Main Structure of GTAP Model

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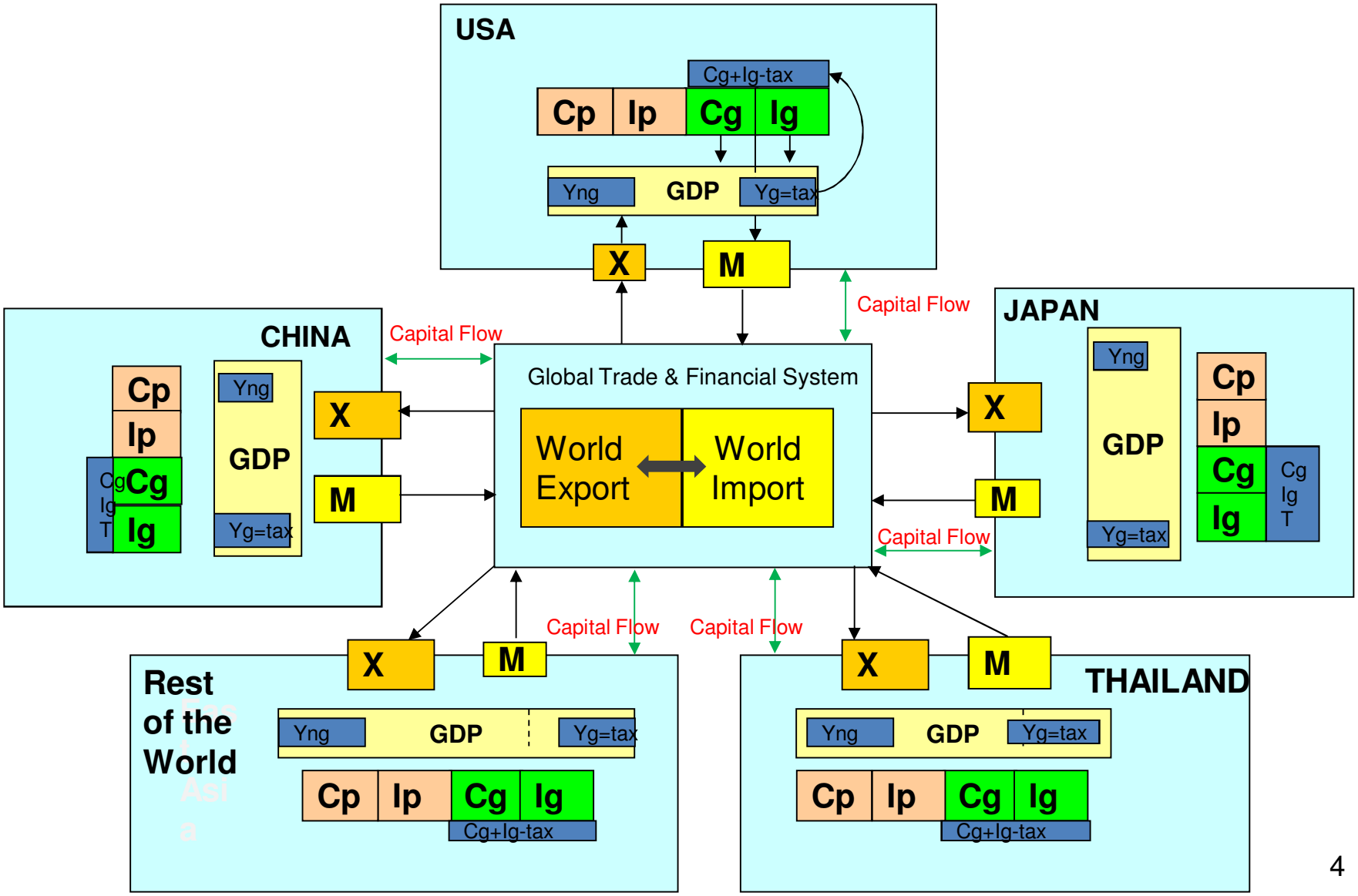
Main topics

(1) Overview
(2) Linearization
(3) Behavior equations
    (3.1) Production side
    (3.2) Consumption side
(4) Price equations
(5) Accounting equations (value equality)
(6) Closure rules
    (6.1) International trade (Current account)
    (6.2) Capital flow (Capital account)
(7) Data set and parameters
    (7.1) Trade and I/O data
    (7.2) Parameter calibration

(1) Overview

- GTAP : Global Trade Analysis Project
- GTAP was developed from Monash University and Purdue University as “World CGE model” to simulation trade pattern
- Run on GEMSPACK platform (different from GAMS in its linearization and compilation properties)
- Policy instruments are technology, endowments, and government’s trade policies (tariff and subsidy)
- Not designed for simulating other types of policies/shocks (related exogenous variables are not available)

Model's Main Structure



(1) Overview (cont'd)

GTAP model (2008)

- 96 regions (v.6.2a) and over 100 in v.7 (2008)
- 57 sectors
- Each region balanced (BoP=0)
  - S-net I = X-M = trade balance
- World is balanced
  - Global saving = global net investment
  - Total exports = total imports
- Features:
  - Perfect competition and CRS
  - Armington assumption
- Comparative static

Standard features

- Demand from a CDE function
- Sluggish primary factors
- Regional household
- Global transport sector
- Global bank

By Tid Mia Mikic, UN-ESCAP

(1) Overview (cont'd)

General Equilibrium (GE) Model

- 2 groups → consumer and producer
- 2 types of traded items → goods and endowments → 2 types of markets
- A model determines changes in price and quantity of each good and endowment
- Good steps to understand model

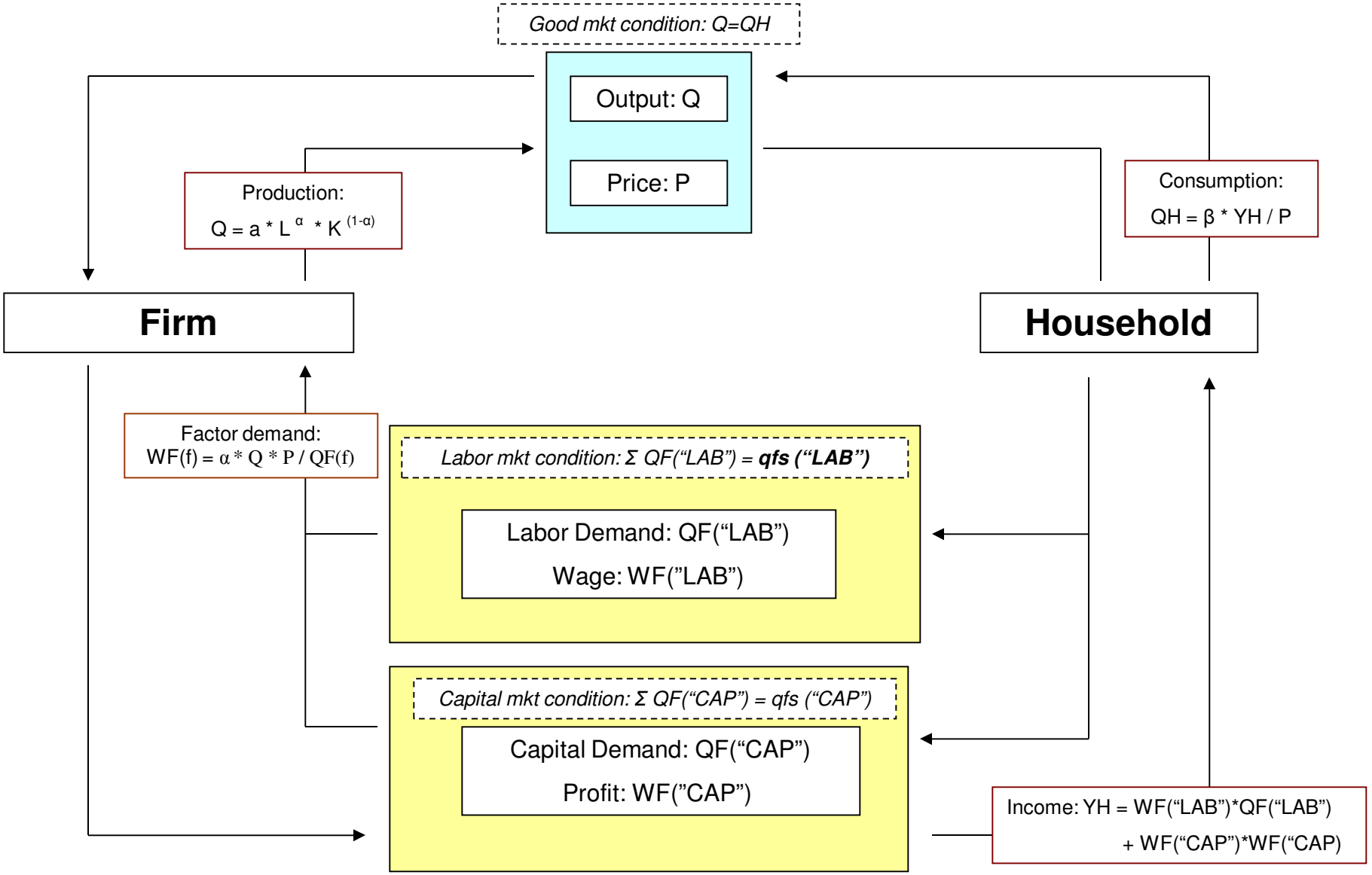
  (1) Identify the scope of model (what to be explained, what are left to be exogenous)

  (2) Draw the diagram to understand how things are connected

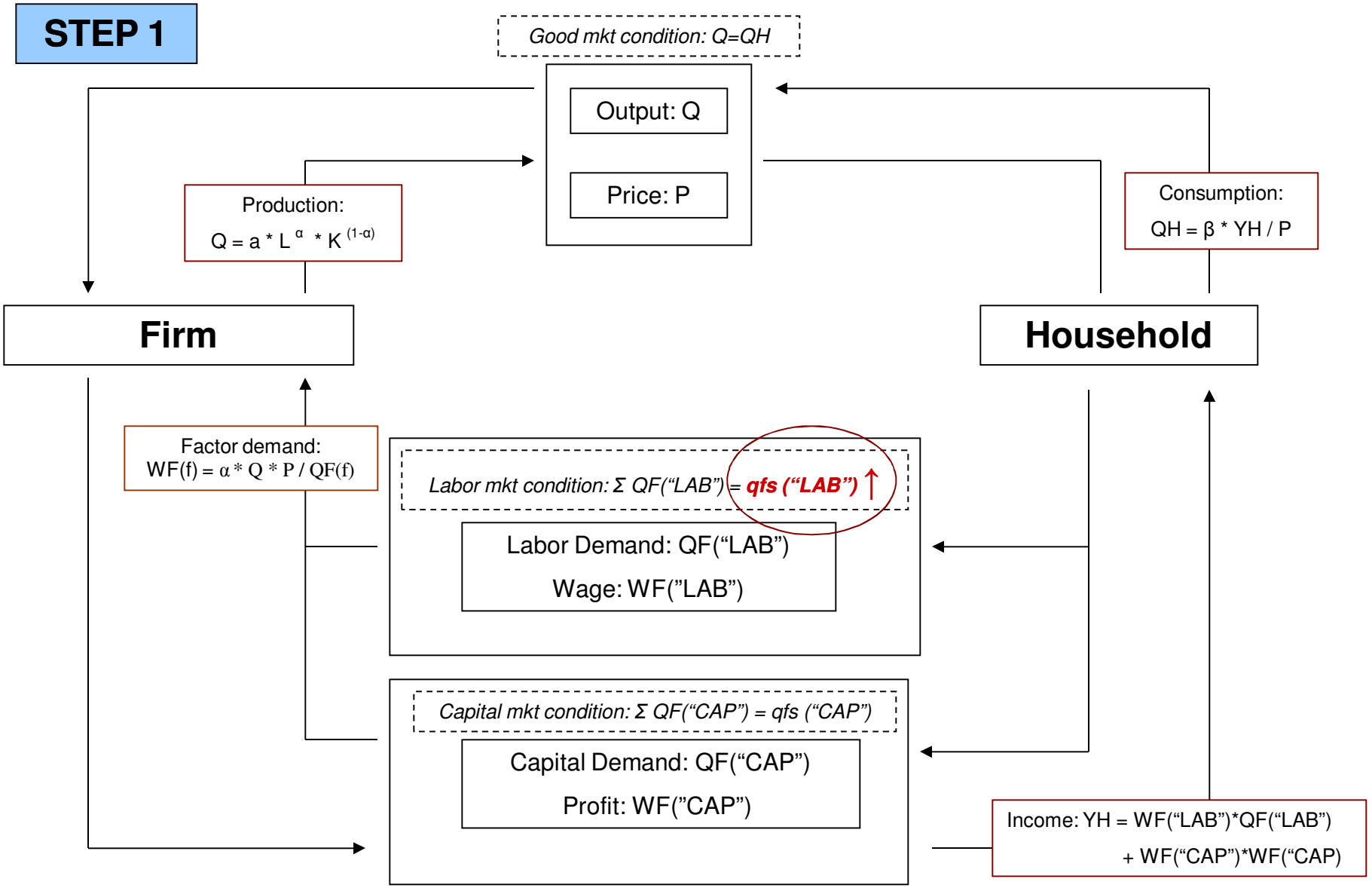
  (3) Translate the diagram into a set of equations

  (4) Translate the system of equations into a computer program

System of 1-Good & 2-Factors



Scenario I: Increasing Labor Supply



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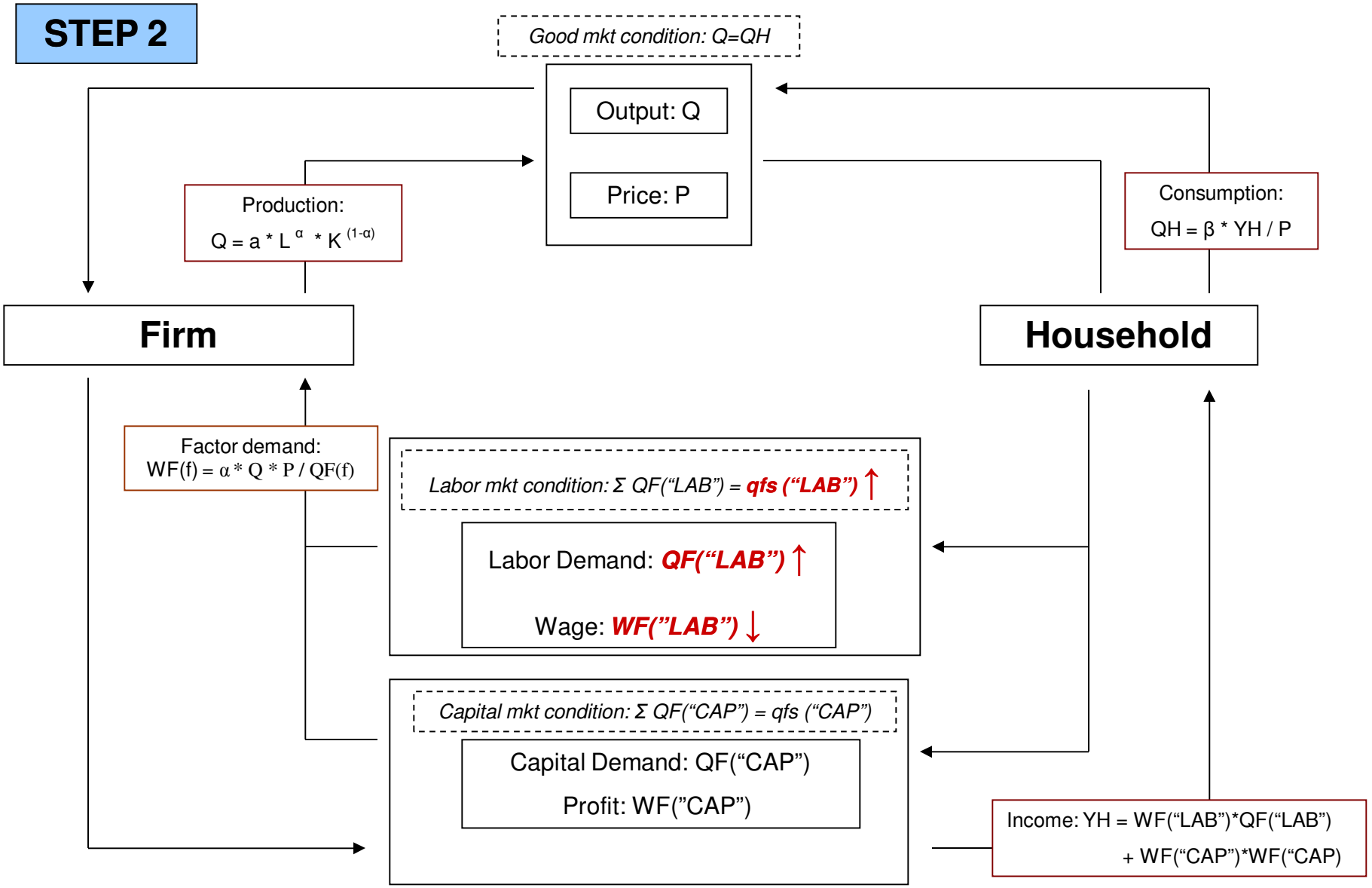


(1) Overview (cont'd)

GE Model and GTAP

- Do not be scared by large numbers of equations; GTAP is just an extension of typical CGE.
- Steps to understand GTAP (and other GE models)

(1) Identify the group of consumer and producer (find the price and quantity variables)

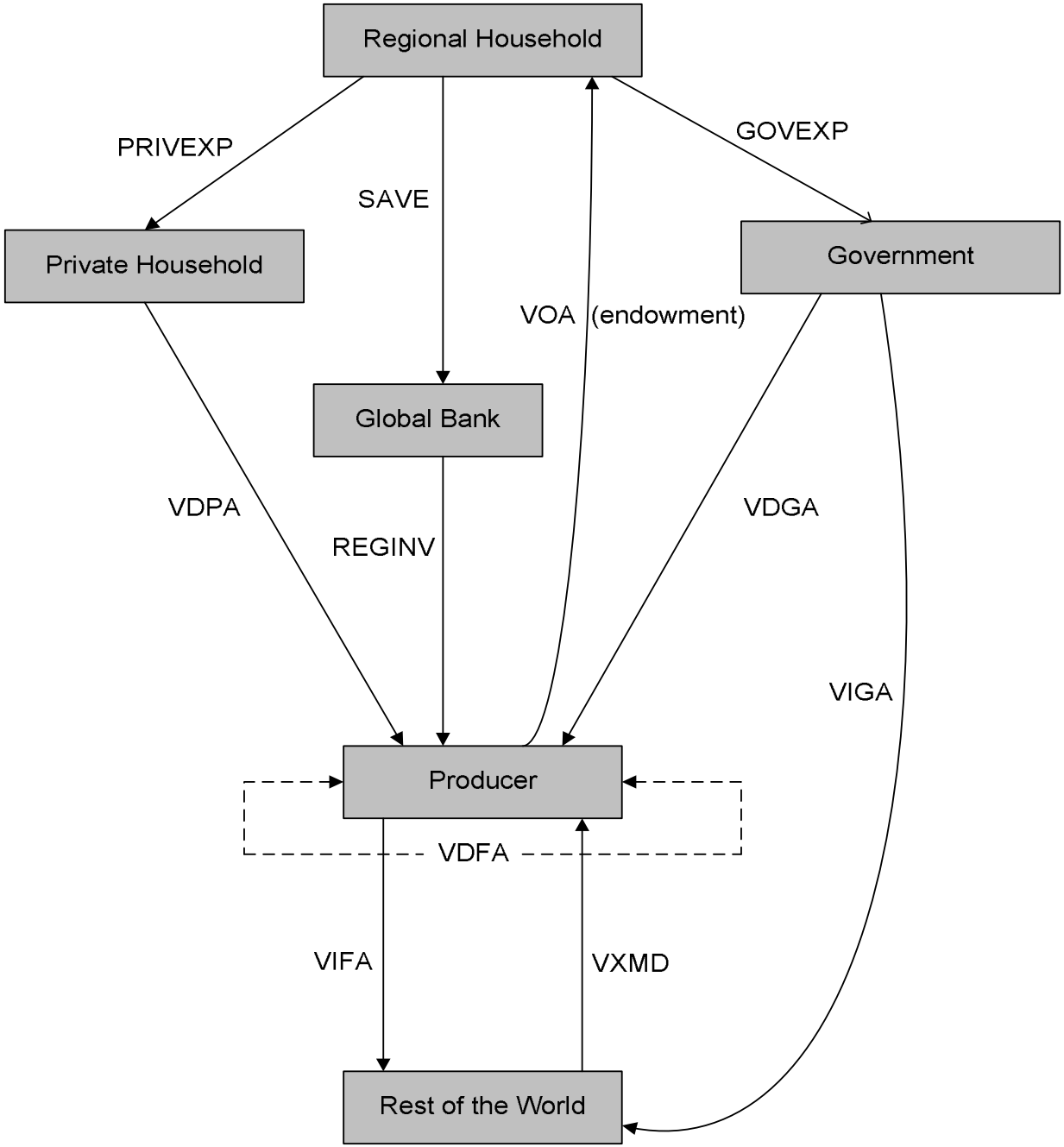
(2) Understand connections representing trades of goods and endowments

(3) Understand the accounting relationship (constraint equations)

(4) Understand the behavioral equations determining the response of quantities to relative prices

(5) Understand the price equations (mostly representing price distortion due to taxes and trade/transport margins)

(6) Understand the closure rules (combinations of exo/endo variables)


Regional Household
PRIVEXP
SAVE
GOVEXP
Private Household
Government
VOA (endowment)
Global Bank
VDPA
REGINV
VDGA
VIGA
Producer
VDFA
VIFA
VXMD
Rest of the World

(2) Linearization

In economic, some relationships are connected in non-linear form.
For example, the simple agri market is represented in the following set of equations.

$$Q_D = const_D \cdot P^{\alpha_1} \cdot Weather^{\alpha_2} \cdot PlantedArea^{\alpha_2}$$ (EQ 1: Demand)

$$Q_S = const_S \cdot P^{-\beta_1} \cdot Population^{\beta_2}$$ (EQ 2: Supply)

$$Q_S = Q_D$$ (EQ 3: Market clearing)

The log-linearization makes it easier to solve and interpret this system.

$$\log Q_D = \log const_D + \alpha_1 \cdot \log P + \alpha_2 \cdot \log Weather + \alpha_3 \cdot \log PlantedArea$$

$$\log Q_S = \log const_S - \beta_1 \cdot \log P + \beta_2 \cdot \log Population$$

$$\log Q_S = \log Q_D$$

Since Log represents the percentage change (Δ%), the system can be interpreted as:

$$\Delta\% Q_D = \Delta\% const_D + \alpha_1 \cdot \Delta\% P + \alpha_2 \cdot \Delta\% Weather + \alpha_3 \cdot \Delta\% PlantedArea$$

$$\Delta\% Q_S = \Delta\% const_S - \beta_1 \cdot \Delta\% P + \beta_2 \cdot \Delta\% Population$$

$$\Delta\% Q_S = \Delta\% Q_D$$

(3) Behavior equations

"How the quantity allocation respond to prices?"

(3.1) Production side

- Nested-structure with CES production function
- International trade is at the intermediate-good selection

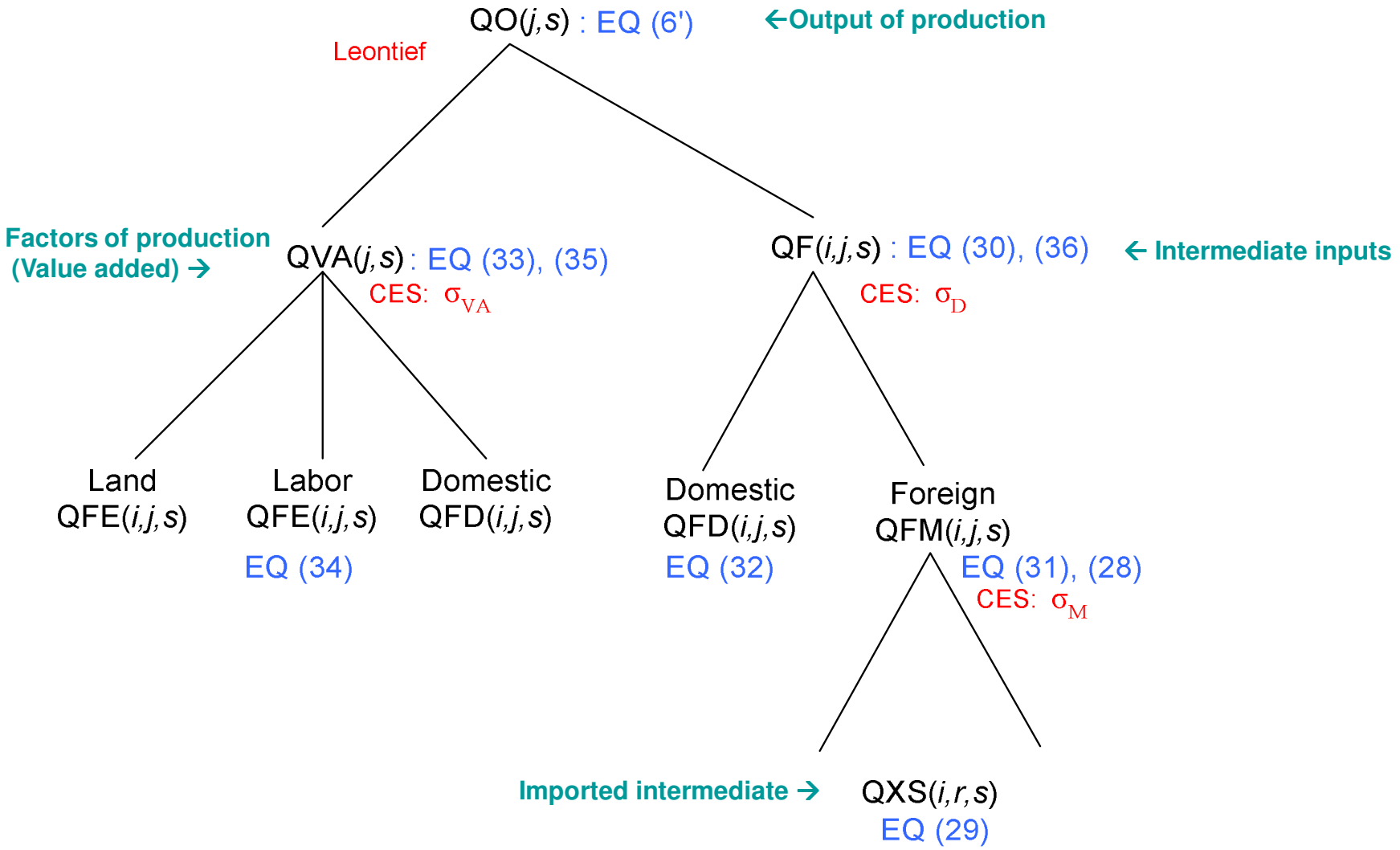
(3.2) Consumption side

- Constant Difference of Elasticity (CDE)

(3.1) Production side

Production

- Mainly based on the nested-structure with CES production function



- Equations are listed on Table 2.10 – 2.11 (page 42)

Linearization of input demand

In CES function, the desired demand function for input is a function of (1) output price (p), (2) Input price (p_i), (3) output (q), and (4) elasticity of substitution (σ). Or $q_i = f(p,p_i,q,\sigma)$

$$\sigma = \frac{\hat{Q}_1 / \hat{Q}_2}{\hat{P}_2 / \hat{P}_1}$$

$$(q_1 - q_2) = \sigma(p_2 - p_1)$$

$$q = \theta_1 \cdot q_1 + (1-\theta_1) \cdot q_2$$

$$q_2 = \frac{(q - \theta_1 \cdot q_1)}{(1-\theta_1)}$$

$$q_1 = (1-\theta_1)\sigma(p_2 - p_1) + q$$

$$q_1 = \sigma(p - p_1) + q$$

$$p = \theta_1 \cdot p_1 + (1-\theta_1) \cdot p_2$$

$$p_2 = \frac{(p - \theta_1 \cdot p_1)}{(1-\theta_1)}$$

$q_i = f(p,p_i,q,\sigma)$

(3.2) Consumption side

Private consumption

- Constant Difference of Elasticity (CDE)
- CDE is a combination of nonhomothetic CGE and the fully flexible function forms
- CDE is easy to calibrate in order to obtain the income and own-price elasticity of substitution coefficients from existing data

$$\sum_i B(i,r)\cdot UP(r)^{\beta(i,r)\gamma(i,r)}\cdot\left[\frac{PP(i,r)}{E(PP(r),UP(r))}\right]^{\beta(i,r)} \equiv 1$$

E(): Minimum expenditure required to attain a prespecified level of utility

UP(r): Vector of prices

PP(r): Minimum expenditure for normalizing individual price

- All linearized representation are on Table 2.12 - 2.14 (page 47-48, 51)

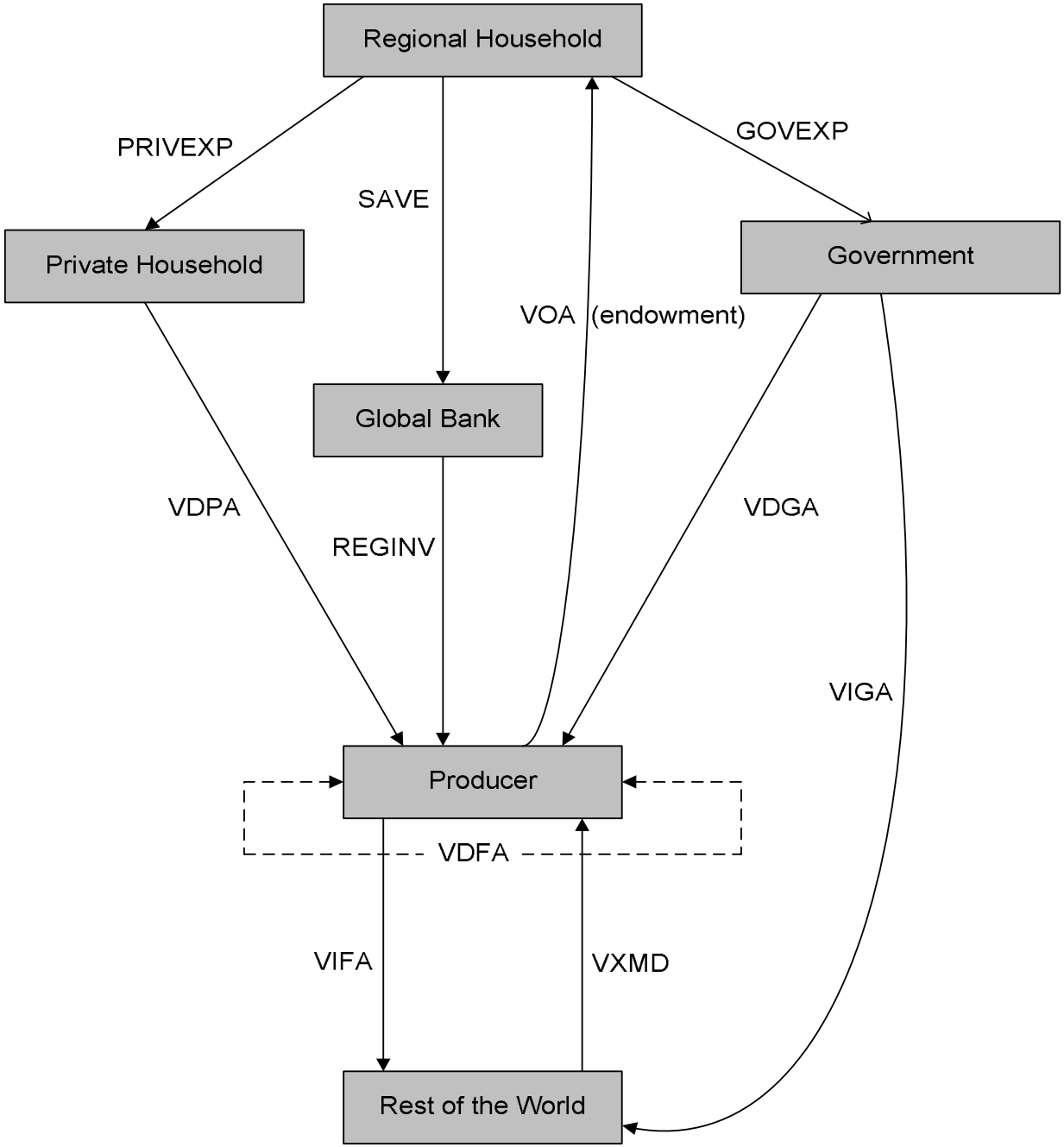
(4) Price equations

- All equations in this block represent the price distortion of policy instruments such as tariff, subsidy, and also the effect of transport margin
- Equations in linearized form are listed on Table 2.9 (page 36)

(5) Accounting equations (value equality)

Domestic market r	VOA(i,r)	Value of output at agent's price	: PS(i,r) * QO(i,r)
	+ PTAX(i,r)	Producer tax	
	= VOM(i,r)	Value of output at marker price	: PM(i,r) * QO(i,r)
	VDM (i,r)	Value of domestic sales at market price	VST(i,r) : transportation sector
	= VDPM(i,r)	Value of domestic sales by HH at market price	: PM(i,r) * QPD(i,r)
	+ VDGM(i,r)	Value of domestic sales by Govt at market price	: PM(i,r) * QGD(i,r)
	+ Σ_j VDFM(i,j,s)	Value of domestic by Firm in sector j at market price	: PM(i,r) * QFD(i,j,r)
World market	VXMD(i,r,s)		: PM(i,r) * QXS(i,r,s)
	+ XTAXD(i,r,s)	Export tax	
	= VXWD(i,r,s)	Value of exports at world price by destination	: PFOB(i,r,s) * QXS(i,r,s)
	+ VTWR(i,r,s)	Transportation margin	
	= VIWS(i,r,s)	Value of export at world price by source (CIF)	: PCIF(i,r,s) * QXS(i,r,s)
	+ MTAX(i,r,s)	Import tax	
	= VIMS(i,r,s)	Value of import at market prices by source	: PMS (i,r,s) * QXS(i,r,s)
Domestic market s	VIM(i,s)	Value of import i market prices by source	: PMS(i,s) * QIM(i,s)
	= VIPM(i,s)	Value of import by HH at market price	: PIM(i,s) * QPM(i,s)
	+ VIGM(i,s)	Value of import by Govt at market price	: PIM(i,s) * QGM(i,s)
	+ Σ_j VIFM(i,j,s)	Value of import by Firm in sector j at market price	: PIM(i,s) * QFM(i,s)

- Accounting equation are on Table 2.1 - 2.4 (page 18, 20-22)
- A list of prices, quantities and values are on the appendix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Rest of the World

(6) Closure rules

(6.1) International trade (Current account)

- Global balance → Total world export = Total world import
- S – I = EX - IM

(6.2) Capital flow (Capital account)

- Saving is a residual to balance saving-investment
- Two alternatives for global investment determination

  (1) Rate of return are equalized across regions

  $$rore(r) = rorg$$

  (2) The global rate of return is a weighted average of regional ones

  $$rorg = \Sigma_r [(NETINV(r) / GLOBINV) * rore(r)]$$

- Equations of regional allocation of investment are listed on Table 2.15-2.16 (page 56,59)

(7) Data set and parameters

(7.1) Data set (3*3 example model)

- The disaggregated 37-sector, 24-country database are the reconciled version of data based on:
  (1) Bilateral trade data from the Statistical Office of the United Nations
  (2) Trade protection and support are from information submitted to GATT
  (3) Input-output (I/O) data are from members of GTAP network (listed on Table 3.13 page(110)). It is noted that I/O data have different base year.

- Bilateral trade data were adjusted to formulate the trade matrix by using TESSY technique
- Trade and I/O data were reconciled by using FIT software package

(7) Data set and parameters

(7.2) Parameters

There are 4 types of behavioral parameters

(1) Elasticity of substitution

- These value are obtained from SALTER project reviewing literature and empirical work to specify the value of elasticity of substitution which is commodity-specific and region-generic
- Values are shown on Table 4.1 (page 125)

(2) Mobility parameters

- $\sigma = 0$: The allocation is nearly fixed; almost unresponsive to changes in relative term
- $\sigma \rightarrow -\infty$: This factor is perfectly mobile

(3) Flexibility of regional investment

- RORDELTA = 1 : An allocation of global investment responds to regional-specific rate of return on capital; The degree of adjustment is governed by *RORFLEX(r)*

(4) Consumer demand elasticities

- Based on CDE expenditure function, all values were obtained from SALTER project, US-FAO, and Theil, Chung and Seale (1989)
- All values are region-specific, listed on Table 4.2 (page 128-132)