

SESSION 3

Theoretical Development of a Basic CGE model

An Introductory Overview
Source: Hans Lofgren course

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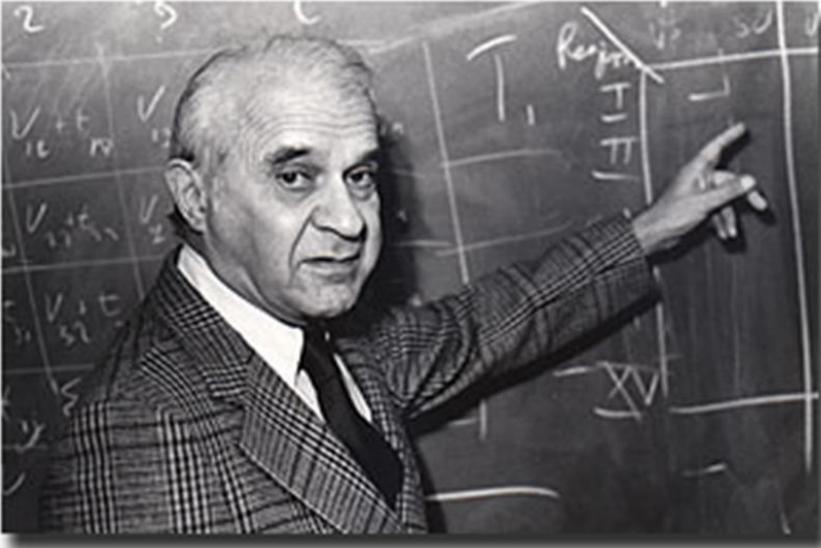
What is a CGE model?

- Computable → solvable numerically
- General → economy-wide (all production, consumption, investment, and trade that is covered by the national accounts)
- Equilibrium →
 - optimizing agents have found their best solutions subject to their budget constraints
 - quantities demanded = quantities supplied in factor and commodity markets
 - macroeconomic balance: receipts = spending for government, balance of payments, and savings-investment balance

What is a CGE model?

- Definition typically satisfied: an open-economy, economy-wide model with (a) flexible prices clearing most markets; (b) one or more production sectors and household groups; and (c) a government with policy tools (taxes, spending).
- Almost all models are “real” – only relative prices matter, not the general price level.
- The “economy” is typically a country but may be defined at other levels of aggregation: household, region within a country, a country, a continent
- Most models cover a single economy (region) but multi-region models also common (including global models).
- For a model with a commonly used structure, see Lofgren et al. (2002).

Brief history of CGE modeling



Key antecedents -- input-output and economy-wide linear programming models:

- Wassily Leontief – Nobel laureate and developer of input-output analysis.
- Hollis Chenery – WB chief economist, developer of two-gap models; made wide-ranging contributions to modeling.



Compared to CGE models, these antecedents were weak in terms of treatment of prices/markets, agent behavior, trade, and economic policy.

Brief history of CGE modeling



- 1st CGE model – a 22-sector model of Norway – developed by Leif Johansen in his doctoral dissertation, published in 1960 as “A Multi-Sectoral Study of Economic Growth”.

Brief history of CGE modeling

- 2nd wave of work started in 1970s with major early contributions from researchers at
 - Monash University, Australia (Peter Dixon et al.)
 - World Bank
- Major publications at the World Bank:
 - Irma Adelman and Sherman Robinson (1978) “Income Distribution Policy in Developing Countries: A Case Study of Korea.”
 - Lance Taylor and co-authors (1980) “Models of Growth and Distribution for Brazil.”
 - Kemal Dervis, Jaime de Melo, and Sherman Robinson (1982) “General Equilibrium Models for Development Policy.”

Brief history of CGE modeling

- Since mid-1970s, methods have been further developed and applied to most countries, both developed and developing.
- Major CGE modeling networks today:
 - GTAP, Purdue University (>7,500 members)
 - PEP Modeling and Policy Impact Analysis (MPIA) Program, Université Laval, Canada



What is a SAM?

- A SAM is
 - a comprehensive, economy-wide data framework.
 - a square matrix with identical row and column accounts where each cell shows payment (at current prices) from its column account to its row account.
 - used for descriptive purposes and as the key data input for CGE models (which explain SAM payments)
- “Social” → often focused on incomes and spending of households of different types.
- Disaggregation and classification of accounts vary widely across different SAMs.
- Column totals = row totals.
- First SAM developed for the UK in 1962 by Richard Stone, Nobel laureate for development of national income accounting.

Stylized SAM

Table. Stylized SAM

	ag	na	l	k	u	r	tot
ag					50	75	125
na					100	50	150
l	62	55					117
k	63	95					158
u			60	90			150
r			57	68			125
tot	125	150	117	158	150	125	

Table. Notation in SAM

Item	Explanation
ag	agricultural sector
na	non-agricultural sector
l	labor
k	capital
u	urban household
r	rural household

- Major account types in many applied SAMs:
 - Activities (carry out production)
 - Commodities (goods and services)
 - produced and/or imported
 - sold domestically and/or exported
 - Factors (labor, capital, natural resources)
 - Domestic non-government institutions: households, enterprises
 - Other institutions: government, rest of world
- Methods have been developed for SAM construction and estimation (Robinson et al. 2001; Round 2003).

Figure. SAM Structure

	Expenditures					
Receipts	Activities	Commodities	Factors	Domestic Institutions	Rest of World	Totals
Activities		Market sales		Home consumption		Activity income
Commodities	Intermediate inputs	Transactions costs		Final market demands	Exports	Commodity demand
Factors	Value added				Transfers	Factor income
Domestic Institutions	Taxes	Tariffs, Taxes	Income, Taxes	Transfers, Taxes, Savings	Transfers, Savings	Institution income
Rest of World		Imports				Foreign exchange outflow
Totals	Activity spending	Commodity supply	Factor spending	Institution spending	Foreign exchange inflow	

Data beyond the SAM

- In addition to a SAM, the core data for CGE models often include:
 - elasticities (trade, consumption, and production)
 - labor employment by sector
 - stocks (factors; foreign and domestic debts)
- Non-practitioners may not always be able to see
 - that all data pieces are not equally important
 - in a consistent system with market and budget constraints (like a CGE model), qualitative insights tend to be insensitive to many elasticities

BUT important to test sensitivity of results to changes in parameter values (including elasticities).

Structure of a country CGE model

- Model written as a set of simultaneous equations.
- Many equations represent first-order conditions to producer and consumer optimization problems; others cover
 - (a) payments from factors to institutions and between institutions
 - (b) Definitions
 - (c) budget constraints
 - (d) market equilibrium conditions.

- How is the model related to the SAM?
 - It “explains” the payments in the SAM
 - It follows the SAM disaggregation
 - It is “calibrated” to the SAM: base-year parameter values defined so that the base-year model solution replicates the data in the SAM

Payments in stylized model

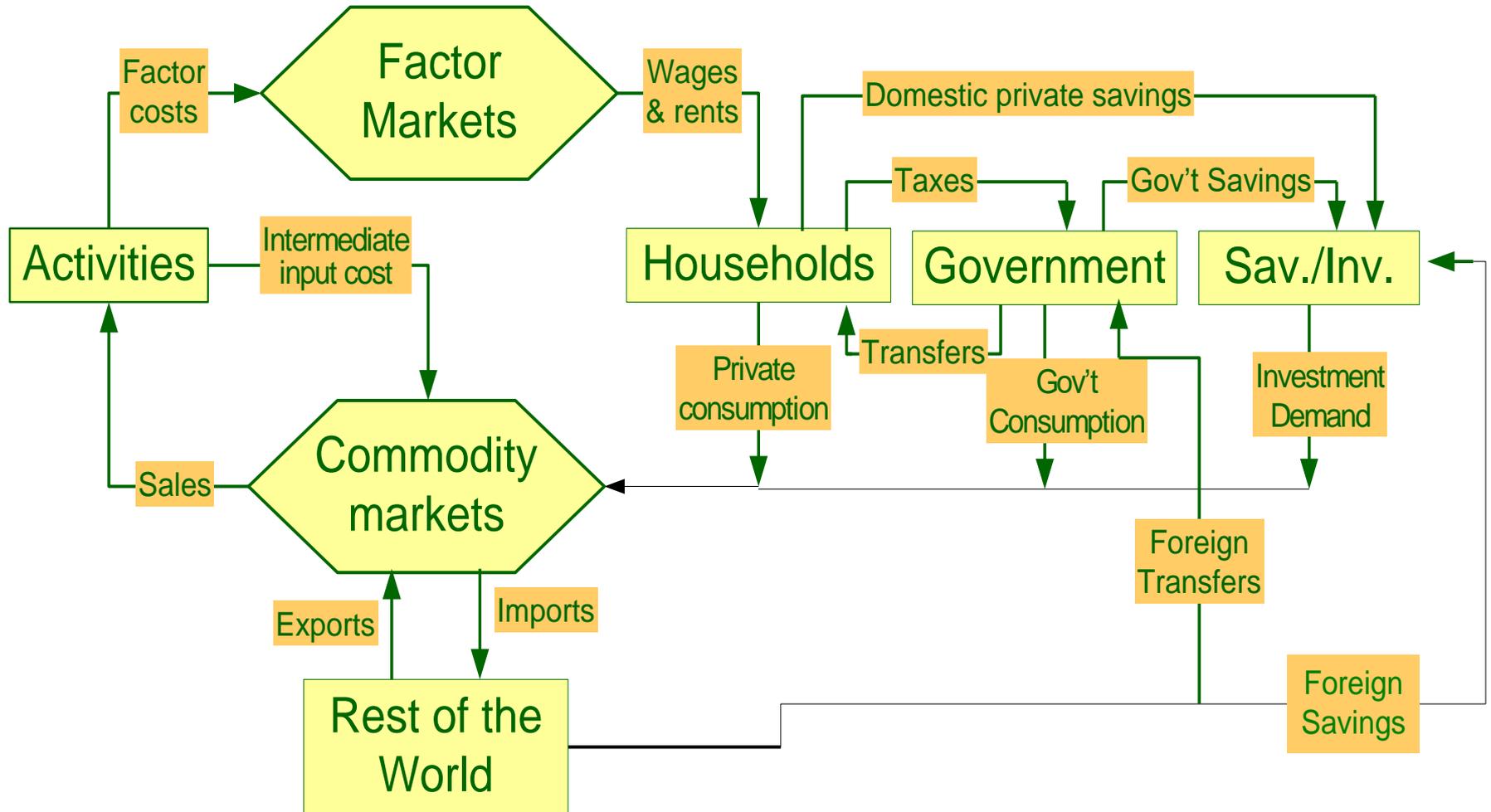


Figure. Production technology

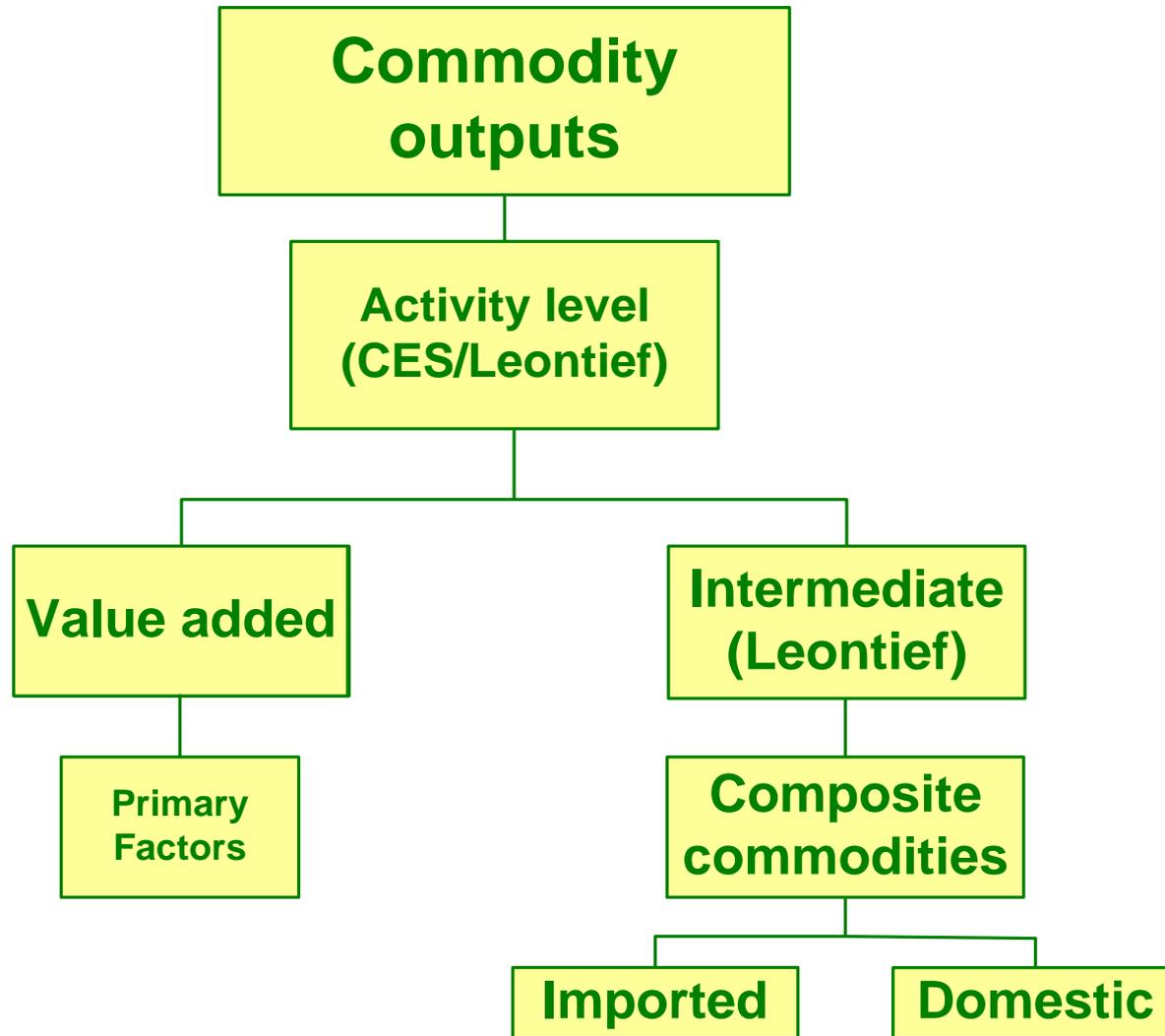
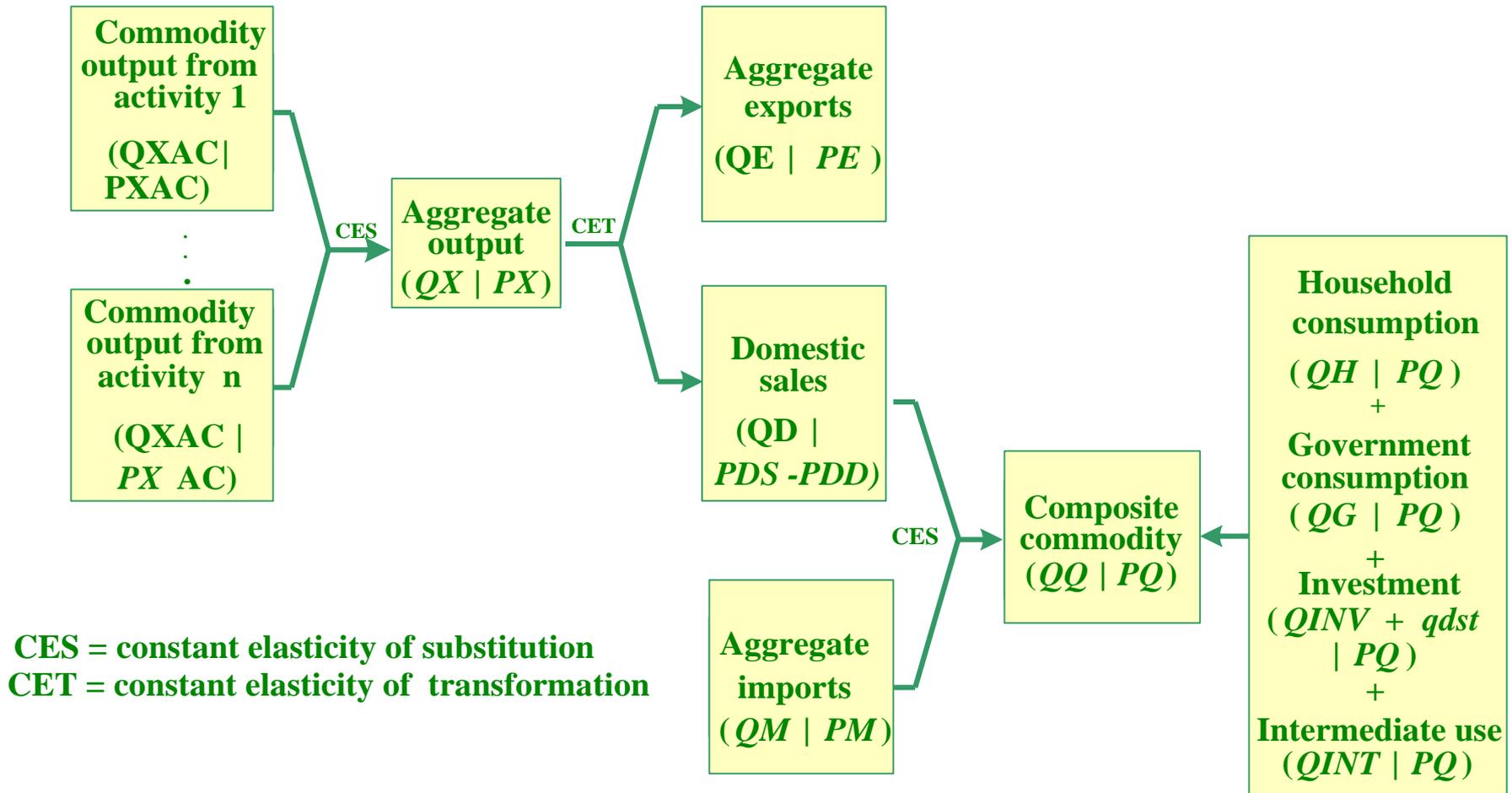


Figure. Commodity flows



Structure of a country CGE model

- Models may be
 - Static (used for comparative static analysis)
 - Dynamic (recursive or intertemporal with perfect foresight)
- In the dynamic case, growth in output and other variables is driven by:
 - Growth in factor stocks (endogenous or exogenous)
 - Growth in factor productivity (endogenous or exogenous)

Structure of a country CGE model

- “Closure” = rule on the basis of which a market (quantity demanded = quantity supplied) or a macro balance (receipts = payments) clears.
- Common options:
 - Domestic factor and commodity markets. Prices (wages, rents) clear; for factors with or without endogenous unemployment.
 - Foreign markets. Exchange rate clears (leading to adjustments in export demand and import supply at exogenous world prices).
 - Government. Adjustment of one or more receipt or spending items.
 - Balance of payments. Adjustment of the real exchange rate or of a non-trade foreign exchange flow.
 - Savings-investment balance. Investment clears (investment is savings driven) or one or more savings flows adjust (savings is investment driven).

GAMS and Other Software for CGE Models

- Major computational achievement to solve applied CGE models – large number of simultaneous, non-linear equations; methods developed since late 1960s.
- GAMS (General Algebraic Modeling System) and GEMPACK (developed at Monash University) are the two major software for CGE modeling.
- GAMS, the software :
 - Initially developed in the mid-1970s at the World Bank by Alex Meeraus and Jan Bisschop; since 1987, the GAMS Development Corporation has developed it further (with backward compatibility).
 - Used to formulate algebraic models, to define their databases, and to call up a solver that can handle the relevant model type (optimization; simultaneous equation).

GAMS and other software for CGE models

- A text editor is needed to program in GAMS (GAMSIDE included with the software).
- GAMS may exchange data with many other software (including Excel).
- In GAMS, the model and its database are represented in a format that is very similar to a mathematical statement.
- The key building blocks (which are reserved words) in GAMS: SET, PARAMETER, VARIABLE, EQUATION, MODEL, SOLVE.
- A small excerpt follows.

Sample GAMS code excerpt from simple CGE model

```
SETS
  a  activities
  /a-agr  agriculture
   a-nagr non-agriculture/

  f  factors
  /f-lab  labor
   f-cap  capital/
;
VARIABLES
  QA(a)      level of activity a
  QF(f,a)    quantity demanded of factor f from activity a
;
PARAMETERS
  ad(a)      efficiency parameter in the production fn for a
  alpha(f,a) share of value-added to factor f in activity a
;
EQUATION
  PRODFN(a)      Cobb-Douglas production function for activity a
;
  PRODFN(a)..    QA(a) =E= ad(a)*PROD(f, QF(f,a)**alpha(f,a));
```

Issues and areas of comparative (dis)advantage for CGE models

- The evolution of CGE models has been influenced by the evolution of policy concerns. Often they address issues in the following areas:
 - international trade (policies, price shocks)
 - fiscal issues (esp. taxation)
 - poverty and income distribution
 - sector policies (often with a focus on agriculture)
 - natural resources - energy - the environment
- See Jorgenson and Dixon, Eds. (2012) for a comprehensive and up-to-date overview.

Issues and areas of comparative (dis)advantage for CGE models

- CGE models are appropriate when one addresses
 - forward-looking medium- to long-run policies/shocks that have repercussions beyond the sector/household that is affected directly (and often indirectly, via feedbacks).
 - “meso”/micro questions: structure and links between different parts of the economy matter.
- CGE models are typically not appropriate for the analysis of
 - short-run adjustments (equilibrium assumptions are violated; the treatment of the timing of impacts is weak).
 - macro and/or financial sector issues.

- The answers to questions are conditional on model structure, database, and assumptions; the impact of alternative scenarios may be explored at low cost (model as laboratory).
- Most simulations are not forecasts (telling us what is expected to happen); instead they focus on how the future may differ depending on the presence/absence of specific exogenous or policy shocks.
- If no one has used a CGE model to address some important issue, then it is probably a bad idea to do it – why didn't anyone pick up the \$100 bill?

Resources on CGE modeling and/or GAMS

- The following websites provide plenty of materials and links:
 - www.gams.com
 - www.gtap.agecon.purdue.edu
 - www.pep-net.org/programs/mpia
 - www.worldbank.org/mams (including the tab “Other resources and links”)
 - www.monash.edu.au/policy/gempack.htm

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