco;
 VTRROHO = trroho;
 VTRHORO = trhoro;
 VTRRORO = trroro;
```

7.7 Equation statement

In the equation statement, structural equations of the model are written. The basic system of equation is divided into several parts:

1. Domestic-import sourcing (which determines the composition of import-domestic source according to Armington specification).
2. Purchaser's price. The equation that relates the producer price, or international price to the purchaser's price.
3. Demand for commodities. The equation that model the demand for goods by various users.
4. Production sector. The equation related to the production of goods and services.
5. Market clearing. The equation that equates the supply with demand, both for commodity as well as production factors.

6. Factor Income. The equation related to the payment of return to factor ownership.
7. Institution. The equation related to the income and expenditure of various institutions i.e., households, government, corporate sector, and the rest of the world.

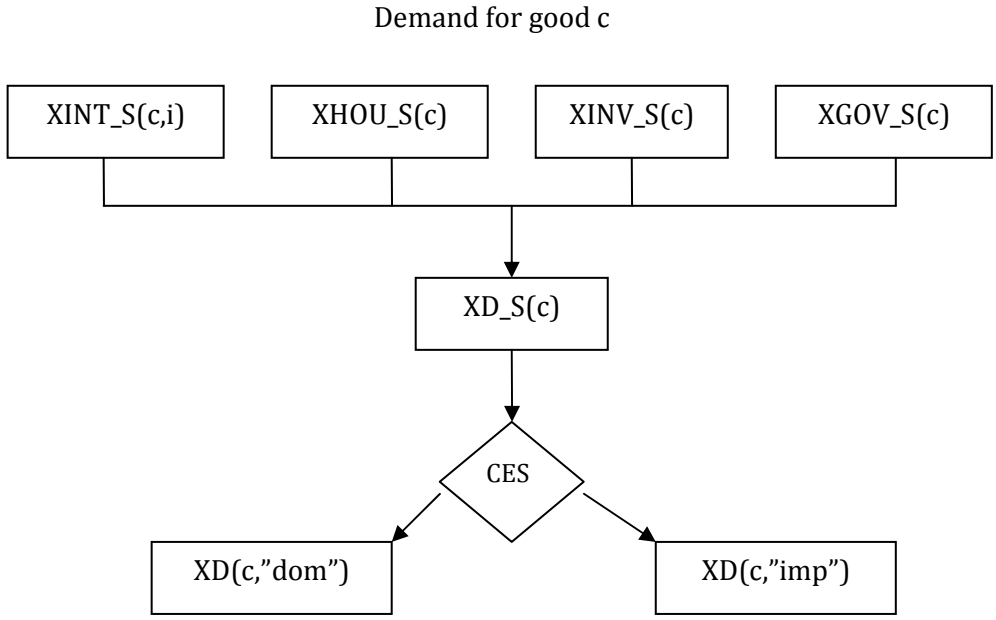
Domestic-import sourcing

Equation eq_xd and eq_pq_s define the optimum allocation of domestic or foreign source commodity for every given unit of commodity composite.

```
! domestic-import sourcing !
eq_xd # domestic-import sourcing # (all,c,COM)(all,s,SRC)
 xd(c,s) = xd_s(c) - SIGARM(c)*[pq(c,s) - pq_s(c)];

eq_pq_s # zero profit in domestic-import sourcing # (all,c,COM)
 VXD_S(c)*[pq_s(c) + xd_s(c)] = SUM{s,SRC,VXD(c,s)*[pq(c,s) + xd(c,s)]};
```

The demand structure can be summarized in the figure below. For each commodity c, user as represented by an agent (representing the whole range of customers i.e., industry, household, investor, and government) find its optimum composition of domestic and impor content.



The economic agent (wholesaler) who optimizes the composition of domestic and import content minimize cost subject to CES aggregation, or more formally,

$$\text{Minimize} \sum_{s} PQ(c,s) \cdot XD(c,s)$$

Subject to

$$XD\_S(c) = CES(XD(c,s) \mid \sigma(c)) = \left(\alpha(c,s) \sum_{s} \delta(c,s) XD(c,s)^{-\rho(c)} \right)^{-\frac{1}{\rho(c)}}$$

First order condition from this optimization is

$$XD(c,s) = \alpha(c,s)^{\frac{-\rho}{1+\rho}} .XD\_S(c) \delta(c,s)^{\frac{1}{\rho+1}} .\left(\frac{PQ(c,s)}{PQ\_S(c)}\right)^{\frac{-1}{\rho+1}}$$

or in the linear or percentage change form:

$$xd(c,s) = xd\_s(c) - \sigma(c)(p(c,s) - p\_s(c))$$

Where σ(c) = 1/(1+ρ(c)) is the Armington elasticity of substitution. This is the equation eq_xd in the tablo file.

The next equation is equation of CES aggregation CES or constraint equation. Constraint equation also can be replaced with the zero-profit equation as follows:

$$PQ\_S(c) XD\_S(c) = \sum_{s} PQ(c,s) XD(c,s)$$

In the linear form,

$$VXD\_S(c)\left(pq\_s(c) + xd\_s(c)\right) = \sum_{c} VXD(c,s)\left(pq(c,s) + xd(c,s)\right)$$

where $VXD\_S(c) = PQ\_S(c) XD\_S(c)$, and $VXD(c,s) = PQ(c,s) XD(c,s)$. The above equation is equation eq_pq_s in the tablo file. To linearize equation eq_pq_s, we use the ordinary linearization rules to linearize A*B i.e., A*a + B*b.

Purchaser's price

These equations relates the basic/producer price and international to the price faced by directly by consumers.

```
! purchaser's prices !
eq_pqdom # purchaser's price of domestic commodities #(all,c,COM)
 pq(c,"dom") = ptot(c) + 100*[VTOT(c)/(VTOT(c) + VTX(c) - VSC(c))]
             * [delTX(c) - delSC(c)];

eq_pqimp # purchaser price of imported commodity # (all,c,COM)
 pq(c,"imp") = pfimp(c) + exr + 100*[VXCIF(c)/ID01[VXCIF(c) + VTM(c)]]*delTM(c);
```

Equation *eq_pqdom* links the consumer's price and producer's price. The consumer's price is a net price after tax and or subsidy are added. The tax will increase the price while the subsidy will decrease the price. In level, the equation is:

$$PQ(c,"dom") = (1 + TX(c) - SC(c))*PTOT(c)$$

where,

PQ(c,"dom") : domestic price of each commodity (c) faced by consumer.
TX (c) : indirect tax
SC(c) : indirect subsidy.
PTOT(c) : basic/producer price of each commodity (c)

To describe the linearization process of the above equation, we start by simplifying the equation:

$$P^C = (1 + t - s)P^P$$

We can write the tax rate or t, as:

$$t = \frac{tP^P Q}{P^P Q} = \frac{TRT}{VTOT} \text{ where:}$$

t : tax or tax revenue
P^P : producer's price
Q : Output
TRT : Total revenue or the total revenue from tax
VTOT : Total Value

Similarly, the subsidy rate s can be written as:

$$s = \frac{TRS}{VTOT}$$

where:

s : subsidy
TRS : revenue from the subsidy

The linearized form of (1 + t - s) then can be written as:

$$\widehat{(1+t-s)} = \frac{\Delta(1+t-s)}{1+t-s}100 = \frac{\Delta t - \Delta s}{1+t-s}100 = \frac{\Delta t - \Delta s}{1+\frac{TRT}{VTOT}-\frac{TRS}{VTOT}}100 = \frac{\Delta t - \Delta s}{\frac{VTOT+TRT-TRS}{VTOT}}100$$
$$= 100\frac{VTOT}{VTOT + TRT - TRS}(\Delta t - \Delta s)$$

The percentage change form of consumer's price equation then becomes:

$$\hat{P}^C = \hat{P}^P + 100\frac{VTOT}{VTOT + TRT - TRS}(\Delta t - \Delta s)$$

Where $\hat{P}^C$ is the percentage change of P^C and $\hat{P}^P$ is the percentage change of P^P

In the Tablo file of AGEFIS, it is finally written as:

$$pq(c,"dom") = ptot(c) + 100\frac{VTOT(c)}{VTOT(c) + VTX(c) - VSC(c)}\left(\Delta TX(c) - \Delta SC(c)\right)$$

where :

pq(c,"dom") : Domestic price of each commodity (c).
ptot(c) : Price of each commodity (c).
VTOT(c) : Value of goods of each commodity (c).
VTX(c) : Value of tax revenue from each commodity (c).
VSC(c) : Value of subsidy revenue from each commodity (c).
TX (c) : Tax that liable to commodity (c).
C(c) : Subsidy that liable to commodity (c).
.
These are equations eq_pqdom in tablo file.

Equation eq_pqimp links the international price to the price that consumer have to pay for each commodity, or:

$$PQ(c,"imp") = EXR*(1 + tm(c))*PFIMP(c)$$

Where EXR is the exchange rate and tm(c) is the tariff rate. The linearization process is similar to the linearization process of domestic price equation. First we simplify the equation and define tariff rate as:

$$t^m = \frac{t^m P^f Q^m}{P^f Q^m} = \frac{VTM}{VCIF}$$

Where
t^m : Import tariff
P^f : Import price
Q^m : Quantity of imported goods
VTM : Revenue from the tariff
VCIF : Value of imported commodities at the world price exclusive of tariff

The term (1 + tm(c)) can be linearized as follows:

$$\widehat{\left(1+t^m\right)} = \frac{\Delta\left(1+t^m\right)}{1+t^m}100 = \frac{\Delta t^m}{1+t^m}100 = \frac{\Delta t^m}{\frac{VCIF+VTM}{VCIF}}100$$
$$= 100\frac{VCIF}{VCIF+VTM}\Delta t^m$$

The whole term of the equation:

$$P^C = P^f \cdot EXR \cdot \left(1+t^m\right)$$

can be linearized as:

$$\hat{P}^C = \hat{P}^f + exr + 100\frac{VCIF}{VCIF+VTM}\Delta t^m$$

Finally in the Tablo file, the complete equation is written as:

$$\text{pq(c,"imp")} = \text{pfimp(c)} + \text{exr} + 100\frac{\text{VCIF(c)}}{\text{VCIF(c)} + \text{VTM(c)}}\text{delTM(c)}$$

That is the equation eq_pqimp in tablo file.

Demand

The equations that describe the demand for commodities by various economic agents is written as follows:

```
! demand for commodities !
eq_xint_s # intermediate demand # (all,c,COM)(all,i,IND)
 xint_s(c,i) - atot(i) = xtot(i);

eq_xhou_s # household demand for commodities # (all,c,COM)
 xhou_s(c) = eh - pq_s(c);

eq_xg_s # government expenditure/demand #
 (all,c,COM) xg_s(c) = fxg_s(c) + fxg_sc;

eq_xexp # export demand # (all,c,COM)
 xexp(c) = fxexp(c)  - expelas(c)*[(pq(c,"dom") - exr) - pfimp(c)];

eq_xd_s # total demand for composite commodities # (all,c,COM)
 VXD_S(c)*xd_s(c) = SUM{i,IND,VXINT_S(c,i)*xint_s(c,i)}
                  + VXHOU_S(c)*xhou_s(c)  + VXG_S(c)*xg_s(c)
                  + VXINV_S(c)*xinv_s(c);
```

Equation eq_int_s is the result of producer's optimization: minimize cost of production subject to Leontief production function, or:

$$\min \text{PPRIM(i)} \cdot \text{XPRIM(i)} + \sum_{c} \text{PQ\_S(c)} \cdot \text{XINT\_S(c,i)}$$

subject to

$$\text{XTOT(i)} = \frac{1}{\text{ATOT(i)}}\text{MIN}\left[\text{ALL,c,COM}: \frac{\text{XINT\_S(c,i)}}{\text{AINT(c,i)}}, \frac{\text{XPRIM(i)}}{\text{APRIM(i)}}\right]$$

The demand equation for intermediate goods from the optimization is:

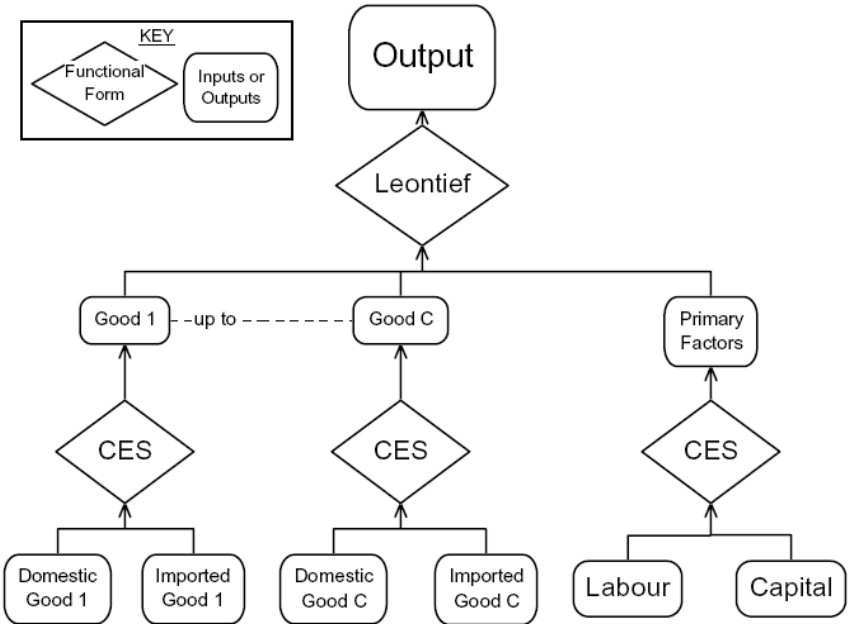
$$\frac{\text{XINT\_S(c,i)}}{\text{ATOT(i)}} = \text{XTOT(i)}$$

and its linearized form is:

$$\text{x int\_ s(c,i)} - \text{atot(i)} = \text{xtot(i)}$$

which simply states that intermediate demand follow the total output and technical change proportionally. This is the equation eq_xint_s in the Tablo file. Following the specification of

most Gempack-based models such as ORANI-G, MINIMAL, or WAYANG, the production structure is illustrated in the following figure[11]:



Production Structure

Household maximizes Cobb-Douglas utility function subject to a given disposable income:

$$\max U = \prod_{c} XHOU\_S(c)^{\alpha(c)} \text{ s.t. } \sum_{c} PQ\_S(c) \cdot XHOU\_S(c) = EH$$

where EH is disposable income and PQ_S is the price for each commodity. The equation of the demand for commodities produced by the optimization is:

$$XHOU\_S(c) = \alpha(c)*[EH/PQ\_S(c)]$$

And its linearized form is:

$$xhou\_s(c) = eh - pq\_s(c)$$

this is equation e_xhou_s in tablo file.

The demand for commodities by government is set to be exogenous.:

$$xg\_s(c) = fxg\_s(c) - fxg\_sc$$

where fxg_s(c) is shifter per commodity, while fxg_sc is shifter for all commodities. These shifters can be shocked in simulations.

In AGEFIS, foreign demand for domestic goods is price-sensitive. If the domestic price of a certain good increase relatively to the international price, the export demand will increase.

[11] Source of the figure: Horridge, Mark, 2001, MINIMAL: A Simplified General Equilibrium Model, Center of Policy Studies, Monash University.

Then, the export equation will have export demand curve with negative slope. At the level, the equation will be:

$$XEXP(c) = FXEXP(c)\left[\frac{PQ(c,"dom")}{EXR \cdot PFIMP(c)}\right]^{EXPELAS(c)}$$

where EXPELAST(c) is the price elasticity of export demand. In its linearized form, this equation will be equation eq_xexp in file tablo, or

$$x\,exp(c) = fx\,exp(c) + exp\,elas(c)\left[pq(c,"dom) - exr - pfimp(c)\right]$$

The total demand for each commodity by domestic users comprise of demand from households, government, private investment and intermediate demand, or:

$$XD\_S(c) = \sum_i XINT\_S(c,i) + XHOU\_S(c) + XG\_S(c) + XINV\_S(c)$$

This equation is equation eq_xd_s in the Tablo file.

<u>Production Sector</u>

The equations related to production function consist of the following:

- Demand for primary factors (f) by each industry (i)
- Price of primary factor composite
- Demand for primary factor composite
- Zero profit conditions

In AGEFIS, output is a function of primary and intermediate input.

Output = F (inputs) = F(Labor, Capital, Domestic Goods, Imported Goods)

Because the function is separable, it can be written as:

output = F(primary factor composite, composite goods)

For each industry, primary factor composite (or sometimes called value added) is the CES aggregation of labor and capital, or:

primary factor composite = CES (Labour, Capital)

As the implication of the separability of the production function, producers can divide the input decision into some different stages. For example, a shoes maker first decide how many labor relative to capital to be used for a given primary factors, then he/she decides how many leather that will be used for shoes (in this case the amount of leather as an intermediate inputs are proportional to the amount of shoes produced due to the Leontief specification).

```
! production sectors !
eq_xfac # demand for factors of production # (all,f,FAC)(all,i,IND)
 xfac(f,i) - afac(f,i) = xprim(i)
             - SIGMAPRIM(i)*[pfac(f) + wdist(f,i) + afac(f,i) - pprim(i)];

eq_pprim # effective price of primary factors # (all,i,IND)
```

```
 pprim(i) = SUM{f,FAC,SFAC(f,i)*[pfac(f) + wdist(f,i) + afac(f,i)]};

eq_xprim # demand for primary factor composite # (all,i,IND)
 xprim(i) - aprim(i) - atot(i) = xtot(i);

eq_ptot # zero profit in production # (all,i,IND)
 VTOT(i)*[ptot(i) + xtot(i)] = VXPRIM(i)*[pprim(i) + xprim(i)]
                       + SUM{c,COM, VXINT_S(c,i)*[pq_s(c) + xint_s(c,i)]};
```

The equation of production factor demand (eq_xfac) is the first order condition of cost minimization subject to a CES production function, or:

$$\min \sum_{f} \mathrm{WDIST}(f,i) \cdot \mathrm{PFAC}(f) \cdot \mathrm{XFAC}(f,i)$$

subject to

$$\mathrm{XPRIM}(i) = \left[\sum_{f} \delta_{f} \left(\frac{\mathrm{XFAC}(f,i)}{\mathrm{AFAC}(f,i)} \right)^{-\rho} \right]^{\frac{-1}{\rho}}$$

where XFAC(f,i) is demand for factor f by industry i, PFAC(f) is price of production factor f, and WDIST(f,i) if distortion[12] premium of factor f in industry i. XPRIM(i) is total value added. First order condition or demand for factors in percentage of change is as follows:

$$\mathrm{xfac}(f,i) - \mathrm{afac}(f,i) = \mathrm{xprim}(i) - \sigma^{\mathrm{PRIM}}(i)\left[\mathrm{pfac}(f) - \mathrm{wdist}(f,i) + \mathrm{afacf},i) - \mathrm{pprim}(i)\right]$$

where

$$\mathrm{pprim}(i) = \sum_{f} \mathrm{SFAC}(f,i) \cdot \left[\mathrm{pfac}(f) + \mathrm{wdist}(f,i) + \mathrm{afac}(f,i)\right]$$

where SFAC(f,i) is cost share factor f in industry i, and σ^{PRIM} is the elasticity of substitution among production factors. The above equation is equation eq_xfac and eq_pprim in the Tablo file.

Equation eq_xprim is the result of cost minimization optimization subject to the Leontief production, or:

$$\min \mathrm{PPRIM}(i) \cdot \mathrm{XPRIM}(i) + \sum_{c} \mathrm{PQ\_S}(c) \cdot \mathrm{XINT\_S}(c,i)$$

subject to

$$\mathrm{XTOT}(i) = \frac{1}{\mathrm{ATOT}(i)} \mathrm{MIN}\left[\mathrm{ALL}, c, \mathrm{COM} : \frac{\mathrm{XINT\_S}(c,i)}{\mathrm{AINT}(c,i)}, \frac{\mathrm{XPRIM}(i)}{\mathrm{APRIM}(i)} \right]$$

The first order condition will produce the demand for primary factor composite:

$$\frac{\mathrm{XPRIM}(i)}{\mathrm{ATOT}(i)} = \mathrm{APRIM}(i) \cdot \mathrm{XTOT}(i)$$

and in percentage change, it becomes:

[12] Distortion premium is needed to accommodate a specification of specific factor model where factor of production is immobile among sectors.

$$\text{xprim(i)} - \text{aprim(i)} - \text{atot(i)} = \text{xtot(i)}$$

This is equation eq_xprim in tablo agefis.tab.

Market clearing Equations

Market clearing equations for commodities guarantee that the total demand for goods must be the same as its supply.

```
! market clearing !
eq_xtot # market clearing for commodities # (all,c,COM)
 [VTOT(c) + VTX(c) - VSC(c)]*[xtot(c)] = VXD(c,"dom")*[xd(c,"dom")]
                                       + VXEXP(c)*[xexp(c)];
```

In level, the equation is

$$\text{XTOT}(c) = \text{XD}(c,"\text{dom}") + \text{XEXP}(c)$$

The linearization process is as follows:

$$\begin{aligned}
\text{XTOT}(c)\,\text{xtot}(c) &= \text{XD}(c,"\text{dom}")\,\text{xd}(c,"\text{dom}") \\
&\quad + \text{XEXP}(c)\cdot \text{x exp}(c) \\
\text{PQ}(c,"\text{dom}")\,\text{XTOT}(c)\,\text{xtot}(c) &= \text{PQ}(c,"\text{dom}")\,\text{XD}(c,"\text{dom}")\,\text{xd}(c,"\text{dom}") \\
&\quad + \text{PQ}(c,"\text{dom}")\,\text{XEXP}(c)\,\text{x exp}(c) \\
\left(1+\text{TX}(c)-\text{TS}(c)\right)\text{PTOT}(c)\cdot\text{XTOT}(c)\,\text{xtot}(c) &= \text{PQ}(c,"\text{dom}")\,\text{XD}(c,"\text{dom}")\,\text{xd}(c,"\text{dom}") \\
&\quad + \text{PQ}(c,"\text{dom}")\,\text{XEXP}(c)\,\text{x exp}(c) \\
\left(\text{VTOT}(c)+\text{VTX(c)}-\text{VSC}(c)\right)\text{xtot}(c) &= \text{VXD}(c,"\text{dom}")\,\text{xd}(c,"\text{dom}") \\
&\quad + \text{VXEXP}(c)\,\text{x exp}(c)
\end{aligned}$$

Market clearing equation for factor of production also equates the supply of and the demand for production factor. In the Tablo file, the equation is as follows (note: the left hand side is demand and the right hand side is supply):

```
eq_pfac # market clearing for factors # (all,f,FAC)
 SUM{i,IND,VXFAC(f,i)*xfac(f,i)} + VXFACRO(f)*xfacro(f)
                  = VXFACSUP(f)*xfacsup(f);
```

In level,

$$\sum_i \text{XFAC}(f,i) + \text{XFACRO}(f) = \text{XFACSUP}(f)$$

Equation eq_yfac defines the total amount of payment from using the primary factor of production factors.

```
! factor income !
eq_yfac # total factor income # (all,f,FAC)
 VXFACSUP(f)*yfac(f) = SUM{i,IND,VXFAC(f,i)*[pfac(f) + wdist(f,i) + xfac(f,i)]} +
VXFACRO(f)*[xfacro(f) + pfac(f)];
```

Institutions

```
! institution: household !
eq_yh # household income #
```

```
VYH*yh = SUM{f,FAC,SXFACSH(f)*VXFACSUP(f)*yfac(f)}
       + VTRHOGO*trhogo + VTRHOCO*trhoco + VTRHORO*trhoro + VTRHOHO*trhoho;
```

Households receive income from their ownership of production factor (f). They also receive payment from transfers from other institutions i.e., central government (TRHOGO), corporate (TRHOCO), rest of the world (TRHORO) and from other households (TROHHO). In level, the equation is:

$$YH = \sum_{f} SFACSH(f)\,YFAC(f) + TRHOGO + TRHOCO + TRHORO + TRHOHO$$

where SFACSH(f) is household share of factor ownership [Note: in a SAM-based model, households are not the only institution that own factor of production. Corporate sector, government, and the rest of the world can also own factor of production].

```
eq_eh # household disposable income #
 eh = yh - 100*[VYH/(VYH - VYTAX)]*delTAXH
    - 100*[(VYH - VYTAX)/(VYH - VYTAX - SAVH)]*delMPSH;
```

Equation eq_eh define household disposable income: household income (YH) net of tax and saving. In level, it can be written as:

$$EH = MPCH*(1 - TAXH)*YH$$

Where MPCH is propensity to consume and TAXH is income tax ratem and:

$$MPCH + MPSH = 1$$

Where MPSH is propensity to save, hence:

$$EH = (1 - MPSH)(1 - TAXH)YH$$

To linearize the equation above, we simplify the equation as follows [Note: '^' over a variable indicate its percentage change]:

$$E = (1-s)(1-t)Y$$
$$\hat{E} = \widehat{(1-s)} + \widehat{(1-t)} + \hat{Y}$$

Where:

$$t = \frac{TRH}{Y}, \text{and } s = \frac{SH}{(1-t)Y}$$

where SH is saving and TRH is government revenue from income tax.
Linearizing (1-t):

$$\widehat{(1-t)} = \frac{\Delta(1-t)}{1-t}100 = -\frac{\Delta t}{1-t}100 = -\frac{\Delta t}{1-\frac{TRH}{Y}}100 = -\frac{\Delta t}{\frac{Y-TRH}{Y}}100$$
$$= -100\frac{Y}{Y-TRH}\Delta t$$

Linearizing (1- s) :

$$\widehat{(1-s)} = \frac{\Delta(1-s)}{1-s}100 = -\frac{\Delta s}{1-s}100 = -\frac{\Delta s}{1-\frac{SH}{(1-t)Y}}100 = -\frac{\Delta s}{1-\frac{SH}{\left(1-\frac{TRH}{Y}\right)Y}}100 = -\frac{\Delta s}{1-\frac{SH}{Y-TRH}}100$$

$$= -\frac{\Delta s}{\frac{Y-TRH-SH}{Y-TRH}}100 = -100\frac{Y-TRH}{Y-TRH-SH}\Delta s$$

Linearizing E:

$$\hat{E} = \hat{Y} - 100\frac{Y}{Y-TRH}\Delta t - 100\frac{Y-TRH}{Y-TRH-SH}\Delta s$$

Or as written in equation eq_eh.

```
! institution: government !
eq_ygc # government revenue #
 VYGC*ygc = SUM{i,IND,VTX(i)*[100*(VTOT(i)/VTX(i))*delTX(i) + ptot(i)
      + xtot(i)]} + SUM{c,COM,VTM(c)*[100*(VXCIF(c)/VTM(c))*delTM(c)
      + exr + pfimp(c) + ximp(c)]} + VYTAX*[100*(VYH/VYTAX)*delTAXH + yh]
      + VCORTAX*trgoco+ VTRGOGO*trgogo + VTRGORO*trgoro
      + SUM{f, FAC,SXFG(f)*VXFACSUP(f)*yfac(f)};
```

Government revenue (YGC) is a sum of the following revenue sources:

1. Revenue from indirect tax of goods and services
2. Revenue from import duty (or tariff) from each commodity
3. Revenue from household Income tax
4. Revenue from corporate income tax
5. Transfer from rest of the world
6. Revenue from the payment of the ownership of production factors

In level,

$$YGC = \sum_i TX(i)\cdot PTOT(i)\cdot XTOT(i) + \sum_c TM(c)\cdot EXR\cdot PFIMP(c)\cdot XIMP(c)$$

$$+TAXH\cdot YH + VTAXCOR + TRGORO + \sum_f SXFG(f)\cdot YFAC(f)$$

Government spends its revenue on expenditure on goods and services and transfer to other institutions such as households and the rest of the world. Subsidy on commodities, in AGEFIS, is also part of government spending. In level, the equation for government expenditure is as follows:

$$EGC = \sum_c PQ\_S(c)XG\_S(c) + TRHOGO + TRROGO + TRGOGO$$

$$+\sum_i SC(i)PTOT(i)XTOT(i)$$

The percentage change of this equation is equation eq_egc in the Tablo file:

```
eq_egc # government expenditure #
 VEGC*egc = SUM{c, COM,VXG_S(c)*[pq_s(c) + xg_s(c)]}
          + VTRHOGO*trhogo + VTRROGO*trrogo + VTRGOGO*trgogo
          + SUM{c,COM, VSC(c)*[100*(VTOT(c)/VSC(c))*delSC(c)
          + ptot(c) + xtot(c)]};
```

Government budget surplus is defined as:

$$SG = YGC - EGC$$

Its percentage change form is equation eq_sgc in the Tablo file:

```
 eq_sgc # government budget surplus/deficit #
 delSG = 0.01*[VYGC*ygc - VEGC*egc];
```

Equation e_delCORINC below define the revenue received by the corporate sector from its ownership of production factors:

```
e_delCORINC # change in corporate factor income #
 delCORFINC = 0.01*SUM{f,FAC,SXFCO(f)*VXFACSUP(f)*yfac(f)} ;
```

The rest of the following equationss define revenue, expenditure, and saving from other instutions. Its derivation is similar to the derivation done previously for household and government.

```
! institution: corporate sector !
eq_yco # coorporate income #

 VYCO*yco = 100*delCORFINC - 100*[VCORFINC*delCORTAX
          + (VCORTAX/VCORFINC)*delCORFINC]
          + VTRCORO*trcoro + VTRCOCO*trcoco;


eq_eco # corporate spending #
 VECO*eco =  VTRROCO*trroco + VTRHOCO*trhoco + VTRCOCO*trcoco;

eq_sco # corporate saving #
 delSCO = 0.01*[VYCO*yco - VECO*eco];

! institution: rest of the world !
eq_ximp # import by commodities # (all,c,COM)
 ximp(c) = xd(c,"imp");

eq_yro # foreign income #
 VYRO*yro = SUM{f,FAC,SXFRO(f)*VXFACSUP(f)*yfac(f)}
          + VTRROGO*trrogo + VTRROHO*trroho + VTRRORO*trroro + VTRROCO*trroco
          + SUM{c,COM,VXCIF(c)*[exr + pfimp(c) + ximp(c)]};

eq_ero # foreign expenditure #
 VERO*ero = SUM{c,COM,VXEXP(c)*[pq(c,"dom") + xexp(c)]} + VTRCORO*trcoro
          + VTRGORO*trgoro + VTRHORO*trhoro + VTRRORO*trroro
          + SUM{f,FAC,VXFACRO(f)*(xfacro(f) + pfac(f))};

eq_sro # foreign saving #
 delSRO = 0.01*[VYRO*yro - VERO*ero];
```

To summarize, Table 4 below lists of all variables and equations in AGEFIS.

Table 4. List of Variables in AGEFIS

Variable	**Dimension**	**Remark**
pq(c,s)	c~COM s~SRC	Consumer price for commodity c, source s
xd(c,s)	c~COM s~SRC	Demand for commodity c, source s
pq_s(c)	c~COM	Consumer price of composite good c
xd_s(c)	c~COM	Demand for commodity composites
xint_s(c,i)	c~COM i~IND	Demand for commodity by industry
xhou_s(c)	c~COM	Demand for commodity by household
xinv_s(c)	c~COM	Demand for commodity for investment
xg_s(c)	c~COM	Demand for commodity by government
xprim(i)	i~IND	Industry demand for primary-factor composite
xfac(f,i)	f~FAC i~IND	Demand for primary factor by industry i
xfacro(f)	f~FAC	Supply of factor f by the rest of the world
pprim(i)	i~IND	Price of Primary factor composite
xtot(c)	c~COM	Output or supply commodity
ptot(i)	i~IND	Producer's price or unit cost of production
Yh		Household income
trhogo		Transfer to household from central government
trhoco		Transfer to household from corporate
trhoro		Transfer to household from the rest of the world
trhoho		Transfer to household from inter household
Eh		Household expenditure
Ygc		government income
Trgoco		Transfer to central government from corporate
Trgoro		Transfer to central government from the rest of the world
Trgogo		transfer from government to government
Trrogo		Transfer to the rest of the world from government
delSG		government saving
Egc		government expenditure
Yco		Corporate income
Trcoro		Transfer to corporate from the rest of the world
Trcoco		Transfer to corporate from cental government
Eco		Corporate expenditure
Trroco		Transfer to the rest of the world from corporate
delSCO		Corporate saving
ximp(c)	c~COM	Demand for commodity by import
Yro		Rest of the world income
pfac(f)	f~FAC	Price of factor f
trroho		Transfer to the rest of the world from household
Exr		Exchange rate
pfimp(c)	c~COM	International price of commodity
xexp(c)	c~COM	Total export for commodity

Table 4 (continued). List of Variables in AGEFIS

Variable	Dimension	Remark
fxexp(c)	c~COM	q-shifter of export demand
delSRO		The rest of the world saving
Ero		The rest of the world expenditure
Trroro		transfer from ROW to ROW
delTX(c)	c~COM	Ordinary change in rate of commodity tax
delSC(c)	c~COM	Ordinary change in rate of commodity subsidy
delTM(c)	c~COM	Ordinary change in rate of com import tarrif
delTAXH		Ordinary change in rate of household tax
delMPSH		Ordinary change in rate of household saving
atot(i)	i~IND	all factors technical change
aprim(i)	i~IND	neutral technical change
afac(f,i)	f~FAC i~IND	factor saving technical change
wdist(f,i)	f~FAC i~IND	factor price distortion
xfacsup(f)	f~FAC	total factor supply
yfac(f)	f~FAC	factor income
fxg_s(c)	c~COM	government expenditure shifter by commodity
fxg_sc		overall government expenditure shifter
delCORTAX		corporate tax rate
delCORFINC		change in corporate factor income
Cpi		consumer's price index
delTRHOGO		Transfer to household from government
delTRROGO		Transfer to the rest of the world from government
delTRGOGO		transfer from government to government
delTRHOCO		Transfer to household from corporate
delTRROCO		Transfer to the rest of the world from corporate
delTRCOCO		Transfer to corporate from corporate
Ftrco		shifter of corporate transfer to all institution
delTRHORO		Transfer to household from the rest of the world
delTRGORO		Transfer to cental government from the rest of the world
delTRCORO		Transfer to coorporate from the rest of the world
delTRRORO		transfer from ROW to ROW
delTRHOHO		Transfer to household from inter household
delTRROHO		Transfer to the rest of the world from household
wcon_c		nominal consumption
winv_c		nominal investment
wgov_c		nominal government spending
wexp_c		nominal export
wimp_c		nominal import
xcon_c		real consumption
xinv_c		real investment
xgov_c		real government spending
xexp_c		real export
ximp_c		real import

Table 4 (continued). List of Variables in AGEFIS

Variable	Dimension	Remark
pcon_c		price of consumption
pinv_c		price of investment
pgov_c		price of government spending
pexp_c		price of export
pimp_c		price of import
gdpcompexp(i,j)	i~GDPEXP j~GDPITEM	GDP by expenditure
xgdpfac		gdp at factor cost
wgdpexp		gdp from expenditure side
pgdpexp		gdp deflator - expenditure side
xgdpexp		real gdp - expenditure side
wgdpinc		nominal GDP from income side
delINDTAXC(c)	c~COM	indirect tax by commodity
delINDTAX		net indirect tax
xgdpinc		Real GDP from the income side
continctax		Tax part of income side real GDP decomposition
continctech		Tech change part of income side real GDP decomposition
delBUDGET(f,i)	f~FIS i~ITEM	Government Budget

Table 5. List of Equations in AGEFIS

Equation	Dimension	Remark
eq_xd(c,s)	c~COM s~SRC	domestic-import sourcing
eq_pq_s(c)	c~COM	zero profit in domestic-import sourcing
eq_pqdom(c)	c~COM	purchaser's price of domestic commodities
eq_pqimp(c)	c~COM	purchaser price of imported commodity
eq_xint_s(c,i)	c~COM i~IND	intermediate demand
eq_xhou_s(c)	c~COM	household demand for commodities
eq_xg_s(c)	c~COM	government expenditure/demand
eq_xexp(c)	c~COM	export demand
eq_xd_s(c)	c~COM	total demand for composite commodities
eq_xfac(f,i)	f~FAC i~IND	demand for factors of production
eq_pprim(i)	i~IND	effective price of primary factors
eq_xprim(i)	i~IND	demand for primary factor composite
eq_ptot(i)	i~IND	zero profit in production
eq_xtot(c)	c~COM	market clearing for commodities
eq_pfac(f)	f~FAC	market clearing for factors
eq_yfac(f)	f~FAC	total factor income
eq_yh		household income
eq_eh		household disposable income
eq_ygc		government revenue
eq_egc		government expenditure
eq_sgc		government budget surplus/deficit

Table 5 (continued). List of Equations in AGEFIS

Equation	Dimension	Remark
e_delCORINC		change in corporate factor income
eq_yco		corporate income
eq_eco		corporate spending
eq_sco		corporate saving
eq_ximp(c)	c~COM	import by commodities
eq_yro		foreign income
eq_ero		foreign expenditure
eq_sro		foreign saving
e_cpi		consumer's price index
e_trhogo		gov't to household
e_trrogo		gov't to ROW
e_trgogo		gov't to gov't
e_trhoco		corporate to household
e_trgoco		corporate to gov't
e_trroco		corporate to ROW
e_trcoco		corporate to corporate
e_trhoro		ROW to household
e_trgoro		ROW to gov't
e_trroro		ROW to ROW
e_trcoro		ROW to corporate
e_trhoho		Household to household
e_trroho		Household to ROW
e_wcon_c		nominal consumption
e_winv_c		nominal investment
e_wgov_c		nominal government spending
e_wexp_c		nominal export
e_wimp_c		nominal import
e_pcon_c		price of consumption
e_pinv_c		price of investment
e_pgov_c		price of government spending
e_pexp_c		price of export
e_pimp_c		price of import
e_xcon_c		real consumption
e_xinv_c		real investment
e_xgov_c		real government spending
e_xexp_c		real export
e_ximp_c		real import
eq_xgdpfac		gdp at factor cost
eq_wgdpexp		gdp from expenditure side
eq_pgdpexp		gdp from expenditure side
eq_xgdpexp		real GDP - expenditure side
eq_delINDTAXC(c)	c~COM	indirect tax by commodity
eq_delINDTAX		net indirect tax

Table 5 (continued). List of Equations in AGEFIS

Equation	Dimension	Remark
eq_wgdpinc		nominal gdp from income side
eq_xgdpinc		Decomposition of real GDP from income side

8. Closure

In a CGE model, the number of equations must be equal to the number of endogenous variables. In general after the model is specified, the number of variable is more than the number of equations. Therefore, we need to assigned some variables as exogenous to 'close' the model. We need what we usually call a 'closure' for the model.

As far as the factor market is concerned, there are 2 standard closures in AGEFIS. First is a long run standard closure, and second is a short run standard closure

Long run closure

In the long-run closure, the supply of factor of production for all factors (labor and capital) i.e., variable xfacsup(f) is exogenous (or fully-employed), and the production factor can move across sectors. As its implication, the price of factor pfac(f) will be the same for all sector. To accommodate this, we assign the distortion premium, wdist(f,i), xogenous, and pfac(f) endogenous or the equilibrating variable. Therefor, variable pfac(f) is not present in the closure file (cmf file) because it is not part of exogenous variables.

Variables that are common to be assigned exogenous are tax rate, import, tariff pajak, inter-institutions transfer, technology parameter is assigned exogenous in this closure. In AGEFIS, exchange rate (exr) is the numeraire.

```
! standard long-run closure  !
```

exogenous

```
! Factor market closure !
! Capital is fully mobile; full employment of factors !

xfacro  ! f~FAC Supply of factor f by rest of the world
xfacsup ! supply of factor of produciton
wdist ! f~FAC factor price distortion

! technical change !

atot ! i~IND all input technical change
aprim ! i~IND netral/all factor technical change
afac ! f~FAC i~IND factor saving techncial change

 ! Transfer institution

 ! Government transfer to other institution !

 delTRHOGO !# Transfer to household from  government #;
 delTRROGO !# Transfer to rest of the world from  government #;
 delTRGOGO !# transfer from government to government #;
```

```
 ! corporate transfer to other institution !

 delTRHOCO !# Transfer to household from coorporate #;
 delTRROCO !# Transfer to rest of the world from corporate #;
 delTRCOCO !# Transfer to corporate from corporate #;
 ftrco !# shifter of corporate transfer to all institution

 ! Rest of the World transfer to other institution !

 delTRHORO !# Transfer to household from rest of the world #;
 delTRGORO !# Transfer to cental government from rest of the world #;
 delTRCORO !# Transfer to coorporate from rest of the world #;
 delTRRORO !# transfer from ROW to ROW #;

 ! Household transfer to other institution !

 delTRHOHO !# Transfer to household from inter household #;
 delTRROHO !# Transfer to rest of the world from household #;

 ! fiscal instrument !
 delTX  !c~COM Ordinary change in rate of  commodity tax
 delSC  !c~COM Ordinary change in rate of commodity subsidy
 delTM  !c~COM Ordinary change in rate of com import tarrif
 delTAXH  ! Ordinary change in rate of household tax
 delCORTAX ! ordinary change in corporate income/profit tax rate
 delMPSH  ! Ordinary change in rate of household saving

! exogenous final demand
 xinv_s  !c~COM Demand for commodity for investment
 fxg_s !# government expenditure shifter by commodity #;
 fxg_sc !# overall government expenditure shifter #;
 fxexp ! q-shifter of export demand

! world/foreign price
 pfimp  !c~COM International price of commodity

! Numneraire
 exr  ! Exchange rate
;
rest endogenous ;
```

Short run closure

In the short run closure, capital is sector-specific. They cannot move to other sectors or immobile. Capital becomes fixed input for each industry. We assign variable xfac("capital",IND) exogenous, and assign variable wdist("capital",ind) endogenous (not in closure). In this closure, we also assume that of aggregate employment can change. We implement this by endogenizing labor supply or xfacsup("labor"), and exogenize price of labor pfac("labor"), hence introducing labor market rigidity (we assume that there is nominal wage rigidity in economy).

```
! standard short-run closure  !

exogenous
! Factor market closure !
! Capital is sector specific; aggregate employment is endogenous !

xfacro  ! f~FAC Supply of factor f by rest of the world
```

```
xfac("capital",IND)
wdist("labor",IND)
pfac ! price of factor of production

! technical change !

atot ! i~IND all input technical change
aprim ! i~IND netral/all factor technical change
afac ! f~FAC i~IND factor saving techncial change

 ! Transfer institution

 ! Government transfer to other institution !

 delTRHOGO !# Transfer to household from  government #;
 delTRROGO !# Transfer to rest of the world from  government #;
 delTRGOGO !# transfer from government to government #;

 ! corporate transfer to other institution !

 delTRHOCO !# Transfer to household from coorporate #;
 delTRROCO !# Transfer to rest of the world from corporate #;
 delTRCOCO !# Transfer to corporate from corporate #;
 ftrco !# shifter of corporate transfer to all institution

 ! Rest of the World transfer to other institution !

 delTRHORO !# Transfer to household from rest of the world #;
 delTRGORO !# Transfer to cental government from rest of the world #;
 delTRCORO !# Transfer to coorporate from rest of the world #;
 delTRRORO !# transfer from ROW to ROW #;

 ! Household transfer to other institution !

 delTRHOHO !# Transfer to household from inter household #;
 delTRROHO !# Transfer to rest of the world from household #;

 ! fiscal instrument !
 delTX  !c~COM Ordinary change in rate of  commodity tax
 delSC  !c~COM Ordinary change in rate of commodity subsidy
 delTM  !c~COM Ordinary change in rate of com import tarrif
 delTAXH  ! Ordinary change in rate of household tax
 delCORTAX ! ordinary change in corporate income/profit tax rate
 delMPSH  ! Ordinary change in rate of household saving

! exogenous final demand
 xinv_s  !c~COM Demand for commodity for investment
 fxg_s !# government expenditure shifter by commodity #;
 fxg_sc !# overall government expenditure shifter #;
 fxexp ! q-shifter of export demand

! world/foreign price
 pfimp  !c~COM International price of commodity

! Numneraire
 exr  ! Exchange rate
;
 rest endogenous ;
```