

TRADE ANALYSIS IMPACT TRAINING

CGE Models (May 8-9 2018) Beirut

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Plan of the presentation

- I. Introduction
- II. Steps in constructing a CGE model
 1. Relevant disaggregation of the economy
 2. Construction of a SAM
 3. Structure of CGE Models
 4. Functional forms and calibration
 5. Simulation

Introduction (1.Cont)

- CGE models are based on the socioeconomic structure of a SAM, with its multisectoral , multiclass disaggregation. They assume that agents decisions are price responsive and that markets reconcile supply and demand decisions.
- CGE models add to multimarket models some macroeconomic components such as investment and savings, balance of payments, and government budget.
- They are best chosen for policy analysis when the socioeconomic structure, prices and macroeconomic phenomena all prove important.
- The use of CGE models has started since the 1960's

Introduction (2)

- They have been used for several purposes and became the “toolkit” available for the economists to analyze various scenarios of economic instruments.
- Foreign shocks such as adverse changes in the terms of trade (for example an increase in the price of imported oil or a decline in the price of the country’s main exports). Because foreign exchange is a scarce resource in many developing countries, the subject of foreign shocks and its impacts on the whole economy has played a central role in the empirical work.
- Changes in economic policies: taxes (VAT in Syria for example!) and subsidies are the most commonly analyzed policy instruments, particularly in the trade sector.
- CGE models were also used to analyze the impacts of global phenomenon's such as: reheating of the planet, VIH and trade liberalization

1. Relevant disaggregation of the economy (1 Cont.)

- Choice of the level of aggregation for an applied model is one of the more difficult design issues that any prospective modeler must confront.
- There is a natural desire to make the model as detailed as possible in the belief that this will increase its realism.
- On the other hand, more detail is not always beneficial, much of it may prove superfluous to the issues at hand.
- Excessive detail can be costly in terms of data gathering, and large dimension models can be difficult to solve and time consuming.

1. Relevant disaggregation of the economy (2)

In practice three considerations enter the choice of aggregation level in applied models

- The need to accurately capture the main features involved in the policy issues under discussion
- The limits of data availability
- The need to constrain computer costs by using a model structure that can be manipulated with relative ease.

2. The construction of a SAM (1 Cont.)

The construction of a SAM will be developed in the next presentation

2. The construction of a SAM (2)

- Once the SAM constructed, the main assumption made in CGE modeling is that the observed data are not obtained by chance, they are the result of an optimization process made by all the agents.

Hence, the accounting equilibrium corresponds to an economic equilibrium.

- This leads to the determination of this optimization process, which constitutes the specification of the model.
- The SAM includes values (price*quantity) and the usual assumption made is that in the base year, all prices are equal to unity. The model is solved in terms of relative prices according to a chosen numéraire (for example, consumer price index or producer price index)

3. Structure of CGE models (1 Cont.)

A CGE can be described by specifying the agents and their behavior, the rules that bring the different markets in equilibrium, and the macroeconomic characteristics.

To accomplish the specification of the CGE model, one needs to understand truly the structure of the economy by addressing five main aspects:

- How do goods and factors flow through the economy?
- In each sector, how does production take place?
- In each industry, how does the market structure look like?
- At the consumer level, how does consumption take place?
- Who owns which factors of production and firms?

3. Structure of CGE models (2 Cont.)

- Market equilibrium:

In a CGE, all the accounts are endogenous and thus must be in equilibrium.

- Producers sell their total production, factors distribute their income, households spend their income, and investment is determined by the available savings. The government budget is usually balanced by letting its savings (deficit) residually computed.

- For the other accounts, there needs to be a reconciliation between the independent supply and demand decisions.

- The standard rules in the markets is price flexibility and endogenous determination of the equilibrium prices: commodity prices, factor prices, and exchange rate.

3. Structure of CGE models (3 Cont.)

- Macroeconomic constraints

There are four macroeconomic components in a CGE:

- The government budget has to be balanced: In CGE's, unlike sectoral models the budgetary consequences of all policies are fully accounted. For example, trade liberalization can not be implemented without raising other taxes, decreasing government expenditures etc. The chosen rule to balance the government budget affects the results of the model.

- Regarding the balance of payment, in most cases it is constrained to an external level of deficit and any change, in the level of borrowing or the trade conditions will affect the whole economy through the change of the real exchange rate.

- The saving investment balance plays small role in most CGE's: In static models, variations of the investment level subsequent to changes in savings have few consequences as they only affect the level of demand.

3. Structure of CGE models (4 Cont.)

- The last important macroeconomic feature is related to the supply of primary factors of production:
 - In most models, capital is considered fixed and fully utilized in every sector. Labor or certain categories of labor are considered mobile across sectors.
 - These assumptions define the horizon of analysis: if long term, all factors are mobile and if short term, factors are fixed.
 - Whether or not there is full employment of these factors affects strongly the obtained results after a policy shock.

3. Structure of CGE models (5 Cont.)

Choosing the functional forms

- The major constraints in applied models is that the functional forms have to be consistent with the theoretical approach (well behaved).
- A functional form is well behaved means: non negative, non decreasing, continuous and quasi-concave in each point. Furthermore, for the demand functions, they have to be homogenous of degree zero and result in a system of demand in conformity with the Walras law.
- This explains why in CGE models, the most used forms are: Cobb-Douglas, CES, CET and LES.

3. Structure of CGE models (6 Cont.)

The C-D function in the case of the consumer theory

- With a Cobb-Douglas utility function, the consumer's demand is obtained as the solution of the following maximization program:

$$\begin{aligned} \text{Max } U &= \prod C_i^{\alpha_i} \\ \text{s.t. } \sum_i P_i \cdot C_i &= R \quad \text{and} \quad \sum_i \alpha_i = 1 \end{aligned}$$

$$C_i = \frac{\alpha_i \cdot R}{P_i}$$

The demand of each commodity i reads:

- Main characteristics: Price and income elasticities, as well as the elasticity of substitution between each pair of goods, are all equal to one whereas the cross price elasticity is nil.
- Despite these strong assumptions, many authors resort to the C-D function given that it can be easily calibrated and don't require outside estimated of the free parameters.

3. Structure of CGE models (7 Cont.)

- With a Cobb-Douglas utility function, the only unknown parameter is the budgetary share of the consumption of each commodity in overall consumption.
- Considering the income, consumption and prices provided by the SAM, the computation of the share of each good in overall consumption income (total expenditures) is a simple inversion of the demand equations.

$$\alpha_i = \frac{C_i \cdot P_i}{R}$$

- However, such restrictions are never observed in empirical estimates. In order to relax some of these restrictions, one may choose some more flexible functional forms.

3. Structure of CGE models (8 Cont.)

The CES function in the case of the consumer theory

The program of the consumer can be written as follows:

$$\max U = [b_1 q_1^{-\rho} + b_2 q_2^{-\rho}]^{-1/\rho} = \left[b_1 q_1^{\frac{\sigma-1}{\sigma}} + b_2 q_2^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$
$$s.t R = p_1 q_1 + p_2 q_2$$

With $\sigma = \frac{1}{1+\rho}$ and

$$\sigma = \frac{\partial \ln(X_i / X_j)}{\partial \ln(P_j / P_i)}$$

If $\sigma = 0$, then the products are said perfect complements and if $\sigma = \text{infinity}$, then the products are said perfect substitutes. If between these two values, the products are imperfect substitutes.

The resulting demand functions can be written as follows

$$q_1 = \frac{b_1^\sigma p_1^{-\sigma} R}{[b_1^\sigma p_1^{1-\sigma} + b_2^\sigma p_2^{1-\sigma}]}$$

$$q_2 = \frac{b_2^\sigma p_2^{-\sigma} R}{[b_1^\sigma p_1^{1-\sigma} + b_2^\sigma p_2^{1-\sigma}]}$$

3. Structure of CGE models (9 Cont.)

- The CES function avoids the unit price elasticity constraint imposed by the C-D function, has a unitary income elasticity as in the C-D case and implies a constant elasticity of substitution between each two commodities.
- The CES function is the most commonly used function for modeling international trade in CGE models
- Two parameters are to be calibrated: the share parameters and the elasticity of substitution. All the other information is provided by the SAM.
- In the practice, we introduce exogenously the elasticity of substitution from econometric studies if possible, or from other studies on countries similar in terms of characteristics.
- Once the elasticity of substitution is available, the share parameter can be deduced straightforward.

3. Structure of CGE models (10 Cont.)

The treatment of international trade in CGE modeling

- In CGEs, foreign and domestic commodities are treated as imperfect substitutes with geographical differentiation that is Armington assumption
- The determination of exports and imports depends on the relative prices
- Total domestic demand is a CES function and the domestic production is a CET function.
- The import demand and the export supply are derived with an optimization process

3. Structure of CGE models (11 Cont.)

If Q is the total domestic demand, the Armington assumption can be written as follows:

The consumer minimizes the cost of a composite product:

$$PQ \times Q = PD \times QD + PM \times M$$

s.t the Armington function

$$Q = A \left[\alpha \cdot M^{-\rho} + (1 - \alpha) \cdot D^{-\rho} \right]^{\frac{-1}{\rho}}$$

We obtain the relative demand for imported versus local goods as a function of their relative prices:

$$\frac{M}{D} = \left[\frac{PD \cdot \alpha}{PM \cdot (1 - \alpha)} \right]^{\sigma}$$

3. Structure of CGE models (12)

Similarly, the export supply may be represented, depending on the destination, by a constant elasticity of transformation CET:

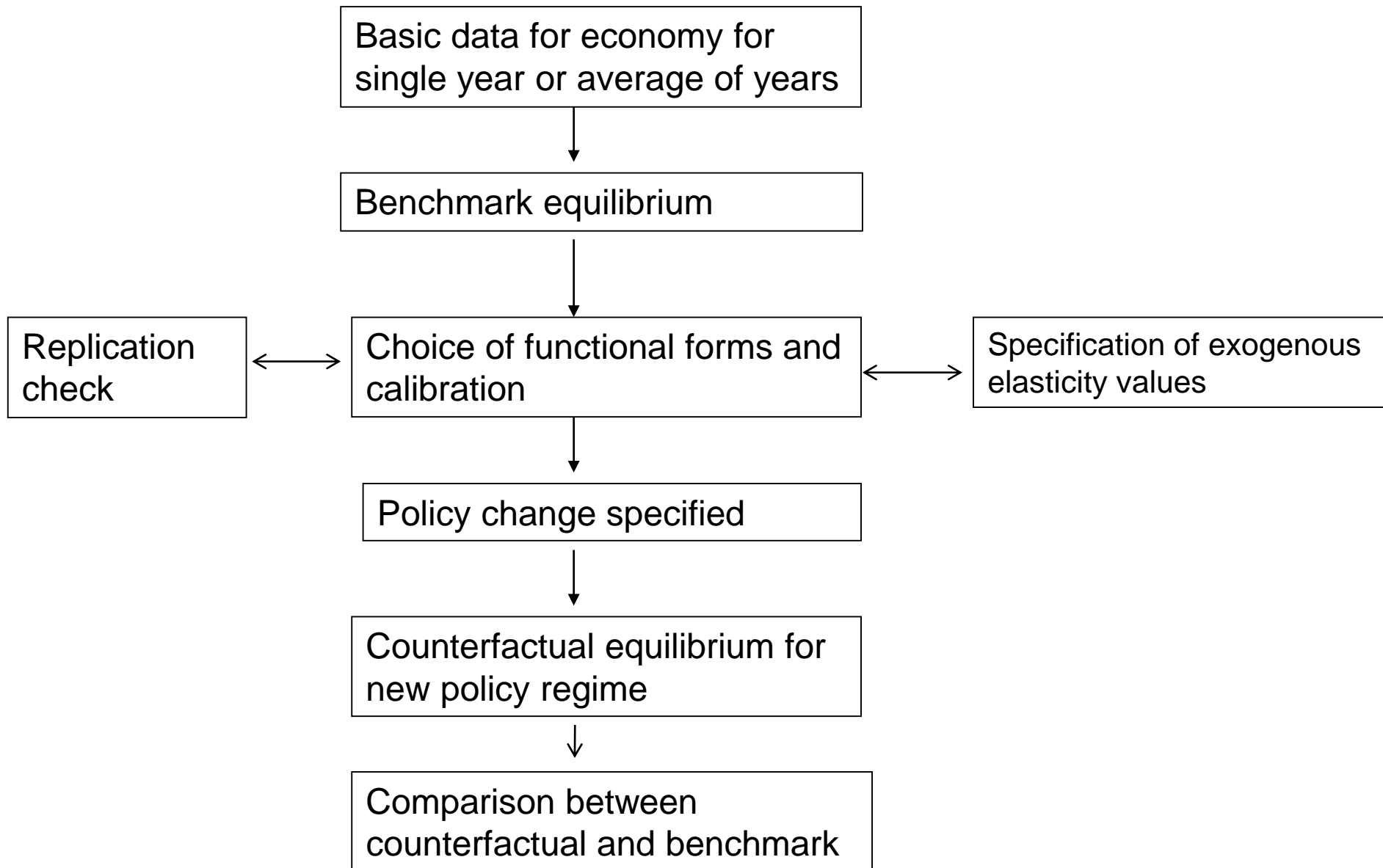
$$X = B. \left[\alpha.E^{-\rho} + (1 - \alpha)D^{-\rho} \right]^{\frac{-1}{\rho}}$$

Export supply resulting from the maximization of profits to the producers reads as follows:

$$\frac{D}{E} = \left[\frac{PE.(1 - \alpha)}{PD.\alpha} \right]^{\sigma T}$$

The elasticity of transformation reflects the ease with which it is possible to shift the composition of sectoral production between domestic and foreign markets.

Model use in typical applied GE model



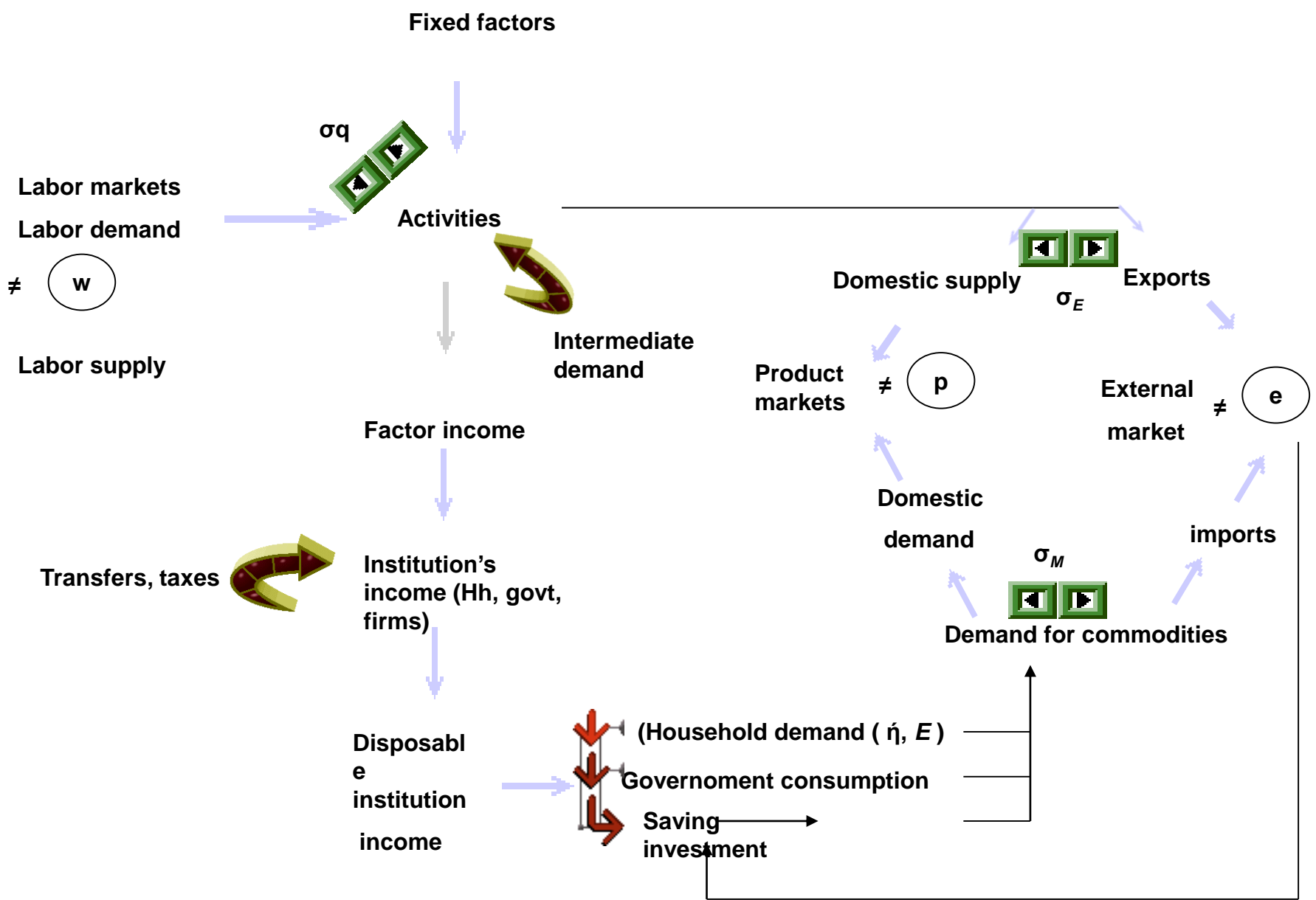


Figure: CGE flow chart (Sadoulet and Dejanvry, 1995)

Different kinds of CGE models (1 Cont.)

- Differences across models reflect differences in the theory behind the behavioral equations, the extent to which linkages within the economy are explained, and the data used to conduct the analysis.
- In the empirical literature, we distinguish a variety of CGE models: Static versus dynamic, single country, regional and global CGE

Static versus dynamic CGE models:

- In their static form, the impact of a policy reform such as a tariff reduction is assessed by comparing equilibrium properties before and after that reform. In other words, Static CGE models don't reveal the path of the economy from the benchmark equilibrium to the new equilibrium when a shock enters.

Different kinds of CGE models (2 Cont.)

- The distinguishing feature of a dynamic CGE model, however, is that growth of output is possible and changes due to policy reforms can be tracked over a given period of time.

There are two types of Dynamic CGE models:

- Recursive dynamic CGE models

- They consist of multiple static models linked to each other sequentially.
- The underlined assumption is that current economic conditions are dependent on past outcomes but are unaffected by forward-looking expectations.
- Some of the variables in the model may evolve exogenously following a pre-determined baseline scenario (for example population demography, productivity)

Different kinds of CGE models (3 Cont.)

- Inter-temporal dynamic CGE models

- These models are based on optimal growth theory, where the behavior of economic agents is characterized by perfect foresight.
- The underlined assumption is that current economic conditions are dependent on past outcomes but are unaffected by forward-looking expectations.
- Households choose a consumption plan (a sequence of consumption decisions) during the period under consideration that maximizes the discounted stream of their utilities. This means that in some periods households may consume more than they earn (dissave), while in other periods they may consume less than they earn (save).
- Firms choose a production plan (a sequence of production decisions) that maximizes their discounted stream of profits.

Different kinds of CGE models (4 Cont.)

Single country CGE models

- The single country CGE models are the most used CGE type to tackle various issues of economic policies. This is because decision makers are generally interested on details and would like to have models as detailed as possible.
- This kind of model has been used extensively to analyze external sector issues as the impact of restrictions on foreign trade or the impact of changes in net foreign transfers or world prices on the equilibrium of the real exchange rate.
- The single country CGE model has also been used widely to explore the likely effects of trade liberalization. We can cite the examples of Tunisia-UE or Morocco-UE.
- The main drawback behind their use to treat trade issues is that they tend to overestimate the impacts on welfare.

Different kinds of CGE models (5 Cont.)

- The reason that underpins this overestimation is related to the modeling of trade in this kind of CGE models. Indeed, it is assumed that the partner of Tunisia or Morocco which is in this case Europe has an infinite demand function of imports. That is the restrictions imposed by Europe on Tunisian or Moroccan exports cannot be modeled explicitly. In this case, the modeler can only impose a weak value of the elasticity of transformation to express a difficulty of exporting to the EU.
- The impacts on welfare of trade associations between Tunisia or Morocco with the EU using Regional and global CGE models are quite modest compared to the single country CGE model because in these kind of models trade restrictions imposed by EU can be introduced explicitly.

Regional CGE models

- Regional trade CGE models add to the previous single country models the desire to examine the interactions or the impact on welfare between two or few number of countries or regions with the distinction of the Rest of the World as a big partner.

Different kinds of CGE models (6 Cont.)

- The rest of the world is still considered as a big residual partner and world prices are set exogenously
- Import demand and export supply are however endogenous.
- When the model is actually used, the within country and between country relationships are solved simultaneously.
- The model database consists of SAMs for each country, including data on their trade flows.
- The literature covers several regional trade CGE models implemented to tackle various issues. For example, Elbehri and Hertel (2004) have conducted a study focused on Morocco, where the effects of a preferential, bilateral liberalization process with the EU are assessed, then compared with those from a multilateral liberalization scenario for Morocco.

Different kinds of CGE models (7 Cont.)

- Ben Hammouda et al. (2007) estimate the impacts of the Tunisian, Moroccan and Egyptian bilateral agreements with the EU jointly in a regional CGE model using “MIRAGE”.
- The authors examine whether broadening the agreements’ coverage to include agriculture could mitigate the losses for North African economies. The answer is negative and none of the measures envisaged to reduce distortions in agriculture manages to yield positive welfare effects for North African economies

Global CGE models

- Typically a global CGE links all countries through a set of import and export demand. The interaction between them determines a new equilibrium for prices and quantities of goods in the world.

Different kinds of CGE models (8 Cont.)

- In this kind of CGE model, there are no exogenous commodities prices, since the model is global. Any price or quantity change in any country inside the model must generate changes in the overall world equilibrium, and a new equilibrium must be computed.
- In a single country CGE modeling, the small country assumption holds, that is world prices are supposed exogenous whereas in global CGE models, they are by definition endogenous
- A global approach has the unquestionable advantage of taking into account within the same theoretical structure the trade relationships of all countries or groups of countries in the world, such as the EU, the USA, China, India and Africa.
- Accordingly, it is very important to have a consistent economic global database that covers all parts of the world

Different kinds of CGE models (9 Cont.)

- GTAP has been created to satisfy this need. It is a global network of researchers who conduct quantitative analysis of international economic policy issues, especially trade policy.
- The latest version of the GTAP database, GTAP 9.0 is a large social account matrix (SAM). It contains complete bilateral trade information as well as transport and protection linkages among 170 countries or groups of countries and 57 sectors for the base years 2004, 2007 and 2011.
- The most used large- scale global CGE trade models are GTAP and MIRAGE. They have been constructed in order to assess the impact of globalization on the individual regions in the global economy.
- In 2015, a new global CGE trade model has been built by OECD known as METRO (Modelling TRade at the OECD)

Different kinds of CGE models (10 Cont.)

- The METRO database currently covers 61 economies across 57 economic sectors. It is based on the GTAP database and allows users to analyze global value chains (TiVA) by drawing on the OECD-WTO Trade in Value Added database.
- Using METRO, it is now possible to track trade flows by their use (intermediate, household, government and investment) in addition to the bilateral links between source and destination markets. This will greatly enhance the ability to model movements of goods and services, especially along global value chains.
- It is also possible to use this global CGE model to assess the impact of global free trade on the countries' welfare and the distribution of income across the regions.

Different kinds of CGE models (11)

- It's also important to highlight that a combination of a single country CGE and a global one can be done when the raised issues necessitate it.
- The interest in this kind of application is growing in recent years, and encompasses a wide range of theoretical as well as practical questions.
- The linkage between the global and the single CGE models can be useful for example when the first determines the new world prices following a given shock which can be transmitted to the single country CGE and feed backs are also possible.

Thank you for your attention...

