

PEP 1-1

April 2012

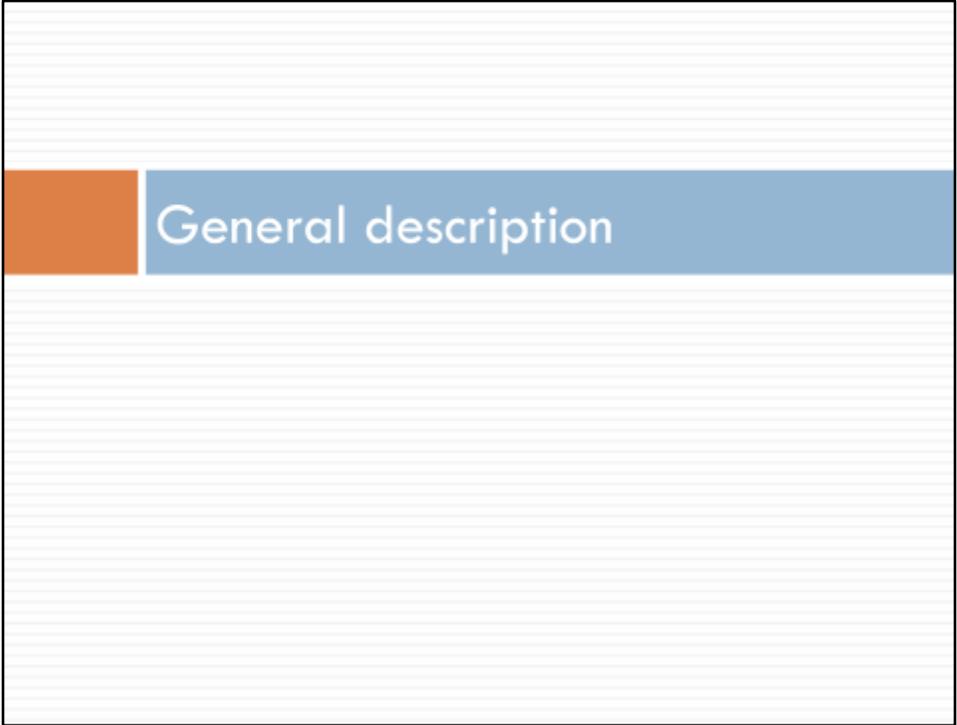
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This material is a joint effort between IFPRI and PEP in the context of the AGRODEP project, and the authors acknowledge the financial support of the AGRODEP project.

Presentation outline

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



General description

General description

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

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- 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.

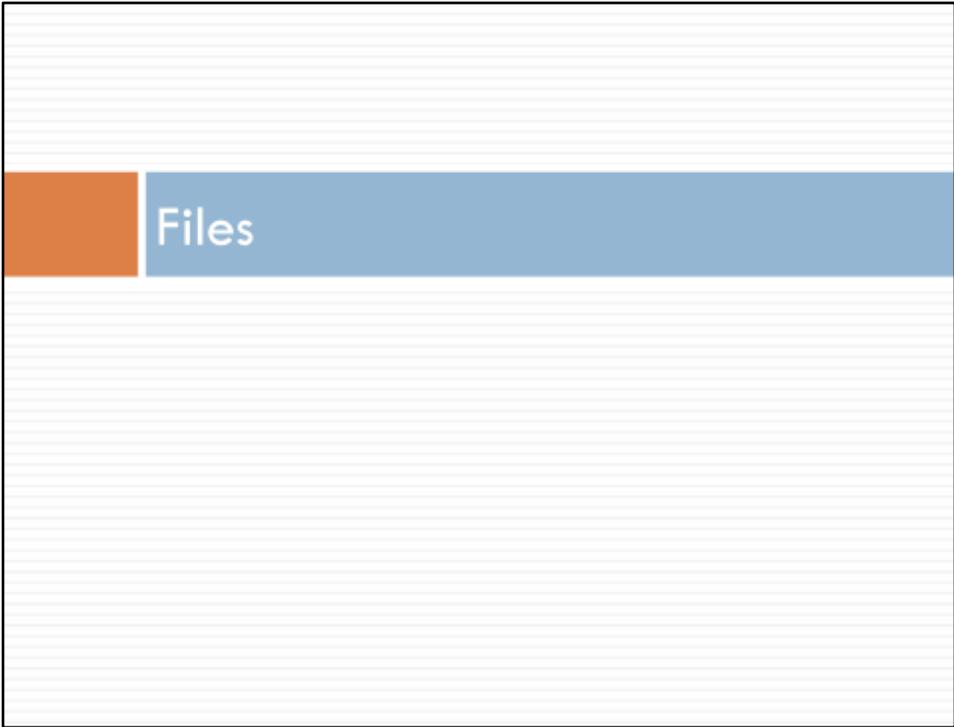
General description (cont'd)

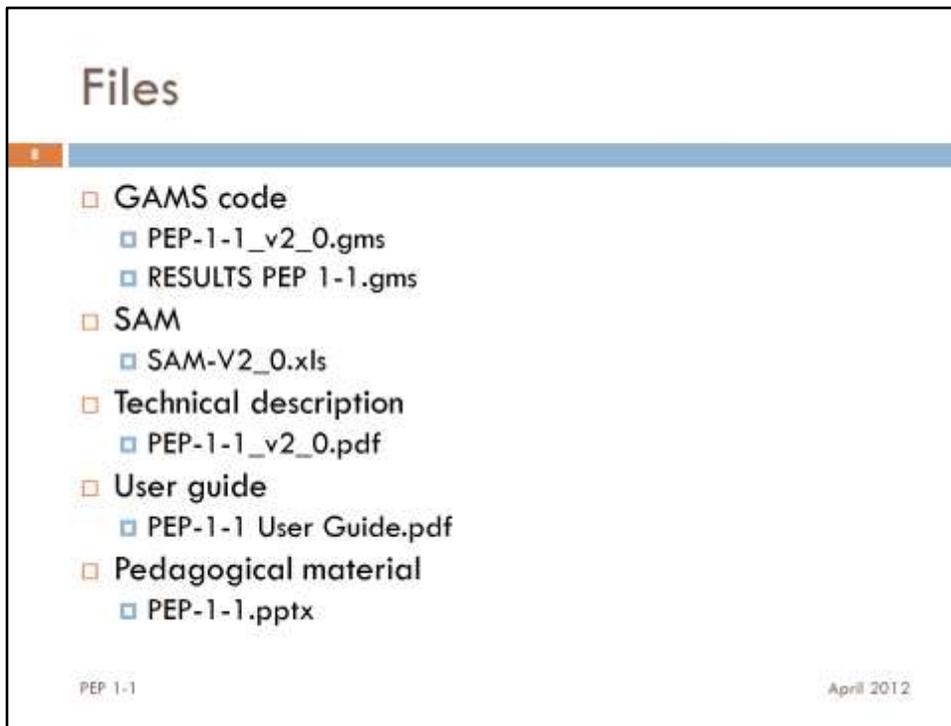
- Flexible common model
- Standard hypothesis
- Easily applicable
- Adaptable to most SAMs

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- 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

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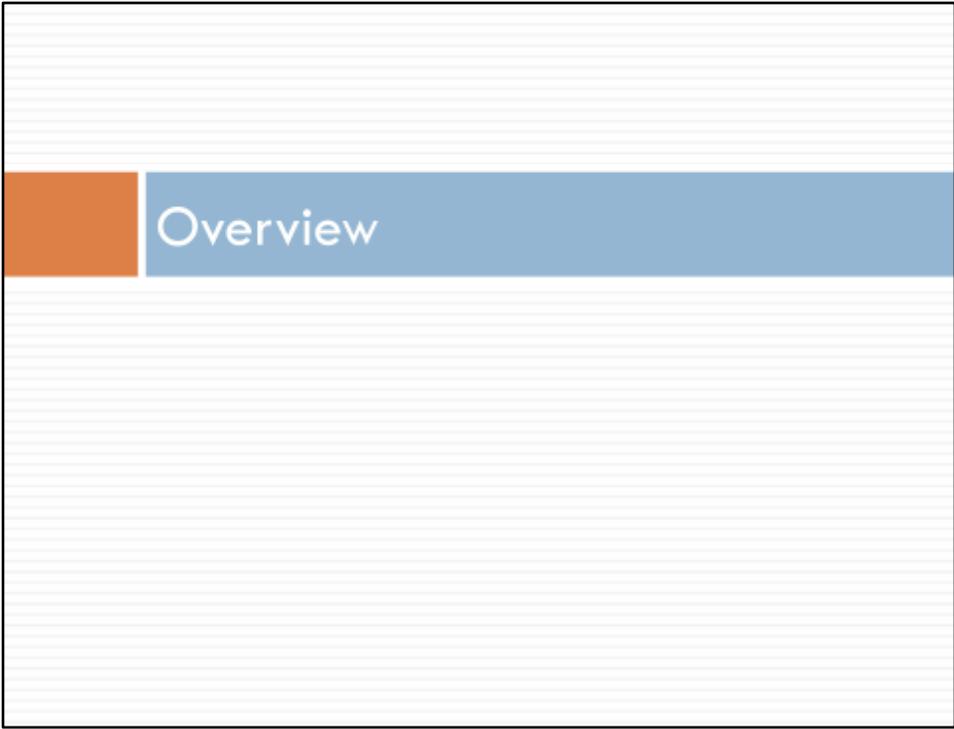
- Overview: income and expenditure circular flow
- Production
- Income and savings
- Demand
- Supply and international trade
- Prices
- Equilibrium
- Gross domestic product
- Default closures

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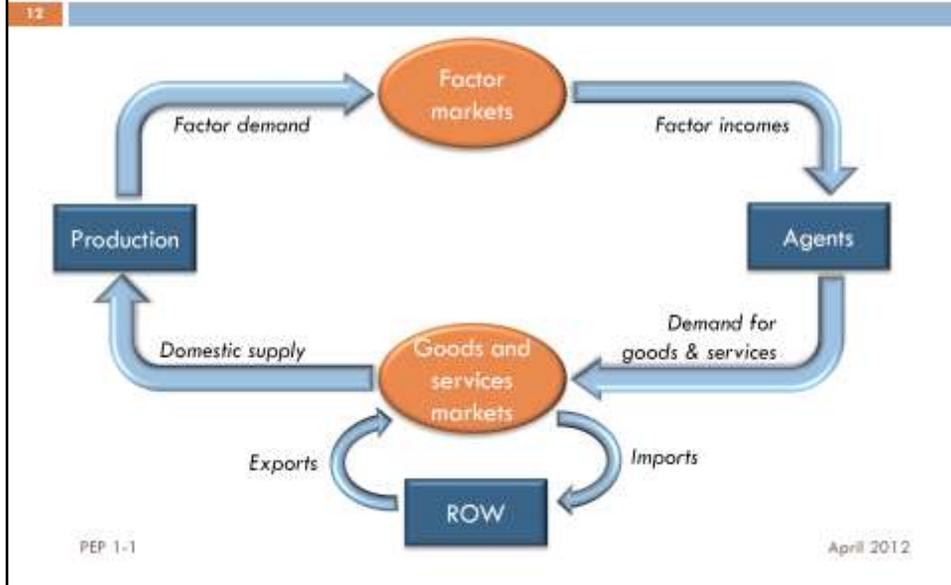
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• The next section reviews the mathematical structure of the PEP-1-1 model. It is based on the technical document (PEP-1-1_v2_0.pdf) as it follows the same presentation structure:

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



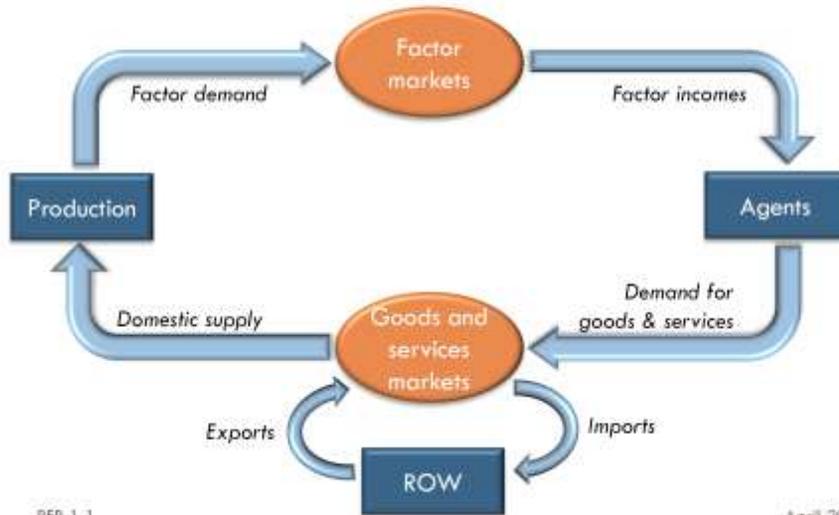
Overview: income and expenditure circular flow



- 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.

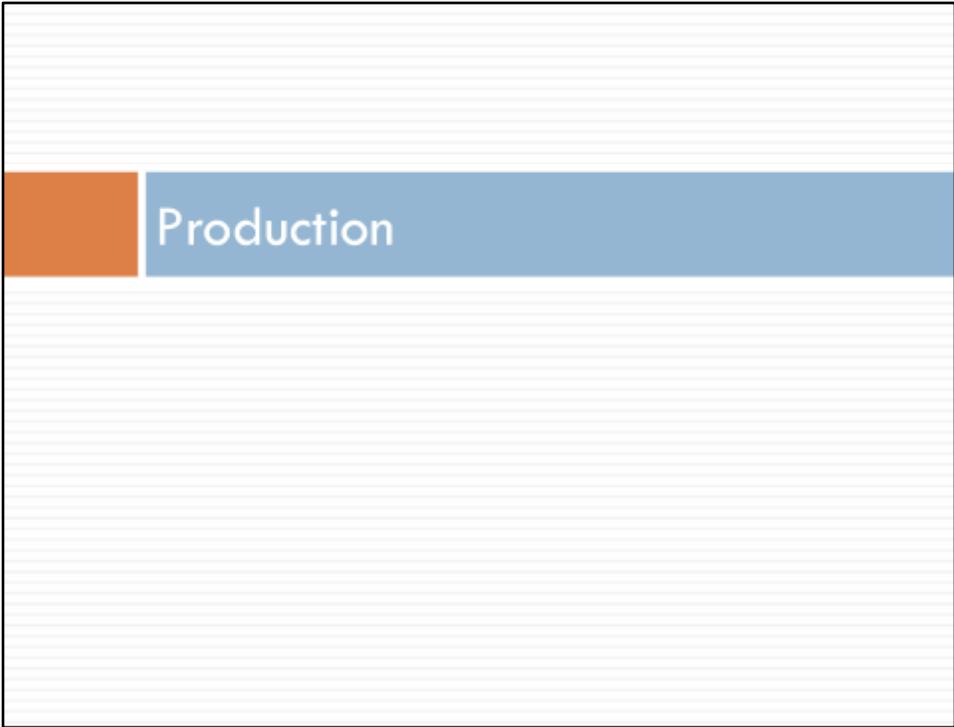
Overview: income and expenditure circular flow

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Production

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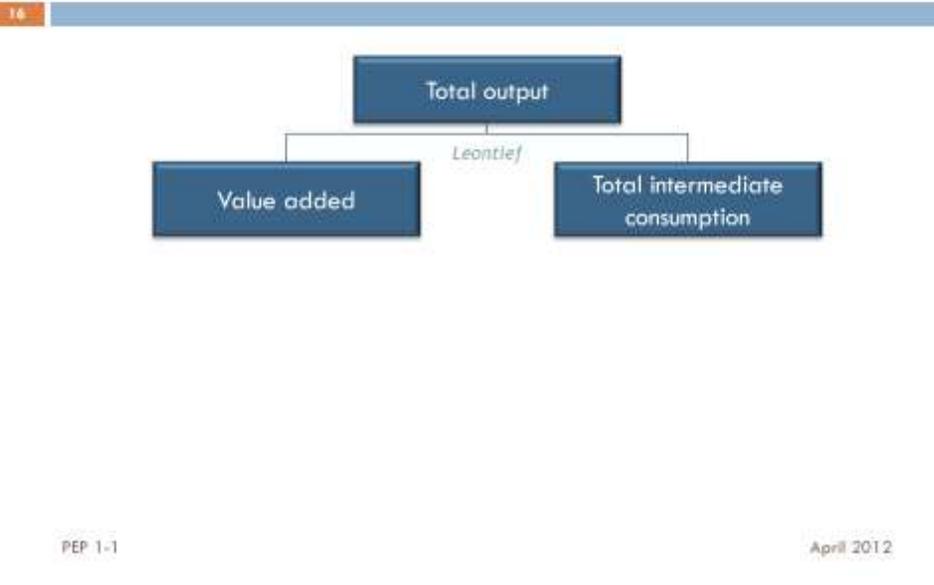
- Perfect competition
 - Profit maximization under production technology
 - Price-taking behavior
- Nested production structure
- Industries are represented by index J

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- 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 .

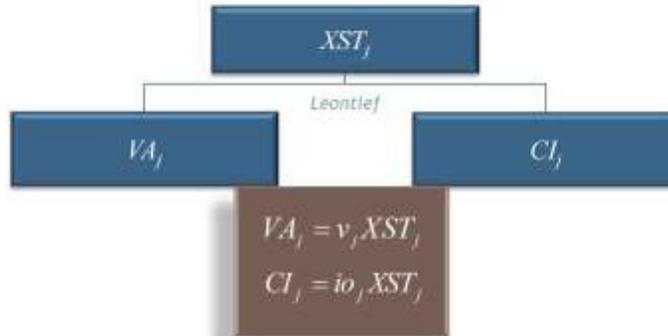
Production – total output



- 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

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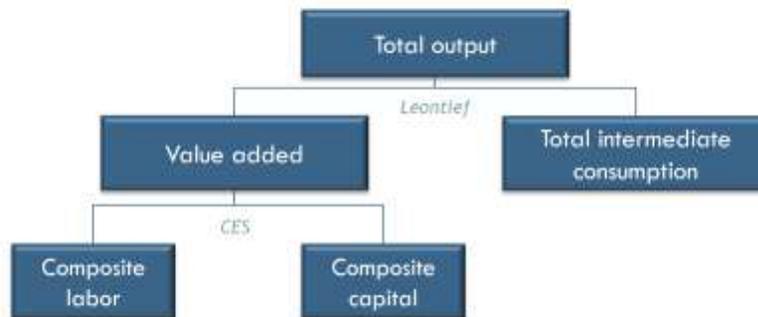
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- Here is the mathematical representation of the Leontief.

Production – value added

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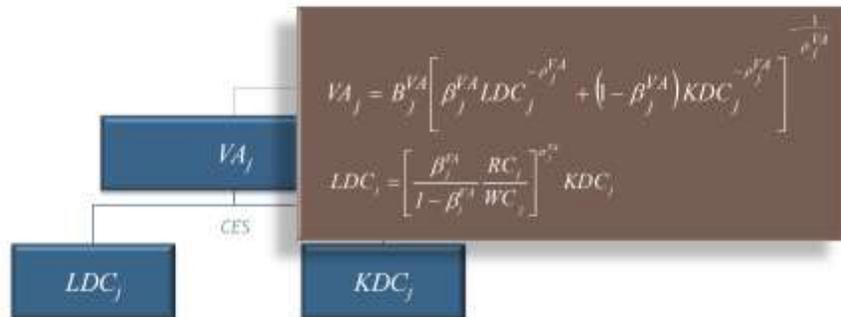
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- At the second level, each industry's value added consists of composite labor and composite capital, following a constant elasticity of substitution (CES) specification.

Production – value added

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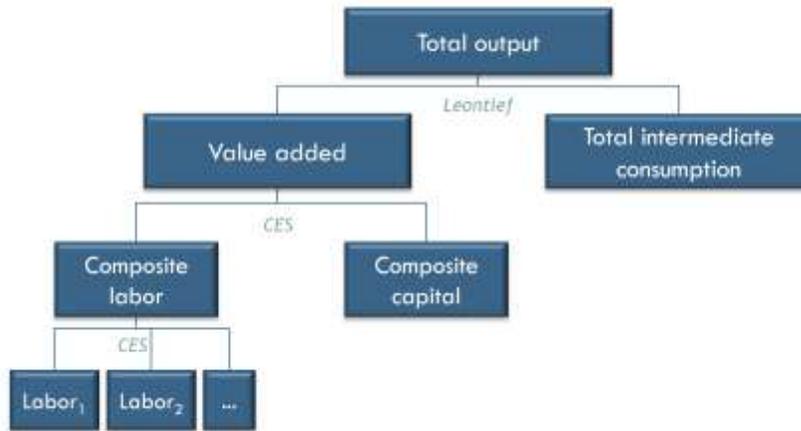
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- Profit maximization (or cost minimization) by the firms leads them to employ labor and capital to the point where the value marginal product of each is equal to its price (the wage rate and the rental rate of capital respectively).
- With a CES production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

Production – composite labor

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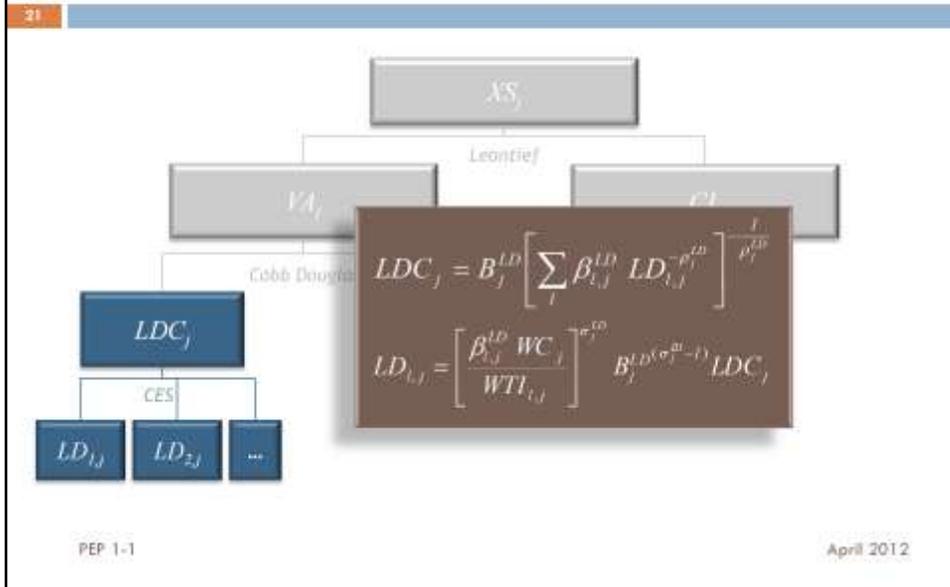


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- At the bottom level on the value added side, the various categories of labor, indexed as L , are combined following a constant elasticity of substitution (CES) technology, which reflects the imperfect substitutability between different types of labor.

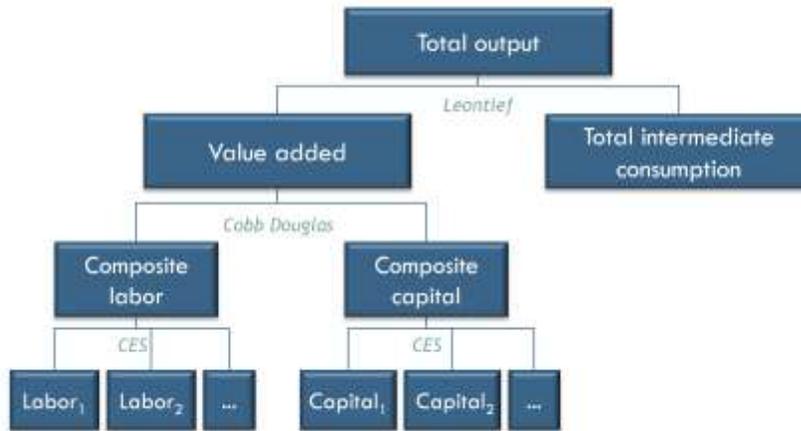
Production – composite labor



- 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

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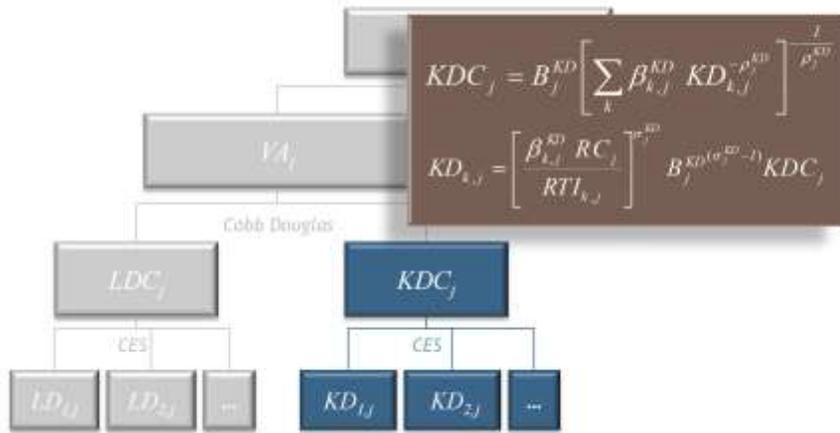
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- Likewise, composite capital is a CES combination of the different categories of capital, indexed as K .

Production – composite capital

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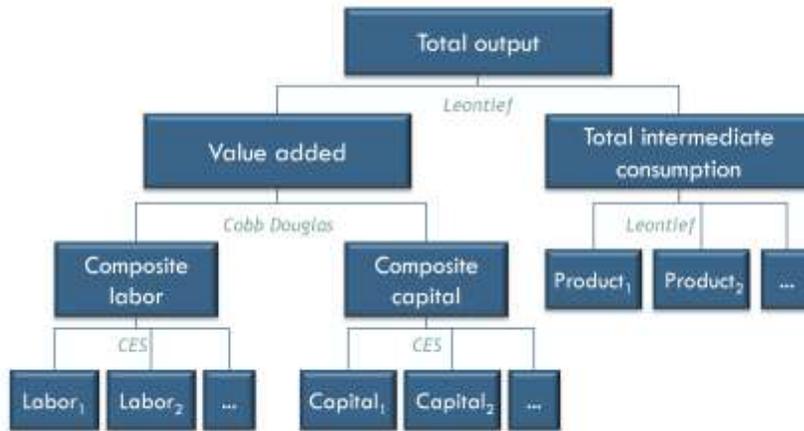
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- As in the case of labor, it is assumed that different categories of capital are imperfect substitutes.
- The demand for each type of capital results from cost minimization.

Production – intermediate consumption

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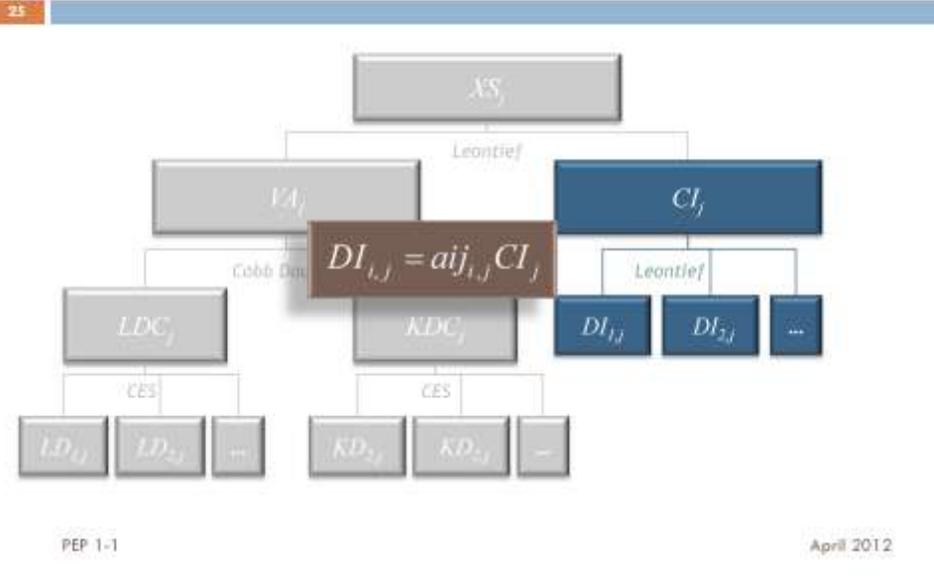


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- Finally, returning to the second level, but on the intermediate consumption side, aggregate intermediate consumption is made up of various goods and services.

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

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

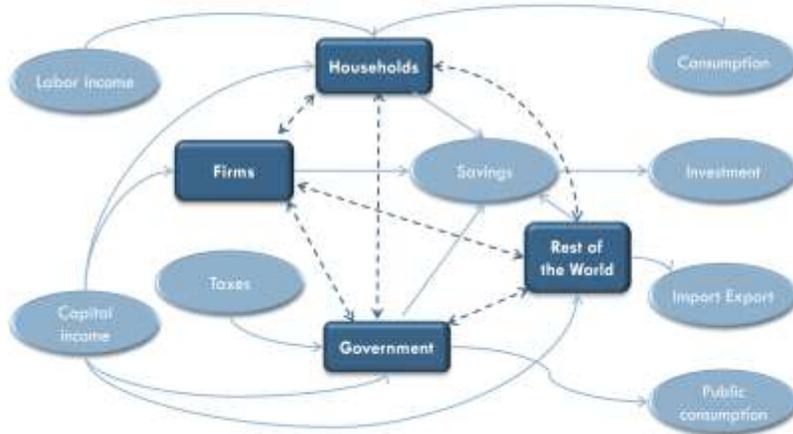
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- The PEP-1-1 model offers the possibility of several categories of households and businesses, respectively indexed as H , and F , together with government, designated as GVT , and the rest of the world, ROW .

Income and savings – overview

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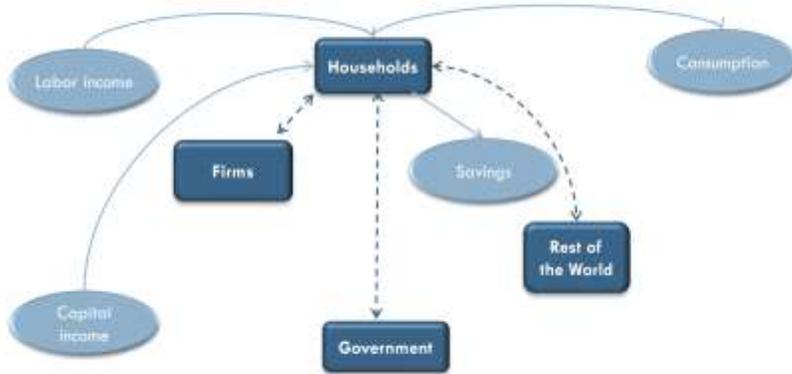
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- Here is the overall schema of the income and expenditures for each agent.
- The following slides will explain the flows for each agent.

Households

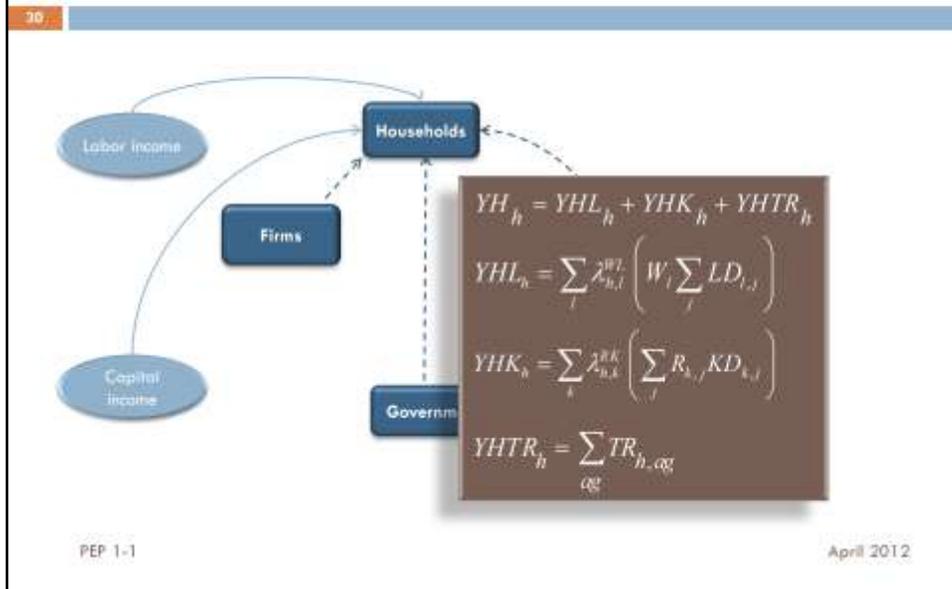
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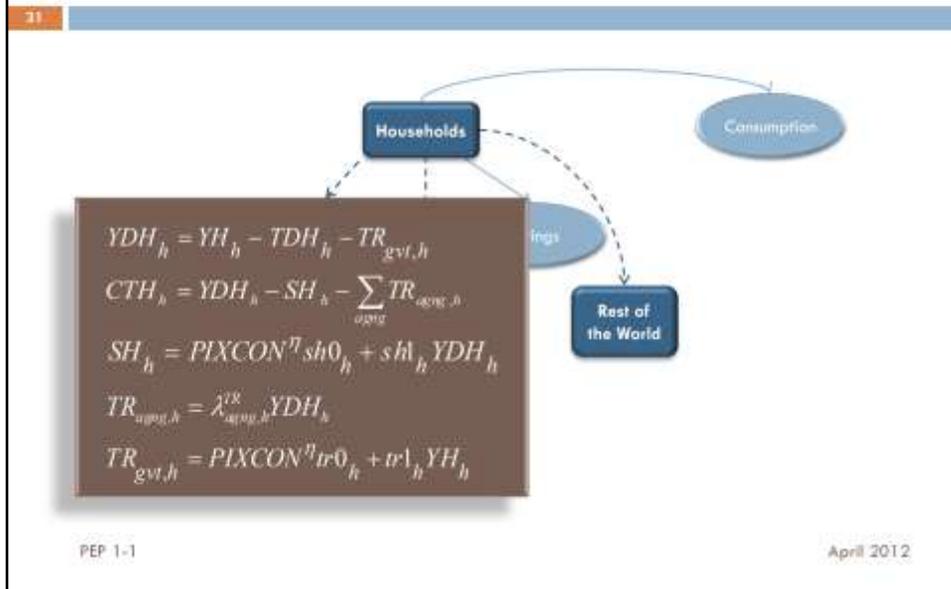
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Households – income



- 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 λ^{WL} of the earnings of each type of labor.
- Likewise, total capital income is distributed between agents, including households, in fixed proportions λ^{RK} .
- Finally, transfer income is simply the sum of all transfers ($TR_{h,ag}$) received by type h households.

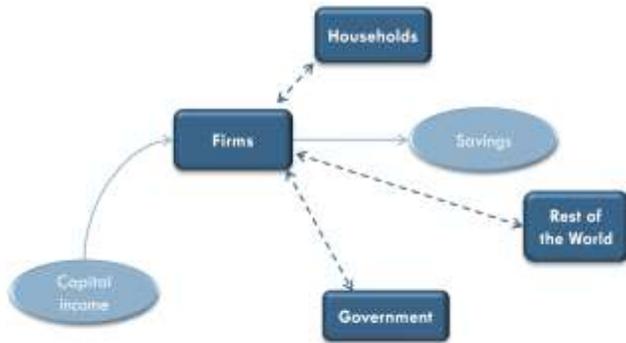
Households – expenditures and savings



- 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 ($TR_{agnt,h}$) 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 η is set to 1.
- Household transfers to non-government agents are simply proportional (λ^{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

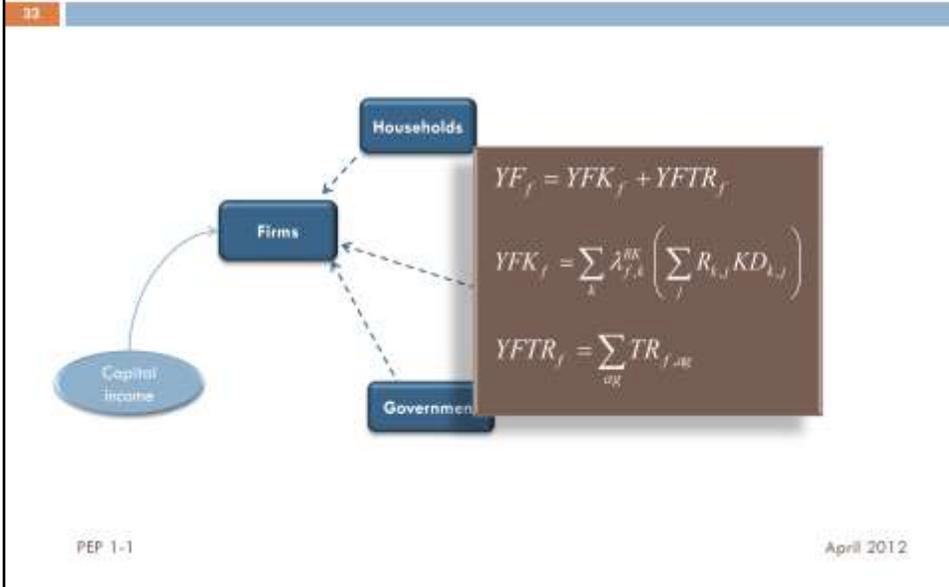
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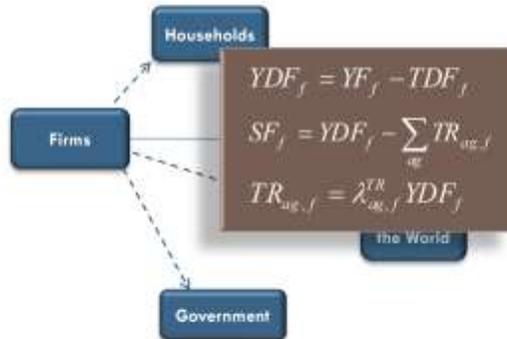
Firms – income



- 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 λ^{RK} of total capital income.
 - Transfer income is simply the sum of all transfers ($TR_{f,ag}$) received by type f firms.

Firms – savings

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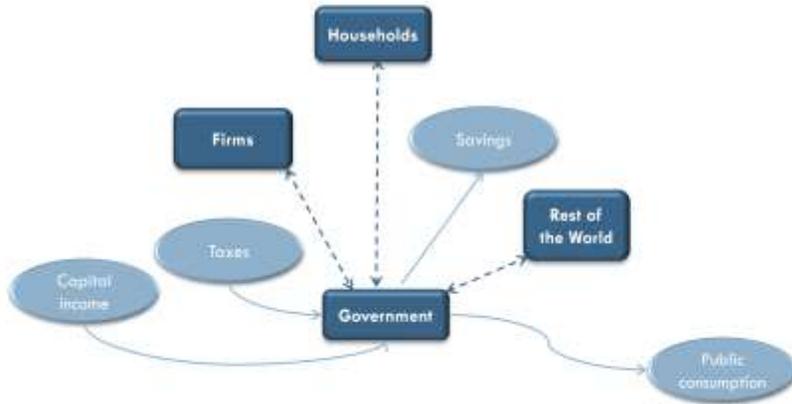
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- Deducting business income taxes (TDF_f) from total income yields the disposable income (YDF_f) of each type of business.
- Likewise, business savings (SF_f) are the residual that remains after subtracting transfers to other agents from disposable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

Government

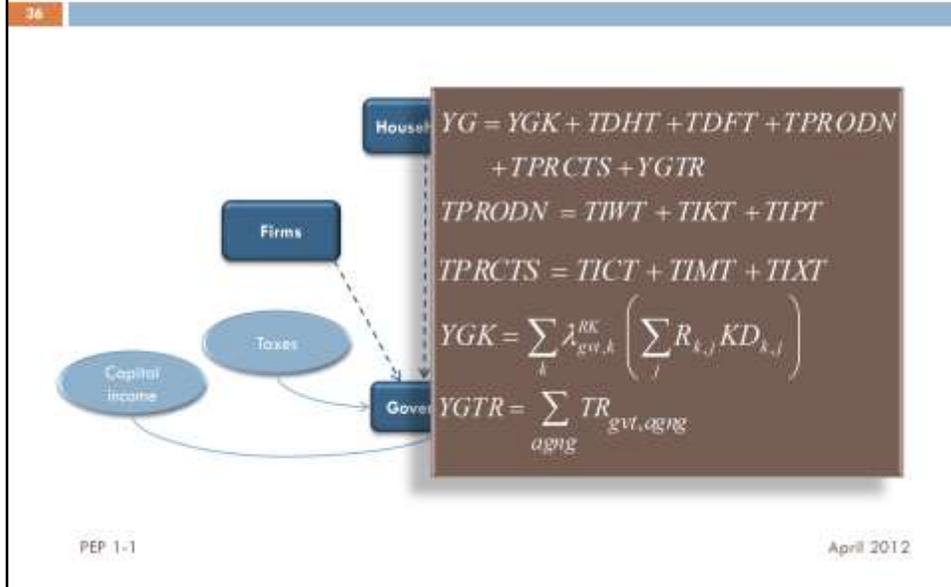
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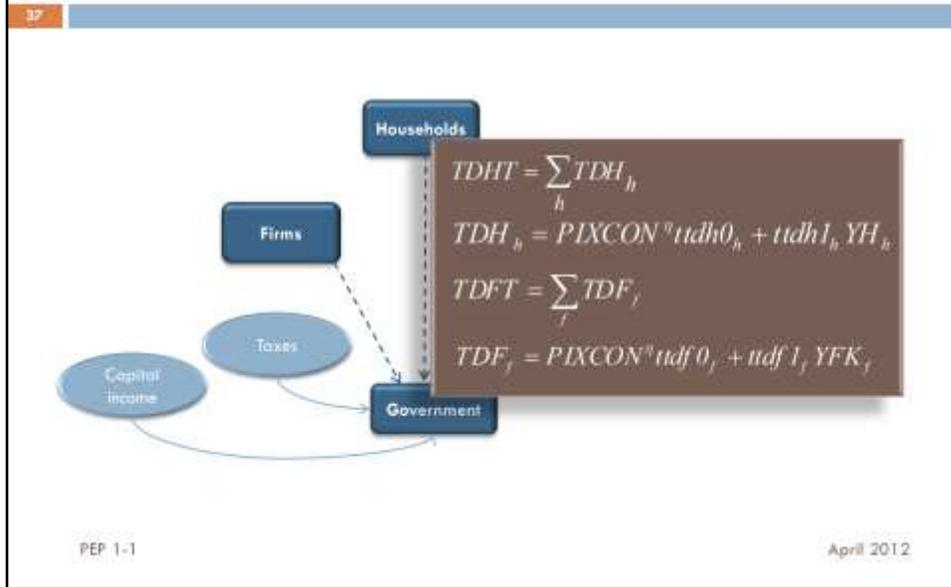
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Government – income



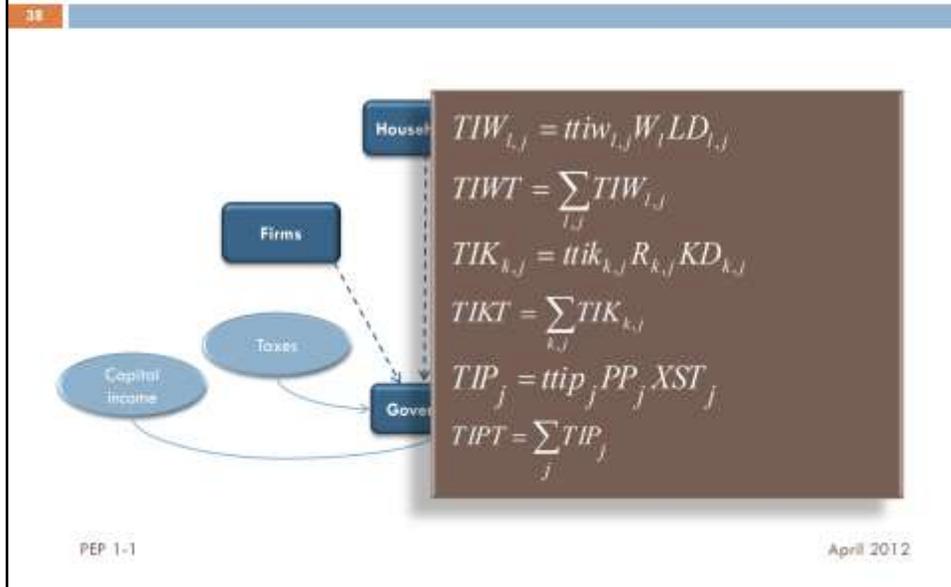
- In the PEP-1-1 model, it is possible to take into account a large variety of tax instruments. Indeed, the government draws its income from household and business income taxes ($TDHT$ and $TDFT$), taxes on products and on imports ($TPRCTS$), and other taxes on production ($TPRODN$).
- According to the 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)



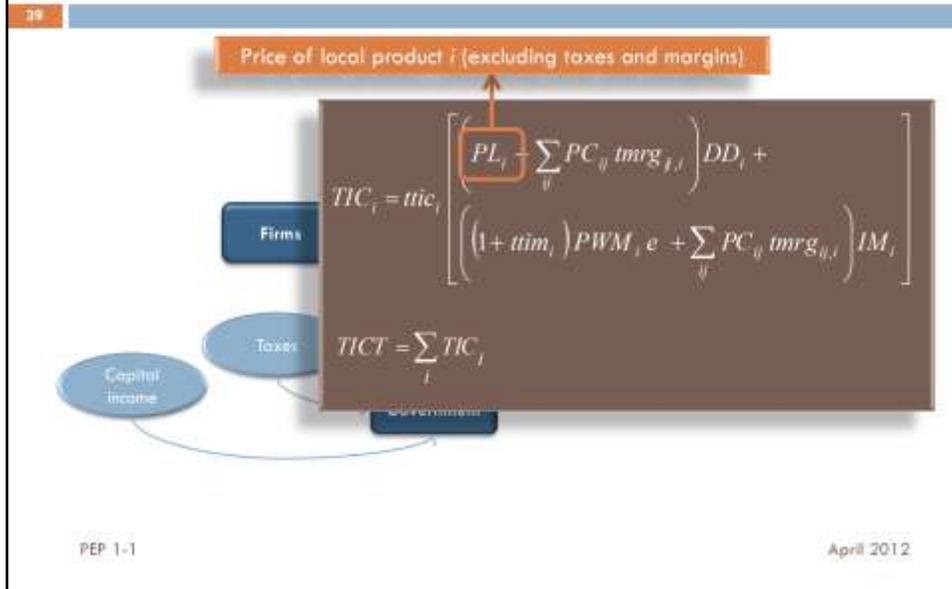
- Similarly to what has been done with household savings, income taxes are described as a linear function of total income, whether it be for households or for businesses.
- That way, when a non-zero intercept ($ttdh0_h$ and $ttdf0_f$) is applied, the marginal rate of taxation ($ttdh1_h$ and $ttdf1_f$)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

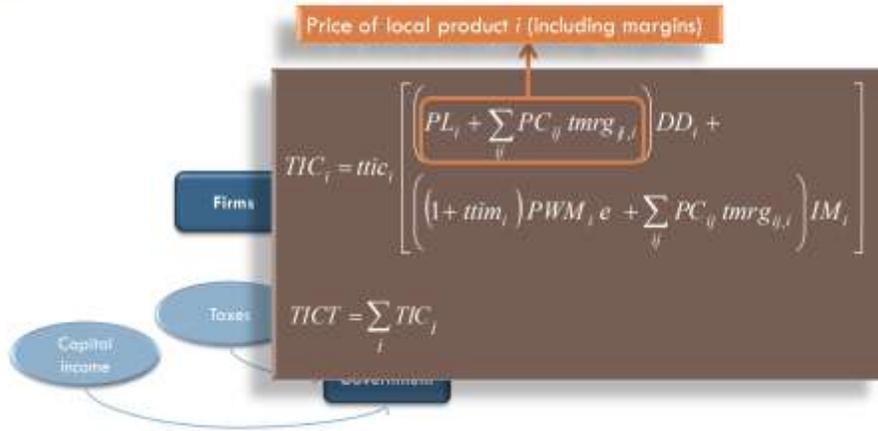
Government – income (cont'd)



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

Government – income (cont'd)

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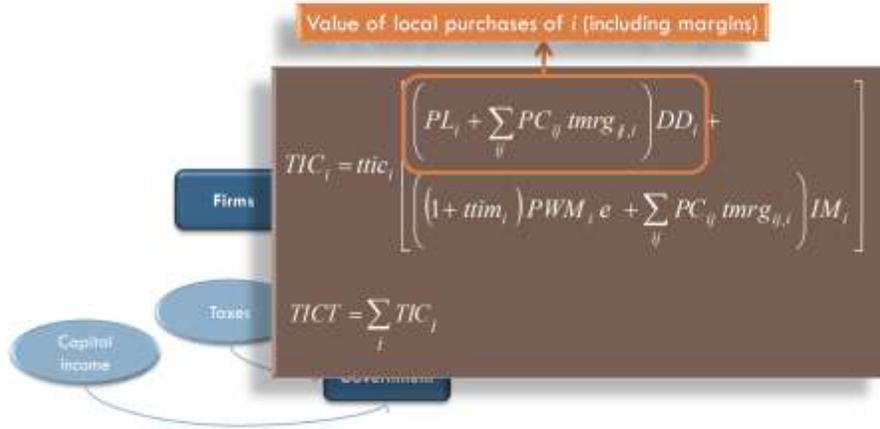


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Government – income (cont'd)

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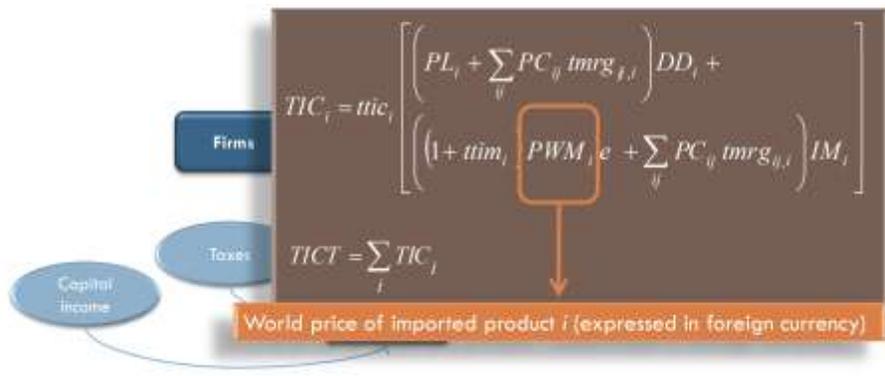


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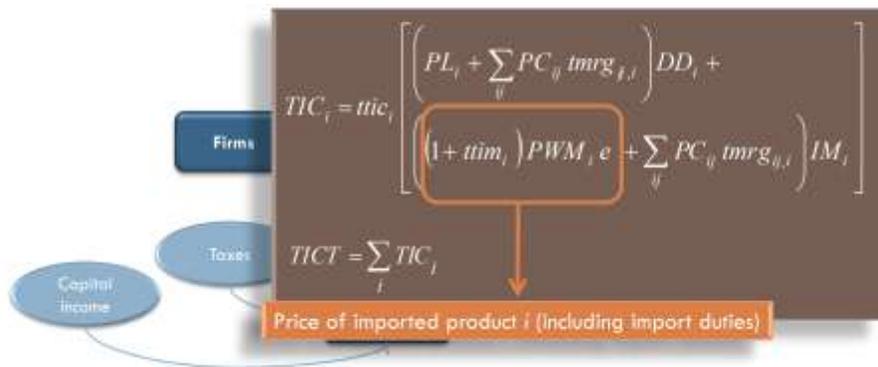
Government – income (cont'd)

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Government – income (cont'd)

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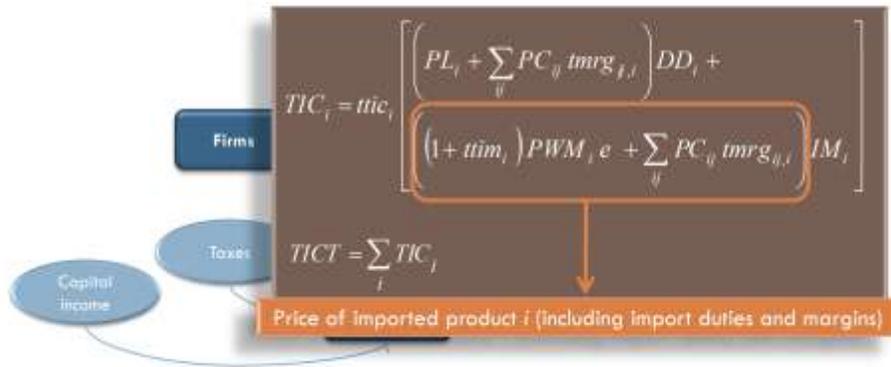


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Government – income (cont'd)

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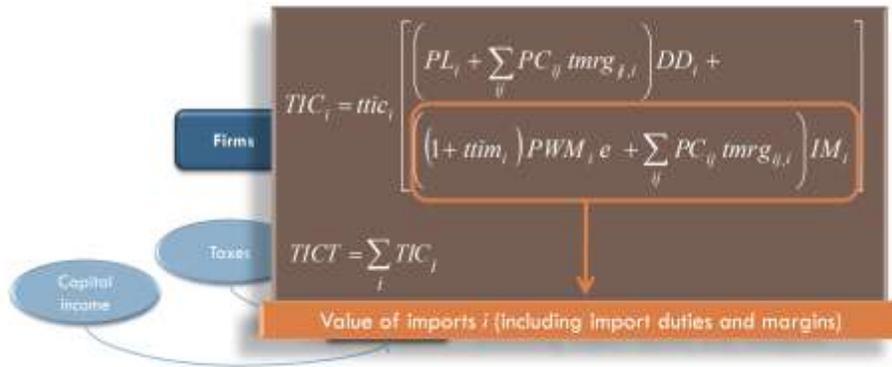


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Government – income (cont'd)

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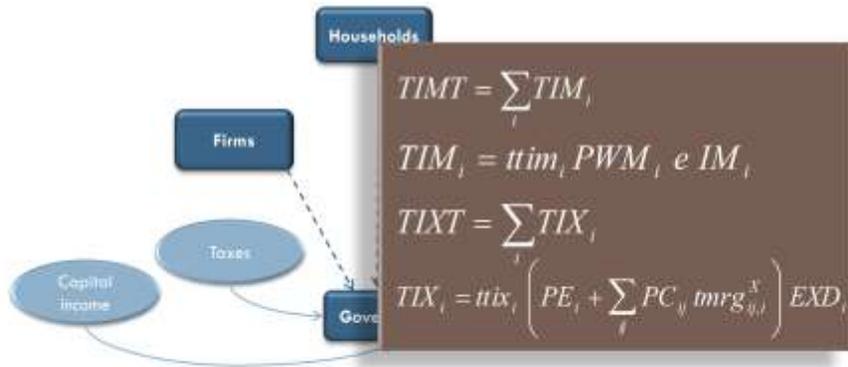


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Government – income (cont'd)

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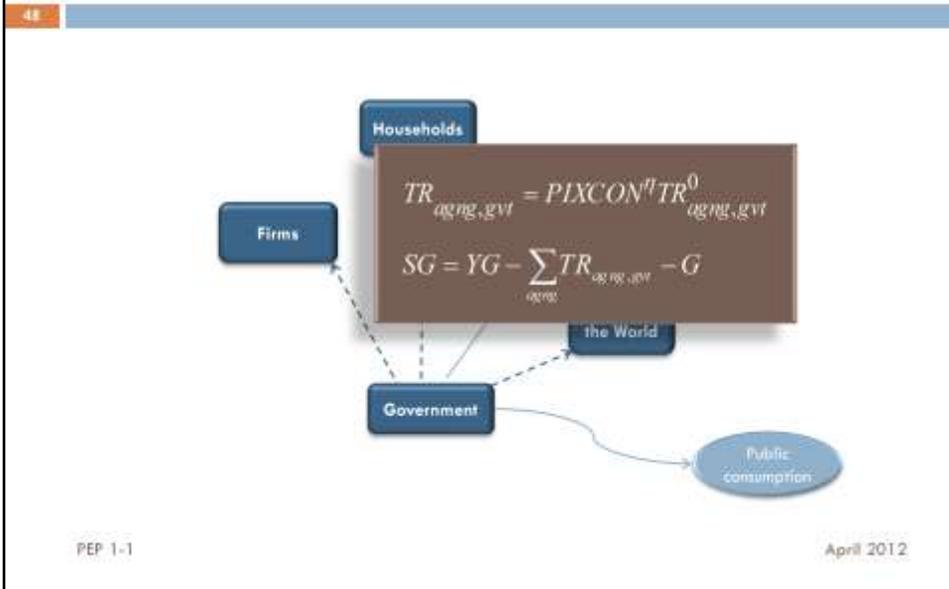


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- Other taxes collected are taxes and duties on imported products (TIM_i), and on exports (TIX_i).

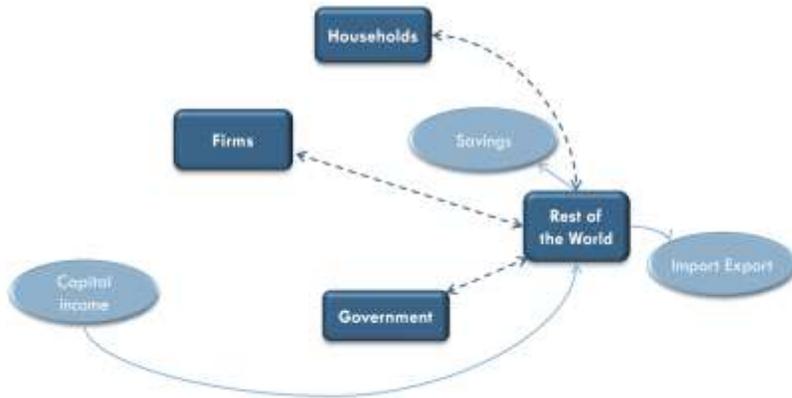
Government – expenditures and savings



- 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

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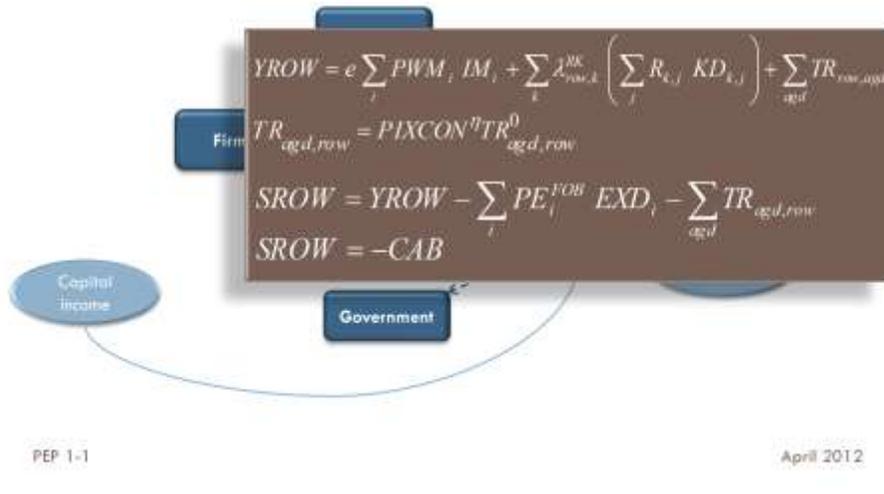


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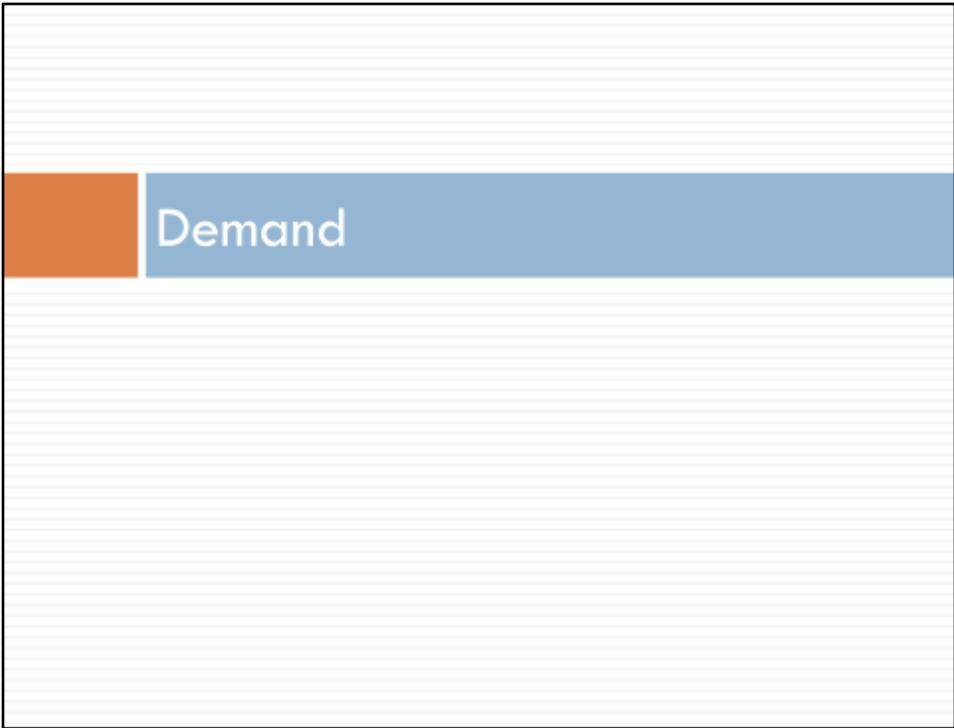
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Rest of the world (cont'd)

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- 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, $TR_{agg,row}$, 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

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• 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

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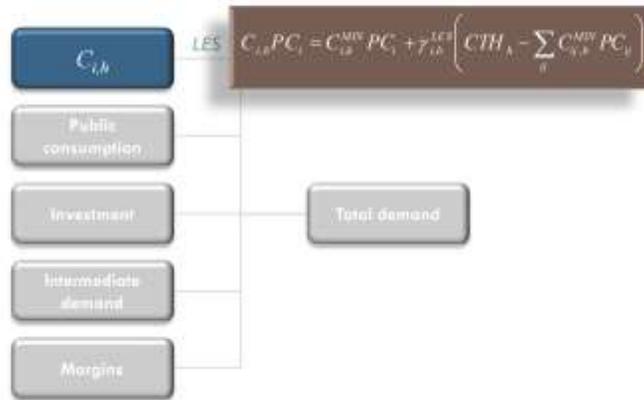
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- It is assumed that households have Stone-Geary utility functions (from which derives the Linear Expenditure System).
- Contrary to Cobb-Douglas utility functions, often used in the literature, this specification imposes neither zero cross-price elasticities 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

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- 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

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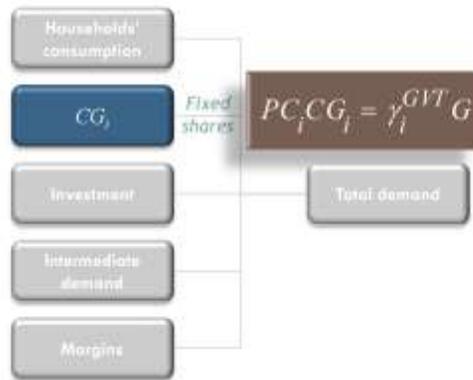


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Public consumption

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

Investment

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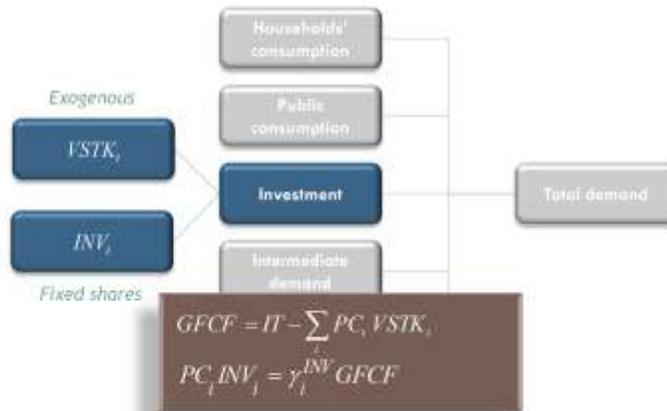
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- Investment demand includes both gross fixed capital formation (GFCF) and changes in inventories.
- Inventory changes are exogenous in PEP-1-1, fixed in volume.

Investment

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- 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, γ^{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

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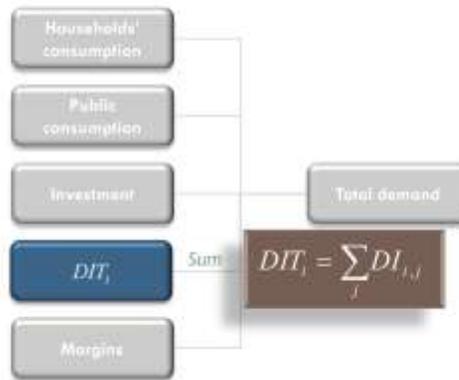
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- In addition to being required for final demand, goods and services are used as inputs in the production process.

Intermediate demand

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

Margins

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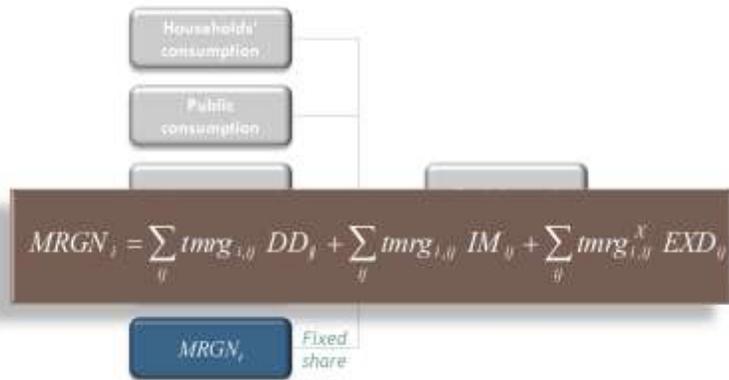
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- Finally, some services, such as transport and retail and wholesale trade, are used to move commodities and make them available to the market.

Margins

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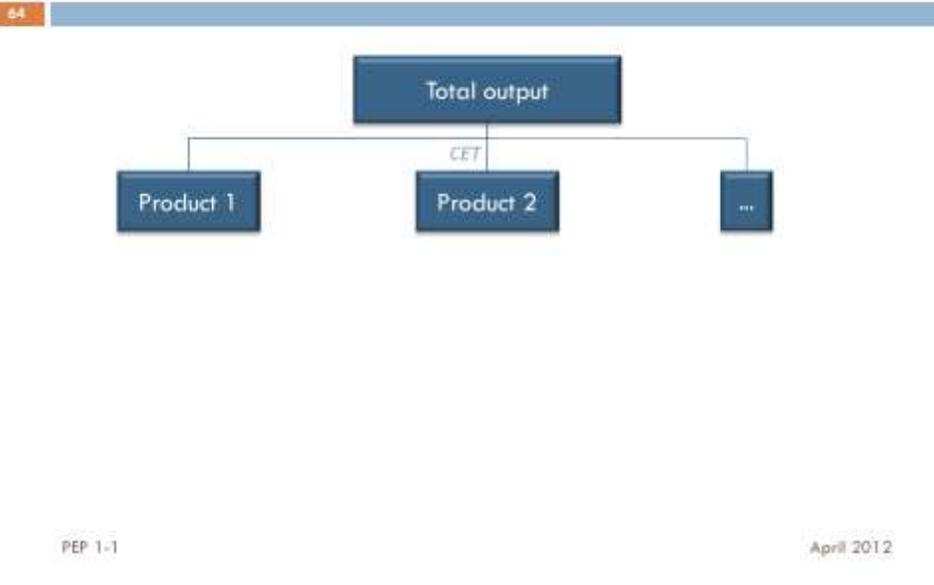
- Margin rates are applied to the volume of domestic production and imports to determine the quantities of these margin services ($MRGN_i$) required to distribute commodities to buyers.



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.

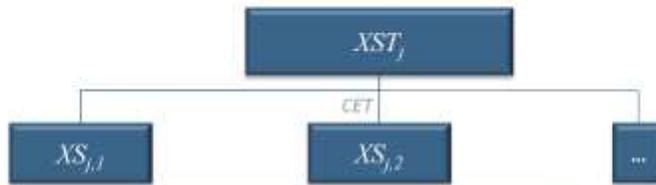
Supply – total output



- 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

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

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

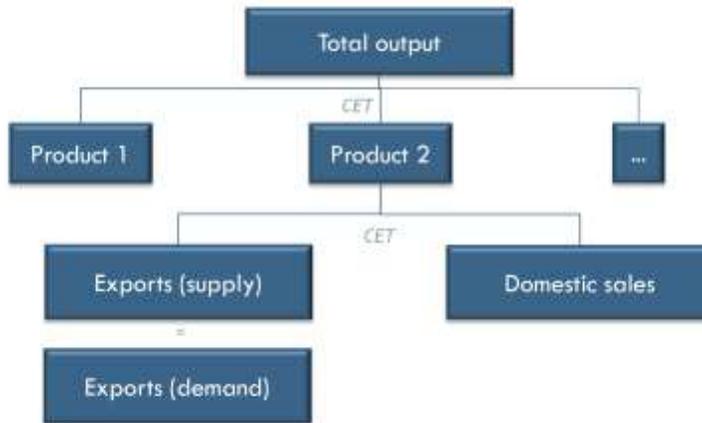
PEP 1-1

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

66



PEP 1-1

April 2012

- 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

67

$$XS_{j,t} = B_{j,t}^X \left[\beta_{j,t}^X EX_{j,t}^{\sigma_{j,t}^X} + (1 - \beta_{j,t}^X) DS_{j,t}^{\sigma_{j,t}^X} \right]^{\frac{1}{\sigma_{j,t}^X}}$$

$$EX_{j,t} = \left[\frac{1 - \beta_{j,t}^X}{\beta_{j,t}^X} \frac{PE_{j,t}}{PL_{j,t}} \right]^{\sigma_{j,t}^X} DS_{j,t}$$

$$EXD_t = EXD_t^W \left(\frac{e^{PWX_t}}{PE_t^{EXD}} \right)^{\sigma_{EXD}}$$

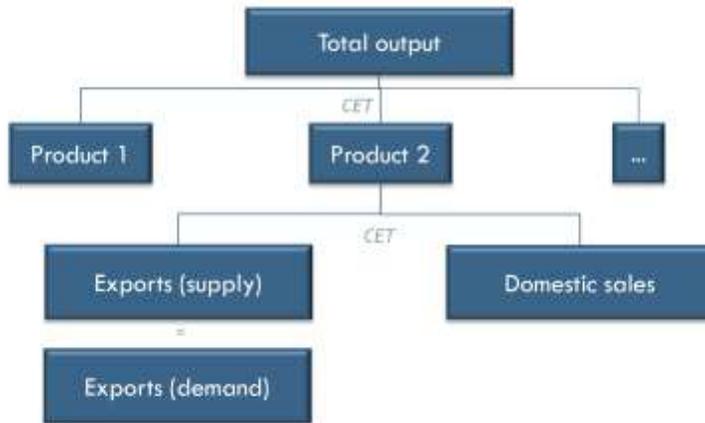
PEP 1-1

April 2012

- 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

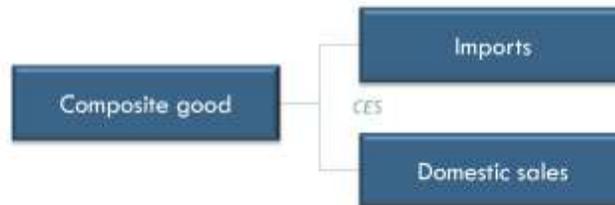


PEP 1-1

April 2012

International trade – Imports

69



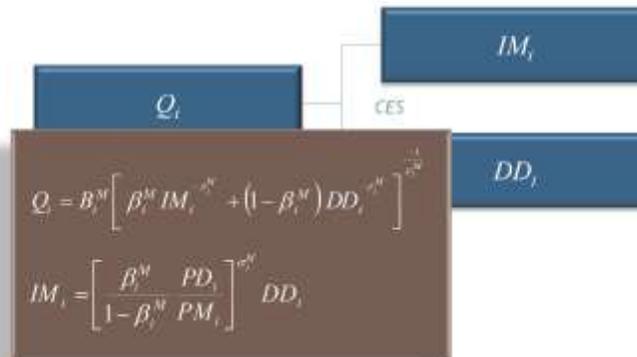
PEP 1-1

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

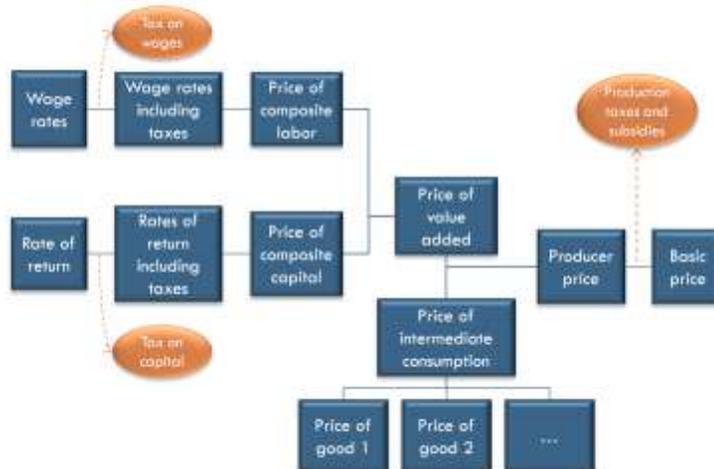
April 2012

- 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.



Producer prices

72

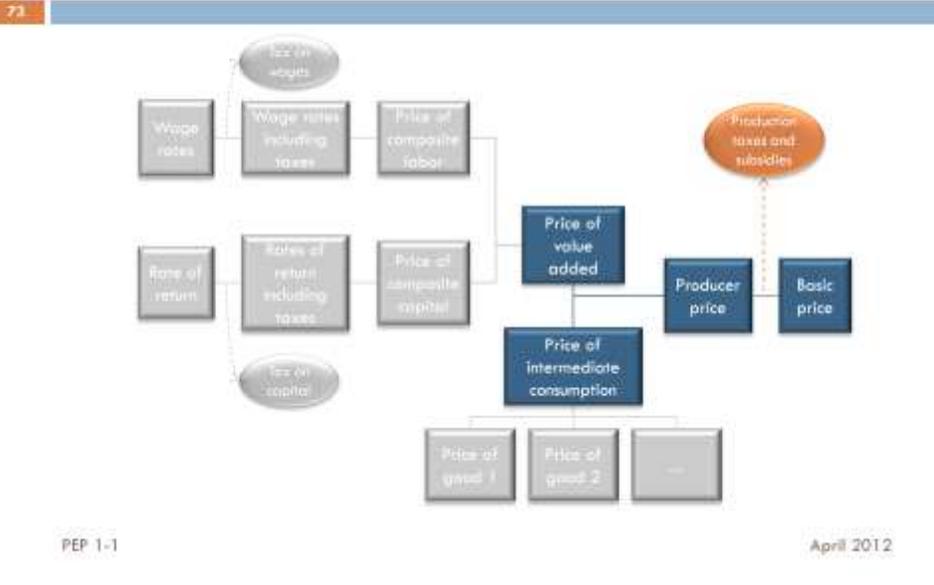


PEP 1-1

April 2012

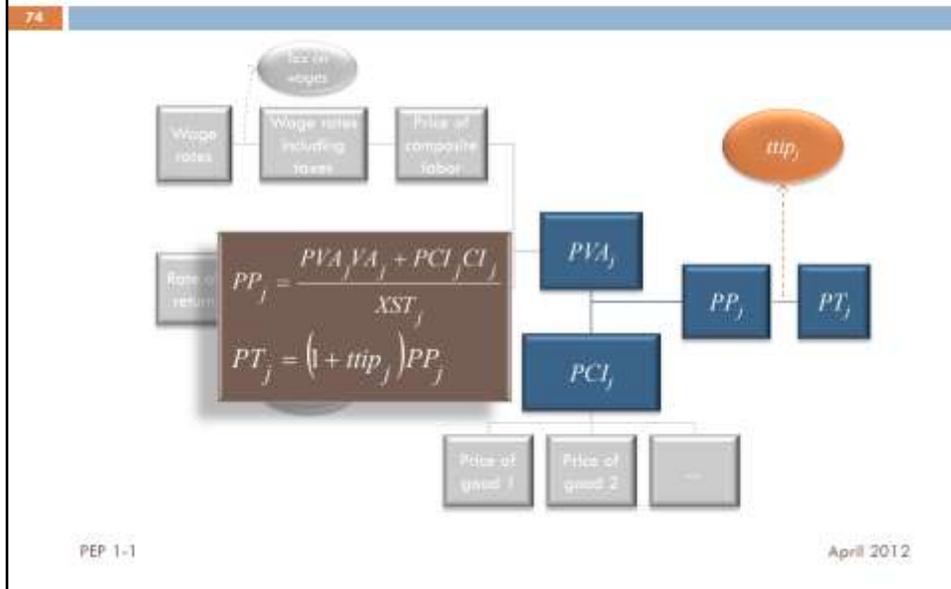
- The different prices and price indexes naturally depend on the hypotheses and functional forms already stated.
- In aggregations, the price of an aggregate is a weighted sum of the prices of its components. The weights are determined by equating the value of the aggregate to the sum of the values of 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



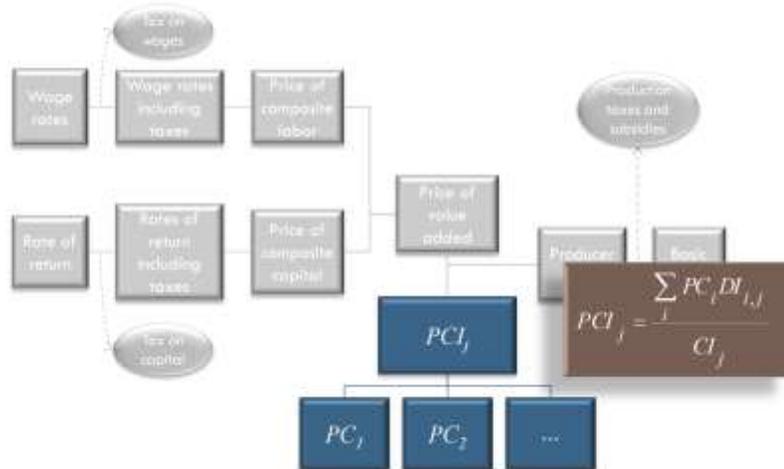
PEP 1-1

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- 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)

77

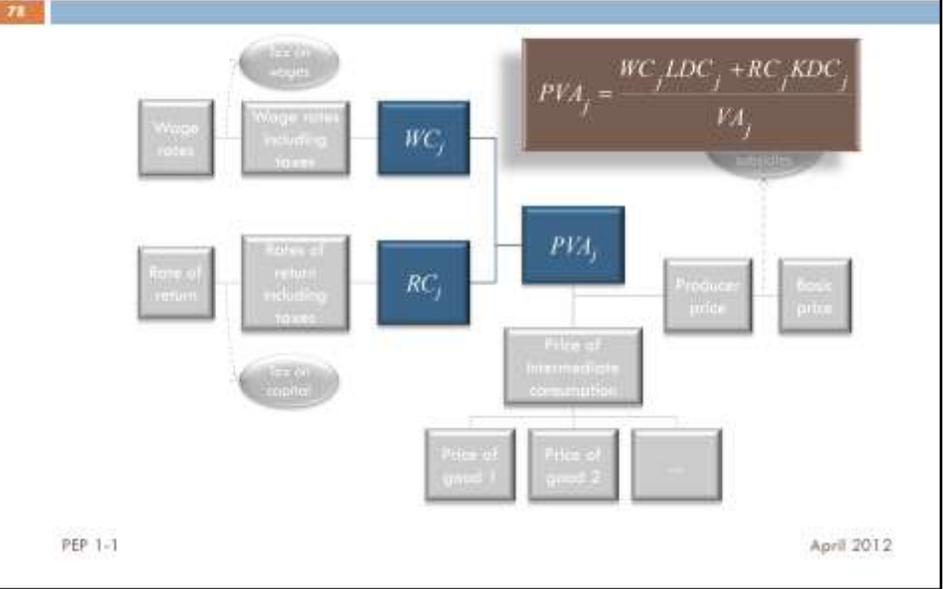


PEP 1-1

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- 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)

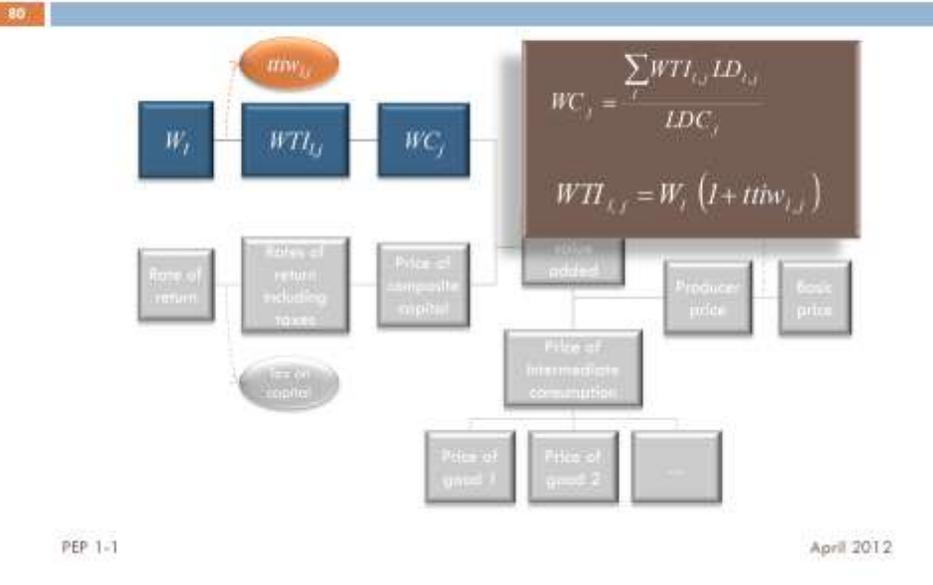
79



PEP 1-1

April 2012

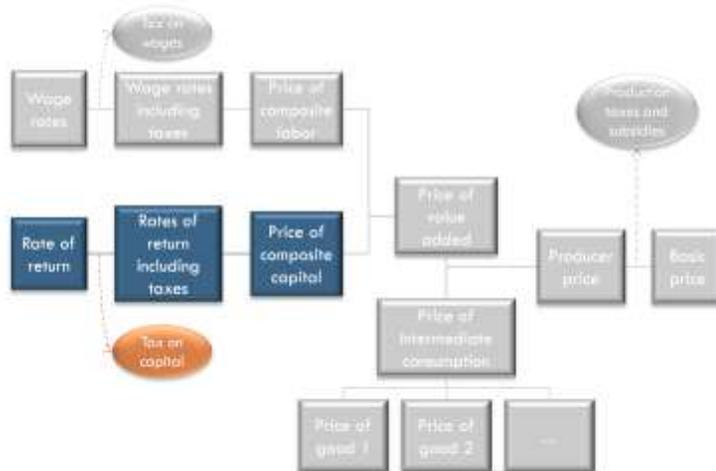
Producer prices (cont'd)



- 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)

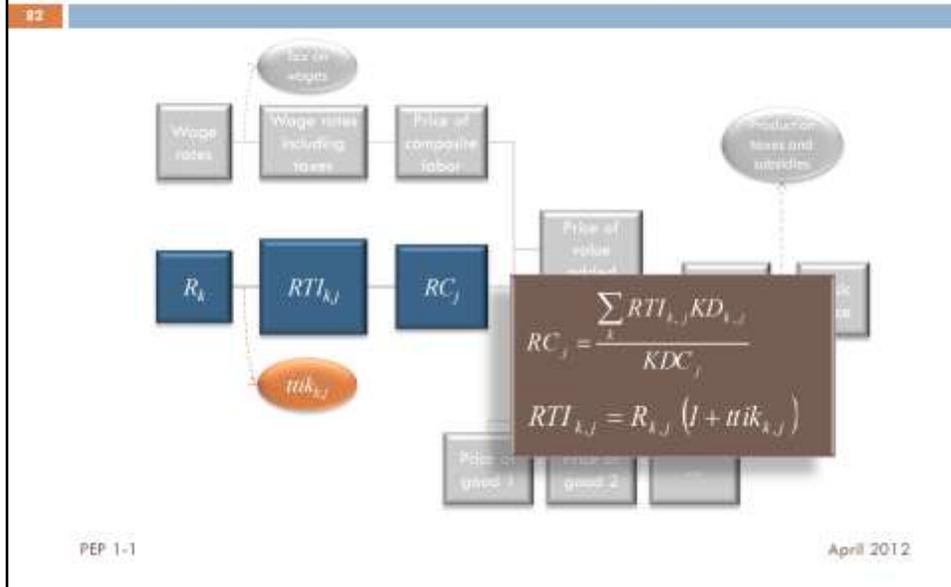
81



PEP 1-1

April 2012

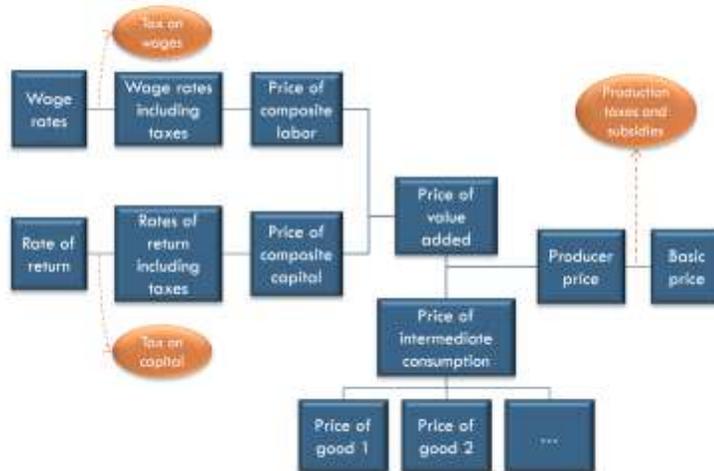
Producer prices (cont'd)



- In the same way, the price of an industry's composite capital is a weighted sum of the rental rates of the different types of capital used by that industry.
- The rental rate of capital paid by industry differ from the one received by capital owners by the amount of capital taxes.

International trade

83

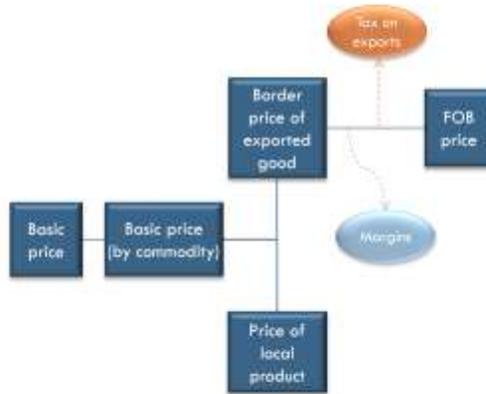


PEP 1-1

April 2012

International trade

84

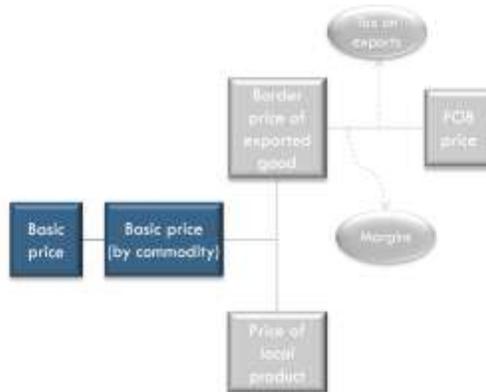


PEP 1-1

April 2012

International trade (cont'd)

85



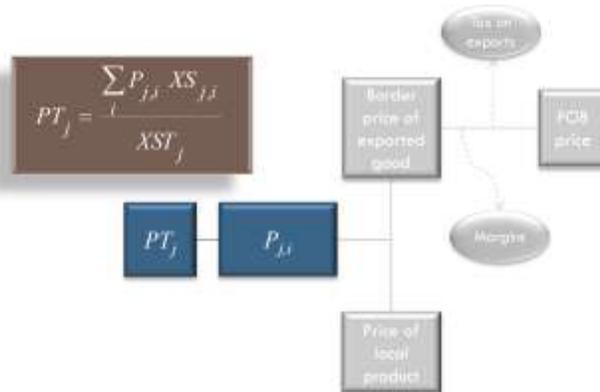
PEP 1-1

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



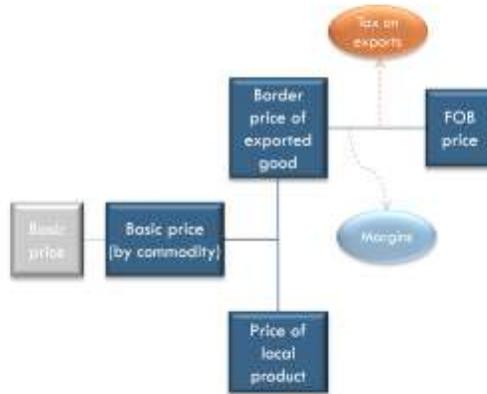
PEP 1-1

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- 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



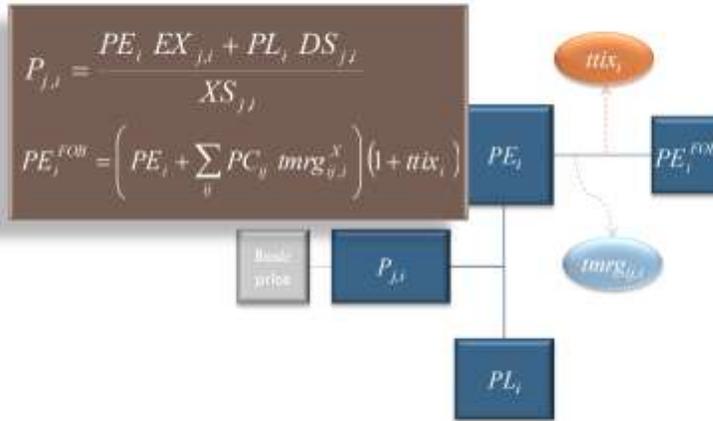
PEP 1-1

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

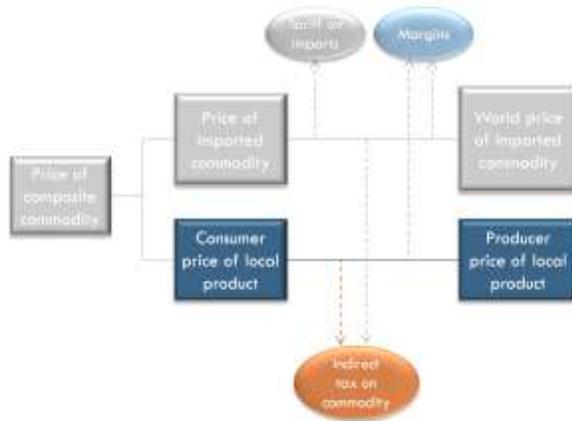


PEP 1-1

April 2012

Consumer prices (cont'd)

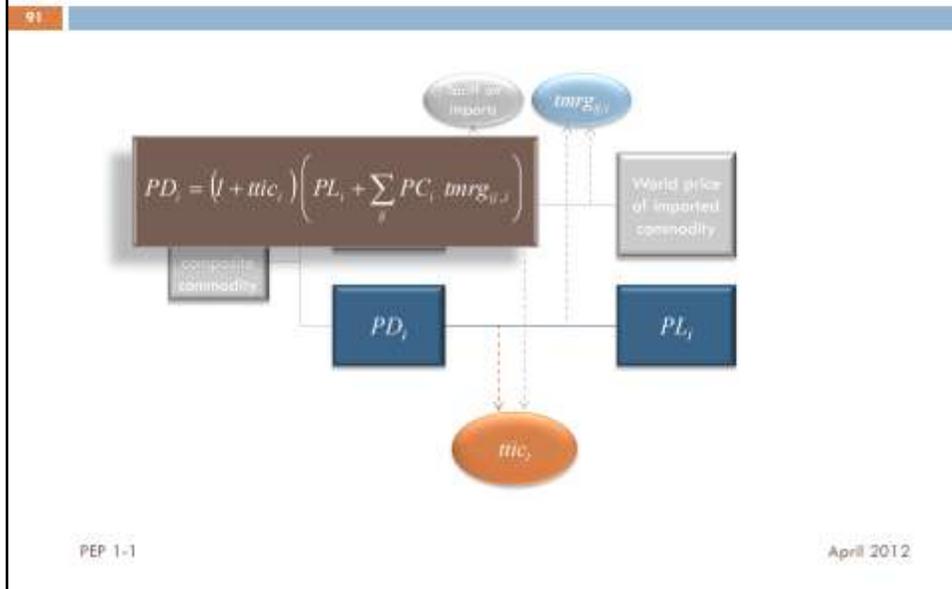
90



PEP 1-1

April 2012

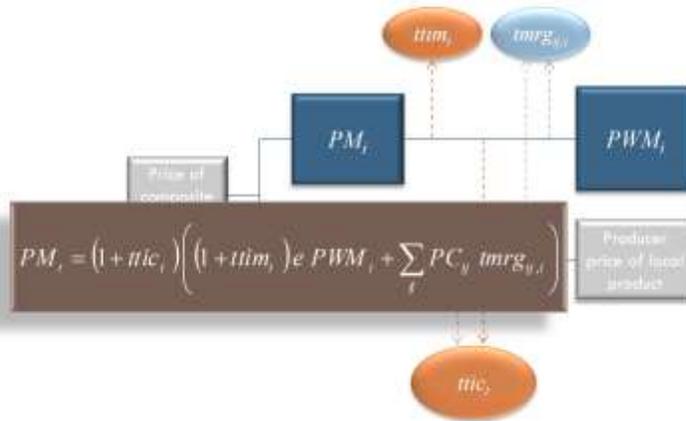
Consumer prices (cont'd)



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

Consumer prices (cont'd)

92



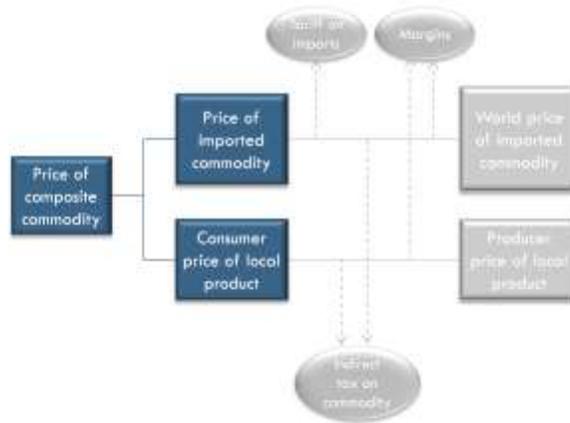
PEP 1-1

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



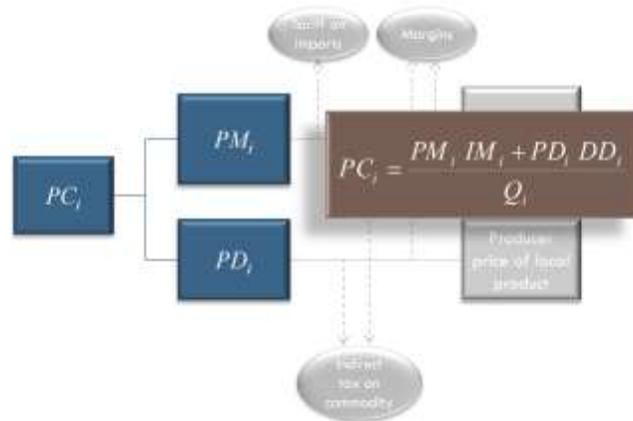
PEP 1-1

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- 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

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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**

- $Q_i = \sum_b C_{i,b} + CG_i + INV_i + VSTK_i + DIT_i + MRGN_i$

- **Labor market**

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

- **Capital market**

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

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

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- 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.

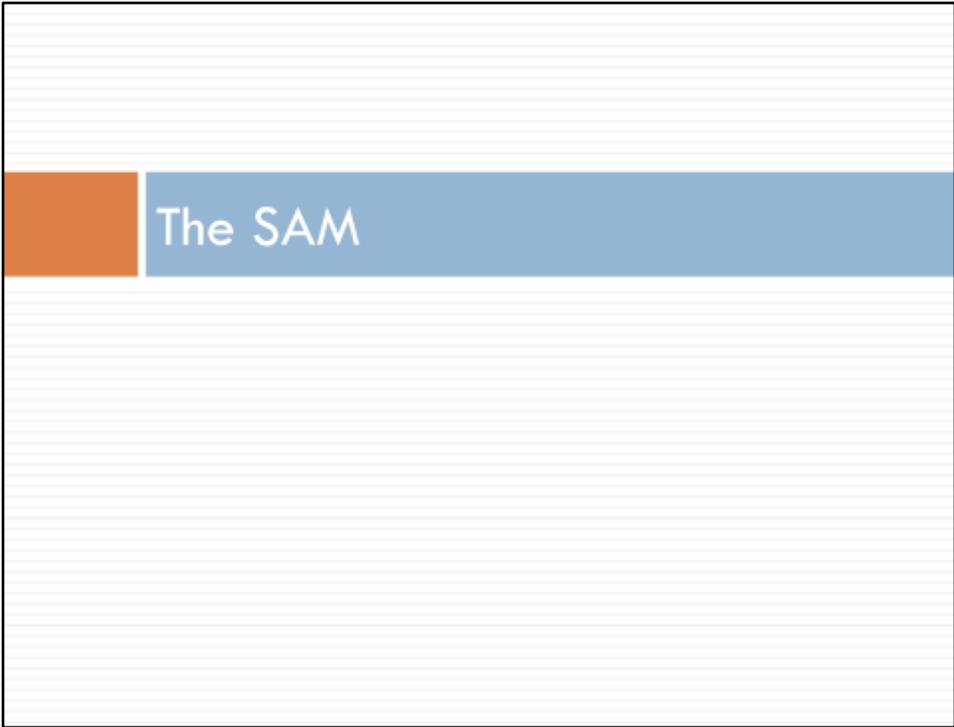


Closures

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

109

		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-shaded 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

The model SAM

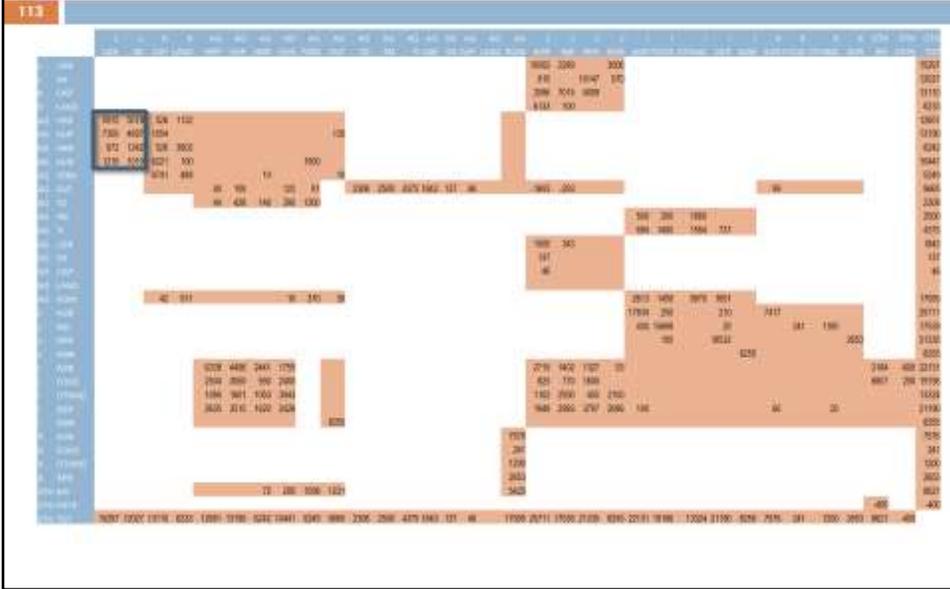
The image shows a large, square matrix representing the Social Accounting Matrix (SAM) for a model. The matrix is composed of numerous rows and columns, each representing a different account. The accounts are listed along the top and left sides of the matrix. The matrix is divided into several distinct blocks of data, with some cells highlighted in orange. The overall structure is a grid with rows and columns representing different economic accounts.

- 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

$$\sum_{i,j} W_{i,j} \left(W_i \sum_j L_{i,j} \right)$$

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

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	GVT		
AG	ROW	42	911

Type K capital income received by agent AG

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

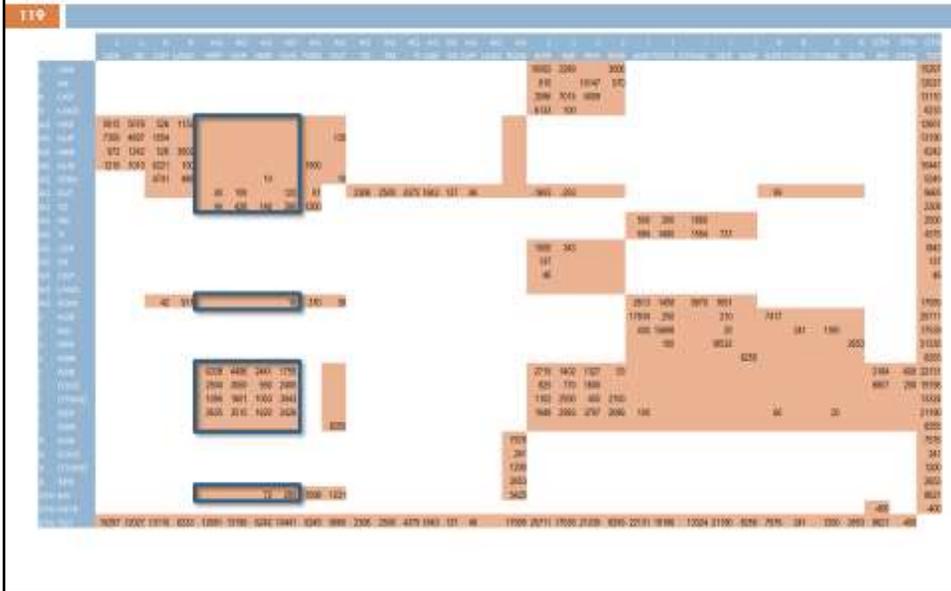
PEP 1-1 April 2012

- 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	2935	3515	1620	2426
I	ADM				
OTH	INV			72	296

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	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	2935	3515	1620	2426
I	ADM				
OTH	INV			72	396

Transfers from household
H to agent AG

$$\rightarrow TR_{ag,h}$$

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	HRR	HUR
AG	HRP				
AG	HUP				
AG	HRR				
AG	HUR				
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	2935	3515	1620	2426
I	ADM				
OTH	INV			72	296

PEP 1-1

Income taxes paid by household H

→ TDH_h

April 2012

- They pay income taxes.

Households – consumption

123

		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	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	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	2935	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

127

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

PEP 1-1

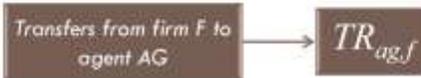
April 2012

- 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	1588



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	1302
AG	BOW	370
OTH	INV	1588



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	BOW	370
OTH	INV	1598



PEP 1-1

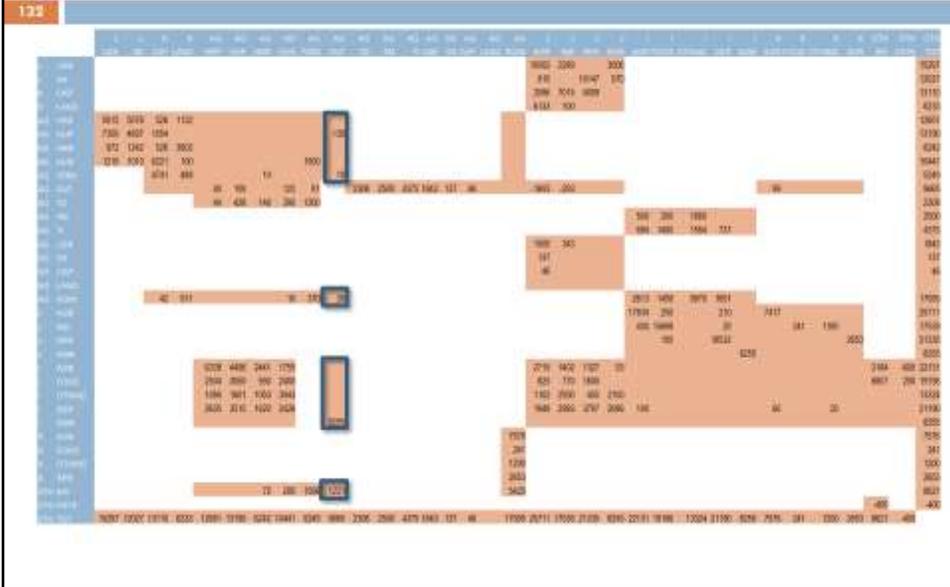
April 2012

- And they save.



Government accounts

Government accounts



Government

133

		AG
		GVT
AG	HRF	
AG	HUP	129
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	20
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

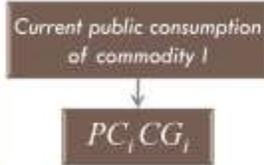
April 2012

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

Government – consumption

135

		AG
		GVT
AG	HRF	
AG	HUP	129
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	129
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.

Government – taxes

138

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

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	-46	

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	-46	

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	-46	

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

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
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

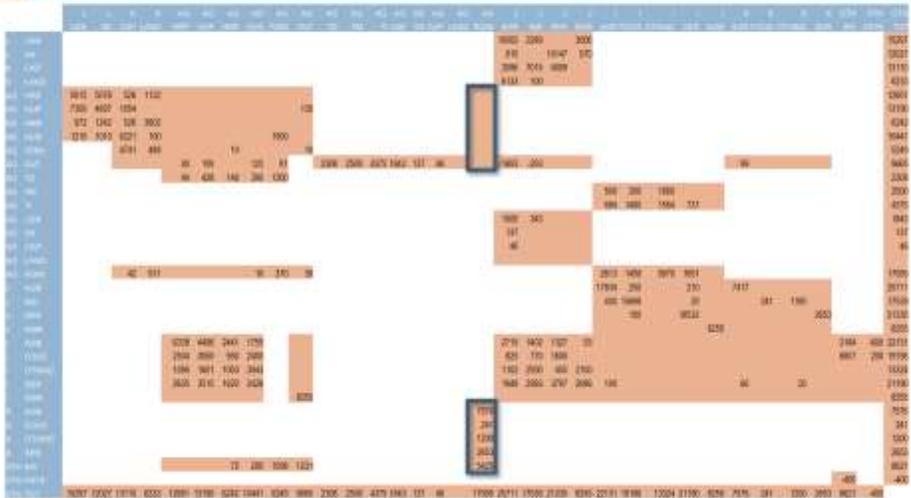
- The sum of each capital tax row appears as an income for the government (intersection of row *AG.GVT* and columns *AG.CAP* and *AG.LAND*).



Rest of the world accounts

Rest of the world

145



Rest of the world – expenditures

146

		AG
		ROW
AG	HRF	
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	HRF	
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 l
(including taxes and margins)

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

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	HRF	
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

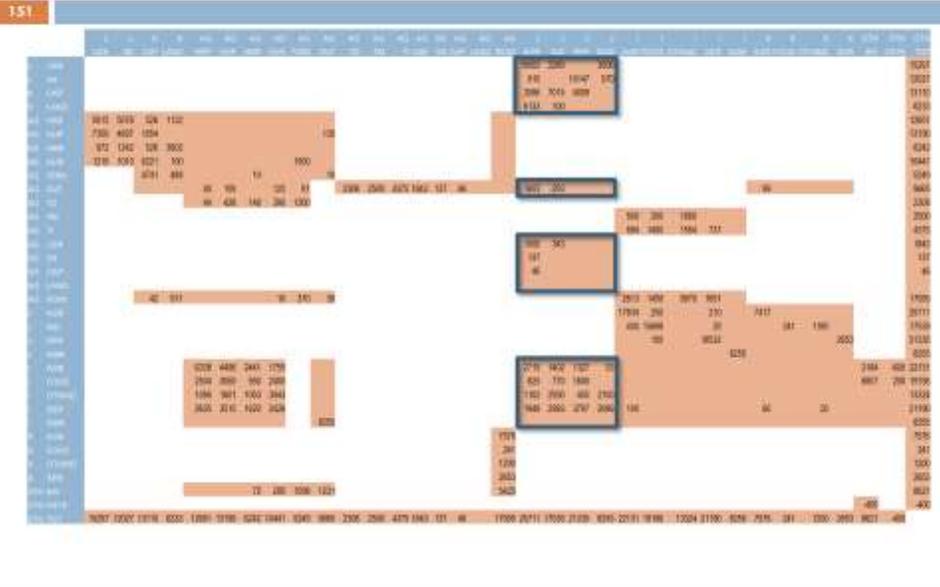
April 2012

- 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

133

		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	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3757	2085
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	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2086
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

154

		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	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2086
I	ADM				

Remuneration of type K capital paid by industry J

$$R_{k,j} K D_{k,j}$$

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	46			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3757	2085
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	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2085
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

137

		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	48			
AG	LAND				
I	AGR	2715	1403	1327	93
I	FOOD	625	770	1600	
I	OTHIND	1102	2930	455	2100
I	SER	1948	2983	3797	2086
I	ADM				

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

TIK_{kj}

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

		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	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

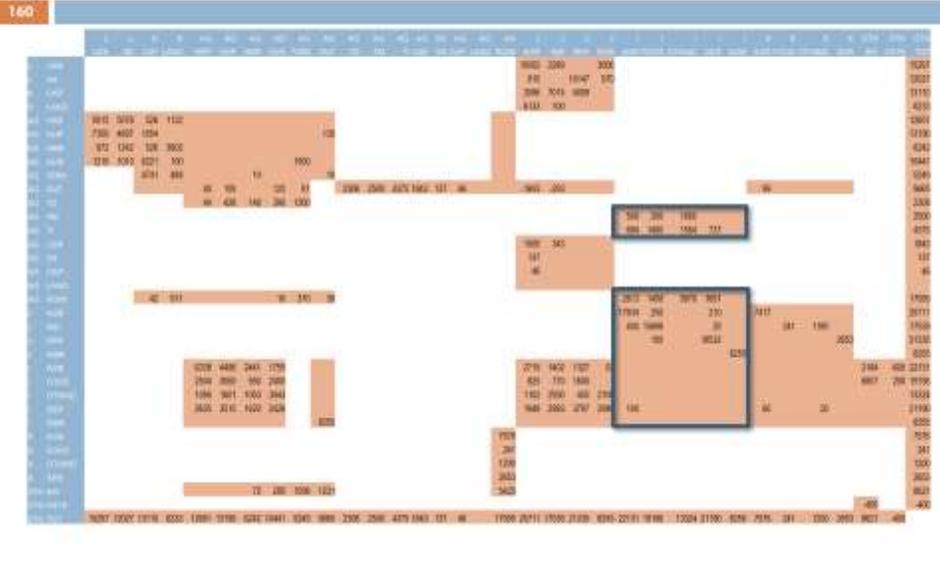
April 2012

- 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
		AGR	FOOD	OTHIND	SER	ADM
AG	TM	500	200	1800		
AG	TI	684	1400	1554	737	
AG	ROW	2813	1458	2970	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	2970	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	664	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	1498	9970	1691	
J	AGR	17834	250		210	
J	IND	400	16698		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	2970	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*

↓

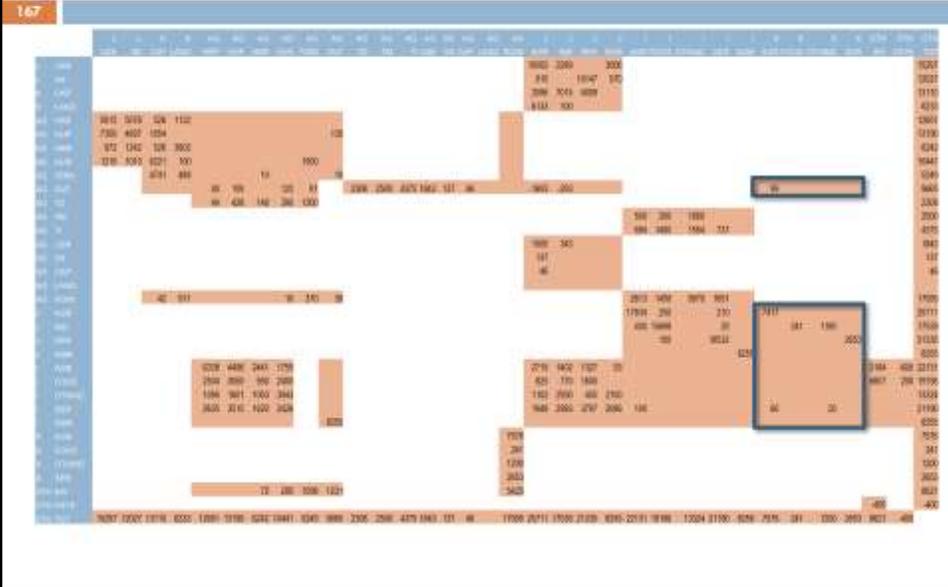
$$PC_{i,i} \text{ mrg}_{i,i} (DD_i + IM_i)$$

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

		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				

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 T

TIX_j

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	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				

Purchases of commodity IJ as margins on exports of exports I

$$PC_{ij} \text{ mrg}_{ij}^X \text{ EXD}_i$$

PEP-1-1

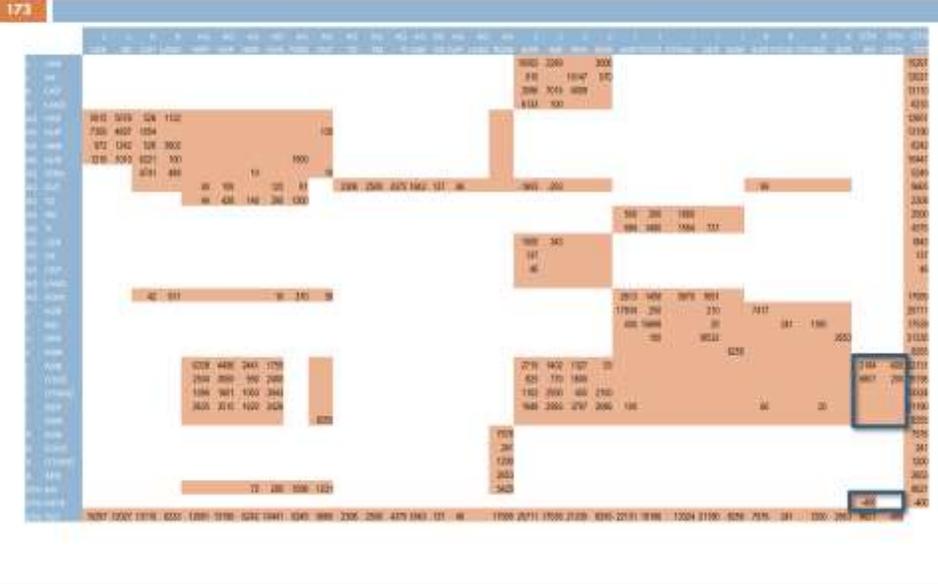
April 2012

- 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

Accumulation accounts



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)

↓

$PC_l INV_{i,j}$

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

$\sum_j PC_j VSTK_j$

PEP 1-1

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- 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

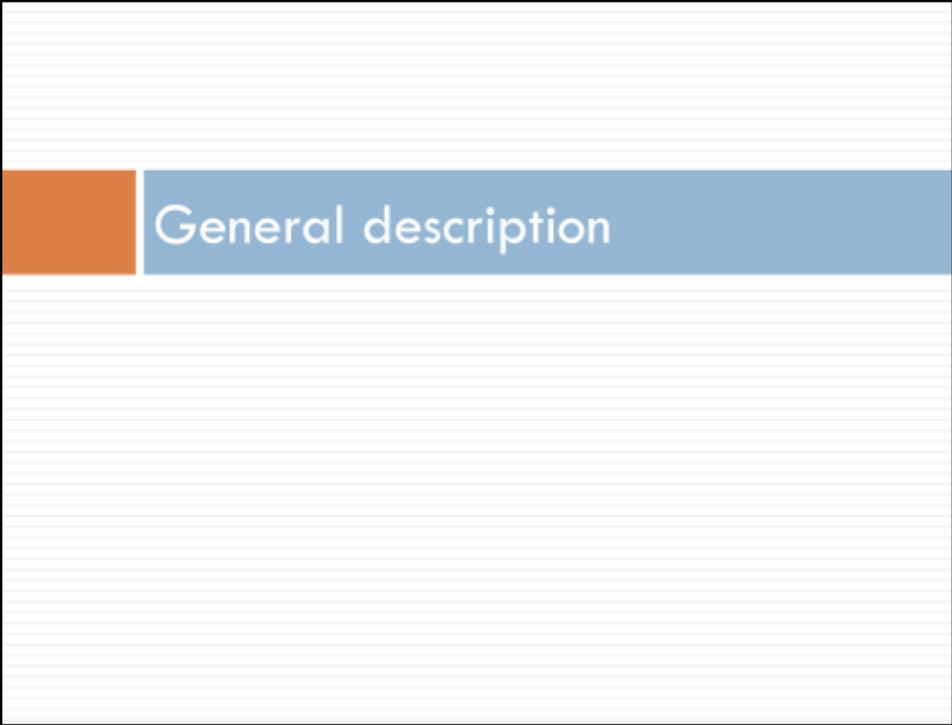
The GAMS code

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

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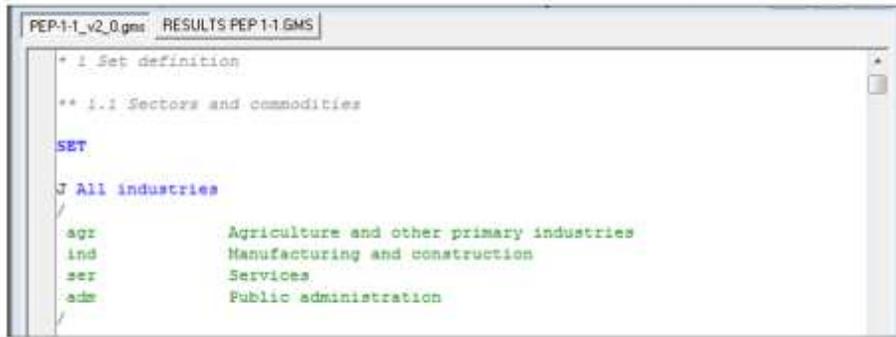
- It is important to note that this document is intended to users who have some experience with CGE modeling and GAMS. It is by no means a tutorial for the software; GAMS offers a user guide to which the reader can refer if required.
- Also, in order to minimize the changes to be made in the code, all 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



```
PEP-1-1_v2_0.gms RESULTS PEP-1-1.GMS
* 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
/

Ii(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

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- 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)

188

```
H (AG) Households
/
hxp      Poor rural households
hup      Poor urban households
hxr      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

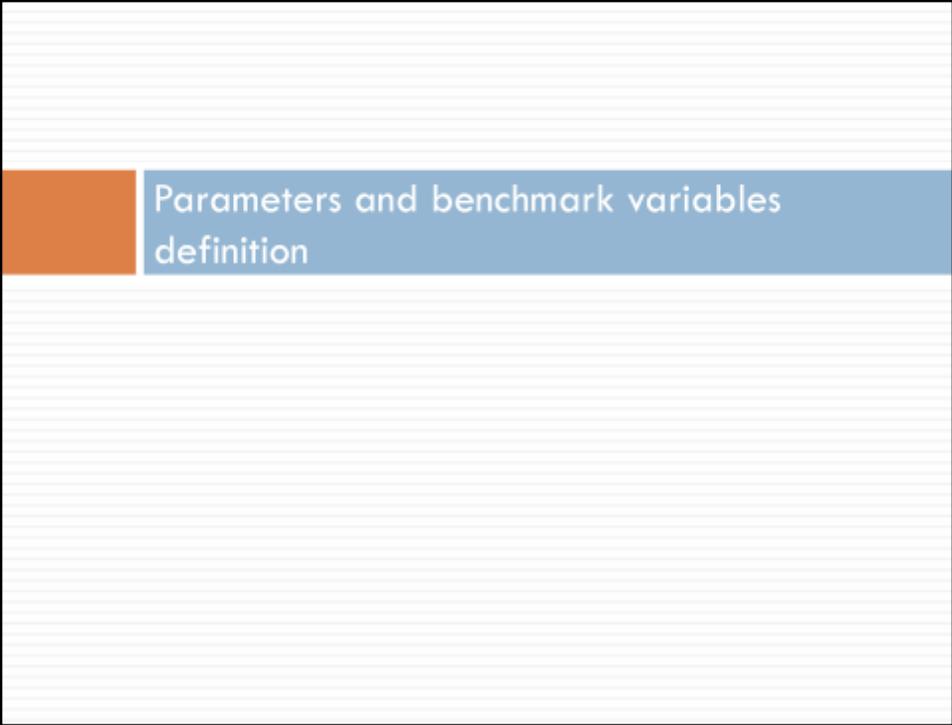
189

```
ALIAS (j, jj)
ALIAS (l, ll)
ALIAS (eg, egg)
ALIAS (h, hj)
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

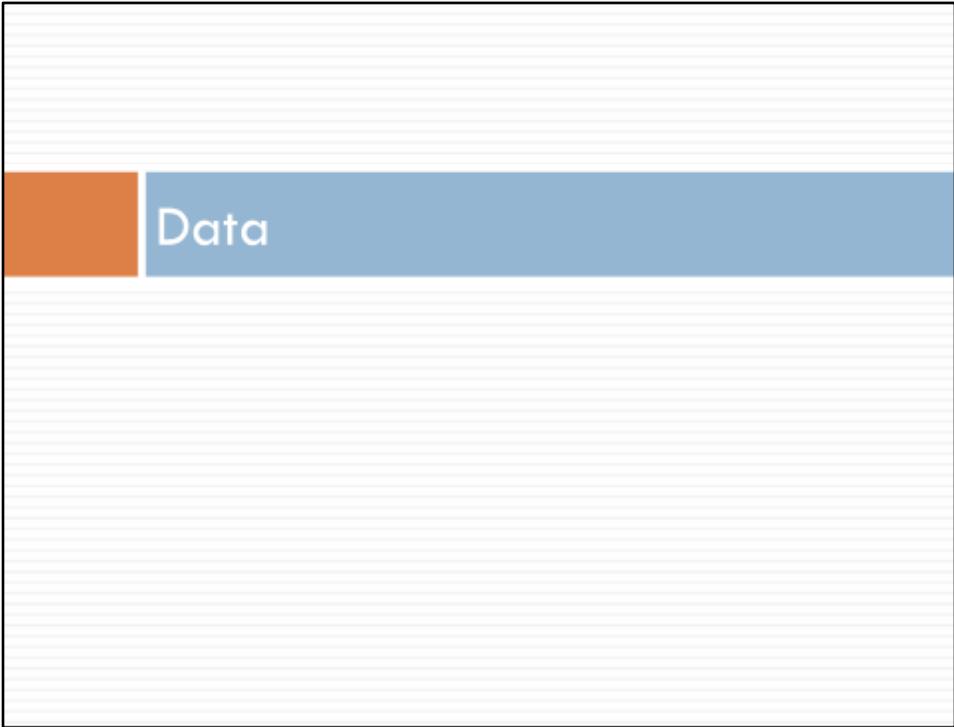
191

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

PEP 1-1

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- 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  
$GDXXIN file_name.gdx
```

□ Example:

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

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_RD(j)  = 0.8;
sigma_LD(j)  = 0.8;
sigma_M(i)   = 2;
sigma_VA(j)  = 1.5;
sigma_X(j,i) = 2;
sigma_XT(j)  = 2;

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

PEP 1-1

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- 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

```
== IES 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)

196

sh0 (h)	=	0:
te0 (h)	=	0:
tedf0 (F)	=	0:
tedh0 (h)	=	0:

e0	=	1:
PE0 (i)	=	1:
FEO (i)	=	1:
FNMO (i)	=	1:
MO (L)	=	1:
RKO (k)	=	1:

PEP 1-1

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- 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

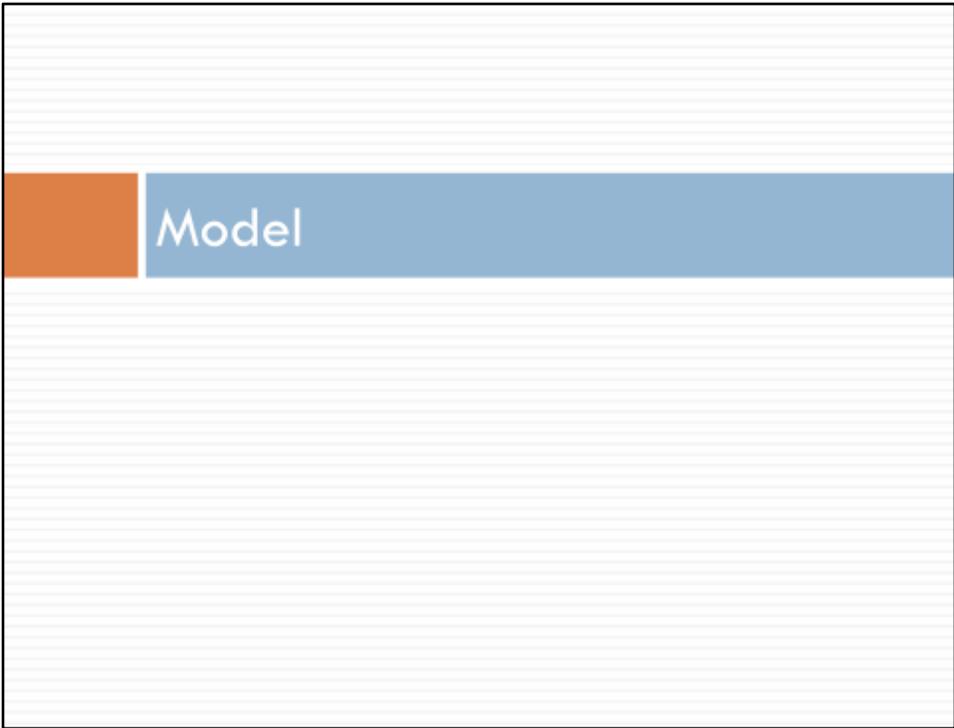
198

- 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')-HRGN('agr');
```

PEP 1-1

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- 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      = KSD(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

201

□ Exogenous variables:

```
e.fx      = 1;  
CAB.fx    = CABO;  
CHIN.fx(i,h) = CHINO(i,h);  
G.fx      = GO;  
IS.fx(1)  = ISO(1);  
FWM.fx(1) = FWMO(1);  
PWX.fx(i) = PWXO(i);  
VSTK.fx(1) = VSTKO(1);
```

PEP 1-1

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- 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;

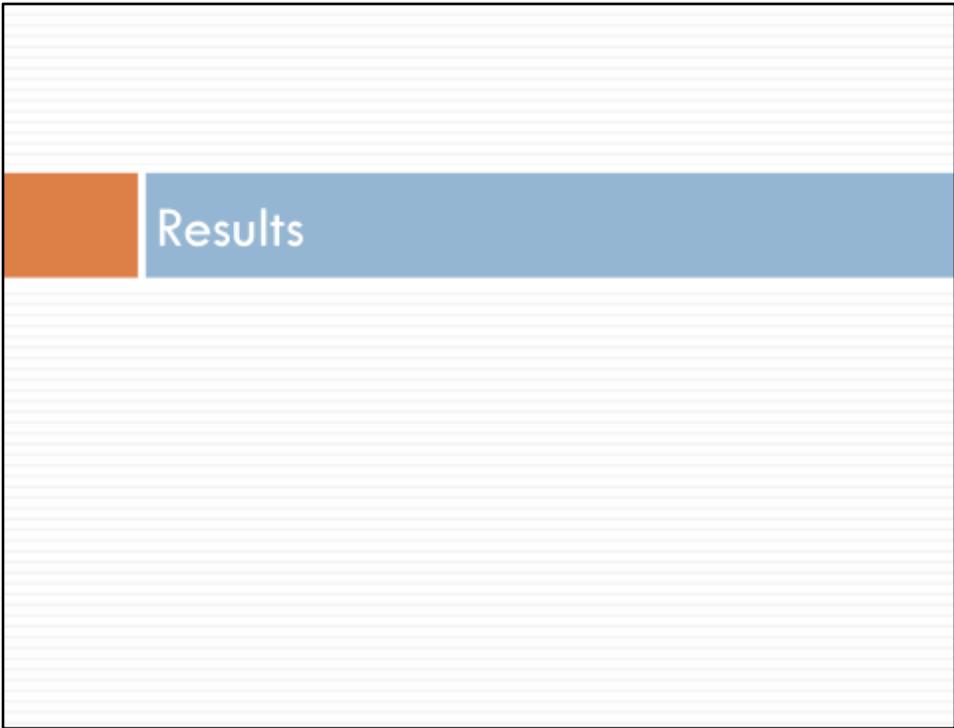
* 50% decrease of the indirect tax rates on all commodities
* ttax(i) = tbtax(i)*0.5;

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

PEP 1-1

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- 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

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- 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.