

# PEP 1-1

April 2012

Véronique Robichaud, André Lemelin,  
Hélène Maisonnave and Bernard Decaluwé

This material is a joint effort between IFPRI and PEP in the context of the AGRODEP project, and the authors acknowledge the financial support of the AGRODEP project.

# Presentation outline

3

- General description
- Files
- Mathematical structure
- The SAM
- The GAMS code



## General description

## General description

5

- Multi-sector
- National model
- Static framework (dynamic extension)
- Multiple labor and capital categories
- Many tax instruments
- Compatible with rectangular input-output tables

PEP 1-1

April 2012

- The PEP-1-1 model is a one country, multi-sector static computable general equilibrium (CGE) model.
- It distinguishes several categories of workers and of capital.
- Also, PEP-1-1 is capable of taking into account a broad set of tax instruments, and it models all possible transfers between institutions (agents).
- Moreover, the aggregate output of each industry consists of several products, consistent with rectangular input-output tables.

## General description (cont'd)

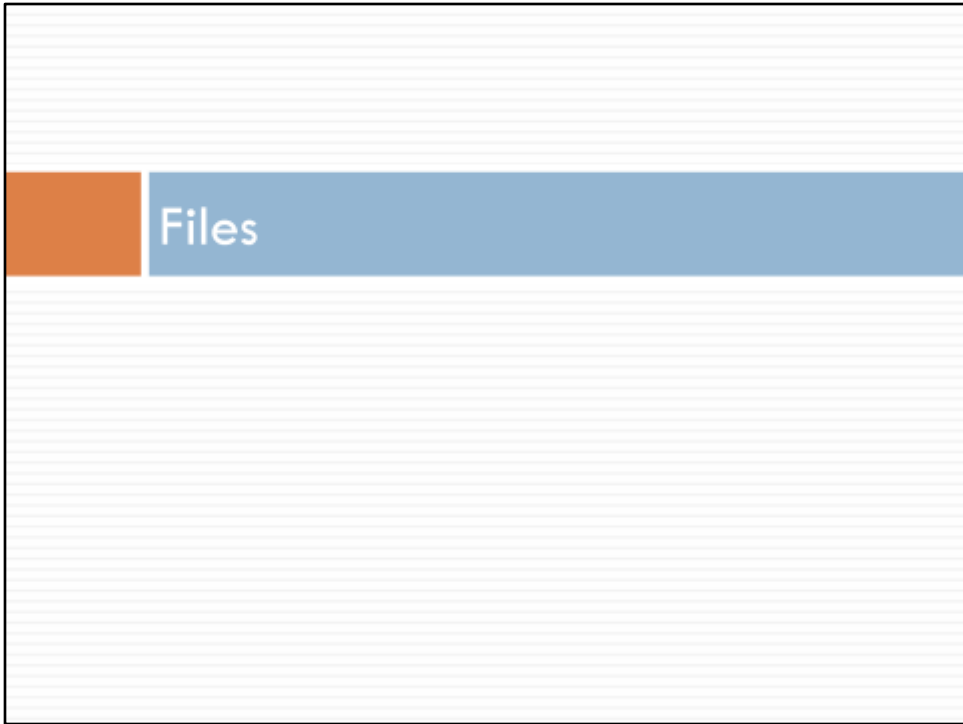
6

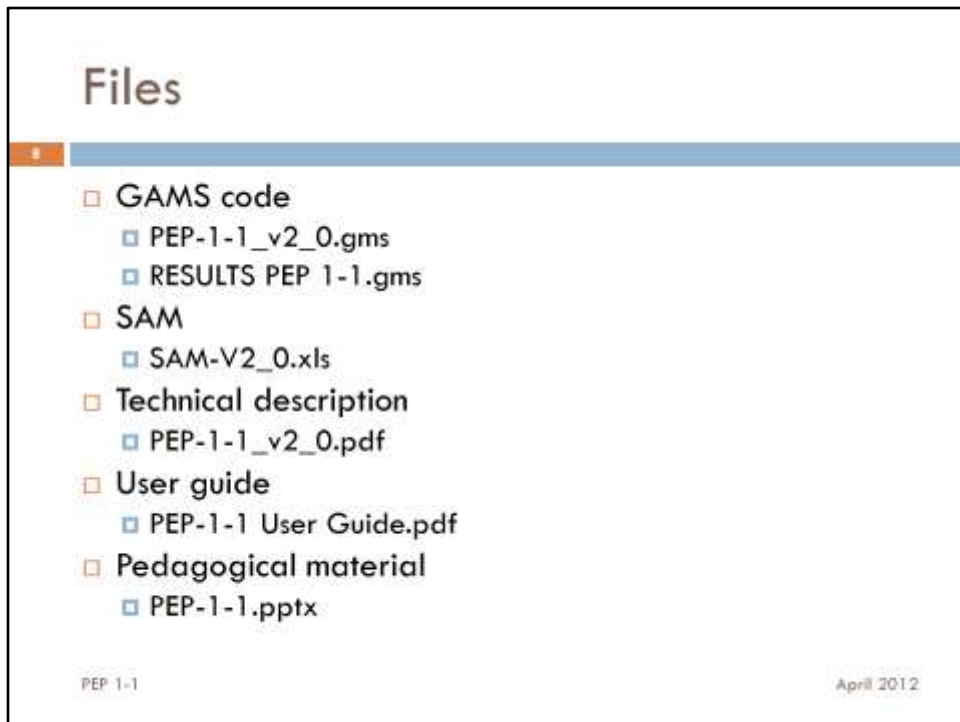
- Flexible common model
- Standard hypothesis
- Easily applicable
- Adaptable to most SAMs

PEP 1-1

April 2012

- The GAMS code has been written in a general form, thanks to the use of sets.
- The modeling is based on standard hypothesis.
- This will facilitate the application of PEP-1-1 to variously aggregated SAMs.





- The PEP-1-1 model comes with a complete set of files:
  - The GAMS code includes two files
    - PEP-1-1\_v2\_0.gms which is the main program including the calibration, the model, its resolution, and examples of simulation.
    - RESULTS PEP 1-1.gms which is included at the end of the previous file and builds automatically tables of results in Excel.
  - The fictitious social accounting matrix (SAM-V2\_0.xls), built in Excel which is also included in the main GAMS code.
  - A complete technical description of the model, including all mathematical derivations (PEP-1-1\_v2\_0.pdf)
  - A user guide that presents the different steps a user should follow to apply this particular model to the SAM of a given country (PEP-1-1 User Guide.pdf)
  - And a PowerPoint presentation that acts as pedagogical material based on the two preceding files (PEP-1-1.pptx).





## Mathematical structure

# Mathematical structure

10

- Overview: income and expenditure circular flow
- Production
- Income and savings
- Demand
- Supply and international trade
- Prices
- Equilibrium
- Gross domestic product
- Default closures

PEP 1-1

April 2012

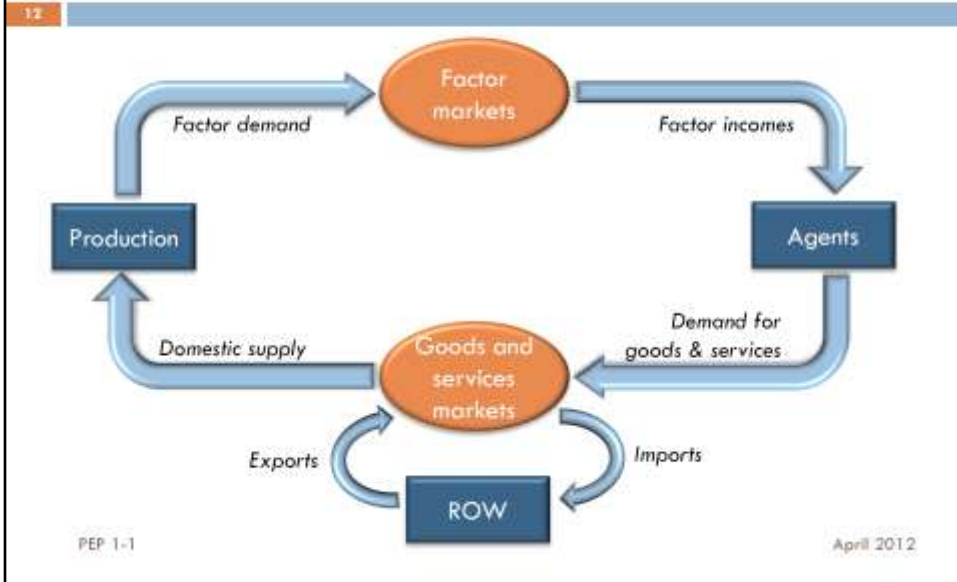
• The next section reviews the mathematical structure of the PEP-1-1 model. It is based on the technical document (PEP-1-1\_v2\_0.pdf) as it follows the same presentation structure:

- Production
- Income and savings
- Demand
- Supply and international trade
- Prices
- Equilibrium
- Gross domestic product
- Default closures



## Overview

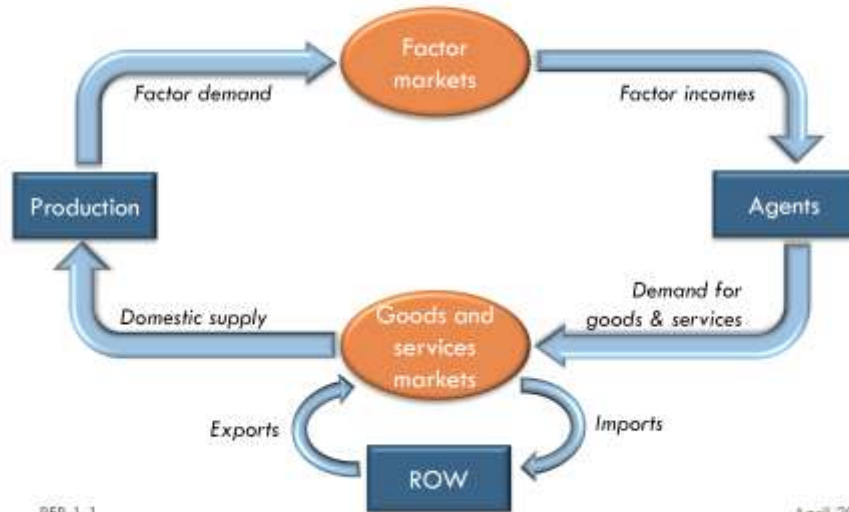
## Overview: income and expenditure circular flow



- Income and expenditure circular flow:
  - Productive activities uses factors of production
  - Agents receive the factor incomes
  - They use their income to purchase commodities, which can either be produced locally or imported.

## Overview: income and expenditure circular flow

12





## Production

# Production

15

- Perfect competition
  - Profit maximization under production technology
  - Price-taking behavior
- Nested production structure
- Industries are represented by index  $J$

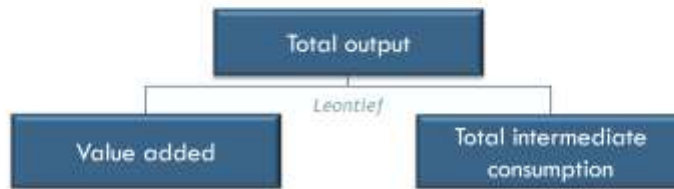
PEP 1-1

April 2012

- Firms are assumed to operate in a perfectly competitive environment.
- So each industry's representative firm maximizes profits subject to its production technology, while it considers the prices of goods and services and factors as given (price-taking behavior).
- The set of productive activities is represented by indices  $J$ .

# Production – total output

16



PEP 1-1

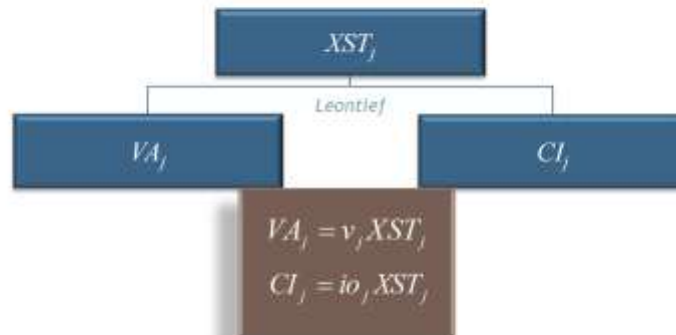
April 2012

- At the top level, the sectoral output of each productive activity  $j$  combines value added and total intermediate consumption in fixed shares.
- In other words, the two aggregate inputs are considered to be strictly complementary, without any possibility of substitution, following a Leontief production function.



## Production – total output

17



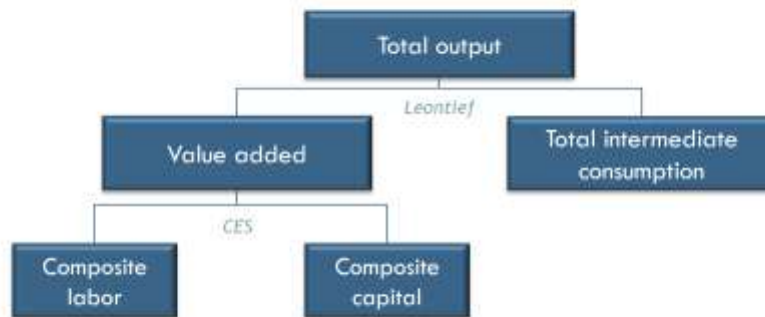
PEP 1-1

April 2012

- Here is the mathematical representation of the Leontief.

# Production – value added

18



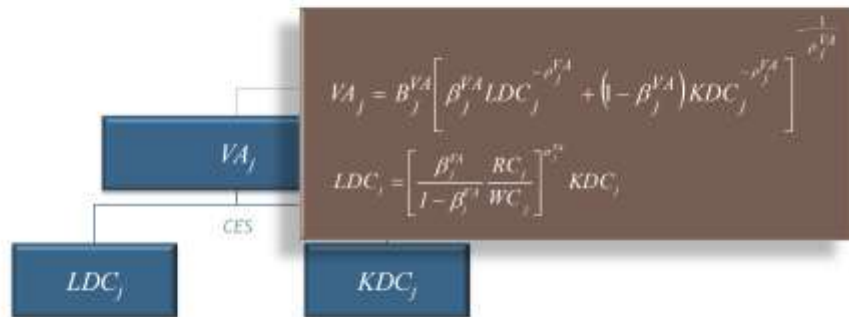
PEP 1-1

April 2012

- At the second level, each industry's value added consists of composite labor and composite capital, following a constant elasticity of substitution (CES) specification.

# Production – value added

19



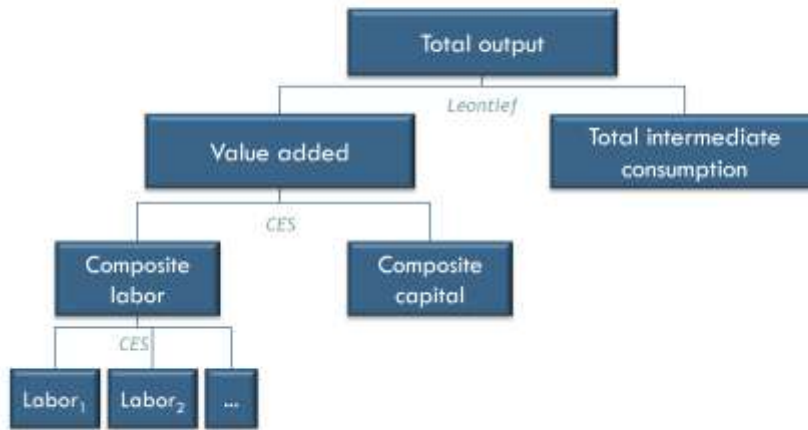
PEP 1-1

April 2012

- Profit maximization (or cost minimization) by the firms leads them to employ labor and capital to the point where the value marginal product of each is equal to its price (the wage rate and the rental rate of capital respectively).
- With a CES production function, such behavior is described by the demand for labor relative to capital.

# Production – composite labor

20

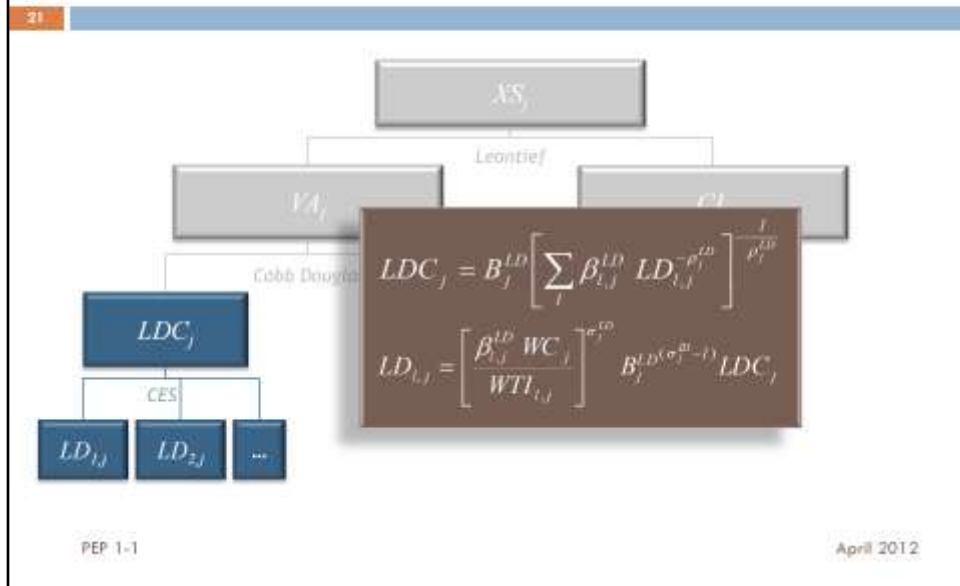


PEP 1-1

April 2012

- At the bottom level on the value added side, the various categories of labor, indexed as  $L$ , are combined following a constant elasticity of substitution (CES) technology, which reflects the imperfect substitutability between different types of labor.

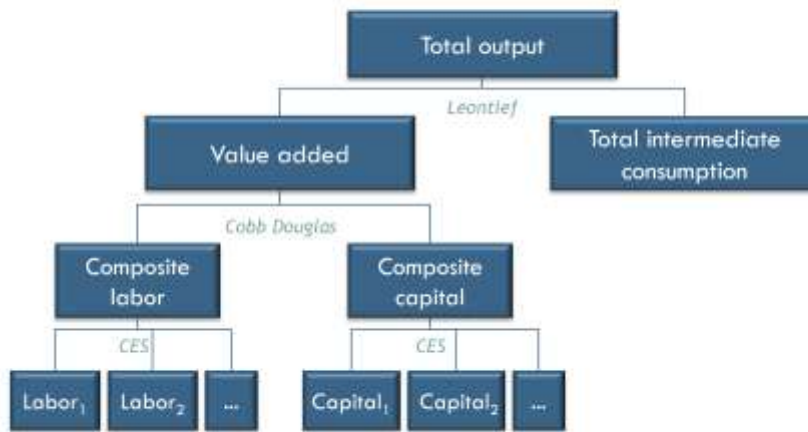
# Production – composite labor



- The firm chooses its labor composition so as to minimize its labor cost given the relative wage rates.
- Labor demand of each type derives from the first-order conditions of cost minimization by the representative firm, subject to the CES technology.

# Production – composite capital

22



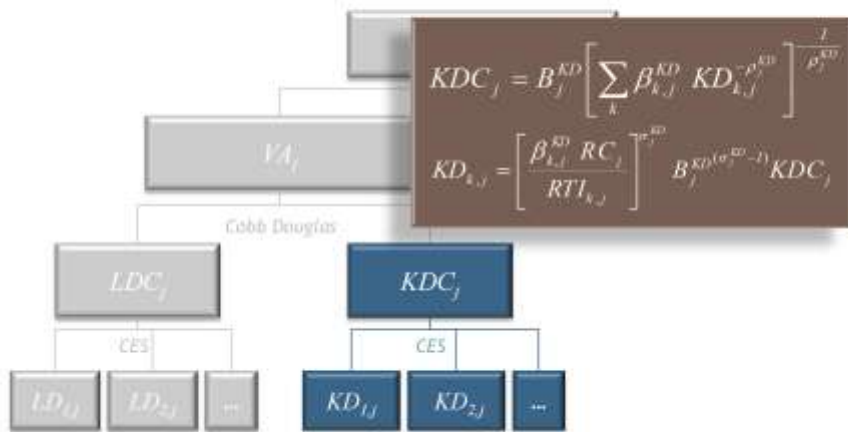
PEP 1-1

April 2012

- Likewise, composite capital is a CES combination of the different categories of capital, indexed as  $K$ .

# Production – composite capital

22



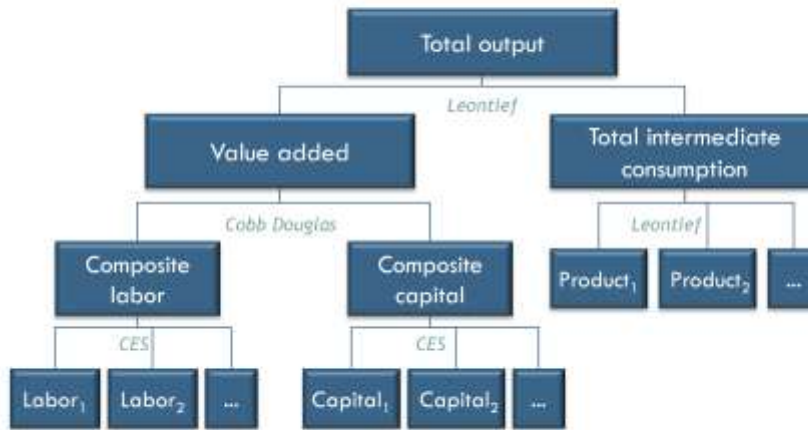
PEP 1-1

April 2012

- As in the case of labor, it is assumed that different categories of capital are imperfect substitutes.
- The demand for each type of capital results from cost minimization.

## Production – intermediate consumption

24



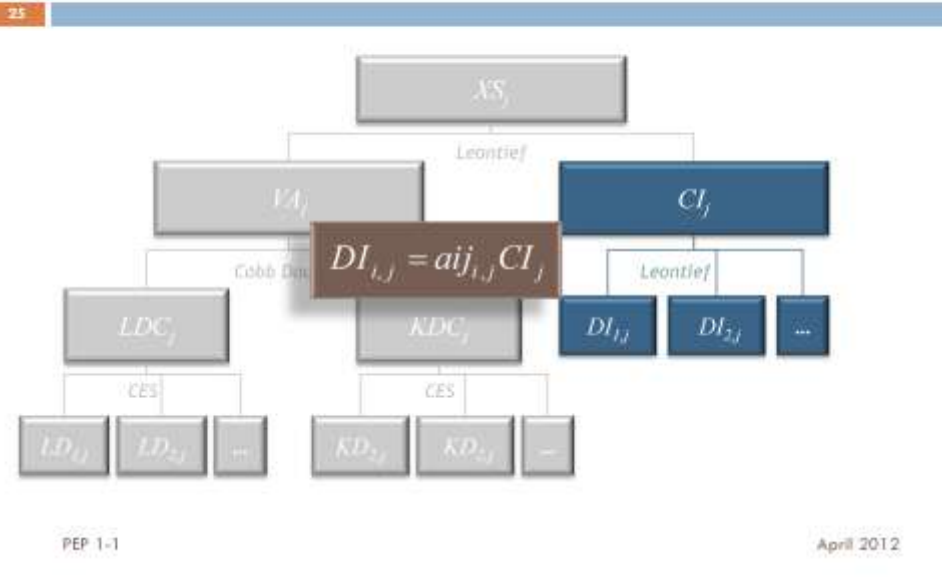
PEP 1-1

April 2012

- Finally, returning to the second level, but on the intermediate consumption side, aggregate intermediate consumption is made up of various goods and services.



## Production – intermediate consumption



- Here it is assumed that intermediate inputs are perfectly complementary, and are combined following a Leontief production function.
- No substitutions are possible.



## Income and savings

# Income and savings

37

- Agents (set  $AG$ )
  - Households (subset  $H$ )
  - Firms (subset  $F$ )
  - Government (element  $GVT$ )
  - Rest of the world (element  $ROW$ )

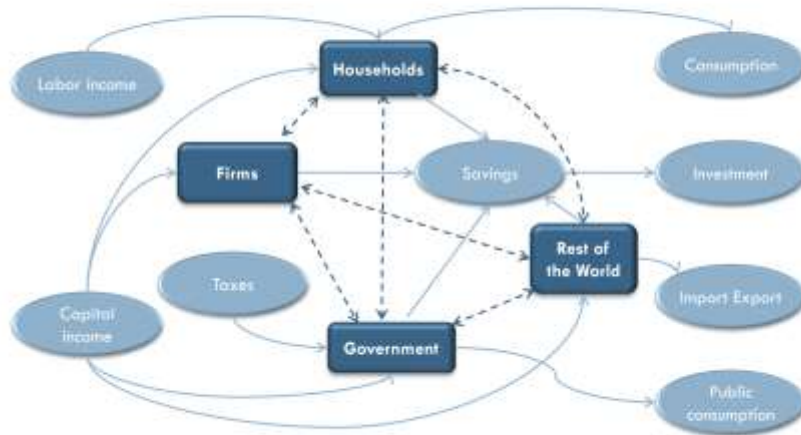
PEP 1-1

April 2012

- The PEP-1-1 model offers the possibility of several categories of households and businesses, respectively indexed as  $H$ , and  $F$ , together with government, designated as  $GVT$ , and the rest of the world,  $ROW$ .

# Income and savings – overview

28



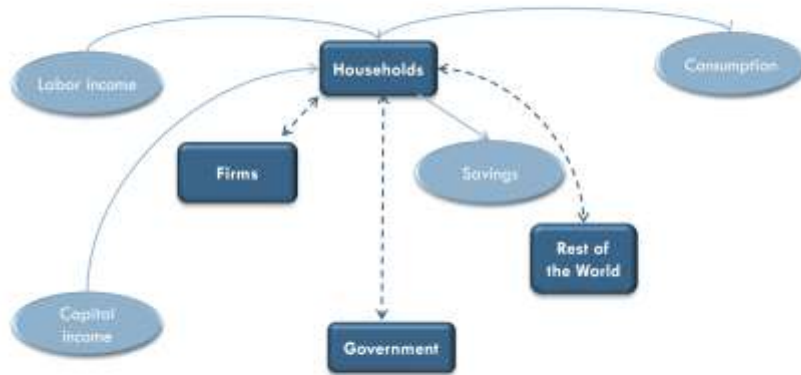
PEP 1-1

April 2012

- Here is the overall schema of the income and expenditures for each agent.
- The following slides will explain the flows for each agent.

# Households

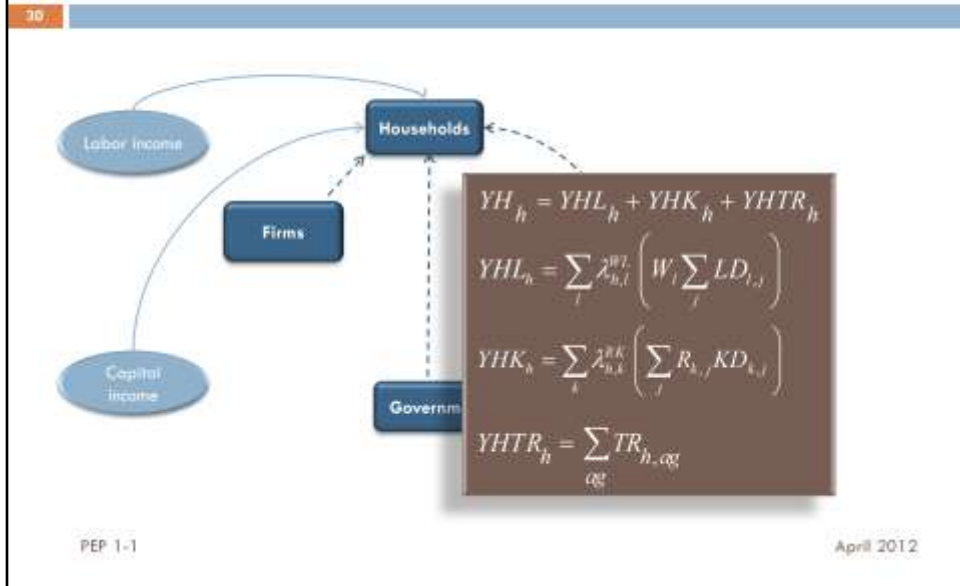
29



PEP 1-1

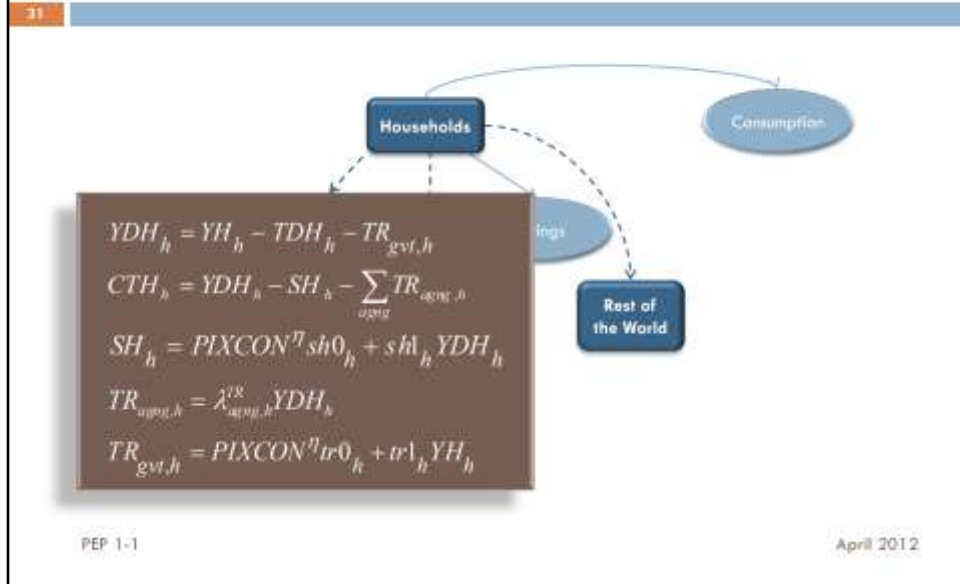
April 2012

# Households – income



- Household incomes ( $YH_h$ ) come from three sources: labor income ( $YHL_h$ ), capital income ( $YHK_h$ ), and transfers received from other agents ( $YHTR_h$ ).
- Each household type receives a fixed share  $\lambda^{WL}$  of the earnings of each type of labor.
- Likewise, total capital income is distributed between agents, including households, in fixed proportions  $\lambda^{RK}$ .
- Finally, transfer income is simply the sum of all transfers ( $TR_{h,ag}$ ) received by type  $h$  households.

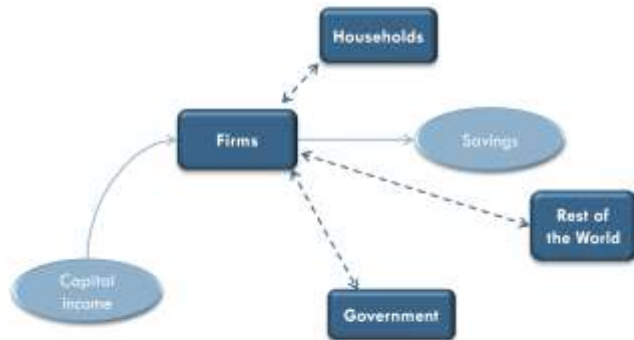
# Households – expenditures and savings



- Subtracting direct taxes ( $TDH_h$ ) and household transfers to government ( $TR_{gvt,h}$ ) yields type  $h$  household disposable income ( $YDH_h$ ). Indeed, since household transfers to government are mostly contributions to various social programs, our calculation of disposable income is consistent with national accounts.
- Whatever disposable income is left after savings ( $SH_h$ ) and transfers to other agents ( $TR_{agng,h}$ ) is entirely dedicated to consumption.
- Household savings are a linear function of disposable income, and allows for the marginal propensity to save ( $sh1_h$ ) to be different from the average propensity. In addition, it is possible to fully or partially index the intercept ( $sh0_h$ ) to changes in the consumer price index ( $PIXCON$ ). This is especially useful for testing the model's homogeneity, in which case price elasticity  $\eta$  is set to 1.
- Household transfers to non-government agents are simply proportional ( $\lambda^{TR}$ ) to disposable income.
- As for household transfers to government, they are akin to social program contributions: as such, they are treated in the same way as household income taxes, i.e. they are described as a linear function of total income (with  $tr0_h$  being the intercept, and  $tr1_h$  the slope).

# Firms

32

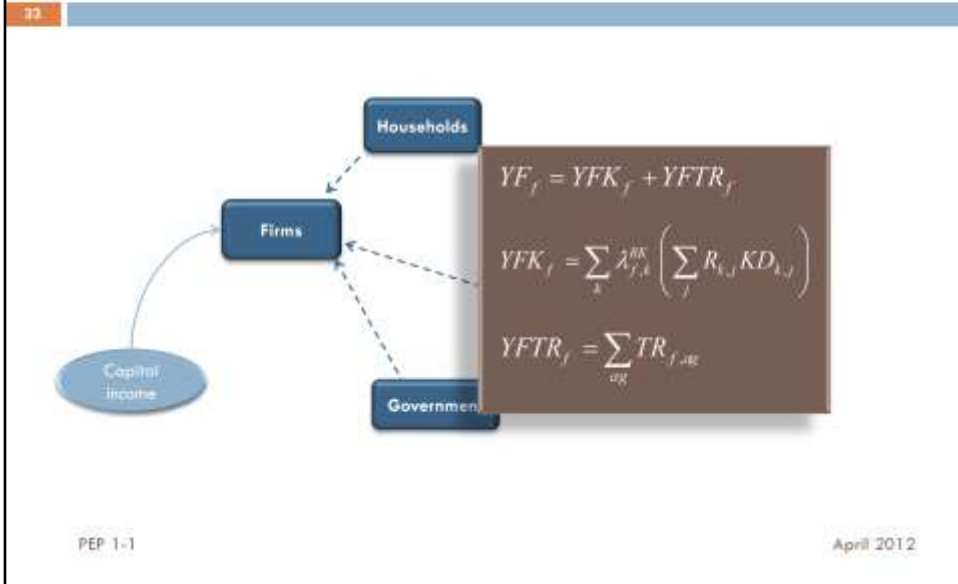


PEP 1-1

April 2012



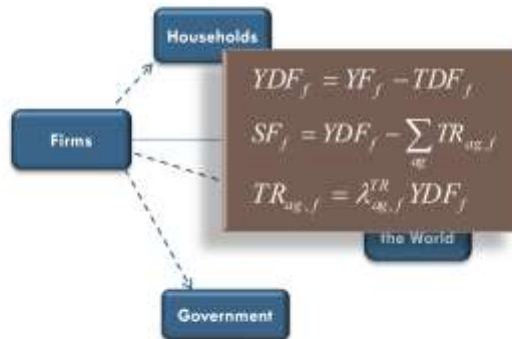
## Firms – income



- Business income ( $YF_f$ ) come from two sources: capital income ( $YFK_f$ ), and transfers received from other agents ( $YFTR_f$ ).
  - Each firm type receives a fixed share  $\lambda^{RK}$  of total capital income.
  - Transfer income is simply the sum of all transfers ( $TR_{f,ag}$ ) received by type  $f$  firms.

## Firms – savings

34



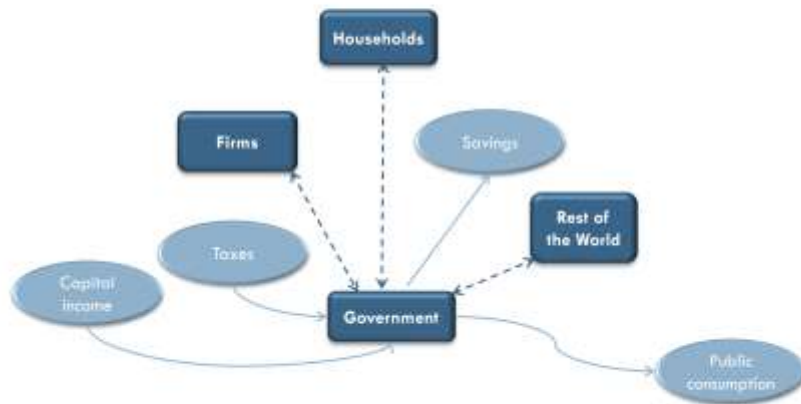
PEP 1-1

April 2012

- Deducting business income taxes ( $TDF_f$ ) from total income yields the disposable income ( $YDF_f$ ) of each type of business.
- Likewise, business savings ( $SF_f$ ) are the residual that remains after subtracting transfers to other agents from disposable income.
- Finally, business transfers to other agents are simply proportional to disposable income.

# Government

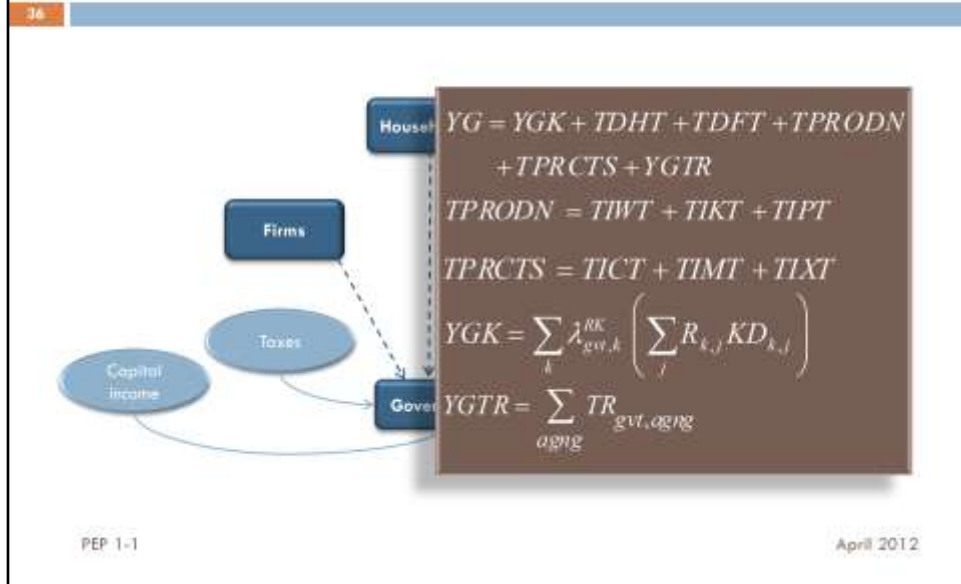
35



PEP 1-1

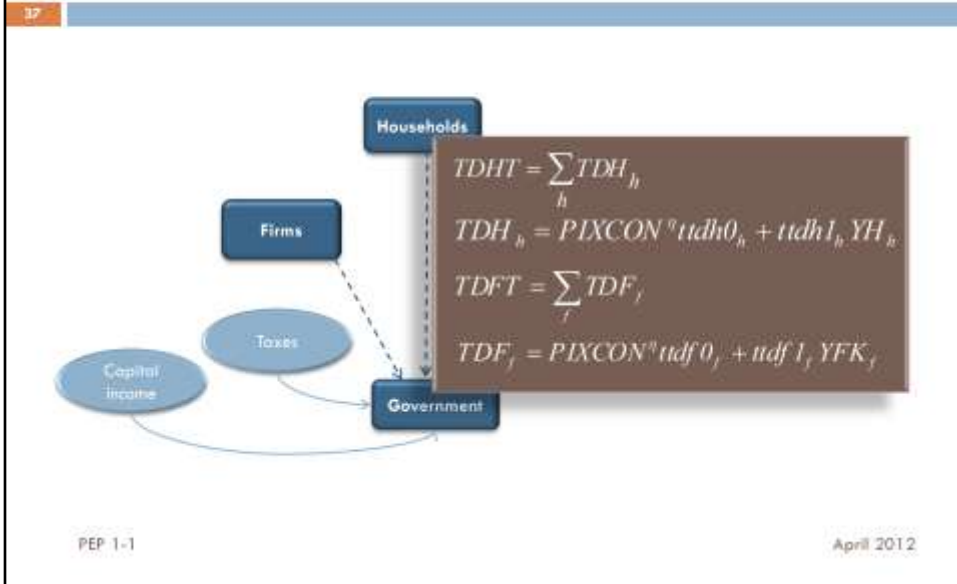
April 2012

# Government – income



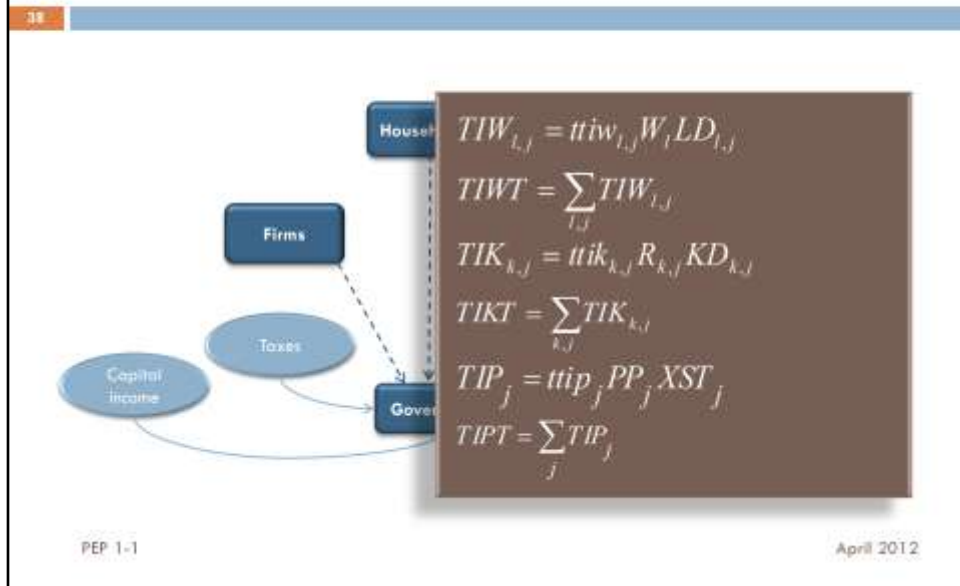
- In the PEP-1-1 model, it is possible to take into account a large variety of tax instruments. Indeed, the government draws its income from household and business income taxes ( $TDHT$  and  $TDFT$ ), taxes on products and on imports ( $TPRCTS$ ), and other taxes on production ( $TPRODN$ ).
- According to the 1993 *System of National Accounts*, taxes on products (not « production ») and imports consist of indirect taxes on consumption ( $TICT$ ), taxes and duties on imports ( $TIMT$ ), and export taxes ( $TIXT$ ).
- Other taxes on production consist of payroll taxes ( $TIWT$ ), taxes on capital ( $TIKT$ ), and taxes on production ( $TIPT$ ).
- In addition to these various forms of fiscal revenue, government receives part of the remuneration of capital ( $YGK$ ) and transfers from other agents ( $YGTR$ ).

## Government – income (cont'd)



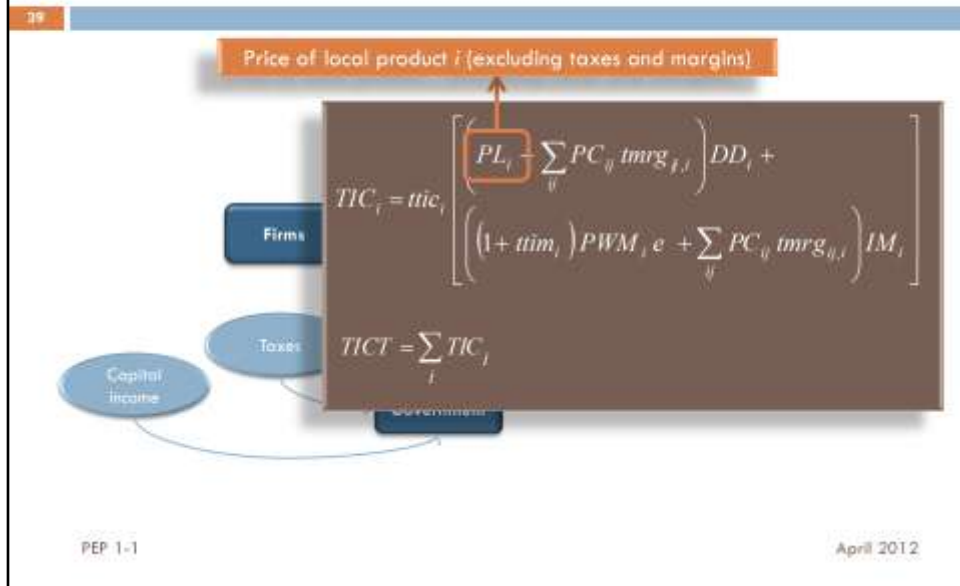
- Similarly to what has been done with household savings, income taxes are described as a linear function of total income, whether it be for households or for businesses.
- That way, when a non-zero intercept ( $ttdh0_h$  and  $ttdf0_f$ ) is applied, the marginal rate of taxation ( $ttdh1_h$  and  $ttdf1_f$ ) is different from the average rate.

## Government – income (cont'd)



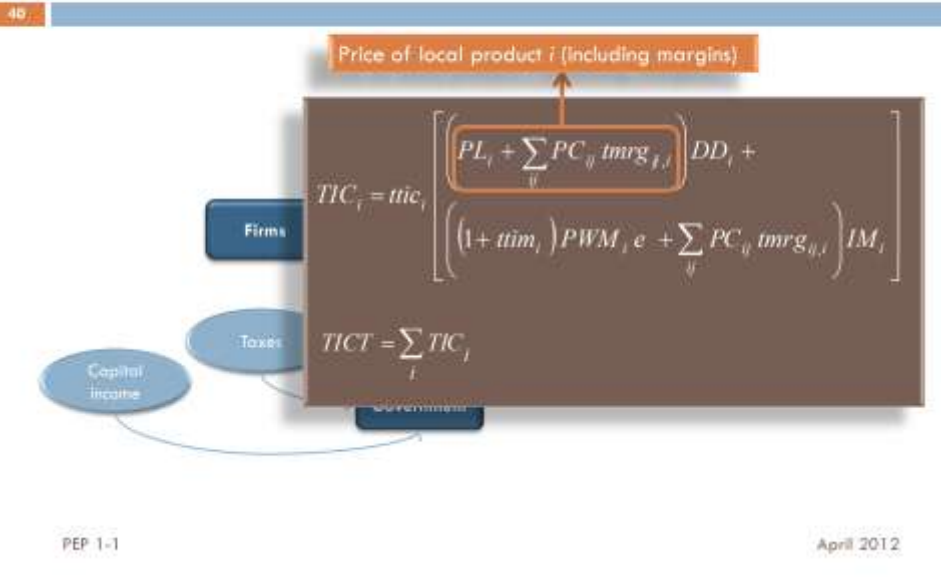
- As mentioned earlier, the model allows for taxes on production factors (payroll taxes and capital taxes), as well as for taxes on production itself (together, these three forms of taxation constitute « other taxes on production »).
- First, as regards taxes on factors of production, the model notation distinguishes tax rates by industry, and also by type of labor or capital. Each rate,  $ttiw_{l,j}$  for payroll and  $ttik_{k,j}$  for capital then applies to the corresponding.
- Next, a tax ( $ttip_j$ ) may be applied to the total value of production ( $PP_j XST_j$ ).

## Government – income (cont'd)



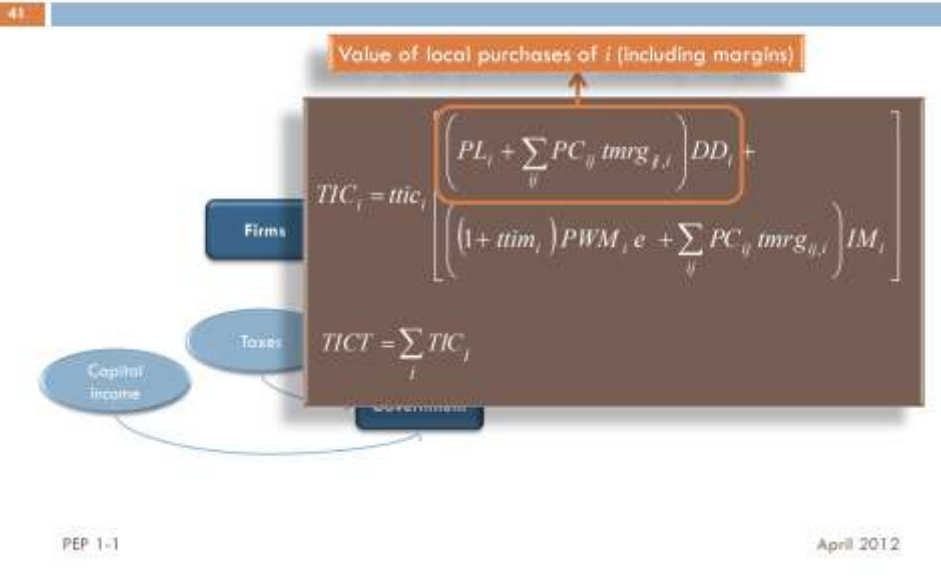
- Indirect taxes on commodities (index  $i$ ) apply on the sales value including margins and custom duties whenever the latter exist.

## Government – income (cont'd)



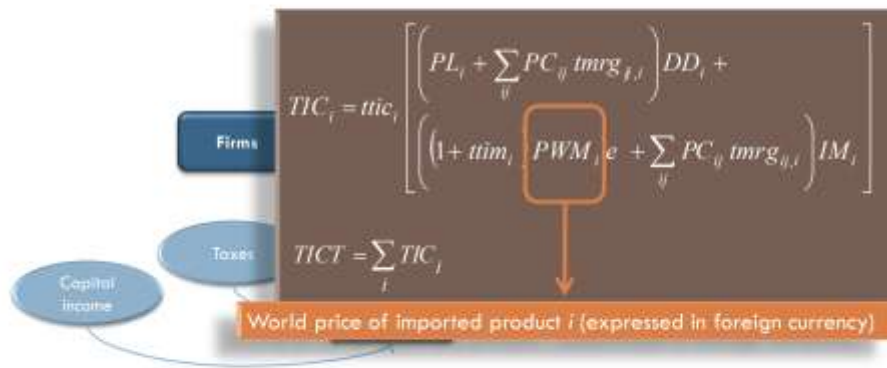


## Government – income (cont'd)



## Government – income (cont'd)

42

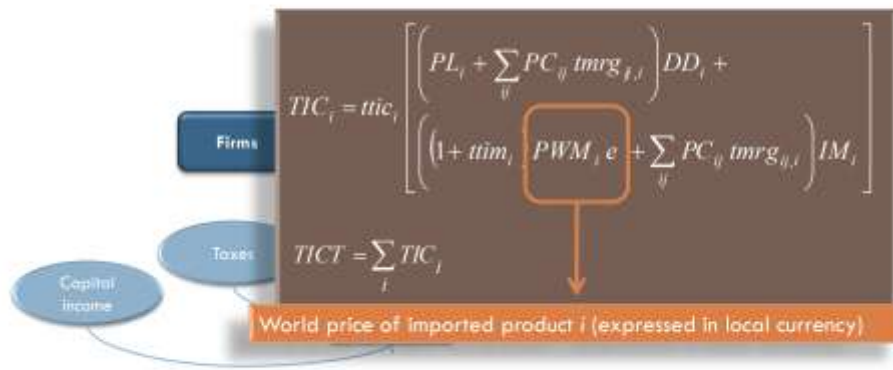


PEP 1-1

April 2012

## Government – income (cont'd)

43

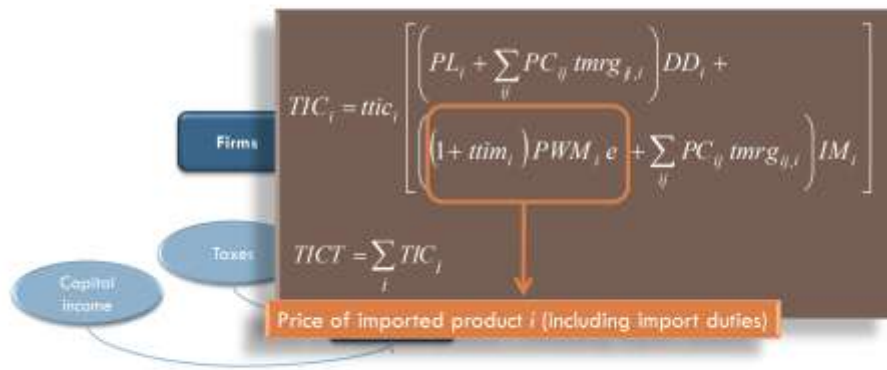


PEP 1-1

April 2012

## Government – income (cont'd)

44

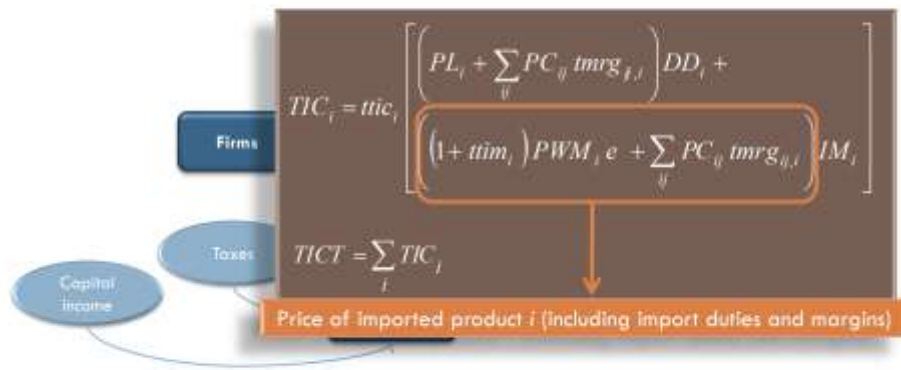


PEP 1-1

April 2012

## Government – income (cont'd)

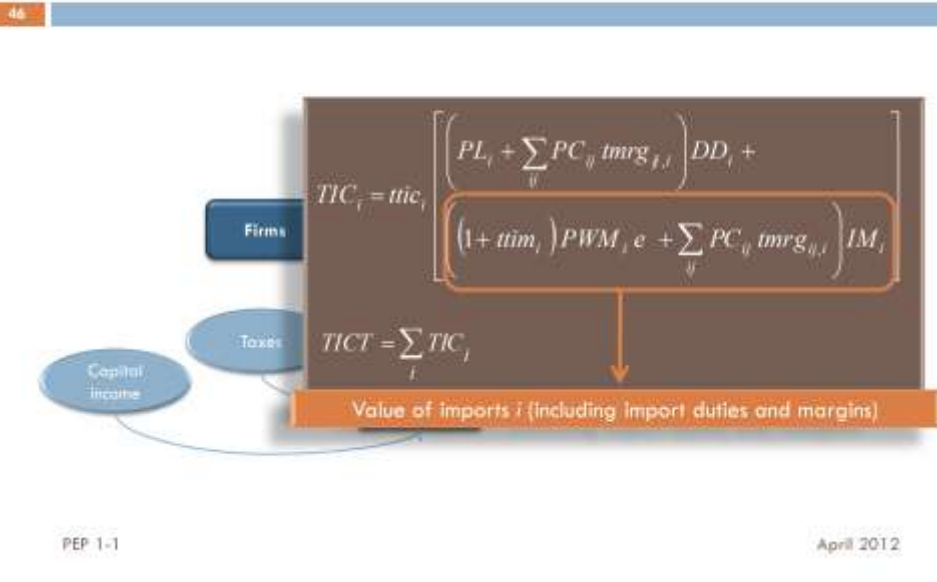
45



PEP 1-1

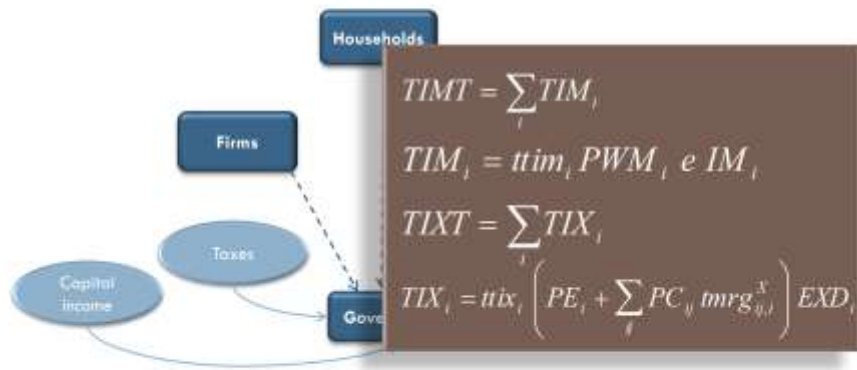
April 2012

## Government – income (cont'd)



## Government – income (cont'd)

47

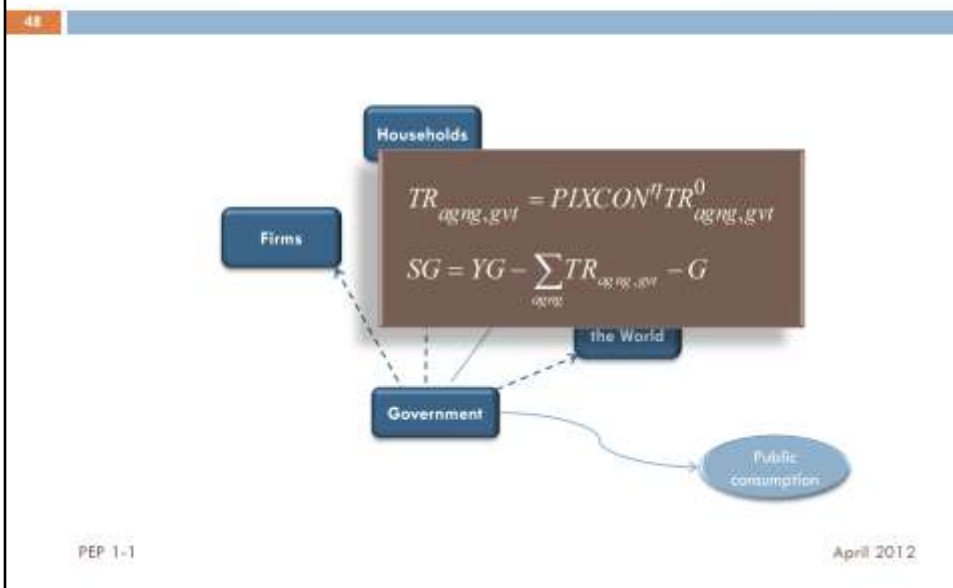


PEP 1-1

April 2012

- Other taxes collected are taxes and duties on imported products ( $TIM_i$ ), and on exports ( $TIX_i$ ).

## Government – expenditures and savings

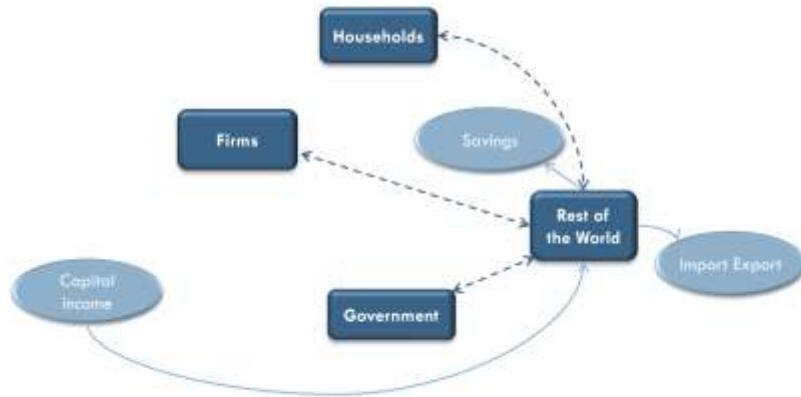


- Transfers paid by the government,  $TR_{agng,gvt}$ , to other agents are initially set equal to their SAM values,  $TR^0$ , and indexed, fully or partially, to the consumer price index.
- The current government budget surplus or deficit (positive or negative savings,  $SG$ ) is the difference between its revenue and its expenditures.
- The latter consist of transfers to agents and current expenditures on goods and services,  $G$ .



# Rest of the world

49

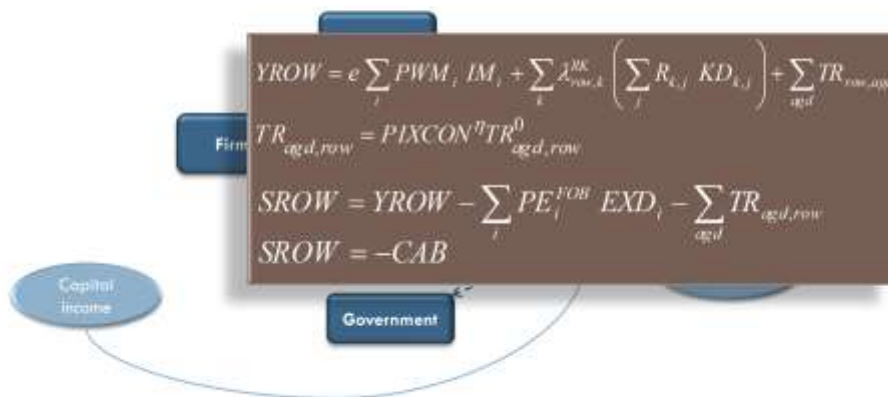


PEP 1-1

April 2012

## Rest of the world (cont'd)

50



PEP 1-1

April 2012

- The rest of the world receives payments for the value of imports, part of the income of capital, and transfers from domestic agents.
- Transfers paid by foreigners to other domestic agents,  $TR_{agd,row}$ , are initially set equal to their SAM values  $TR^0$ , and indexed to the consumer price index.
- Foreign spending in the domestic economy consists of the value of exports, and transfers to domestic agents.
- The difference between foreign receipts ( $YROW$ ) and spending is the amount of rest-of-the-world savings ( $SROW$ ), which are equal in absolute value to the current account balance ( $CAB$ ), but of opposite sign.



Demand

# Demand

32



PEP 1-1

April 2012

- The demand for goods and services, whether domestically produced or imported, consists of:

- household consumption demand;
- demand by public administrations;
- investment demand;
- intermediate demand;
- demand as transport or trade margins.

# Households' demand

53



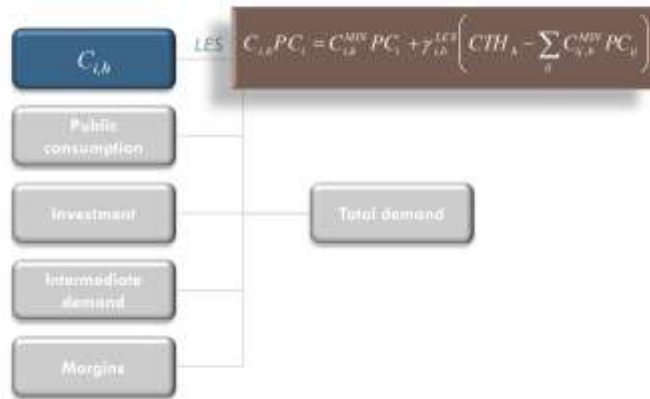
PEP 1-1

April 2012

- It is assumed that households have Stone-Geary utility functions (from which derives the Linear Expenditure System).
- Contrary to Cobb-Douglas utility functions, often used in the literature, this specification imposes neither zero cross-price elasticities between all pairs of goods, nor unit income-elasticities for all goods.
- Thus, it offers a degree of flexibility with respect to substitution possibilities in response to relative price changes.

# Households' demand

54



PEP 1-1

April 2012

- Type  $h$  household demand for each good,  $C_{i,h}$ , is determined by utility maximization subject to the budget constraint.
- A characteristic of these utility functions is that there is a minimum level of consumption of each commodity,  $C_{i,h}^{MIN}$ , (which may be zero for some commodities).

# Public consumption

55

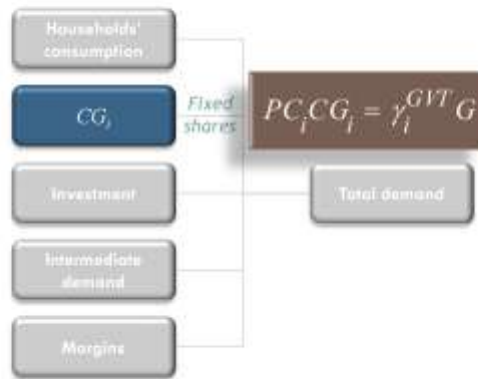


PEP 1-1

April 2012

# Public consumption

56



PEP 1-1

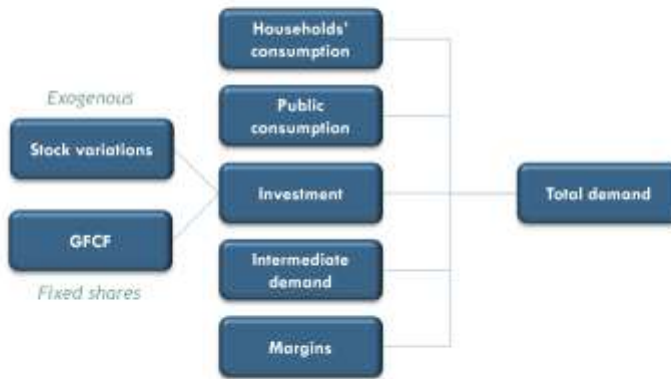
April 2012

- Current expenditure budget, is distributed among commodities in fixed shares  $\gamma^{GVT}$ .
- The quantity demanded of each commodity,  $CG_i$ , varies inversely with its price.



# Investment

57



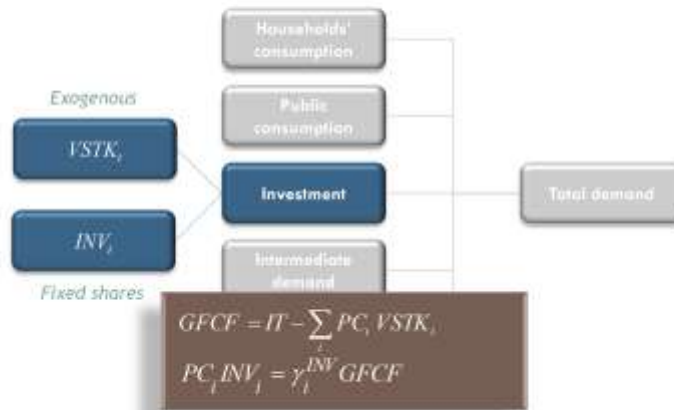
PEP 1-1

April 2012

- Investment demand includes both gross fixed capital formation (GFCF) and changes in inventories.
- Inventory changes are exogenous in PEP-1-1, fixed in volume.

# Investment

58



PEP 1-1

April 2012

- GFCF expenditure, obtained by subtracting the cost of changes in inventories ( $VSTK_i$ ) from total investment expenditure ( $IT$ ), is distributed among commodities in fixed shares,  $\gamma^{INV}$ .
- So, for a given amount of investment expenditures, the quantity demanded of each commodity  $INV_i$  for investment purposes is inversely related to its purchaser price.

# Intermediate demand

59



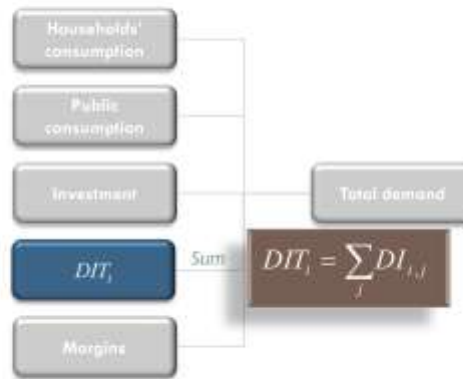
PEP 1-1

April 2012

- In addition to being required for final demand, goods and services are used as inputs in the production process.

# Intermediate demand

60



PEP 1-1

April 2012

- Intermediate demand for each commodity ( $DIT_i$ ) is the sum of industry demands ( $DI_{i,j}$ ) .

# Margins

61



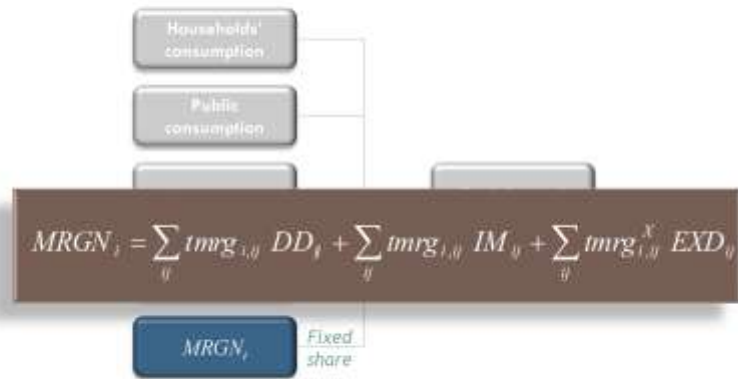
PEP 1-1

April 2012

- Finally, some services, such as transport and retail and wholesale trade, are used to move commodities and make them available to the market.

# Margins

62



PEP 1-1

April 2012

- Margin rates are applied to the volume of domestic production and imports to determine the quantities of these margin services ( $MRGN_i$ ) required to distribute commodities to buyers.



## Supply and international trade

- In this section, we define the trade relations with the rest of the world, that is, the supply of exports and the demand for imports.
- This is achieved through specifying domestic buyers' behavior with respect to the different supply sources, and domestic producers' supply behavior.
- The latter comprises two aspects: first, how composite output translates into the supply of products, and, second, how the supply of each product is directed to destination markets.
- The small-country hypothesis is adopted, in the sense that the world price of traded goods (imports and exports) is exogenous.

## Supply – total output

64



PEP 1-1

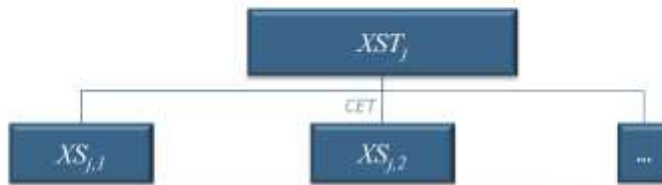
April 2012

- It is assumed that, although an industry can reorganize its production to change the proportions of goods produced, the different products are not perfectly « transformable » into one another.
- This is represented by means of a constant elasticity of transformation (CET) function that describes how easily the product-mix can be adjusted in response to price changes.



## Supply – total output

65



$$XST_j = B_j^{XT} \left[ \sum_i \beta_{j,i}^{XT} XS_{j,i}^{p_{j,i}^{XT}} \right]^{\frac{1}{\sigma_j^{XT}}}$$

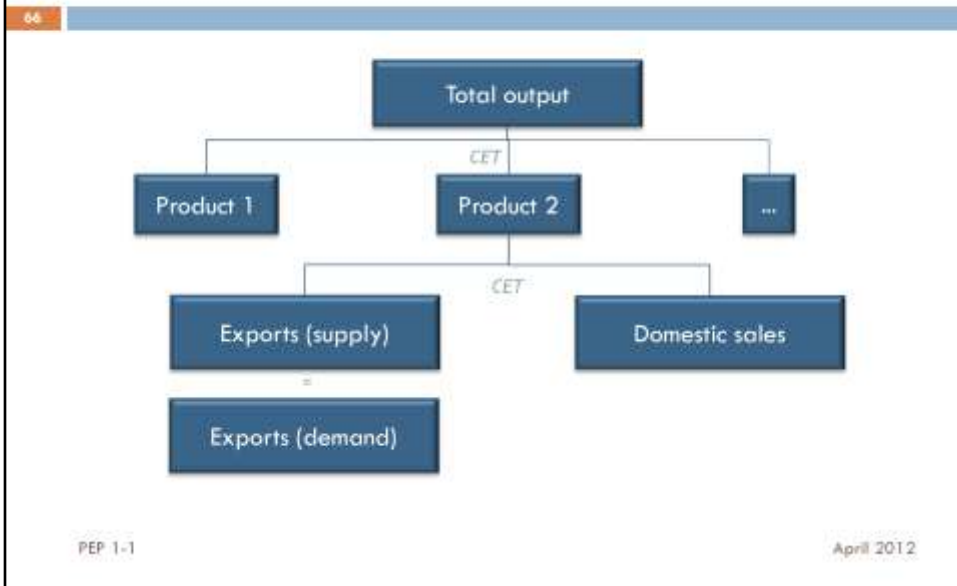
$$XS_{ji} = \frac{XST_j}{\left(B_j^{XT}\right)^{\frac{1}{1+\sigma_j^{XT}}}} \left[ \frac{P_{j,i}}{\beta_{j,i}^{XT} P_T^j} \right]^{\sigma_j^{XT}}$$

PEP 1-1

April 2012

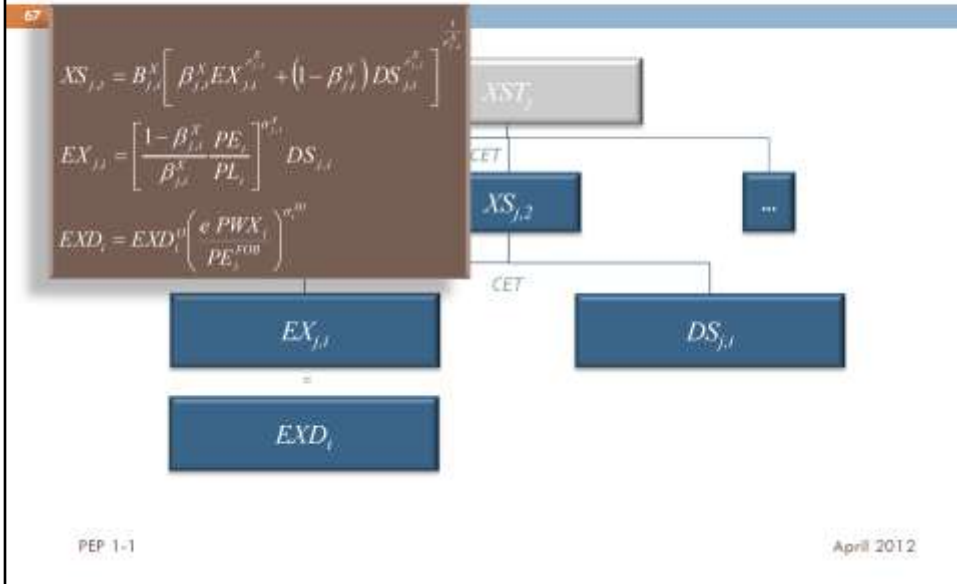
- Producers allocate output among products so as to maximize sales revenue, given product prices, subject to the CET function.
- Individual product supply functions are derived from the first-order conditions of revenue maximizing .

## International trade – Exports



- Next, the output of every product of an industry is shared out among markets (domestic or export), again with the goal of maximizing the firm's total revenue, given the demand in each market and the various taxes that apply.
- It is assumed that production directed to one market is somewhat different from production directed to another market.
- This imperfect substitutability is represented in PEP-1-1 by means of a constant elasticity of transformation (CET) aggregator function that describes how readily production can be redirected from one market to another.

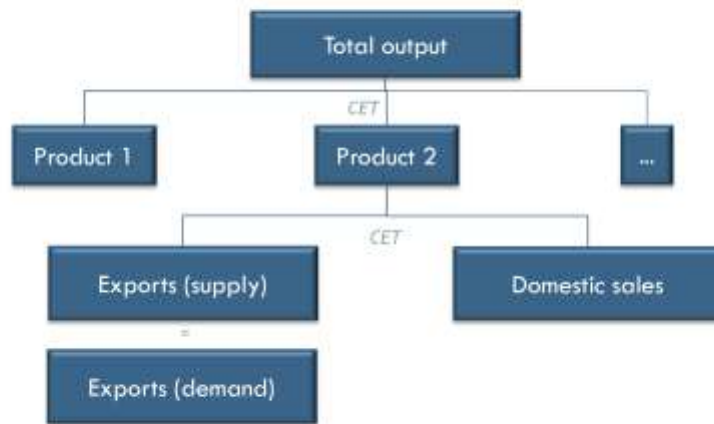
# International trade – Exports



- Relative supply functions are derived from the first-order conditions of revenue maximizing subject to the CET aggregator function.
- Local producer can increase his share of the world market only by offering a price that is advantageous relative to the (exogenous) world price.

# International trade – Imports

68

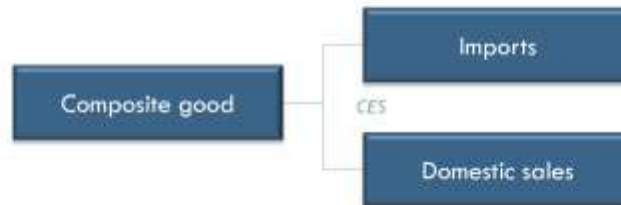


PEP 1-1

April 2012

# International trade – Imports

69



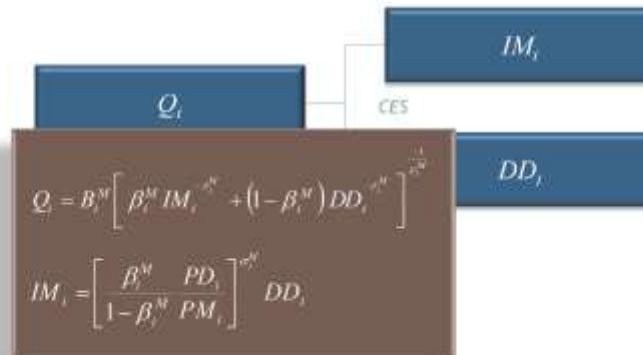
PEP 1-1

April 2012

- Buyer behavior is symmetrical to producer behavior, in that it is assumed that local products are imperfect substitutes for imports, or, in other words, that goods are heterogeneous with respect to their origin.
- So commodities demanded on the domestic market are composite goods, combinations of locally produced goods and imports.
- The imperfect substitutability between the two is represented by a constant elasticity of substitution (CES) aggregator function.

## International trade – Imports

70



PEP 1-1

April 2012

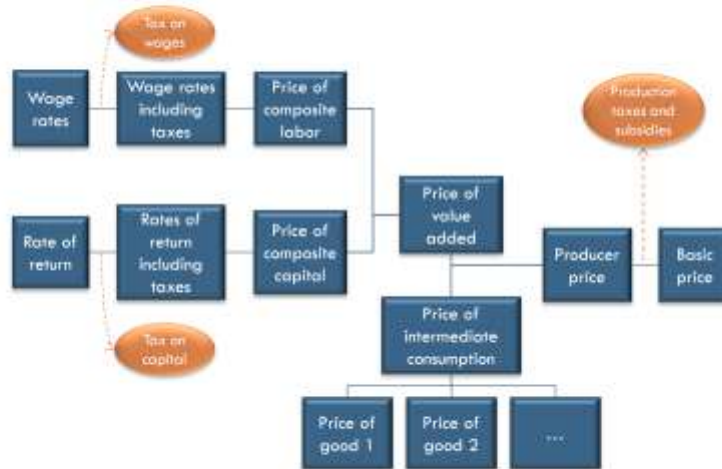
- Just as sellers seek to maximize revenue, buyers minimize expenses, subject to the CES aggregation function.
- Relative demand functions derive from the first-order optimum conditions.



## Prices

# Producer prices

72



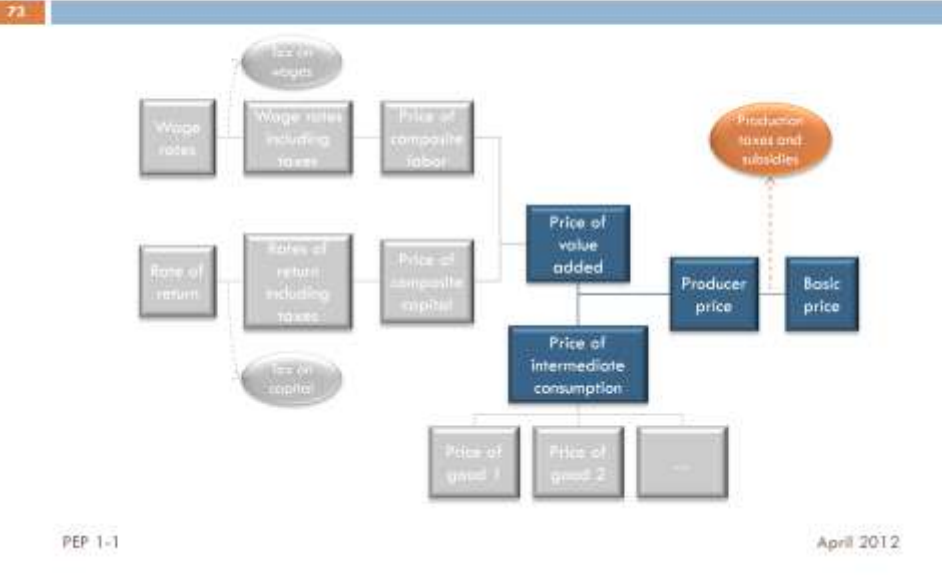
PEP 1-1

April 2012

- The different prices and price indexes naturally depend on the hypotheses and functional forms already stated.
- In aggregations, the price of an aggregate is a weighted sum of the prices of its components. The weights are determined by equating the value of the aggregate to the sum of the values of its components, given the quantity of the aggregate (which is determined from the aggregator function).
- The weight assigned the price of each component is therefore the ratio of its volume (or quantity) to the volume (or quantity) of the aggregate.
- Only in Leontief fixed-proportions aggregations are the weights invariant to relative price changes; in other cases, component proportions, and, consequently, component price weights, change in response to relative price changes, and they change more or less sharply, depending on the elasticity of substitution or transformation.

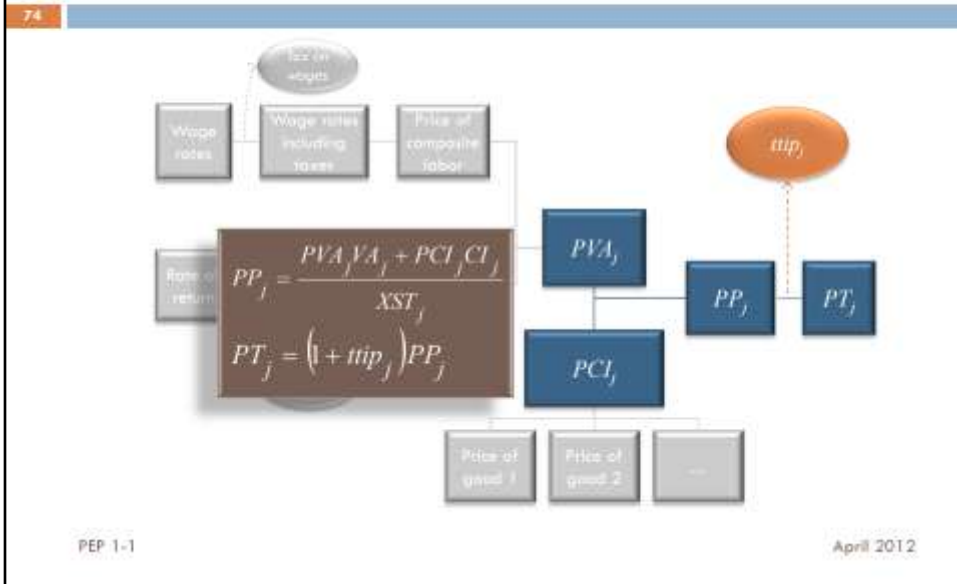


## Producer prices (cont'd)



- For instance, the unit cost of an industry's output (including taxes directly related to the use of capital and labor, but excluding other taxes on production) is a weighted sum of the prices of value added and aggregate intermediate consumption.

## Producer prices (cont'd)



- Here, the weights are  $VA_j/XST_j$  and  $CI_j/XST_j$ . Multiplying both sides of the equation by  $XST_j$  yields the value accounting identity  $PP_j XST_j = PVA_j VA_j + PCI_j CI_j$ . The same principle applies to the prices of other aggregates.
- The basic price of production ( $PT_j$ ) is obtained from the unit cost by adding taxes on production (other than taxes on labor or capital, already included in the unit cost).

## Producer prices (cont'd)

75



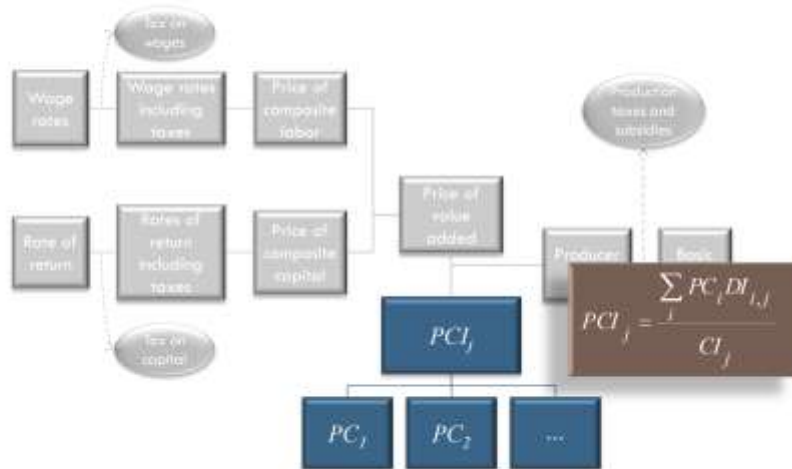
PEP 1-1

April 2012

- The price of aggregate intermediate consumption is a combination of the commodity prices of the industry's intermediate inputs.

## Producer prices (cont'd)

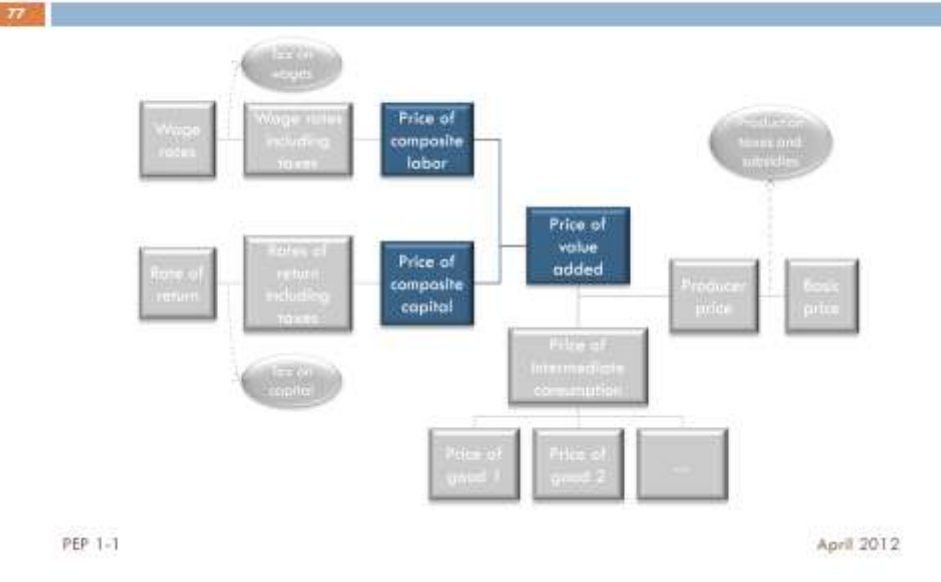
76



PEP 1-1

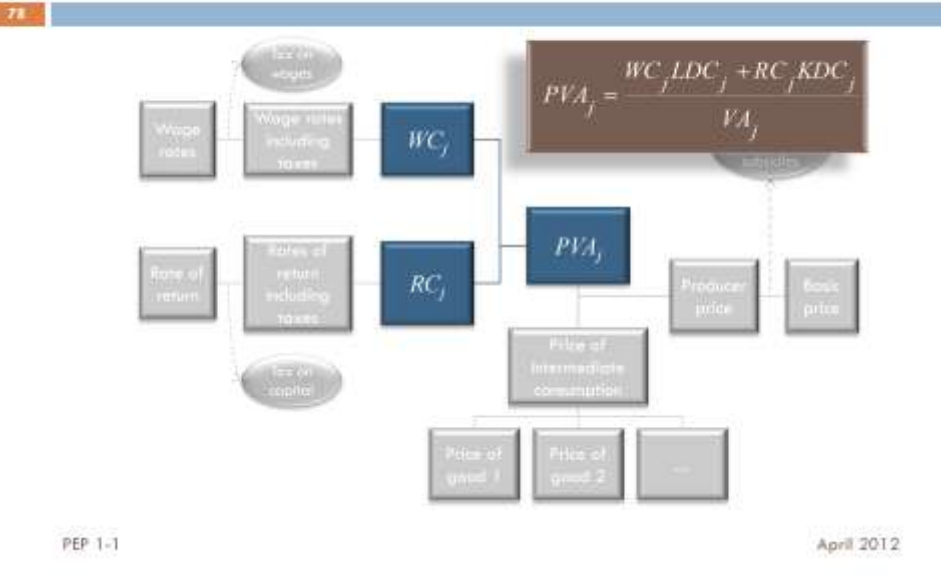
April 2012

## Producer prices (cont'd)



- Similarly, the price of value added is a combination of the prices of composite labor and composite capital.

## Producer prices (cont'd)



- So is it with the prices of composite factors.

## Producer prices (cont'd)

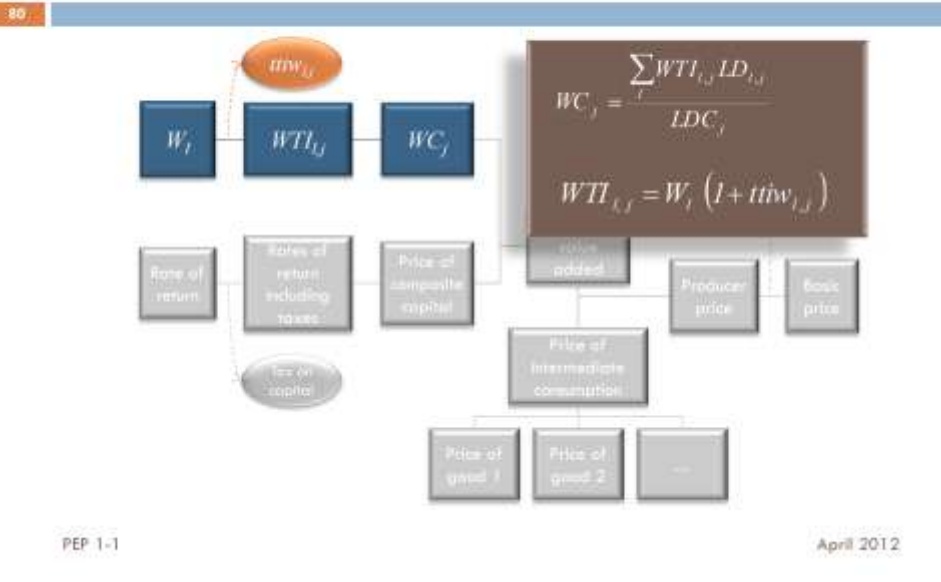
79



PEP 1-1

April 2012

## Producer prices (cont'd)

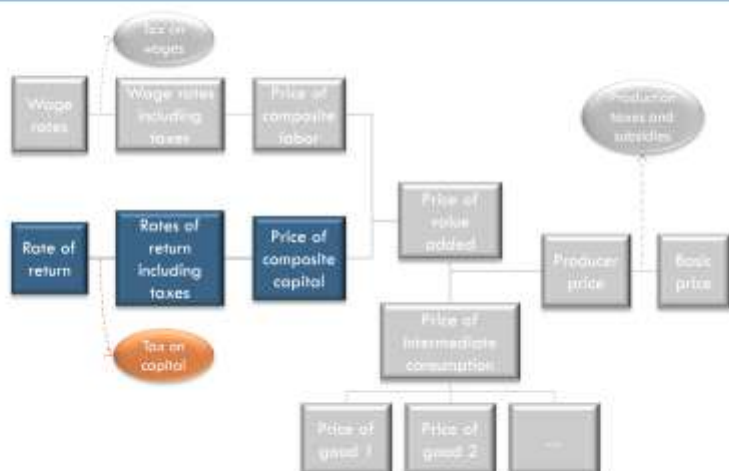


- The price of an industry's composite labor is a weighted sum of the wage rates (including payroll taxes) of the different categories of labor used by that industry.
- Wages paid by industry differ from wages received by workers by the amount of payroll taxes.



# Producer prices (cont'd)

81



PEP 1-1

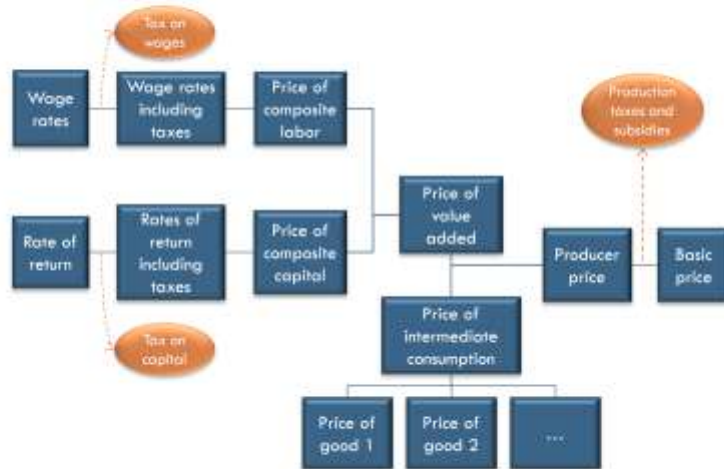
April 2012

[illegible]

- 82

# International trade

83

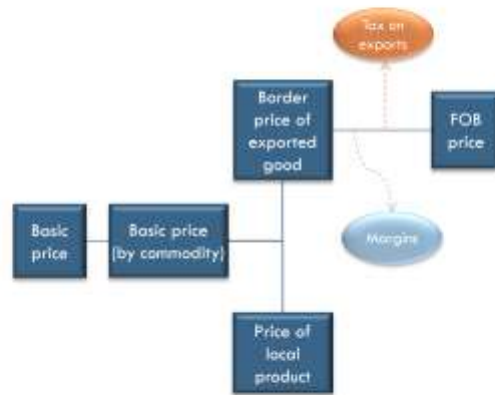


PEP 1-1

April 2012

# International trade

84

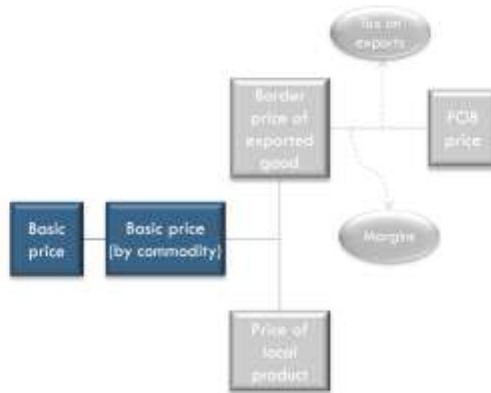


PEP 1-1

April 2012

## International trade (cont'd)

85



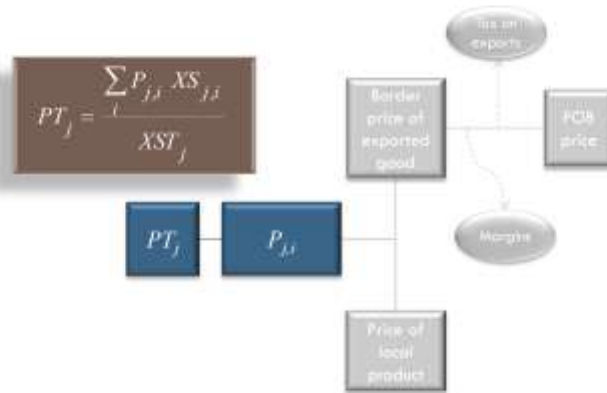
PEP 1-1

April 2012

- Exporting industries have the possibility of selling their output on the international market or the domestic market.
- So the price of their aggregate production is a weighted sum of the price obtained on each market, following the price aggregation principle.

## International trade (cont'd)

86



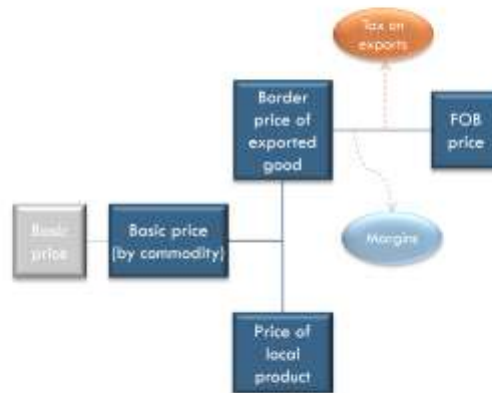
PEP 1-1

April 2012

- The weight assigned to each market is proportional to the quantity sold on that market.
- These weights vary in response to relative price changes, more or less sharply, depending on the elasticity of transformation in the CET.

## International trade (cont'd)

87



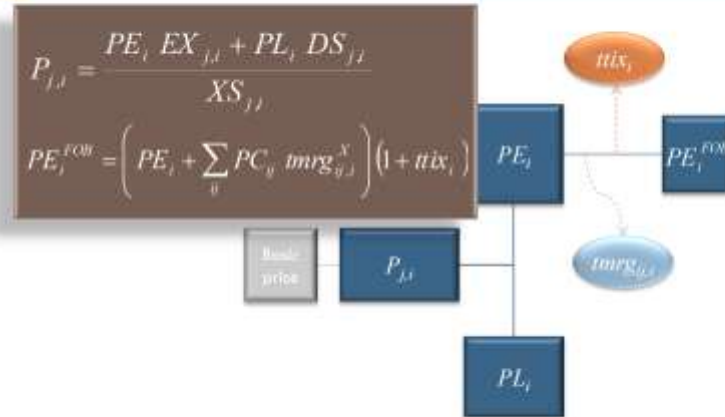
PEP 1-1

April 2012

- The basic price obtained by industry  $j$  for product  $i$  is a weighted sum of its basic price on the domestic market and its basic price on the export market.

## International trade (cont'd)

88



PEP 1-1

April 2012

- The FOB price paid by purchasers on the export market is different from the one received by the producer, since margins and export taxes must be added on.



# Consumer prices

89



PEP 1-1

April 2012

## Consumer prices (cont'd)

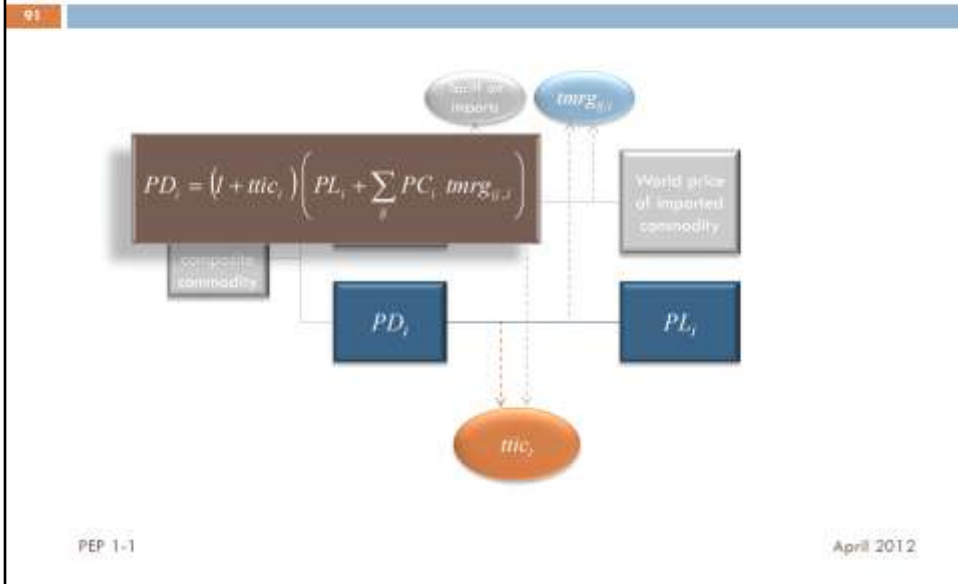
90



PEP 1-1

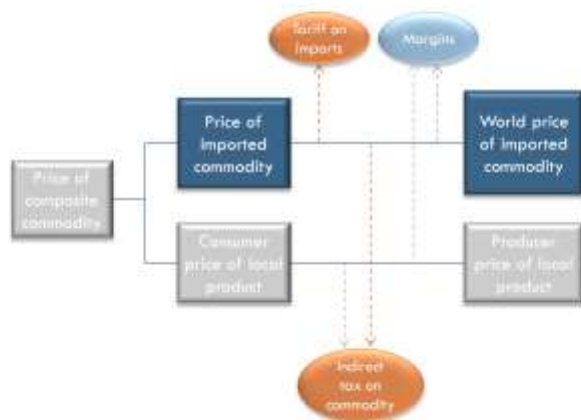
April 2012

## Consumer prices (cont'd)



- The price paid for the local product is the sum of the price received by the producer, margins, and indirect taxes.

## 92

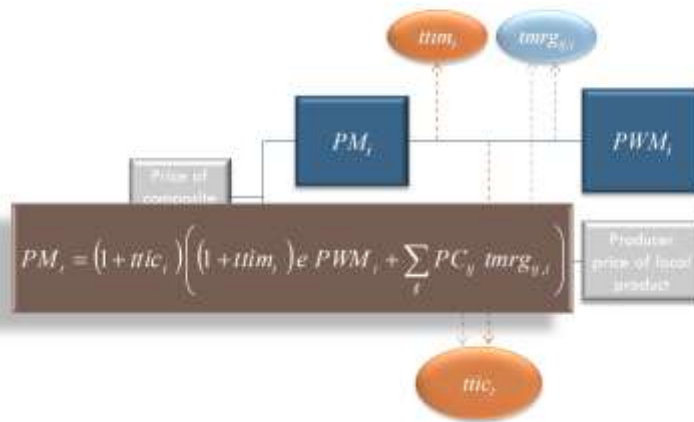


PEP 1-1

April 2012

## Consumer prices (cont'd)

92



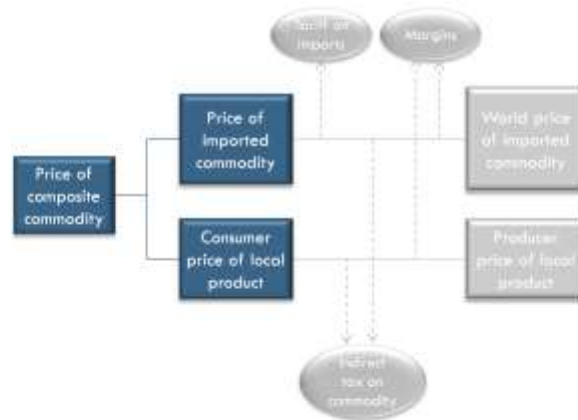
PEP 1-1

April 2012

- Similarly, the price paid for the imported product is the world price, translated into the local currency, plus taxes and duties on imports, margins, and domestic indirect taxes.

## Consumer prices (cont'd)

94



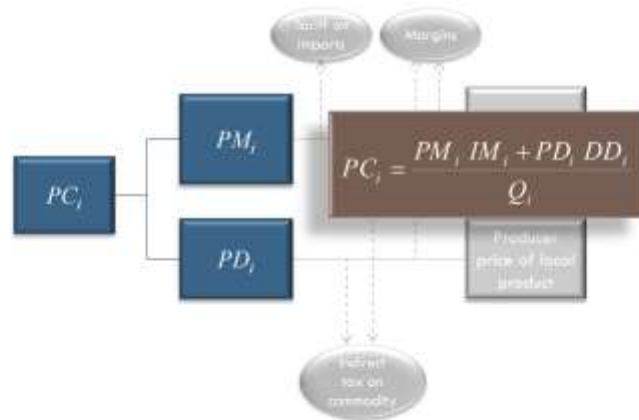
PEP 1-1

April 2012

- As was previously explained, commodities purchased on the domestic market are composites.

## Consumer prices (cont'd)

95



PEP 1-1

April 2012

- The price of the composite is a weighted sum of the price paid for domestically produced, and imported goods.

# Price indexes

96

- GDP deflator:

$$PIX_{GDP} = \sqrt{\frac{\sum_j PVA_j VAO_j}{\sum_j PVAO_j VAO_j} \frac{\sum_j PVA_j VA_j}{\sum_j PVAO_j VA_j}}$$

- Consumer price index:

$$PIX_{CON} = \frac{\sum_i PC_i \sum_h C_{i,h}^0}{\sum_{ij} PC_{ij}^0 \sum_h C_{ij,h}^0}$$

PEP 1-1

April 2012

Finally, four price indexes have been defined:

- The GDP deflator is a Fisher index
- The consumer price is a Laspeyres index



## Price indexes (cont'd)

97

- Investment price index:

$$PIXINV = \prod_i \left( \frac{PC_i}{PC_i^0} \right)^{\gamma_i^{INV}}$$

- Public expenditures price index:

$$PIXGVT = \prod_i \left( \frac{PC_i}{PC_i^0} \right)^{\gamma_i^{GVT}}$$

PEP 1-1

April 2012

- The two other ones are exact price indexes, dual to the Cobb-Douglas functions which describe commodity demand for investment purposes and for public consumption.



## Equilibrium

# Equilibrium

99

## □ Market for commodities

$$\square Q_i = \sum_h C_{i,h} + CG_i + INV_i + VSTK_i + DIT_i + MRGN_i$$

## □ Labor market

$$\square \sum_j LD_{l,j} = LS_l$$

## □ Capital market

$$\square \sum_j KD_{k,j} = KS_k$$

PEP 1-1

April 2012

- Whether it be for the goods and services market or the factor market, supply and demand equilibrium must be verified.

## Equilibrium (cont'd)

100

### Investment – Savings

$$\square IT = \sum_h SH_h + \sum_f SF_f + SG + SROW$$

### Domestic market

$$\square \sum_j DS_{j,i} = DD_i$$

### Export market

$$\square \sum_j EX_{j,i} = EXD_i$$

PEP 1-1

April 2012

- Likewise, total investment expenditure must be equal to the sum of agents' savings.
- The sum of supplies of every commodity by local producers must be equal to domestic demand for that commodity produced locally.
- And finally, supply to the export market of each good must be matched by demand.



## Gross domestic product

# Gross domestic product

102

## □ GDP at basic prices

$$GDP^{BP} = \sum_j PVA_j VA_j + TIPT$$

## □ GDP at market prices

$$GDP^{MP} = GDP^{BP} + TPRCTS$$

PEP 1-1

April 2012

- GDP at basic prices is equal to payments made to factors, plus taxes on production other than taxes on labor or capital already included in factor costs.
- GDP at market prices exceeds GDP at basic prices by exactly the amount of taxes on products and imports.

## Gross domestic product (cont'd)

103

- GDP at market prices – income perspective

$$GDP^{IB} = \sum_{l,j} W_l LD_{l,j} + \sum_{k,j} R_{k,j} KD_{k,j} + TPROD_N + TPRCTS$$

- GDP at market prices – final demand perspective

$$GDP^{FD} = \sum_i PC_i \left[ \sum_h C_{i,h} + CG_i + INV_i + VSTK_i \right] + \sum_i PE_i^{FOB} EXD_i - e \sum_i PWM_i IM_i$$

PEP 1-1

April 2012

- As for GDP at market prices from the income perspective, it is equal to the sum total of income paid to labor and to capital, plus taxes on products and imports, plus other taxes on production.
- On the other hand, GDP at market prices from the final demand perspective is the sum of net final expenditures: household consumption, current public expenditures on goods and services, investment expenditures, plus the value of exports, minus the value of imports.

## Closures



# Closures

105

- The nominal exchange rate is the *numeraire*
- Fixed current account balance
- Fixed stock variations
- Small open economy (world prices are given)
- Fixed public expenditures



## The SAM

# The SAM

107

- General overview
- The accounts of the model SAM
  - Labor
  - Capital
  - Households
  - Firms
  - Government
  - Rest of the world
  - Industries
  - Commodities
  - Accumulation



## General overview

## General overview

100

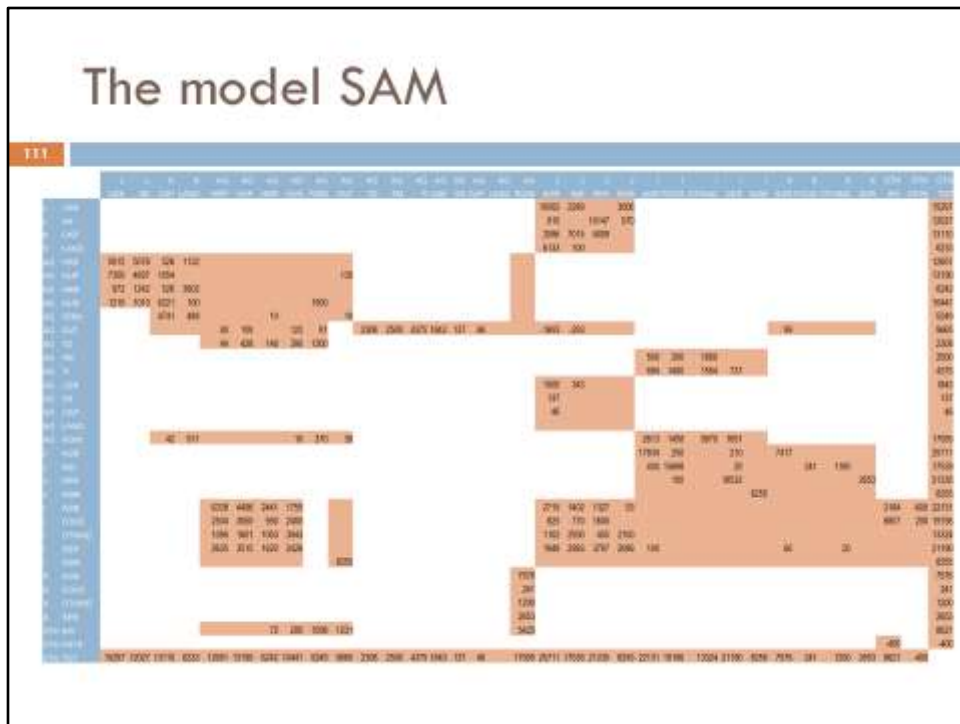
		L	K	H	F	GVT	ROW	J	I	X	INV	TOT
Labor	L											
Capital	K											
Agents (AG)	H											
	F											
	GVT											
	ROW											
Industries	J											
Commodities	I											
Exports	X											
Savings	INV											
Total	TOT											

PEP 1-1 April 2012

- Accounts in the SAM are grouped into five main categories: factors of production, institutions (or agents), commodities, industries and accumulation.
- Each account has two titles (both in rows and in columns): one representing the set of accounts to which it belongs, the other indicating which element it is in that set.
- Only flows appearing in the shaded areas are taken into account in the PEP-1-1 model. Consequently, the matrix must be balanced when all non-shades areas are blank.
- Conversely, the real SAM to be used does not have to show values for every flow present in the fictitious one.



## The fictitious SAM



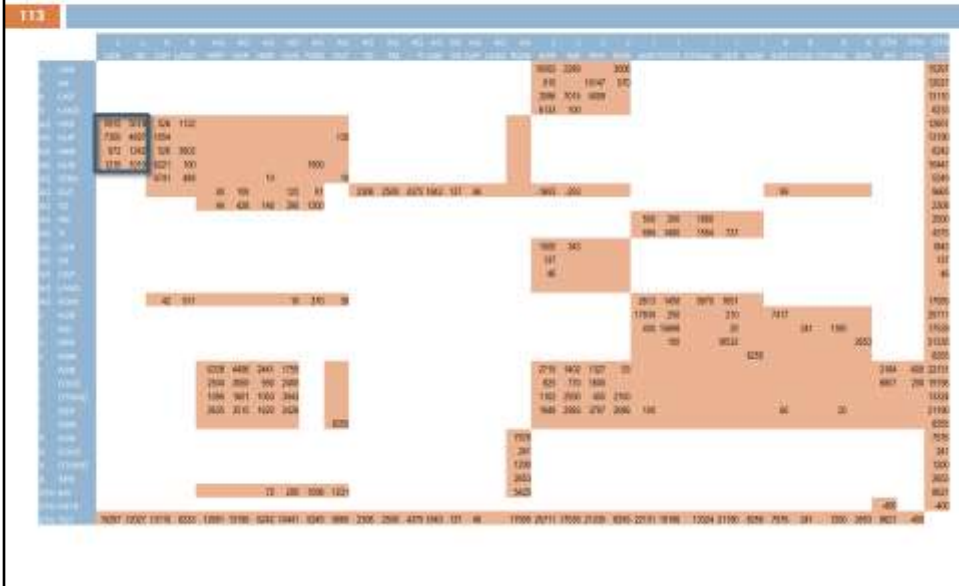
- A SAM must be square because each account appears both as a row and as a column of the table: the account's income is registered in the corresponding row, and its expenditures in the corresponding column.
- The value in every cell of the matrix, therefore, is an expenditure for the corresponding column-account, and an income for the corresponding row-account.
- The SAM to be used as the basis of a CGE model must be balanced, meaning that, for each account, the sum of income from all sources must be exactly equal to the sum of expenditures.
- The order in which the accounts are listed does not have to be followed; any order will do.
- The model SAM is presented in this slide.
- The next slides will explain the different flows of each column.



## Labor accounts



## Labor accounts



# Labor accounts

TT4

		L	L
		USK	SK
AG	HRP	5915	5078
AG	HUP	7300	4697
AG	HRR	872	1242
AG	HUR	1210	1010

Type L labor income received by type H household

$\lambda_{H,J}^{WL} \left( W_L \sum_j LD_{L,j} \right)$

PEP 1-1

April 2012

- The PEP model can manage multiple types of workers, although the model will run perfectly if there is only one.
- Labor is referred to in the model by set  $L$ . In the SAM, the first title that should appear on top of the columns and on the left of the rows for the labor accounts should therefore be  $L$  and any other title will imply changes in the GAMS code.
- There must be at least one labor category. In our example, there are two types of labor which are called  $USK$  and  $SK$ . In adapting her/his own SAM, the user is free to use the element labels that are relevant given her/his data.
- The names of the elements must respect GAMS syntax and must be the same in row and in column.



## Capital accounts

# Capital accounts

T16																			
1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019
1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039
1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059
1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079
1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099
1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119
1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139
1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159
1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179
1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199
1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219
1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239
1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259
1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279
1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299
1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319
1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339
1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359
1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379
1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399
1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419
1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439
1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459
1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479
1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499
1500	1501	1502	1503	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519
1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538	1539
1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	1558	1559
1560	1561	1562	1563	1564	1565	1566	1567	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579
1580	1581	1582	1583	1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599
1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616	1617	1618	1619
1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636	1637	1638	1639
1640	1641	1642	1643	1644	1645	1646	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659
1660	1661	1662	1663	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679
1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696	1697	1698	1699
1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718	1719
1720	1721	1722	1723	1724	1725	1726	1727	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739
1740	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759
1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776	1777	1778	1779
1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799
1800	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819
1820	1821	1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839
1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079
2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099
2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119
2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139
2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159
2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179
2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199
2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219
2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239
2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259
2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279
2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299
2300	2301	2302	2303</																

# Capital accounts

117

		K	K
		CAP	LAND
AG	HRP	525	1132
AG	HUP	1054	
AG	HRR	526	3602
AG	HUR	5221	100
AG	FIRM	4741	488
AG	GOVT		
AG	ROW	42	811

Type K capital income received by agent AG

$$R_{AG,k}^{KK} \left( \sum_j R_{k,j} K D_{k,j} \right)$$

PEP 1-1

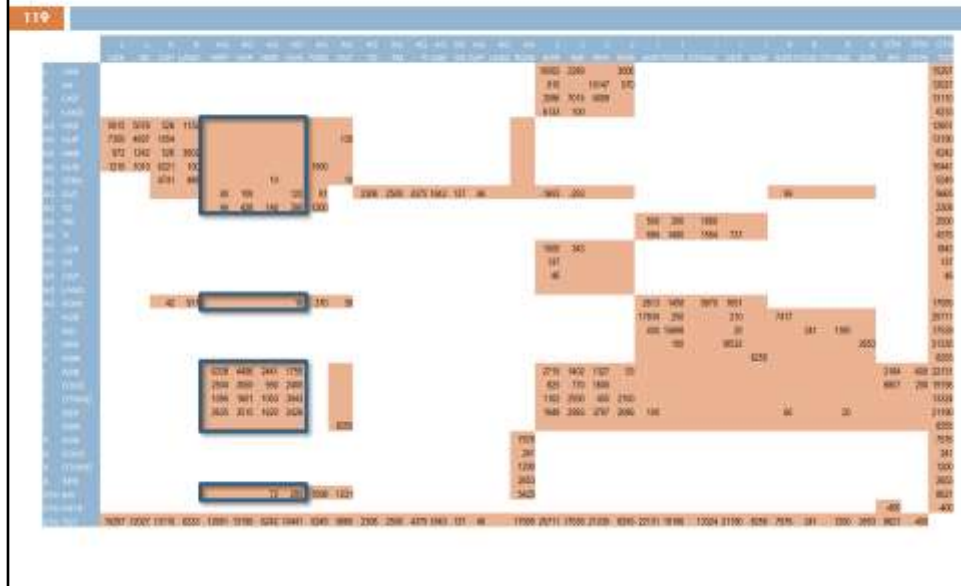
April 2012

- The PEP model can manage multiple types of capital, although the model will run perfectly if there is only one element.
- Capital is referred to in the model by set  $K$ . In the SAM, the first title that should appear on top of the columns and on the left of the rows for the capital accounts should therefore be  $K$  and any other title will imply changes in the GAMS code.
- There must be at least one capital category. In our example, there are two types of capital which are called  $CAP$  and  $LAND$ . In adapting her/his own SAM, the user is free to use the element labels that are relevant given her/his data.
- The names of the elements must respect GAMS syntax and must be the same in row and in column.
- All agents can receive income from capital.



## Households accounts

# Households accounts



# Households accounts

120

		AG	AG	AG	AG
		HRP	HUP	HRR	HUR
AG	HRP				
AG	HUP				
AG	HRR				
AG	HUR				
AG	FINM			10	
AG	GVT	40	100		122
AG	TD	44	426	146	390
AG	ROW				10
I	AGR	6338	4496	2441	1755
I	FOOD	2604	3050	950	2400
I	OTHIND	1090	1601	1003	3043
I	SER	2035	3515	1620	2426
I	ADM				
OTH	INV			72	295

PEP 1-1

April 2012

- There can be several types of households but there needs to be at least one.
- In our fictitious SAM, there are four types of households named *HRP*, *HUP*, *HRR* and *HUR*. These acronyms are evocative of the following categories: rural poor, urban poor, rural rich and urban rich.
- These are the acronyms that are used in the standard PEP-1-1 GAMS code. It is therefore important that the user utilize the same acronyms in the SAM as he/she will use in the GAMS code.
- Of course, the names should be the same in rows and in columns.



# Households – transfers

121

		AG	AG	AG	AG
		HRP	HUP	MRR	MUR
AG	HRP				
AG	HUP				
AG	MRR				
AG	MUR				
AG	FINM			10	
AG	GVT	40	100		122
AG	TD	44	426	146	390
AG	ROW				10
I	AGR	6338	4496	2441	1755
I	FOOD	2604	3050	950	2400
I	OTHIND	1090	1601	1003	3043
I	SEN	2035	3515	1620	2426
I	ADM				
OTH	INV			72	295

Transfers from household  
H to agent AG

$TR_{ag,h}$

PEP 1-1

April 2012

- Households use their income to make transfers to other agents.

# Households – income taxes

122

		AG	AG	AG	AG
		HRP	HUP	MRR	MUR
AG	HRP				
AG	HUP				
AG	MRR				
AG	MUR				
AG	FINM			10	
AG	GVT	40	100		122
AG	TD	44	428	146	390
AG	ROW				10
I	AGR	6338	4496	2441	1755
I	FOOD	2604	3050	950	2400
I	OTHIND	1090	1601	1003	3043
I	SER	2035	3515	1620	2426
I	ADM				
OTH	INV			72	295

PEP 1-1

Income taxes paid by household  $H$

$TDH_h$

- They pay income taxes.

April 2012

# Households – consumption

123

		AG	AG	AG	AG
		HRP	HUP	MRR	MUR
AG	HRP				
AG	HUP				
AG	MRR				
AG	MUR				
AG	FINM			10	
AG	GVT	40	100		122
AG	TD	44	426	146	390
AG	ROW				10
I	AGR	6338	4496	2441	1756
I	FOOD	2504	3050	950	2400
I	OTHIND	1090	1621	1003	3043
I	SER	2635	3515	1620	2426
I	ADM				
OTH	INV			72	295

Consumption of commodity  
I by household H

$$PC_i C_{i,h}$$

PEP 1-1

April 2012

- They purchase commodities.

# Households – savings

124

		AG	AG	AG	AG
		HRP	HUP	MRR	MUR
AG	HRP				
AG	HUP				
AG	MRR				
AG	MUR				
AG	FINM			10	
AG	GVT	40	100		122
AG	TD	44	426	146	390
AG	ROW				10
I	AGR	6338	4496	2441	1755
I	FOOD	2604	3050	950	2400
I	OTHIND	1090	1601	1003	3043
I	SEN	2035	3515	1620	2426
I	ADM				
OTH	INV			72	296

PEP 1-1

Household  $H$  savings

$SH_h$

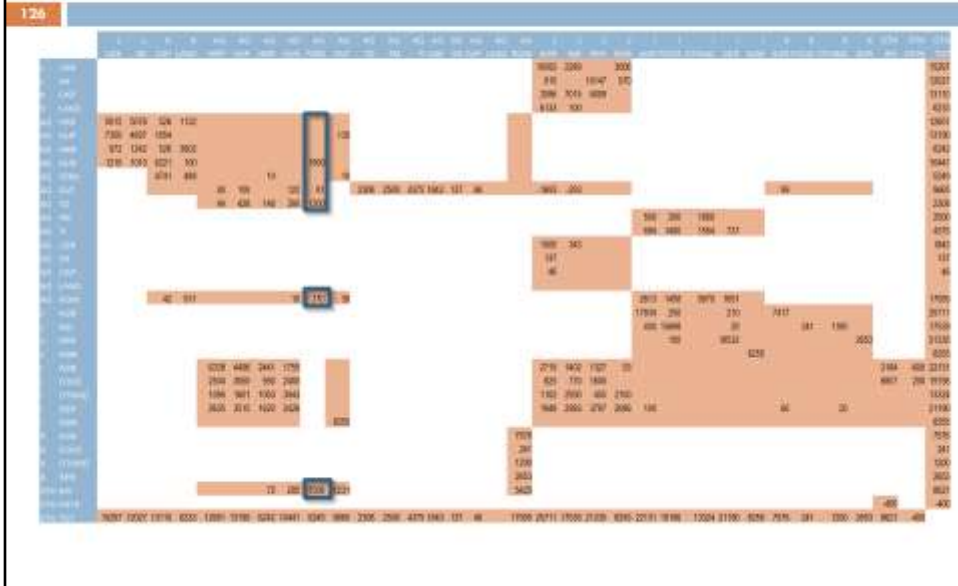
April 2012

- They save.



## Firms accounts

# Firms accounts



## Firms accounts

127

		AG
		FIRM
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	1900
AG	FIRM	
AG	GVT	01
AG	TD	1300
AG	ROW	370
OTH	INV	1500

PEP 1-1

April 2012

- As for the households, there needs to be at least one firm, and the model can manage multiple types of businesses.
- Here again, the number of firm categories will depend on data availability and on the structure of the user's SAM.
- In our example, there is only one firm, which is called *FIRM*.

## Firms – transfers

128

		AG
		FIRM
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	1900
AG	FIRM	
AG	GVT	81
AG	TD	1300
AG	ROW	370
OTH	INV	1500

Transfers from firm  $F$  to agent AG

$TR_{ag,f}$

PEP 1-1

April 2012

- Firms use their income make transfers to other agents.



## Firms – income taxes

129

		AG
		FIRM
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	1900
AG	FIRM	
AG	GVT	81
AG	TD	1300
AG	ROW	370
OTH	INV	1508



PEP 1-1

April 2012

- They also pay income taxes.

## Firms – savings

130

		AG
		FIRM
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	1900
AG	FIRM	
AG	GVT	81
AG	TD	1300
AG	ROW	370
OTH	INV	1598



PEP 1-1

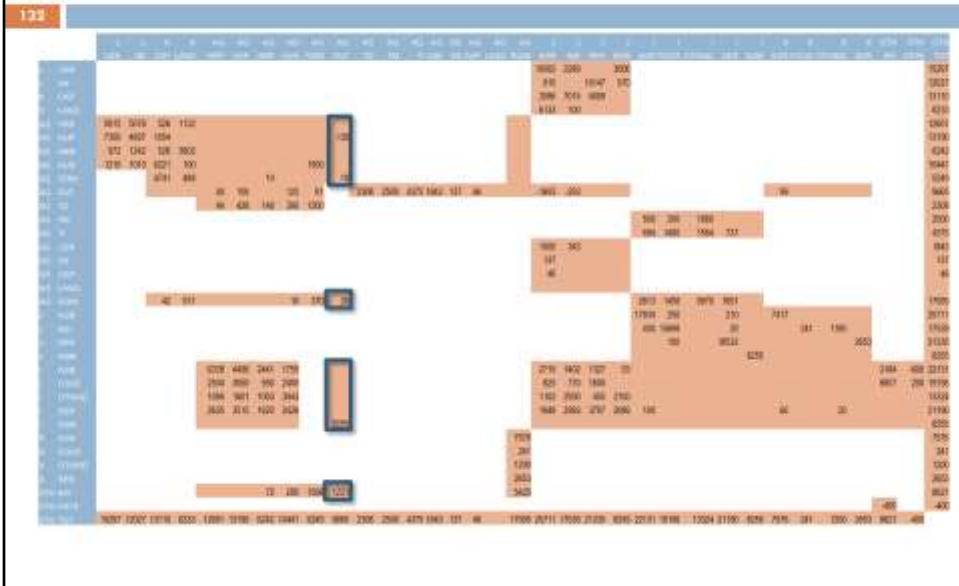
April 2012

- And they save.



## Government accounts

## Government accounts



# Government

133

		AG
		GVT
AG	HRF	
AG	HUP	139
AG	HRR	
AG	HUR	
AG	FIRM	10
AG	ROW	30
I	AGR	
I	FOOD	
I	OTHIND	
I	SER	
I	ADM	8255
OTH	INV	1231

PEP 1-1

April 2012

- The model can only manage with a single government.
- In other words, it cannot deal with SAMs that show multiple government levels.
- To avoid having to modify the GAMS code, government should be called *GVT*.

# Government – transfers

134

		AG
		GVT
AG	HRF	
AG	HUP	139
AG	HRR	
AG	HUR	
AG	FIRM	10
AG	ROW	30
I	AGR	
I	FOOD	
I	OTHIND	
I	SER	
I	ADM	8255
OTH	INV	1231

Transfers from GVT to  
non government agents

$$TR_{agg, GVT}$$

PEP 1-1

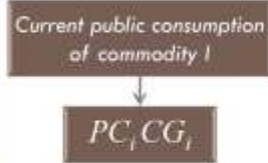
April 2012

- The government uses its income to make transfers to non governmental agents.

# Government – consumption

135

		AG
		GVT
AG	HRP	
AG	HUP	139
AG	HRR	
AG	HUR	
AG	FIRM	10
AG	ROW	30
I	AGR	
I	FOOD	
I	OTHIND	
I	SER	
I	ADM	8255
OTH	INV	1231



PEP 1-1

April 2012

- They also purchase commodities.

# Government – savings

136

		AG
		GVT
AG	HRF	
AG	HUP	139
AG	HRR	
AG	HUR	
AG	FIRM	10
AG	ROW	30
I	AGR	
I	FOOD	
I	OTHIND	
I	SER	
I	ADM	8255
OTH	INV	1231



PEP 1-1

April 2012

- And they save.



# Gouvernement accounts (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490
--	---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

# Government – taxes

138

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	-4375	1843	137	-48	

PEP 1-1

April 2012

- Furthermore, as the model allows for multiple tax instruments, additional accounts should be created for the government.
- Here again, the titles for these accounts should stick to the ones used in the fictitious SAM, namely *TD*, *TM*, *TI* for direct taxes, import duties and indirect taxes respectively.
- Wage-bill tax accounts should be named according to the elements of set *L*.
- The same goes for taxes on capital; capital tax accounts should be named according to the elements of set *K*.

# Government – direct taxes

139

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	-4375	1843	137	-48	

Total direct taxes



*TDHT + TDFT*

PEP 1-1

April 2012

- The government receives the total amount of direct taxes collected from households and firms (total of row *AG.TD*), as shown at the intersection of row *AG.GVT* and column *AG.TD*.

# Government – import duties

140

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	4375	1843	137	-48	

Total import duties



*TIMT*

PEP 1-1

April 2012

- As for direct taxes, the sum of import duties collected on the different commodities (i.e. total of row *AG.TM*) is then paid to the government (intersection of row *AG.GVT* and column *AG.TM*).

## Government – indirect taxes

141

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	-4375	1843	137	-48	

Total indirect taxes



*TICT*

PEP 1-1

April 2012

- Similarly, the sum of indirect taxes (i.e. total of row *AG.TI*) is a source of income for the government (intersection of row *AG.GVT* and column *AG.TI*).

# Government – taxes on wage bill

142

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	-4375	1843	137	-48	

Total taxes on  
wage bill  $L$

$$\sum_j TIW_{l,j}$$

PEP 1-1

April 2012

- The sum of each wage-bill tax row appears as an income for the government (intersection of row  $AG.GVT$  and columns  $AG.USK$  and  $AG.SK$ ).

# Government – taxes on capital

143

		AG	AG	AG	AG	AG	AG	AG
		TD	TM	TI	USK	SK	CAP	LAND
AG	GVT	2308	2500	4375	1843	137	46	

Total taxes on  
capital K

$$\sum_j TIK_{k,j}$$

PEP 1-1

April 2012

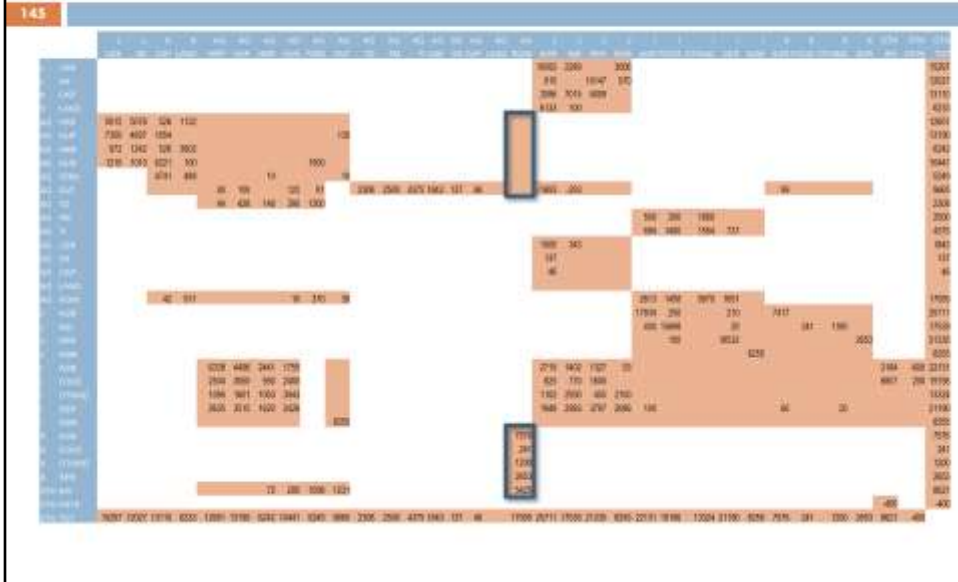
- The sum of each capital tax row appears as an income for the government (intersection of row *AG.GVT* and columns *AG.CAP* and *AG.LAND*).



## Rest of the world accounts



# Rest of the world



## Rest of the world – expenditures

146

		AG
		ROW
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	
AG	FIRM	
AG	GVT	
X	AGR	7576
X	FOOD	241
X	OTHIND	1200
X	SER	2653
OTH	INV	5425

PEP 1-1

April 2012

- As for government, there can only be one rest of the world, i.e. the model cannot manage multiple trading partners.
- In order to facilitate inclusion of the SAM into the GAMS code, this agent must be called *ROW*.

## Rest of the world – transfers

147

		AG
		ROW
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	
AG	FIRM	
AG	GVT	
X	AGR	7576
X	FOOD	241
X	OTHIND	1200
X	SER	2653
OTH	INV	5425

Transfers from the rest of the world to domestic agents

$$TR_{agd,ROW}$$

PEP 1-1

April 2012

- The rest of the world makes transfers to domestic agents.

## Rest of the world – exports

148

		AG
		ROW
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	
AG	FIRM	
AG	GVT	
X	AGR	7576
X	FOOD	241
X	OTHIND	1200
X	SER	2653
OTH	INV	5425

Exports of commodity  $i$   
(including taxes and margins)

$$\sum_i PE_i^{FOB} EXD_i$$

PEP 1-1

April 2012

- The rest of the world spends in the local economy through the purchase of export commodities.

## Rest of the world – savings

149

		AG
		ROW
AG	HRP	
AG	HUP	
AG	HRR	
AG	HUR	
AG	FIRM	
AG	GVT	
X	AGR	7576
X	FOOD	241
X	OTHIND	1200
X	SER	2653
OTH	INV	5425

*Rest of the world savings*

*SROW*

PEP 1-1

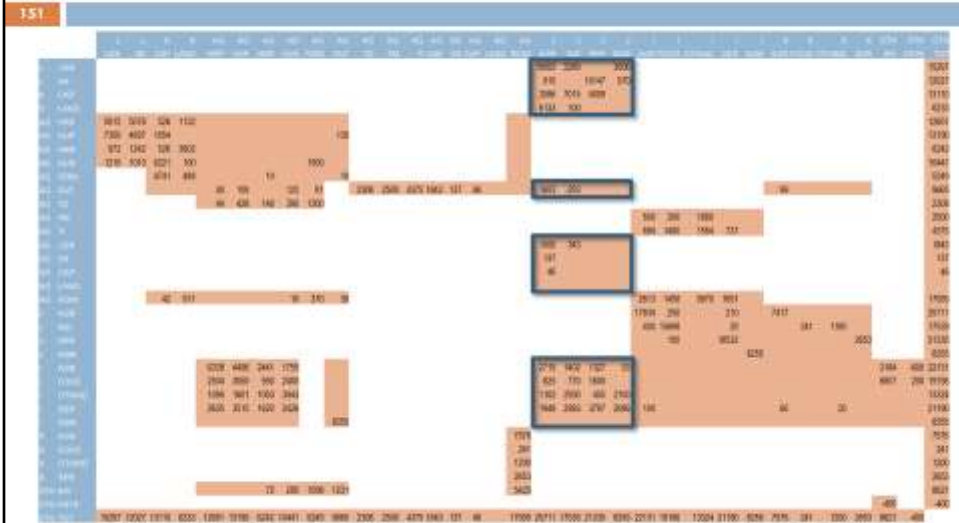
April 2012

- The surplus of rest-of-the-world income over its expenditures, i.e. its savings (equal to minus the current account balance) appear at the intersection of row *OTH.INV* and of column *AG.ROW*.



## Industries accounts

## Industries



## Industries accounts

3.52

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2085	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	45			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1946	2983	3757	2066
I	ADM				

PEP 1-1

April 2012

- Industries are represented in the GAMS code as elements of set  $J$ .
- As mentioned previously, the nomenclature of productive activities can be different from that of commodities.
- In our fictitious SAM, there are four industries: *AGR*, *IND*, *SER* and *ADM*.
- Once again, the user must use the same acronym for each industry as he will use in the GAMS code, and these acronyms must be identical in rows and columns.



# Industries – wages

153

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2086	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	46			
AG	LAND				
I	AGR	2715	1402	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1946	2963	3797	2066
I	ADM				

Wages paid by industry  
J to type L labor

$$W_L LD_{LJ}$$

PEP 1-1

April 2012

- To produce the different commodities, industries use production factors.
- It is not necessary that each industry uses every type of labor.

# Industries – capital

354

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2086	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	46			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3757	2086
I	ADM				

Remuneration of type K capital paid by industry J

$$R_{k,j} KD_{k,j}$$

PEP 1-1

April 2012

- It can also manage sectors that do not use capital, like the industry *ADM* in our example.

# Industries – taxes on production

3.55

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2085	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	45			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2086
I	ADM				

Net taxes on production  
paid by industry J

$TIP_j$

PEP 1-1

April 2012

- Three types of taxes can be paid by productive activities (industries).
- Taxes on production should appear directly at the intersection of row AG.GVT and of columns representing the industries, labeled J.

## Industries – taxes on wage bill

3.56

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2085	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	46			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1946	2983	3757	2066
I	ADM				

Taxes on wage bill  $L$   
paid by industry  $J$

$TIW_{I,J}$

PEP 1-1

April 2012

- There can also be taxes paid by industries on their wage bills.
- These are collected from each industry by wage-bill tax accounts. These tax-collecting accounts belong to the agent category of accounts, labeled AG. To allow for the tax rates to vary according to the labor categories, there are as many wage-bill tax accounts as there are elements in set  $L$ .
- Hence, the intersection of row  $AG.USK$  and of columns  $J$ , will represent the taxes paid by industries on salaries paid to workers of type  $USK$ .

# Industries – taxes on capital

157

		J	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2085	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	46			
AG	LAND				
I	AGR	2715	1402	1327	93
I	FOOD	825	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1946	2983	3757	2086
I	ADM				

Taxes on the remuneration  
of type K capital paid by  
industry J

$TIK_{k,j}$

PEP 1-1

April 2012

- The same mechanism applies to capital. The model considers taxes paid on the remuneration of capital by the productive activities.
- The user should add as many capital-tax accounts as there are types of capital, under the main first-level label AG.

# Industries – intermediate demand

3.58

		I	J	J	J
		AGR	IND	SER	ADM
L	USK	10002	2289		3006
L	SK	910		10147	970
K	CAP	2085	7015	4009	
K	LAND	6133	100		
AG	GVT	-1693	-293		
AG	USK	1500	343		
AG	SK	137			
AG	CAP	45			
AG	LAND				
I	AGR	2715	1402	1327	93
I	FOOD	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2086
I	ADM				

Intermediate demand of  
commodity I by industry J

$$PC_I DI_{IJ}$$

PEP 1-1

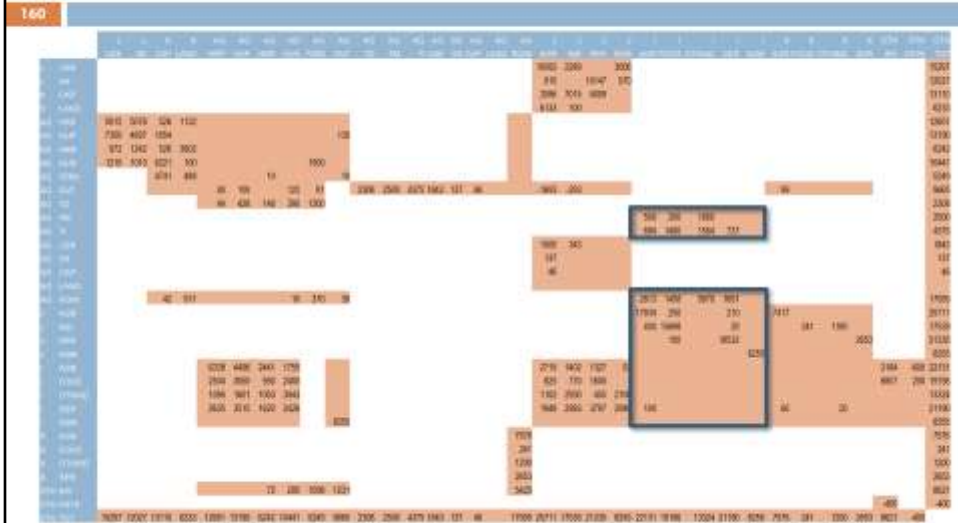
April 2012

- To produce the different commodities, industries also use intermediate consumption.
- The user should note that PEP-1-1 cannot handle industries that do not use any intermediate commodity; otherwise, the model has to be modified to accommodate these cases.



## Commodities accounts

# Commodities





# Commodities accounts

I&I						
		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

PEP 1-1

April 2012

- Commodities consist of the different goods and services produced and/or consumed in the economy. They are referred to, in the GAMS code, as elements of set *I*.
- To accommodate for rectangular input-output tables, commodities and industries are represented through distinct sets, respectively *I* and *J*. If a user's SAM has exactly the same elements for industries and commodities, she/he should nevertheless create two separate sets, even if their elements are identical.
- It is also important to note that the PEP-1-1 model does not manage re-exports (to do so, it would have to be modified accordingly). Only commodities that are produced locally can be exported, and imports can solely be purchased by local agents and industries.
- The list of commodities obviously depends on the user's SAM. In our example, there are five commodities named *AGR*, *FOOD*, *OTHIND*, *SER* and *ADM*. The user's commodity acronyms must be the same as will be used later in the GAMS code as elements of set *I*.

# Commodities – import duties

162

		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

Import duties on imports  $I$

$TIM_i$

PEP 1-1

April 2012

- Taxes on imports are registered at the intersection of row  $AG.TM$  and commodity-account columns, labeled  $I$ .

# Commodities – indirect taxes

163

		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

Indirect taxes on  
commodity I

$TIC_i$

PEP 1-1

April 2012

- Row AG.TI represents the other indirect taxes collected on commodities sold locally.
- Similarly to AG.TM, account AG.TI receives its income from the different commodity accounts (columns labeled I).

# Commodities – imports

164

		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2613	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

Imports of commodity I  
(excluding taxes and  
margins)

$$e PWM_i IM_i$$

PEP 1-1

April 2012

- The value of imports (excluding taxes and margins) appear at the intersection of row AG.ROW and I-columns.

# Commodities – local supply

165

		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

Supply of commodity *I* on the local market by sector *J* (excluding taxes and margins)

$$PL_i DS_{j,i}$$

PEP 1-1

April 2012

- Each industry can produce any commodity and sell it on the local market and/or on the export market.
- Local sales will appear at the intersection of *J*-rows and *I*-columns.
- All sales should be expressed at producer prices.

# Commodities – margins

166

		I	I	I	I	I
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	9970	1691	
J	AGR	17834	250		210	
J	IND	400	15698		20	
J	SER		150		18532	
J	ADM					8255
I	AGR					
I	FOOD					
I	OTHIND					
I	SER	100				
I	ADM					

Purchases of commodity *I*  
as margins on local  
purchases of composite  
commodity *I*

↓

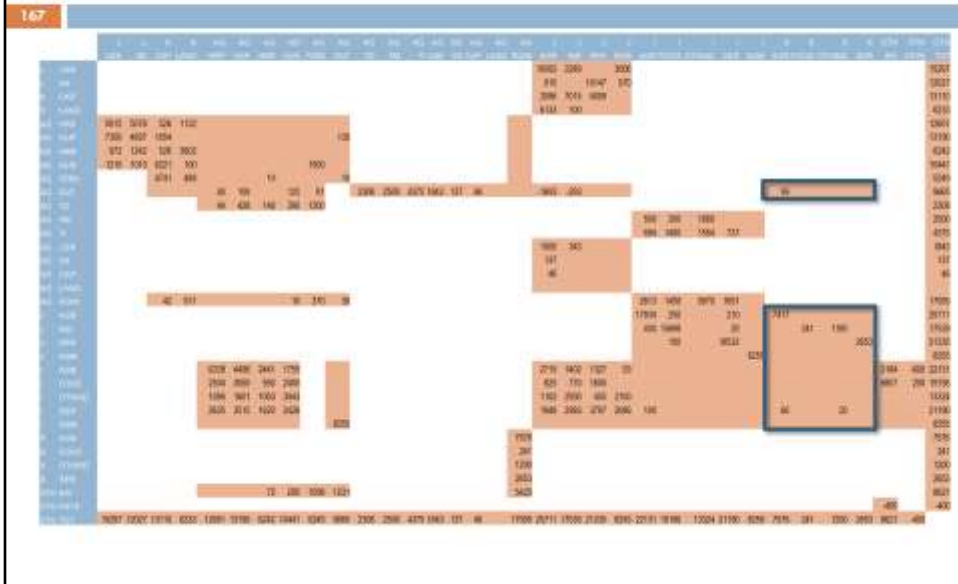
$$PC_{y,I} \text{tmrg}_{I,I} (DD_I + IM_I)$$

PEP 1-1

April 2012

- The PEP-1-1 model also takes into account trade and transport margins.
- In our example, only the commodity *SER* is used as a margin, but in a detailed SAM, there can be more than one margin commodity.
- Margins are applied to local purchases (thus under the *I*-columns).

## Commodities (cont'd)



# Exports

168					
		X	X	X	X
		AGR	FOOD	OTHIND	SER
AG	GVT	99			
J	AGR	7417			
J	IND		241	1180	
J	SER				2653
J	ADM				
I	AGR				
I	FOOD				
I	OTHIND				
I	SER	60		20	
I	ADM				

PEP 1-1

April 2012

- In the SAM, commodities appear twice: once in account category *I* and a second time in account category *X*.
- Although this might seem repetitive, it is very convenient to represent exports at both producer and purchaser prices.
- Besides, it facilitates taking into account cases where, for a given commodity, industries sell different proportions of their production on the local and international markets.
- If some commodities are not exported, the user can simply omit them under category *X*, as in our example for commodity *ADM*.



# Exports – taxes

169

		X	X	X	X
		AGR	FOOD	OTHIND	SER
AG	GVT	99			
J	AGR	7417			
J	IND		241	1180	
J	SER				2653
J	ADM				
I	AGR				
I	FOOD				
I	OTHIND				
I	SER	60		20	
I	ADM				

Taxes on exports  $I$

$TIX_i$

PEP 1-1

April 2012

- Indirect taxes can also be applied on exports.
- Contrary to the preceding types of taxes, they are not collected in a separate account, and they should appear at the intersection of row *AG.GVT* and of the exported commodity columns labeled *X*.

# Exports – supply

170

		X	X	X	X
		AGR	FOOD	OTHIND	SER
AG	GVT	00			
J	AGR	7417			
J	IND		241	1180	
J	SER				2653
J	ADM				
I	AGR				
I	FOOD				
I	OTHIND				
I	SER	60		20	
I	ADM				

Supply of commodity  $I$  on the export market by sector  $J$  (excluding taxes and margins)

$$PE_i EX_{j,i}$$

PEP 1-1

April 2012

- Exports appear at the intersection of  $J$ -rows and under  $X$ -columns.
- All sales should be expressed at producer prices.

# Exports – margins

171

		X	X	X	X
		AGR	FOOD	OTHIND	SER
AG	GVT	99			
J	AGR	7417			
J	IND		241	1180	
J	SER				2653
J	ADM				
I	AGR				
I	FOOD				
I	OTHIND				
I	SER	60		20	
I	ADM				

Purchases of commodity  
IJ as margins on exports  
of exports I

$$PC_{ij} \text{ tmrgr}_{ij,j}^X \text{ EXD}_i$$

PEP-1-1

April 2012

- The PEP-1-1 model also takes into account trade and transport margins on exports.
- In our example, only the commodity *SER* is used as a margin, but in a detailed SAM, there can be more than one margin commodity.



## Accumulation accounts

The image shows a detailed spreadsheet with a blue header and footer, and a large orange data area. The data area contains various numbers and formulas, with some cells highlighted in blue. The spreadsheet appears to be a financial or accounting model, possibly for a company like Tesla, given the context of the document.

# Accumulation accounts

174

		OTH	OTH
		INV	VSTK
I	AGR	2164	-600
I	FOOD	6857	200
I	OTHIND		
I	SER		
I	ADM		
OTH	VSTK	-400	

PEP 1-1

April 2012

- The last account category in PEP-1-1 consists in the savings and investment accounts.
- No set in the GAMS code is used to represent this category, so we chose the title *OTH*, which is also used as a header for the total (*TOT*) account.
- Accumulation is split into two accounts: savings/investment (*INV*) and inventory changes (*VSTK*).
- As part of the GAMS code directly refers to these accounts, the user must keep these exact same titles in her/his SAM (*OTH*, *TOT*, *INV* and *VSTK*).

# Accumulation – GFCF

175

		OTH	OTH
		INV	VSTK
I	AGR	2154	-600
I	FOOD	6857	200
I	OTHIND		
I	SER		
I	ADM		
OTH	VSTK		-400

Demand of commodity  $l$  for investment purposes (GFCF)

↓

$PC_l INV_{ij}$

PEP 1-1

April 2012

- Total savings, or the sum of row *OTH.INV*, will finance both gross fixed capital formation and inventory changes.
- Demand for investment purposes appears at the intersections of column *OTH.INV* and of the commodity rows (*l*).

## Accumulation – inventory changes

176

		OTH	OTH
		INV	VSTK
I	AGR	2164	-600
I	FOOD	6857	200
I	OTHIND		
I	SER		
I	ADM		
OTH	VSTK	-400	

Inventory changes of commodity I

↓

$PC_i VSTK_{i,j}$

PEP 1-1

April 2012

- Inventory changes appear at the intersections of column *OTH.VSTK* and of the commodity rows (*I*).



## Accumulation – inventory changes

177

		OTH	OTH
		INV	VSTK
I	AGR	2164	-600
I	FOOD	6857	200
I	OTHIND		
I	SER		
I	ADM		
OTH	VSTK	-400	

Total inventory changes

$$\sum_i PC_i VSTK_i$$

PEP 1-1

April 2012

- As mentioned previously, total inventory changes, i.e the sum of the column *OTH.VSTK*, is financed through savings.
- This value should hence appear at the intersection of row *OTH.VSTK* and of column *OTH.INV*.



## The GAMS code

# The GAMS code

179

- General description
- Definition of sets
- Parameters and benchmark variables definition
- Data
- Model
- Closures
- Simulations
- Results

PEP 1-1

April 2012



## General description

## General description

- Experienced CGE modelers
- All files in a same directory
  - PEP-1-1\_v2\_0.gms
  - RESULTS PEP 1-1.gms
  - SAM-V2\_0.xls
- The SAM should have the same format as the one discussed earlier

PEP 1-1

April 2012

- It is important to note that this document is intended to users who have some experience with CGE modeling and GAMS. It is by no means a tutorial for the software; GAMS offers a user guide to which the reader can refer if required.
- Also, in order to minimize the changes to be made in the code, all files should be saved in a single directory. The user will then create a project in that same directory and from then on, will not have to specify the complete path to access the different files.
- The directory should include the GAMS files (in our example PEP-1-1\_v2\_0.gms and RESULTS PEP 1-1.GMS) and the Excel file of the SAM (SAM-V2\_0.xls).
- Note that the name of the Excel file in which the SAM is located must not include any space. Also, GAMS can handle more recent versions of Excel, so the extension can be either XLS or XLSX.
- Once the SAM is correctly formatted, changes to be made in the GAMS code should be straightforward.
- The remainder of this section follows the order in which the code is written.



## Definition of sets

# Definition of sets – industries

183



The screenshot shows a GAMS software window with two tabs: 'PEP-1-1\_v2\_0.gms' and 'RESULTS PEP-1-1.GMS'. The 'PEP-1-1\_v2\_0.gms' tab is active, displaying the following code:

```
* 1 Set definition
** 1.1 Sectors and commodities

SET
J All industries
/
agr      Agriculture and other primary industries
ind      Manufacturing and construction
ser      Services
adm      Public administration
/
```

PEP 1-1

April 2012

- Set *J* refers to the different industries in the model.
- The user can simply delete the list of elements in the PEP-1-1 model (namely *AGR*, *IND*, *SER* and *ADM*) and replace them with the list of industries in her/his own SAM.
- The acronyms should be the same as under title *J* in the SAM.

## Definition of sets – commodities

184



```
I All commodities
/
agr      Agriculture and other primary commodities
food     Food and beverages
othind   Other manufacturing and construction
ser      Services
adm      Public administration
/

I1(I) All commodities except agriculture
* agr      Agriculture and other primary commodities
food     Food and beverages
othind   Other manufacturing and construction
ser      Services
adm      Public administration
```

PEP 1-1

April 2012

- A similar procedure should be followed for set  $I$ , which refers to commodities in the model. In our example, there are five commodities, *AGR*, *FOOD*, *OTHIND*, *SER* and *ADM*.
- Set  $I1$  refers to all the elements in set  $I$ , but one. Indeed, by Walras' Law, we know that when all markets but one are in equilibrium, then the last one is automatically in equilibrium as well. The equilibrium equation that states that supply is equal to demand is therefore defined over set  $I1$ .
- For set  $I1$ , the user should copy and paste the elements of set  $I$  and take one element out.



# Definition of sets – factors

185

```
** 1.2 Production factors

L Labor categories
/
usk      Unskilled workers
sk       Skilled workers
/

K Capital categories
/
cap      Capital
land     Land
/
```

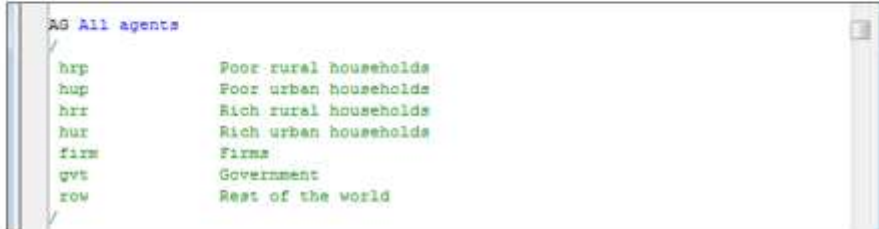
PEP 1-1

April 2012

- The PEP-1-1 model allows for multiple labor and capital categories. Set  $L$  refers to the labor categories, set  $K$  to the ones related to capital.
- If only one type of labor (or capital) is present in the SAM, then the set should consist in a single element.
- The model will automatically accommodate to the size of these two sets.
- The acronyms used in set  $L$  must be the same as in the SAM under title  $L$ . Similarly, the names of the elements in set  $K$  must be identical to the ones under title  $K$  in the SAM.

## Definition of sets – agents

186



```
AG All agents
hrp      Poor rural households
hup      Poor urban households
hrr      Rich rural households
hur      Rich urban households
firm     Firms
gvt      Government
row      Rest of the world
```

PEP 1-1

April 2012

- Set *AG* refers to the different institutions used in the model. As mentioned previously, in our example, there are multiple households, one firm, the government and the rest of the world.
- The model will run if different assumptions are made (one single household and/or multiple firms), but it is important that the government element be called *GVT* and that the rest of the world be represented by element *ROW*.

## Definition of sets – agents (cont'd)

187

```
AGNG (AG) Non governmental agents
/
hrp      Poor rural households
hup      Poor urban households
hrr      Rich rural households
hur      Rich urban households
firm     Firms
* gvt     Government
row      Rest of the world
/

AGD (AG) Domestic agents
/
hrp      Poor rural households
hup      Poor urban households
hrr      Rich rural households
hur      Rich urban households
firm     Firms
gvt      Government
* row    Rest of the world
/
```

PEP 1-1

April 2012

- From set AG, four subsets are created:
  - The first one, AGNG refers to non-government agents and includes all elements of set AG except GVT.
  - Similarly, subset AGD consists of domestic agents and includes all elements of set AG except ROW.

## Definition of sets – agents (cont'd)

```
H(AG) Households
/
hrp      Poor rural households
hup      Poor urban households
hrr      Rich rural households
hur      Rich urban households
/
F(AG) Firms
/
firm     Firms
/
```

PEP 1-1

April 2012

- The last two subsets,  $H$  and  $F$ , include households and firms respectively.
- Once again, the user should not change these sets' names, because they are referred to later in the GAMS code.
- The list of elements in both sets must be the same as in the user's SAM.

## Definition of sets – aliases


189

```
ALIAS (j,jj)
ALIAS (l,lj)
ALIAS (eq,eqj)
ALIAS (h,hj)
ALIAS (i,ij)
ALIAS (k,kj)
j
```

PEP 1-1

April 2012

- The last part of the **SET** section defines a second name that could be used to refer to the sets just defined, through the **ALIAS** statement.
- For simplicity, we just added the letter “j” to the name of each set.
- As for the names for the different sets, and for the same reasons, it is not advisable to change the names used in the **ALIAS**.



## Parameters and benchmark variables definition

## Parameters and benchmark variables definition

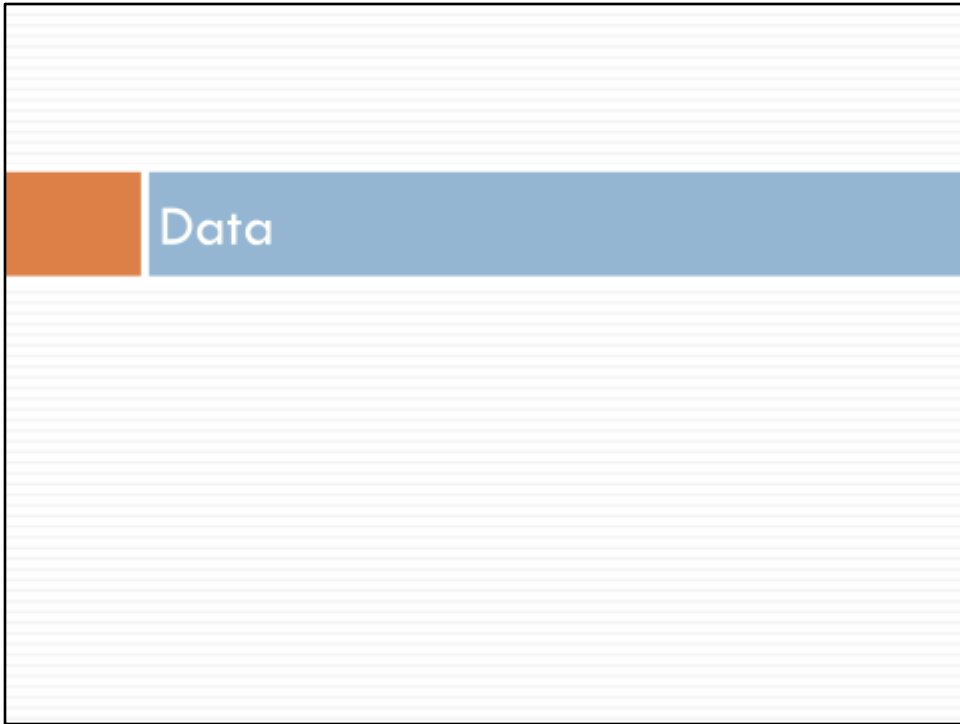
191

- All parameters used throughout the model
- One parameter per variable (benchmark value)
- No changes to be made in this section.

PEP 1-1

April 2012

- This part of the GAMS code defines the different parameters used in the model.
- It also creates one parameter for each variable; the name of the parameter is created by adding the letter “O” to the variable name. This facilitates the calibration process as well as the assignment of starting values for model resolution.
- In this part of the GAMS code, nothing should be changed if the user wants to utilize the PEP model exactly as it is.





## Data – the SAM

193

### □ Syntax for introducing the SAM:

```
$CALL GDXXRW.EXE file_name.xls par=SAM rng=spreadsheetrange Rdim=2 Cdim=2  
$GDXIN file_name.gdx
```

### □ Example:

```
$CALL GDXXRW.EXE SAM-V2_0.xls par=SAM rng=SAM!A4:AJ39 Rdim=2 Cdim=2  
$GDXIN SAM-V2_0.gdx  
$LOAD SAM  
$GDXIN
```

PEP 1-1

April 2012

- If the user correctly followed the previous steps in formatting her/his SAM, this part will be straightforward, although a bit technical.
- There is a command in GAMS that allows converting Excel spreadsheets into GDX files, which can then be read in a GAMS code. That command is included in the recent versions of the GAMS software. The syntax for introducing the SAM appears on this slide.
- It is important that only the parts written in blue be modified. Note that GAMS can read more recent versions of Excel files; make sure to use the correct extension (XLS or XLSX).
- In our example, as the fictitious SAM is located in the Excel file named SAM-V2\_0.xls, in the spreadsheet SAM, in cells A4 to AJ39.

## Data – other data

194

```
** Price elasticity (should be set equal to one when verifying model homogeneity)
eta          = 1;

** CES and CET elasticities
sigma_KD(j)  = 0.8;
sigma_LD(j)  = 0.8;
sigma_M(1)   = 2;
sigma_VA(j)  = 1.5;
sigma_X(j,1) = 2;
sigma_XT(j)  = 2;

** Elasticity of international demand for exported commodity x
sigma_XD(1)  = 2;
```

PEP 1-1

April 2012

- Besides the data taken from the SAM, some values must be assigned to the parameters in the model that cannot be calibrated (so-called “free” parameters).
- The price elasticity (parameter *eta*) should be set equal to one when verifying model homogeneity. The user can assign a value different from one to this parameter, depending on her/his knowledge of the economy to be modeled.
- Values have been assigned to the elasticities used in CES and CET functions. In our example, the same value has been assigned to all industries and commodities. Although these values will allow the model to run, the user should assign values that are specific to the economy being modeled, if possible.
- The elasticity of international demand for exported commodities (*sigma\_XD*) was assigned a value of two for all commodities. Once again, the user will want to eventually modify this value.

## Data – other data (cont'd)

195

```
== 155 parameters
frisch(h)      = -1.5;
sigma_y('agr',h)= 0.7;
sigma_y('food',h)
              = 1.1;
sigma_y('othind',h)
              = 1.1;
sigma_y('ser',h)= 1.05;
sigma_y('adm',h)= 1.05;
```

PEP 1-1

April 2012

- It is assumed that households have Stone-Geary utility functions. This specific functional form implies several parameters, and not all of them can be calibrated.
- In the PEP-1-1 code, we assigned a different income elasticity to each commodity, so the user will have to modify this part of the GAMS code to ensure that the names of the commodity elements correspond to the ones in the set definition.
- Hence, for every element of set  $I$ , there should be a value for the income elasticity of consumption.
- Finally, the same value has been assigned to the Frisch parameter for every household; the user might once again assign a value that better represents the economy she/he wishes to model.

## Data – other data (cont'd)

1980	
sh0 (h)	= 0.2
se0 (h)	= 0.2
sedf0 (E)	= 0.2
sedh0 (h)	= 0.2
se0	= 1.2
PEO (i)	= 1.2
ELO (i)	= 1.2
PNMO (i)	= 1.2
MO (L)	= 1.2
RMO (k)	= 1.2

PEP 1-1 April 2012

- In household savings and transfers-to-government functions, and in income-tax functions, one can choose to assign a value to the intercept and calibrate the slope accordingly, or the other way around.
- This type of modeling can be useful to take into account known marginal savings or taxation rates or to deal with negative average saving rates in cases where savings are negative for some household groups.
- When no specific information is available, one can simply set the intercepts to zero and calibrate an average rate: this is what we have done in our example.
- The base value of some prices is arbitrary, insofar as it is constrained only by the price  $\times$  quantity product. In such cases, the arbitrary value assigned to the price implicitly determines the measurement unit of the quantity. The most convenient arbitrary price is obviously 1, although the calibration procedure can automatically manage prices with different values.



## Calibration

# Calibration

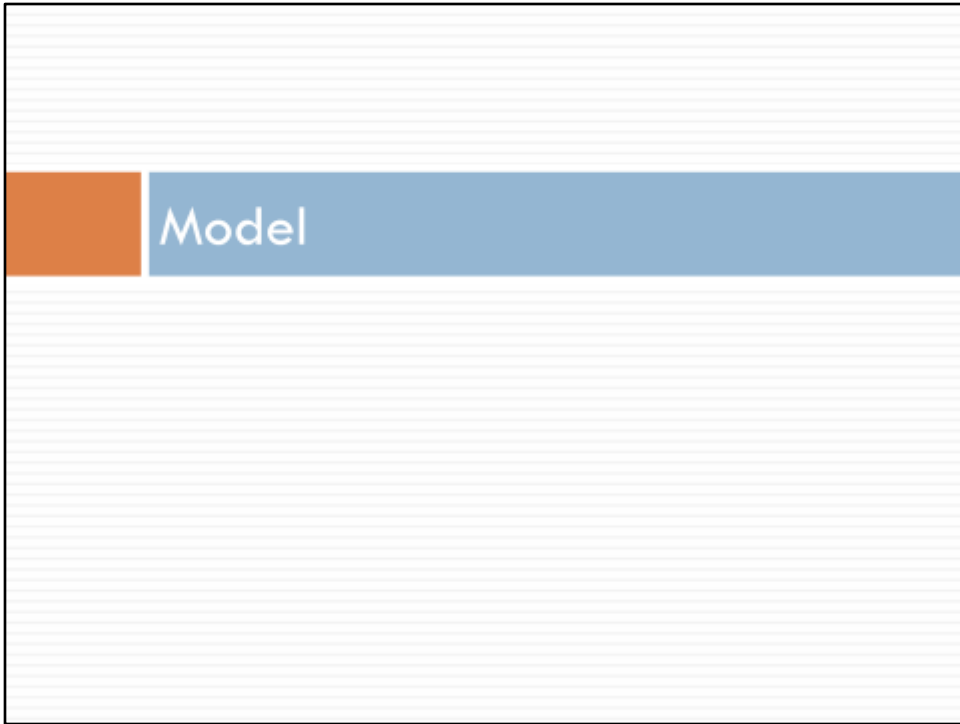
198

- No other changes needed in the calibration.
- See details in Appendix F in PEP-1-1\_v2\_0.pdf

PEP 1-1

April 2012

- The rest of the calibration does not need to be adapted, regardless of the SAM structure. Therefore, it should not be modified.
- The user interested in further information on the calibration process will find a thorough explanation of every step in Appendix F of PEP-1-1\_v1\_0.pdf.



# Model

200

- Definition of variables
- Definition of equations
- Equations:
  - Equation WALRAS to be modified:

```
WALRAS..      LEON =e= Q('agr')-SUM{h,C('agr',h)}-CG('agr')-INV('agr')  
               -VSTK('agr')-DIT('agr')-MRGN('agr');
```

PEP 1-1

April 2012

- The part of the GAMS code which is commonly referred to as the model itself, includes six main sections.
  - The first section defines the variables (both endogenous and exogenous) that are used in the model. The user does not need to modify anything in this section.
  - The second part consists in the definition of equations where, once again, the user does not need to change anything.
  - In the third part, which consists in the equations *per se*, only the last equation should be modified. Indeed, and as mentioned earlier, the equation *WALRAS* evaluates the difference between supply and demand for the commodity that was removed from set *I* to create subset *I1*. In our example, the commodity *AGR* is the commodity that has been set aside in our example. The modeler should replace *AGR* with the relevant acronym.



## Model (cont'd)

201

- Initialization
- Capital mobility:
  - Sector-specific ( $kmob = 0$ )
  - Perfectly mobile ( $kmob = 1$ )

```
* If kmob=1, capital is mobile, if kmob=0, it is sector-specific
kmob      = 0;
KD.fx(k,j)$(kmob .eq. 0)
           = KDO(k,j);
KS.fx(k)$(kmob
           = KSO(k);
```

PEP 1-1

April 2012

- The fourth part consists in the initialization of variables to their benchmark value, i.e. their value in the SAM. Assuming that the SAM has been correctly formatted, nothing should be changed in that section.
- The fifth part allows the modeler to choose whether he wishes the capital to move freely between industries or whether it should be industry-specific. *KMOB* is a flag parameter that allows switching from one assumption to the other very easily. If *KMOB* is set to one, then capital will be mobile; the opposite happens if it is set to zero.



## Closures

# Closures

2013

## □ Exogenous variables:

<code>e.fx</code>	<code>= 1;</code>
<code>CAB.fx</code>	<code>= CABO;</code>
<code>CHIN.fx(i,h)</code>	<code>= CHINO(i,h);</code>
<code>G.fx</code>	<code>= GO;</code>
<code>LS.fx(i)</code>	<code>= LSO(i);</code>
<code>FNM.fx(i)</code>	<code>= FNM0(i);</code>
<code>PNX.fx(i)</code>	<code>= PNWO(i);</code>
<code>VSTK.fx(i)</code>	<code>= VSTEO(i);</code>

PEP 1-1

April 2012

- Finally, the exogenous variables are defined. In our example, the nominal exchange rate is used as the *numeraire* of the model, the current account is fixed and so are the current government expenditures on goods and services. Labor supply, world prices and inventory changes are also exogenous.
- The user might want to make other choices regarding model closure. We suggest, however, that she/he first run the model using these rules to verify that there are no errors in the code.
- Once this verification is done, then the modeler can choose different hypothesis. That being said, the user should keep in mind that the model must be square, meaning that there should be as many endogenous variables as there are equations. Hence, the user cannot fix an additional variable unless she/he releases one constraint.



## Simulations

# Simulations

205

## □ Three examples:

```
** 6.4 Simulations
* 25% increase of international import price of AGR
* PWN.Fx('agr') = PWHO('agr')*1.25;

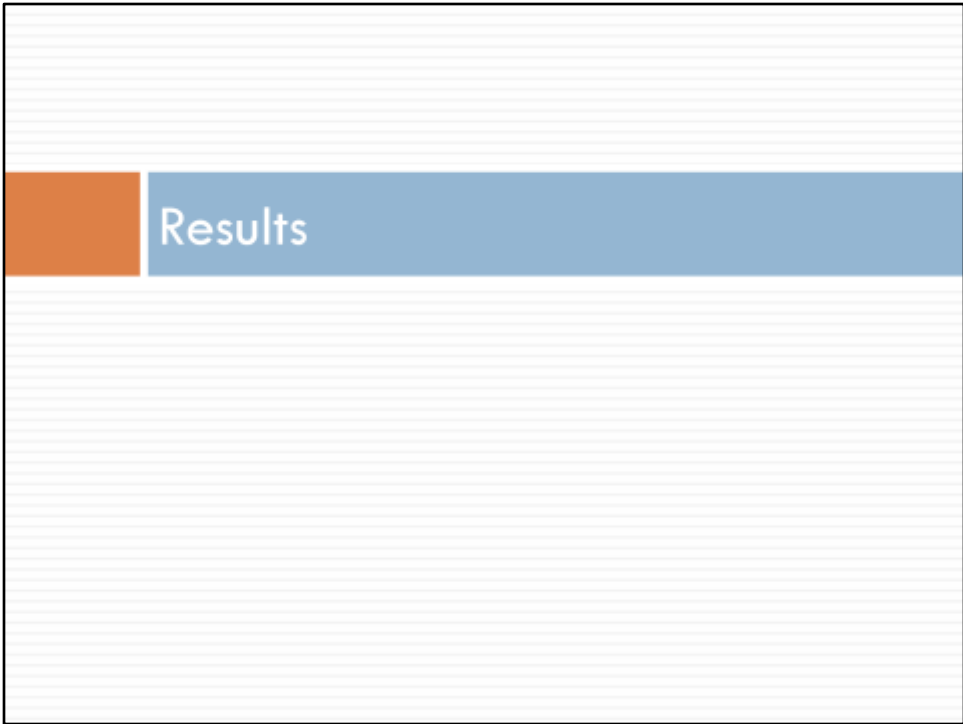
* 50% decrease of the indirect tax rates on all commodities
* ttax(i) = tbtax(i)*0.5;

* 20% increase of public expenditures
* G.Fx = GO*1.2;
```

PEP 1-1

April 2012

- Typically, a modeler will want to shock exogenous variables (i.e. the ones that appear with the suffix .FX), or tax rates.
- In the GAMS file, there are three examples of shocks:
  - 25% increase of international import price of agriculture
  - 50% decrease of the indirect tax rates on all commodities
  - 20% increase of public expenditures



## Results

207

- The RESULTS PEP 1-1.gms creates 2 files:
  - Results.gdx (readable in GAMS)
  - Results.xls (readable in Excel)
- Both include benchmark and solution values for all variables.

PEP 1-1

April 2012

- The file RESULTS PEP 1-1.GMS will automatically produce two files containing the solution values of all variables in the model.
- These files are called RESULTS. Their contents are identical, but their formats are different. One of them has a GDX extension, and it can be opened directly in GAMS; the other has an XLS extension, and it can be opened in Excel.
- The user will find both files in the same directory where all other files are located and where she/he defined his project.