

Global Trade Analysis Project (GTAP) models for the analysis of climate change and trade policies linkages

Truong P. Truong
Honorary Professor in Sustainable Transport Systems
Institute of Transport and Logistics Studies
Faculty of Economics and Business
The University of Sydney

ESCAP/WTO Sixth ARTNeT Capacity-Building for Trade Research
21-25 June 2010, Vientiane, Lao PDR

Overview

- GTAP model – trade policy issues
- GTAP-E – energy & climate change issues
- European Union studies
- Japan, South Africa
- Asia-Pacific countries?

GTAP and GTAP-E model structures

Data ↔ Structure ↔ Equations

Current production (CES, Leontief)

Investment (Leontief)

Demand (CES, CDE)

Zero pure profit (economic accounting)

Imports, exports, taxes, transfer (National Income Accounting)

ORANI Model – data base

		Domestic Industries (Current production)	Absorption or Final Demands				
			Investment	Household Consumption	Government Consumption	Exports	Change in Inventories
USE matrix		V1BAS <i>C x S x I</i>	V2BAS <i>C x S x I</i>	V3BAS <i>C x S x I</i>	V4BAS <i>C x S x I</i>	V5BAS <i>C x S x I</i>	V6BAS <i>C x S x I</i>
Basic flows of Domestic commodities							
Basic flows of Imported commodities							
Margin type <i>m</i> on	domestic flows	V1MAR <i>M x C x S x I</i>	V2MAR <i>M x C x S x I</i>	V3MAR <i>M x C x S x I</i>	V4MAR <i>M x C x S x I</i>	V5MAR <i>M x C x S x I</i>	
	imports flows						
Taxes on	domestic flows	V1TAX <i>C x S x I</i>	V2TAX <i>C x S x I</i>	V3TAX <i>C x S x I</i>	V4TAX <i>C x S x I</i>	V5TAX <i>C x S x I</i>	
	imports flows						
Primary Factors	Labour	V1LAB <i>O x I</i>	<i>C</i> commodities <i>S</i> sources (domestic, imported) <i>I</i> industries <i>M</i> margins <i>O</i> occupations				
	Capital	V1CAP <i>1 x I</i>					
	Land	V1LND <i>1 x I</i>					
Production tax		V1PTX <i>1 x I</i>	Joint production (or Make) matrix				
Other costs		V1OCT <i>1 x I</i>					
Domestic commodities		MAKE <i>C x I</i>	V0TAR <i>C x 1</i>	Import tariff			

GTAP Model – data base

		Domestic Industries (Current production)	Final Demands			
			Investment	Household Consumption	Government Consumption	Exports
Domestic commodities		$\mathbf{g} \times \mathbf{h} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$
Imported commodities		$\mathbf{g} \times \mathbf{h} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$
Taxes on	Domestic commodities	$\mathbf{g} \times \mathbf{h} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$
	Imported commodities	$\mathbf{g} \times \mathbf{h} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	$\mathbf{g} \times \mathbf{1} \times \mathbf{r}$	
Labour		$\mathbf{e} \times \mathbf{h} \times \mathbf{r}$	<p>\mathbf{r} regions</p> <p>\mathbf{e} endowments; \mathbf{g} commodities = \mathbf{h} industries</p> <p>SINGLE-PRODUCT INDUSTRIES</p> <p>No domestic margin (but there are international margin on traded goods & services)</p>			
Capital						
Land						
Taxes on	Labour	$\mathbf{e} \times \mathbf{h} \times \mathbf{r}$				
	Capital					
	Land					
Other costs e.g. production tax		$\mathbf{1} \times \mathbf{h} \times \mathbf{r}$				

GTAP Model – data base

		Domestic Industries (Current production)	Final Demands			
			Investment	Household Consumption	Government Consumption	Exports
Domestic commodities		$\mathbf{g} \times [\mathbf{h}+1] \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	
Imported commodities		$\mathbf{g} \times [\mathbf{h}+1] \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	
Taxes on	Domestic commodities	$\mathbf{g} \times [\mathbf{h}+1] \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	
	Imported commodities	$\mathbf{g} \times [\mathbf{h}+1] \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$	$\mathbf{g} \times 1 \times \mathbf{r}$		
Labour		$\mathbf{e} \times \mathbf{h} \times \mathbf{r}$	<p>\mathbf{r} regions</p> <p>\mathbf{e} endowments; \mathbf{g} commodities = \mathbf{h} industries</p> <p>SINGLE-PRODUCT INDUSTRIES</p> <p>No domestic margin (but there are international margin on traded goods & services)</p>			
Capital						
Land						
Taxes on	Labour	$\mathbf{e} \times \mathbf{h} \times \mathbf{r}$				
	Capital					
	Land					
Other costs e.g. production tax		$1 \times \mathbf{h} \times \mathbf{r}$				

Types of prices in ORANI-G

- **Basic** price: including production costs, but excluding sales taxes, trade and transport margins.
- **Producers'** price: including production costs and net taxes on products, but excluding trade and transport margins.
- **Purchasers'** price: including production costs, net taxes on products, and also trade and transport margins.

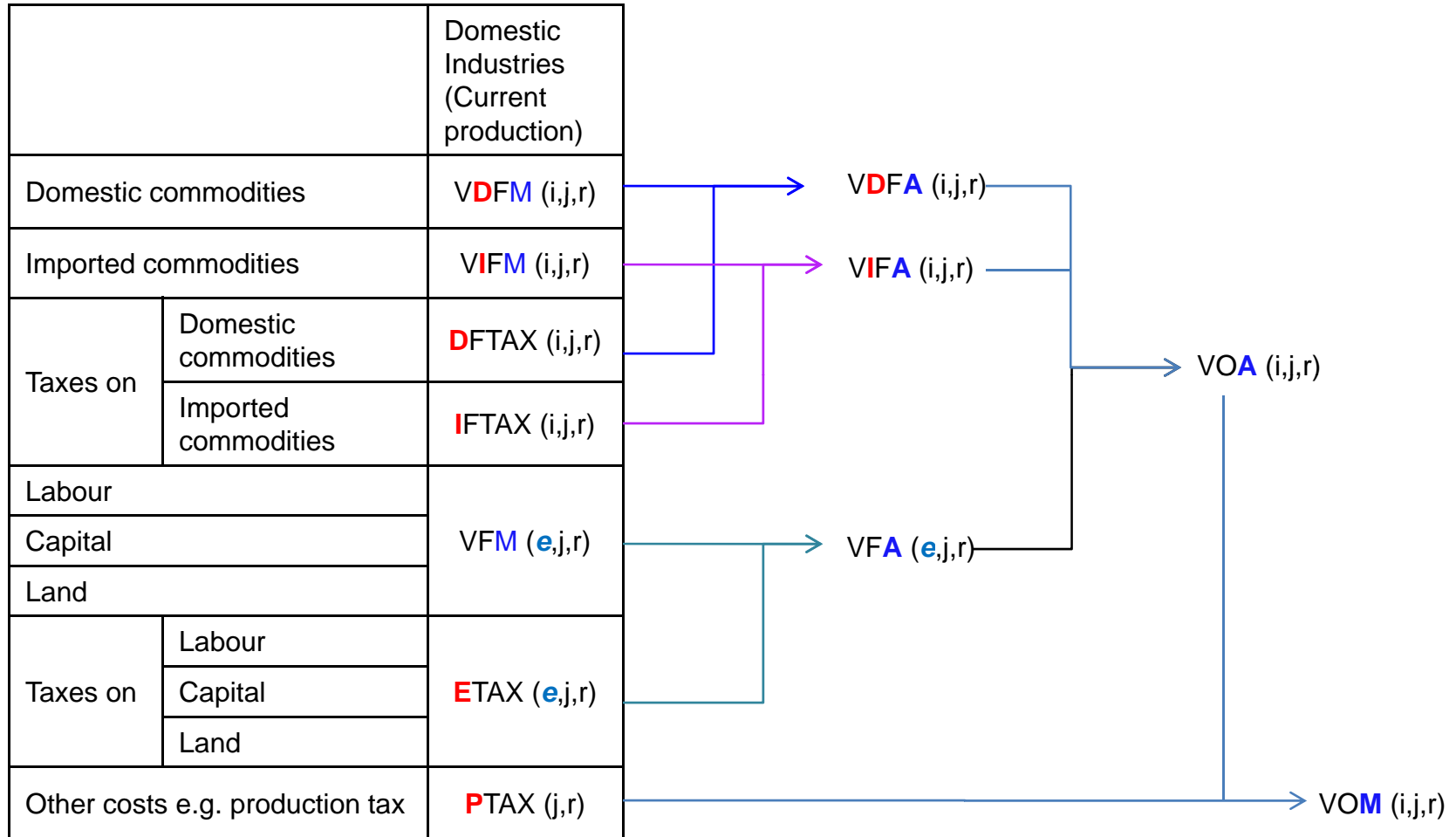
Types of prices in GTAP

- **Agent's** price: price payable by an agent (producer, private consumer, government consumer, RoW) for the product.
- **Market** price: price as prevailing in the market for the product.

GTAP Model – data base

		Domestic Industries (Current production)	Final Demands			
			Investment	Household Consumption	Government Consumption	Exports
Domestic commodities		$VDFM(i,j,r)$	$VDPM(i,r)$	$VDGM(i,r)$	$VXMD(i,r,s)$	
Imported commodities		$VIFM(i,j,r)$	$VIPM(i,r)$	$VIGM(i,r)$	$VIWS(i,r,s)$	
Taxes on	Domestic commodities	$DFTAX(i,j,r)$	$DPTAX(i,r)$	$DGTAX(i,r)$	$XTAXD(i,r,s)$	
	Imported commodities	$IFTAX(i,j,r)$	$IPTAX(i,r)$	$IGTAX(i,r)$	$MTAXD(i,r,s)$	
Labour		$VFM(e,j,r)$	<p>r regions</p> <p>e endowments; g commodities = h industries</p> <p>SINGLE-PRODUCT INDUSTRIES</p> <p>No domestic margin (but there are international margin on traded goods & services)</p>			
Capital						
Land						
Taxes on	Labour	$ETAX(e,j,r)$				
	Capital					
	Land					
Other costs e.g. production tax		$PTAX(j,r)$				

GTAP Model – data base



GTAP Model – data base

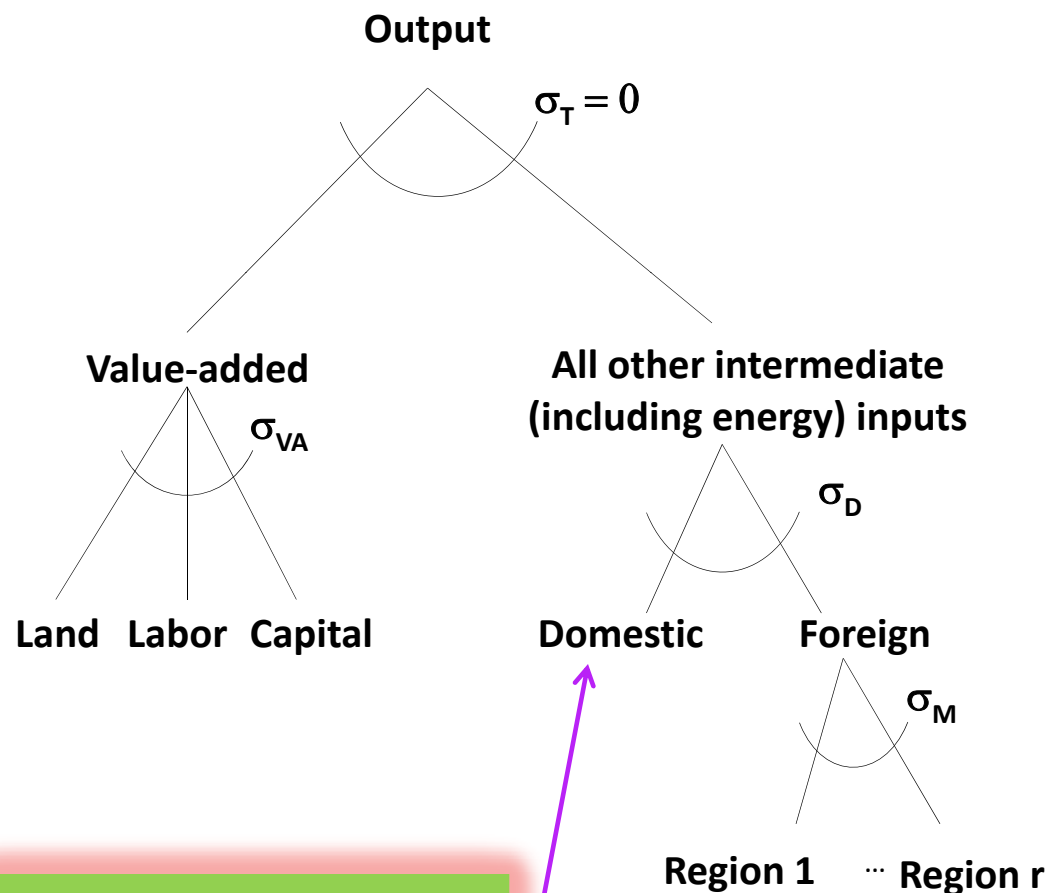
		Domestic Industries (Current production)	Final Demands				
			Investment	Household Consumption	Government Consumption	Exports	
Domestic commodities						VXMD (i,r,s)	
Imported commodities						VIMS (i,j,r)	VIWS (i,r,s)
Taxes on	Domestic commodities					XTAXD(i,r,s)	
	Imported commodities					MTAXS(i,r,s)	
Labour		VFM (e,j,r)					
Capital							
Land							
Taxes on	Labour	ETAX (e,j,r)					
	Capital						
	Land						
Other costs e.g. production tax		PTAX (j,r)					

GTAP Model

Production data base

		Domestic Industries (Current production)
Domestic commodities		VDFM (i,j,r)
Imported commodities		VIFM (i,j,r)
Taxes on	Domestic commodities	DFTAX (i,j,r)
	Imported commodities	IFTAX (i,j,r)
Labour		VFM (e,j,r)
Capital		
Land		
Taxes on	Labour	ETAX (e,j,r)
	Capital	
	Land	
Other costs e.g. production tax		PTAX (j,r)

Production structure

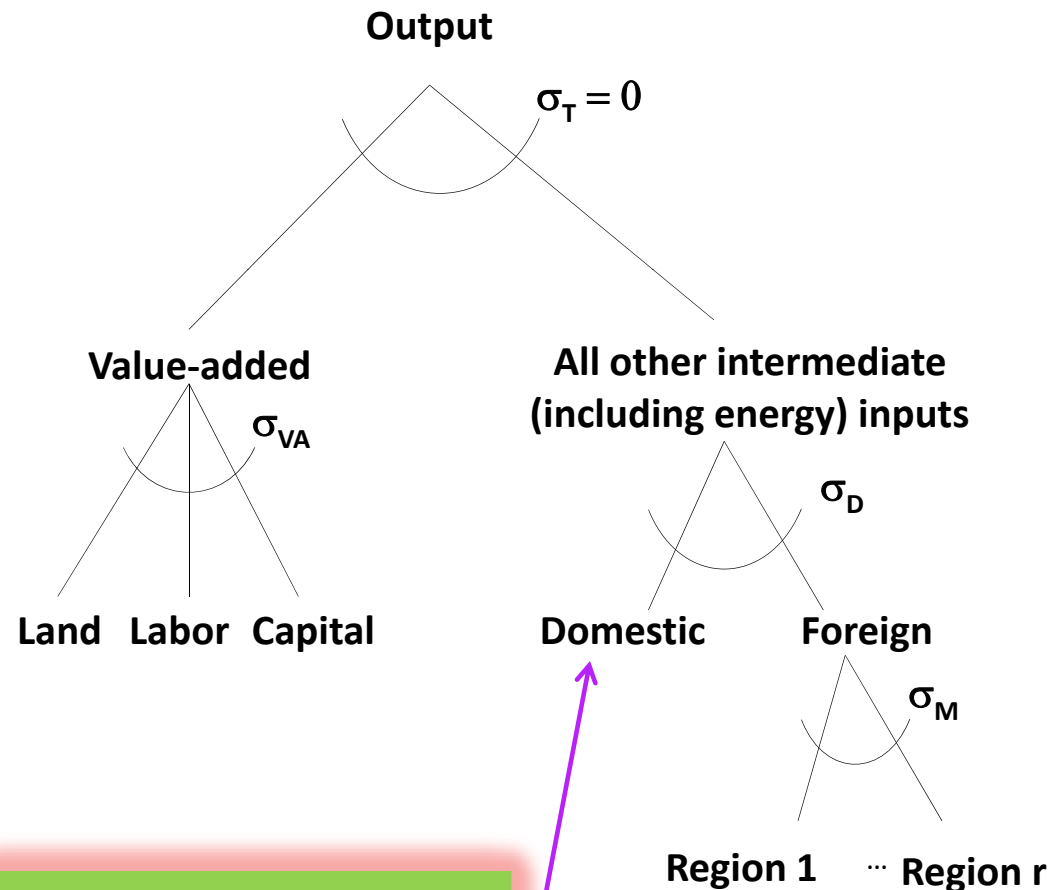


GTAP Model

Production data base

	Domestic Industries (Current production)
Domestic commodities	V D F A (i,j,r)
Imported commodities	V I F A (i,j,r)
Labour	EV F A (e,j,r)
Capital	
Land	

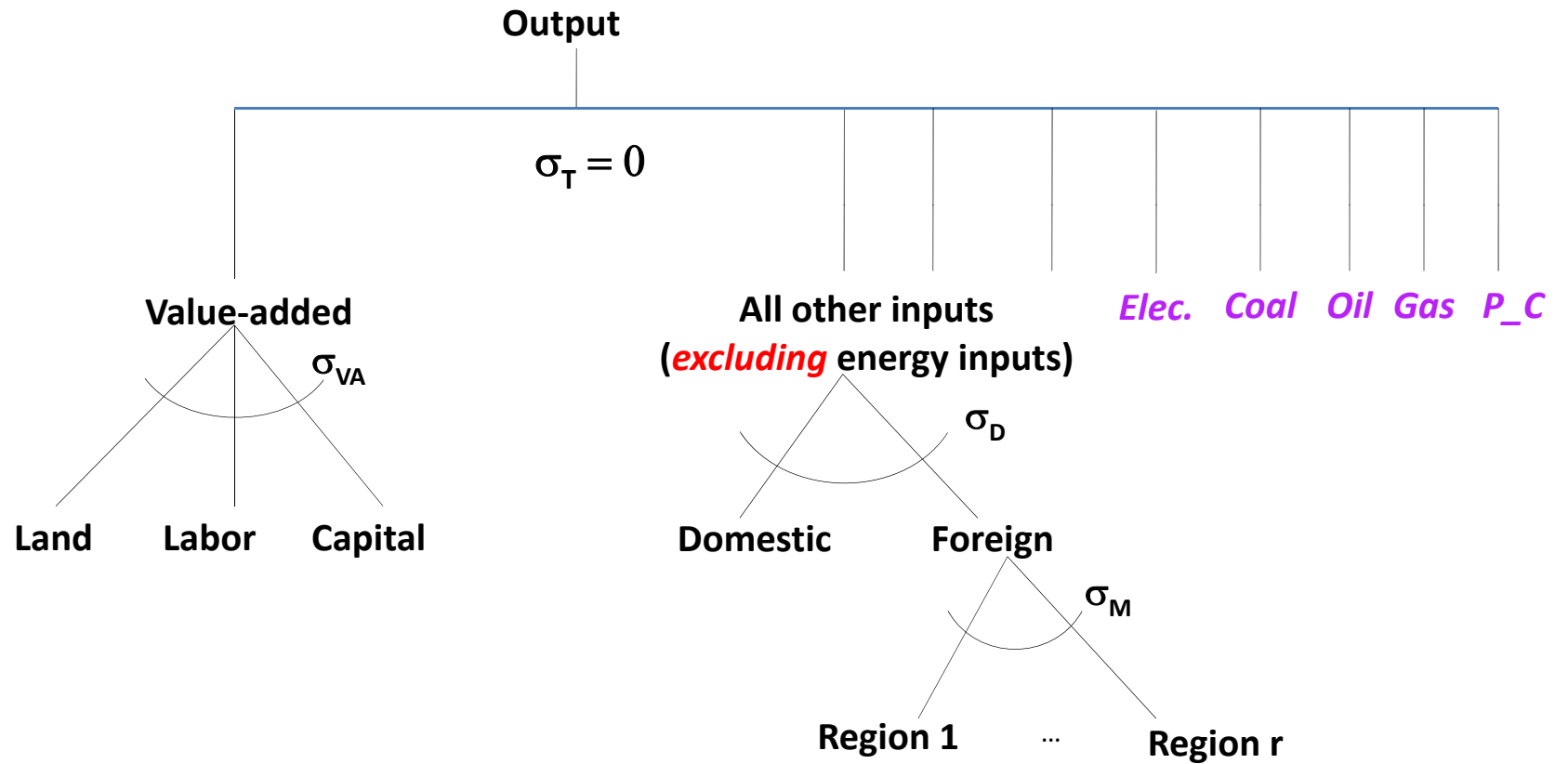
Production structure



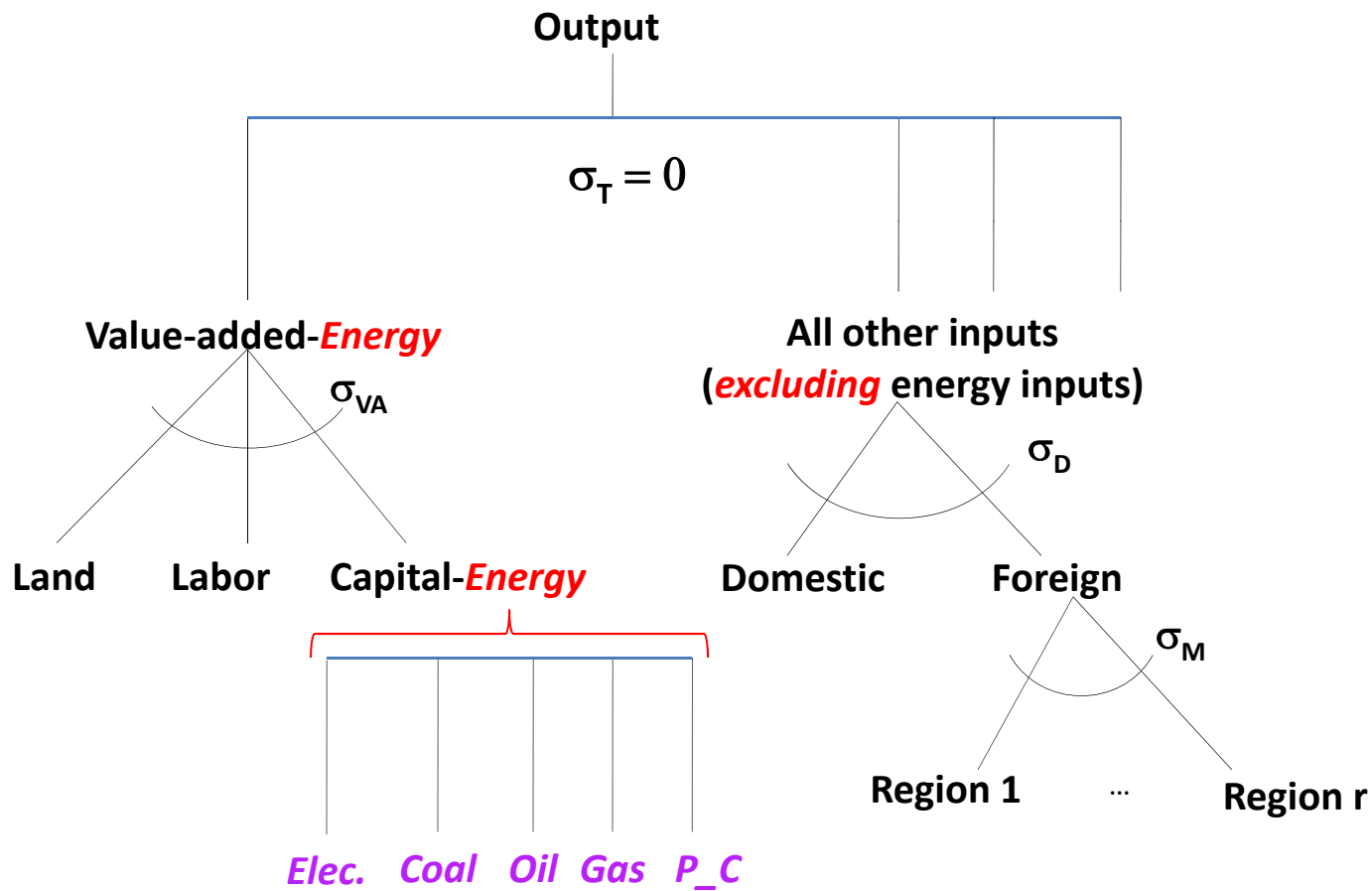
Multi-regional
Trade policies

Introducing energy substitution into GTAP Model

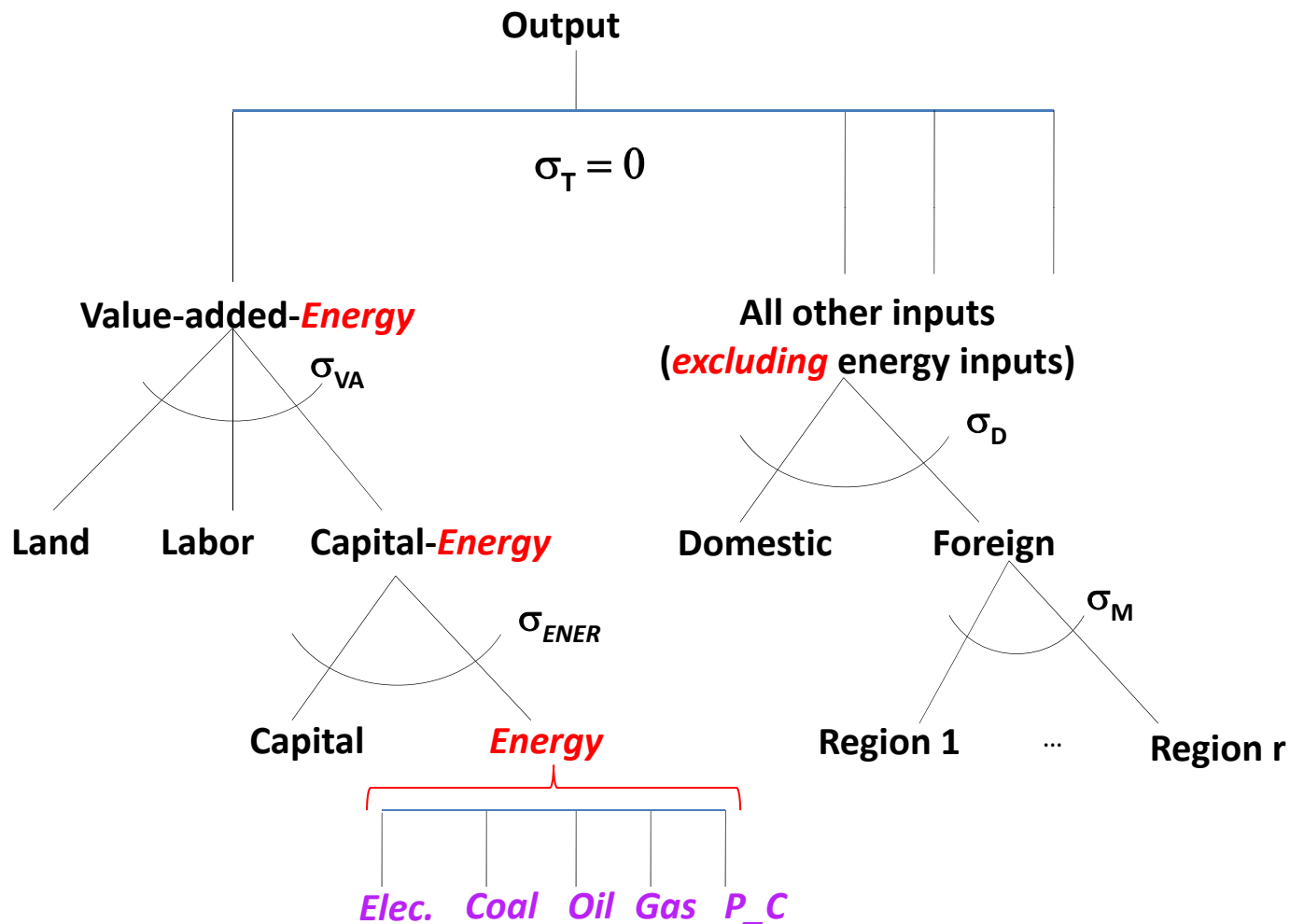
GTAP production structure



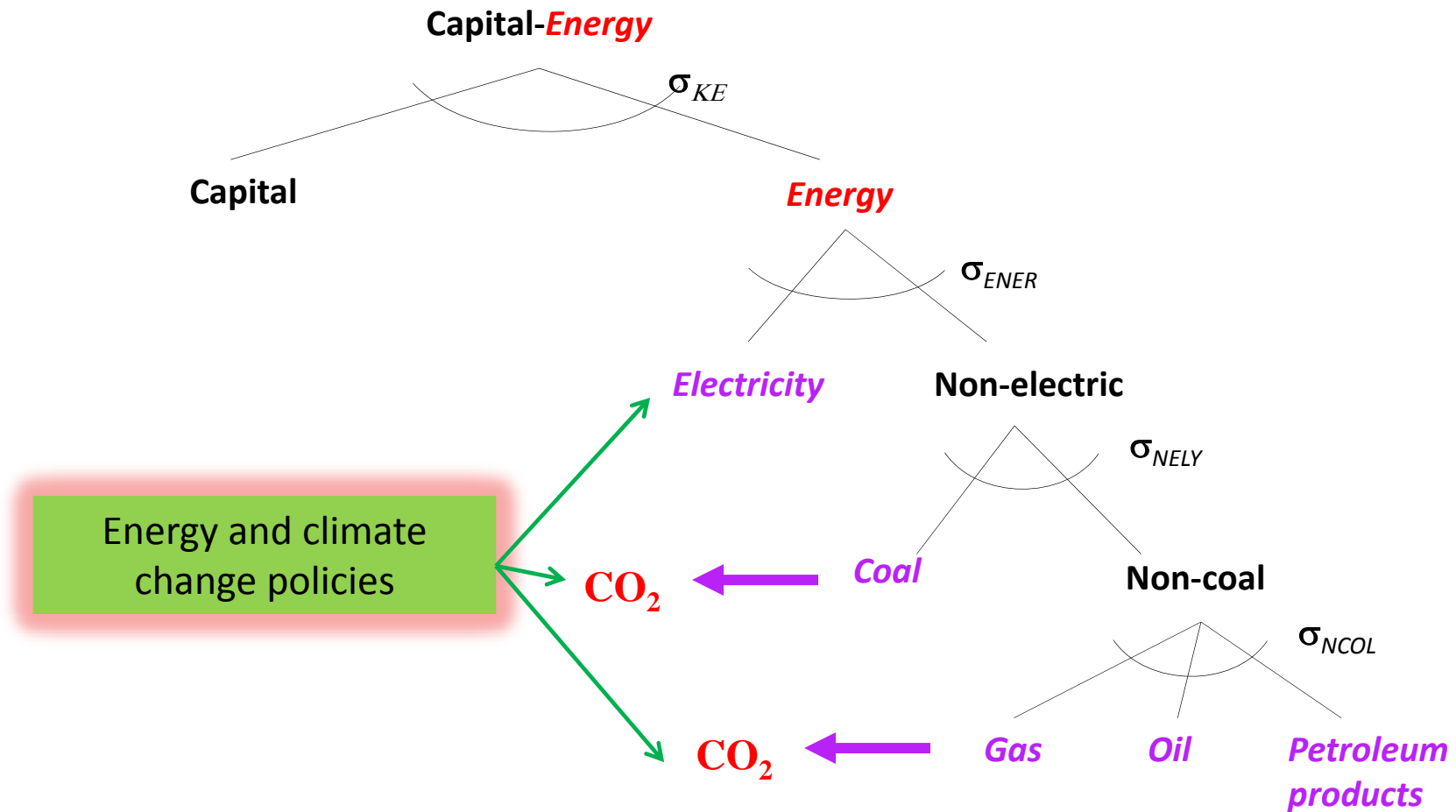
GTAP-E production structure



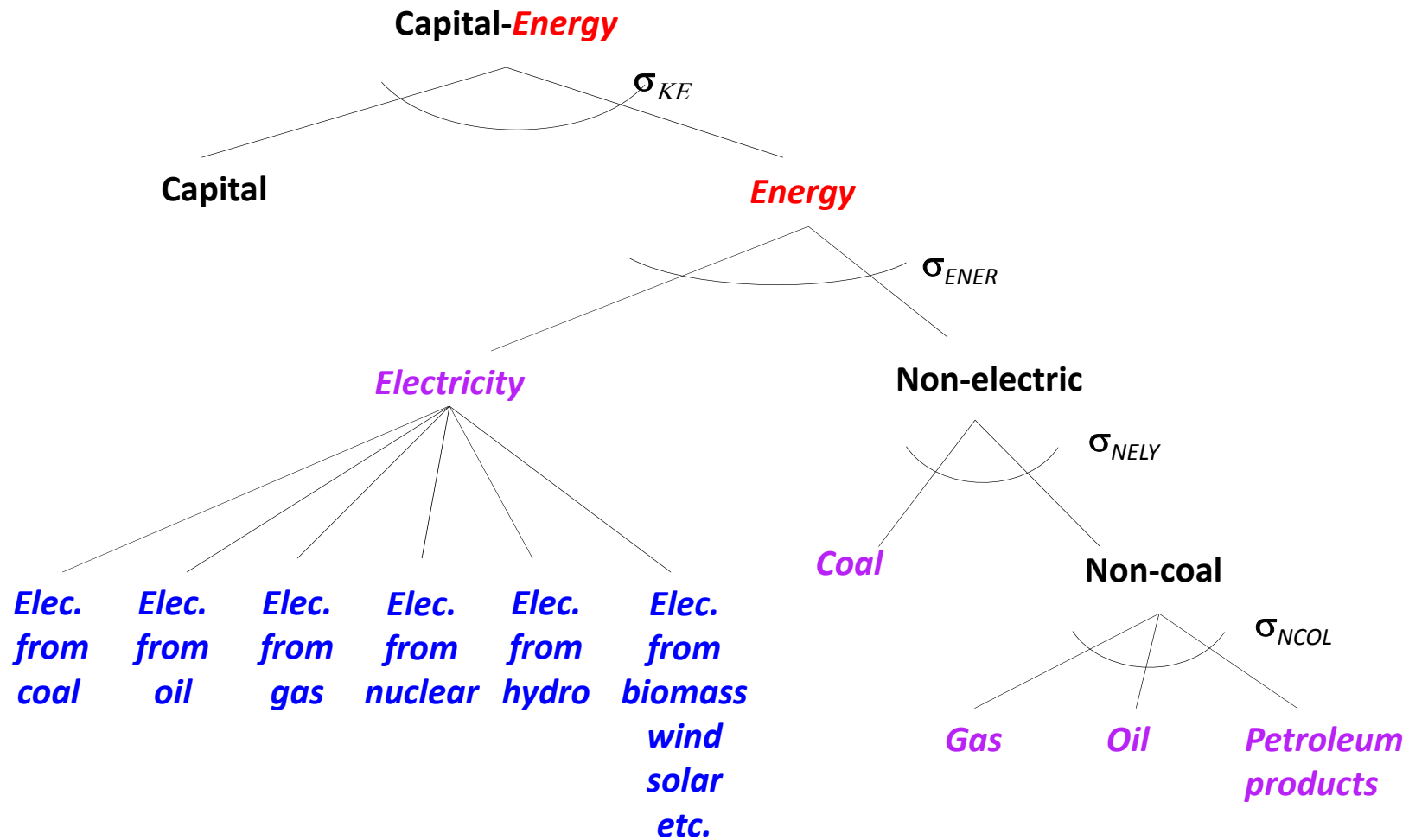
GTAP-E production structure



GTAP-E energy structure



Further extensions for GTAP-E



Introducing carbon tax into GTAP-E Model

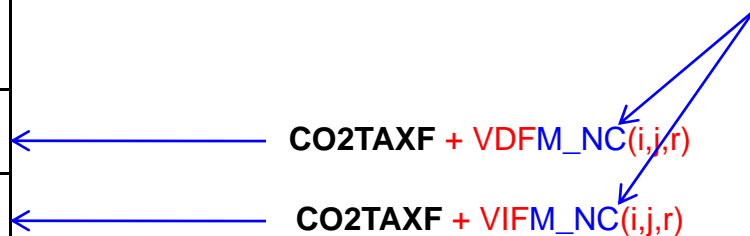
CO2 Tax – First Best

		Domestic Industries (Current production)
Domestic commodities		$VDFM(i,j,r)$
Imported commodities		$VIFM(i,j,r)$
Taxes on	Domestic commodities	$DFTAX(i,j,r)$
	Imported commodities	$IFTAX(i,j,r)$
Labour		$VFM(e,j,r)$
Capital		
Land		
Taxes on	Labour	$ETAX(i,j,r)$
	Capital	
	Land	
Other costs e.g. production tax		$PTAX(j,r)$

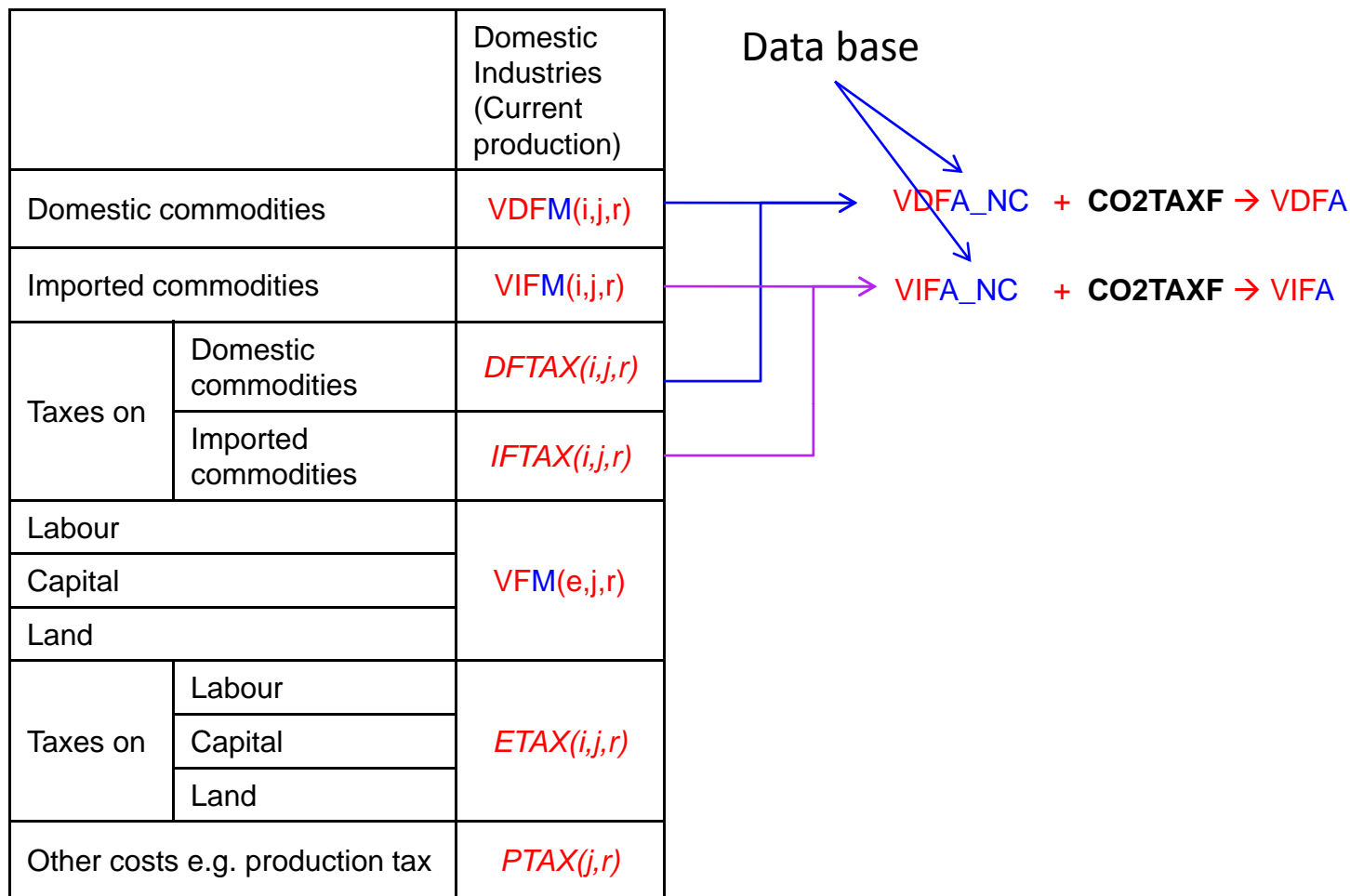
$CO2TAXF + VDFM_NC(i,j,r)$

$CO2TAXF + VIFM_NC(i,j,r)$

Data base



CO2 Tax – Second Best



Tax on Domestic produced goods purchased by Private HH

- Define the power of a tax as the ratio of the price *with* tax over the price without tax; tax rate is then equal to the power of the tax minus 1; tax revenue is equal to the tax base multiplied by the tax rate.
- If tax base is **VDPM** (Value of **D**omestic commodity purchase by **P**rivate HH at **M**arket price, and **VDPA** is the same commodity at **A**gent's (i.e. consumer's) price, then if $VDPA > VDPM$, the (positive) difference must be attributed to Tax on Domestic produced commodities levied at Private HH:

$$\mathbf{DPTAX} = VDPA - VDPM$$

The power of this tax is :

$$\mathbf{TPD} = VDPA/VDPM$$

The ad valorem tax rate is $(TPD - 1)$ and the revenue from this (consumption) tax is $VDPM*(TPD-1)$.

Tax on Domestic produced goods purchased by Firms

- Similarly if V_{DFM} (Value of Domestic produced intermediate commodity purchased by Firms at Market price, and V_{DFA} is the same commodity but at Agent's (i.e. Firm's) price, then if $V_{DFA} > V_{DFM}$, the (positive) difference must be attributed to Tax on Domestic produced commodities levied at the Firm

$$D_{FTAX} = V_{DFA} - V_{DFM}$$

The power of this tax is :

$$TFD = V_{DFA}/V_{DFM}$$

The ad valorem tax rate is $(TFD - 1)$ and the revenue from this sales tax to firms is $V_{DFM} * (TFD - 1)$.

Carbon Tax on Domestic goods purchased by HH – First best

- In the First best situation, Carbon Tax is assumed to be levied *before* pre-existing taxes, so that all the variables **VDPM** and **TPD** must be relabeled as without or “No Carbon” tax, i.e. **VDPM_NC** and **TPD_NC** :

$$\text{TPD_NC} = \text{VDPA}/\text{VDPM_NC}$$

and then re-define:

$$\text{VDPM} = \text{VDPM_NC} + \text{CO2TAXC (carbon tax on HH's purchase)}$$

The power of this tax is :

$$\text{TPD} = \text{VDPA}/\text{VDPM} = \text{TPD_NC} * [1 - (\text{CO2TAXC}/\text{VDPM})]$$

Carbon Tax on Domestic goods purchased by Firms – First best

- Similarly for firms, in the First best situation, Carbon Tax is assumed to be levied *before* pre-existing taxes, so that all the variables **VDFM** and **TFD** must be relabeled as without or “No Carbon” tax, i.e. **VDFM_NC** and **TFD_NC** :

$$\text{TFD_NC} = \text{VDFA} / \text{VDFM_NC}$$

and then re-define:

$$\text{VDFM} = \text{VDFM_NC} + \text{CO2TAXF} \text{ (carbon tax on Firm's purchase)}$$

The power of this tax is :

$$\text{TFD} = \text{VDFA} / \text{VDFM} = \text{TFD_NC} * [1 - (\text{CO2TAXF} / \text{VDFM})]$$

Carbon Tax on Domestic goods purchased by HH – Second best

- In the second best situation, Carbon Tax is assumed to be levied on top of pre-existing taxes, so that all the variables **VDPA** and **TPD** must be relabeled as without or “No Carbon” tax, i.e. **VDPA_NC** and **TPD_NC** :

$$\text{TPD_NC} = \text{VDPA_NC} / \text{VDPM}$$

and then re-define:

$$\text{VDPA} = \text{VDPA_NC} + \text{CO2TAXC (carbon tax on on HH's purchase)}$$

The power of this tax is :

$$\text{TPD} = \text{VDPA} / \text{VDPM} = \text{TPD_NC} + (\text{CO2TAXC} / \text{VDPM})$$

Carbon Tax on Domestic goods purchased by Firms – Second best

- Similarly, in the second best situation, Carbon Tax is assumed to be levied on top of pre-existing taxes, so that all the variables **VDFA** and **TFD** must be relabeled as without or “No Carbon” tax, i.e. **VDFA_NC** and **TFD_NC** :

$$\text{TFD_NC} = \text{VDFA_NC} / \text{VDFM}$$

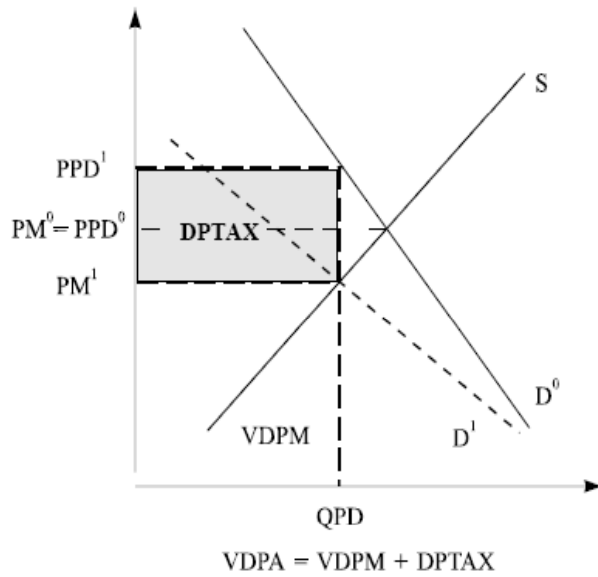
and then re-define:

$$\text{VDFA} = \text{VDFA_NC} + \text{CO2TAXF} \text{ (carbon tax on Firm's purchase)}$$

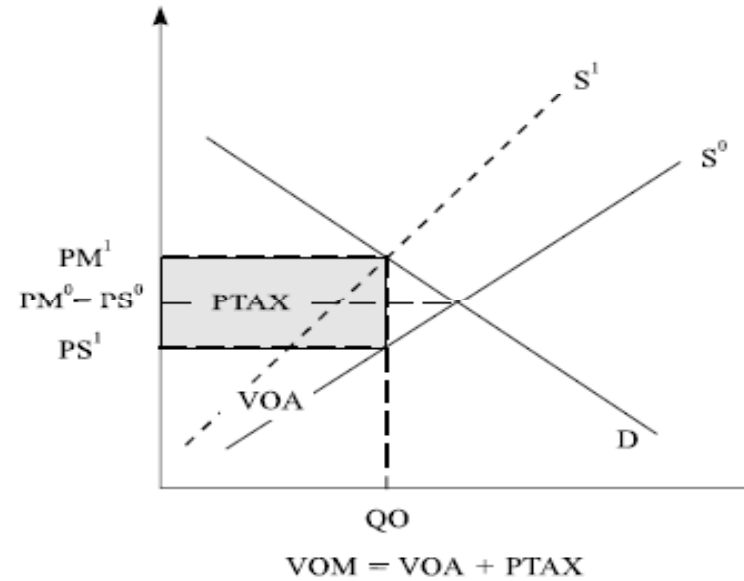
The power of this tax is :

$$\text{TFD} = \text{VDFA} / \text{VDFM} = \text{TFD_NC} + (\text{CO2TAXF} / \text{VDFM})$$

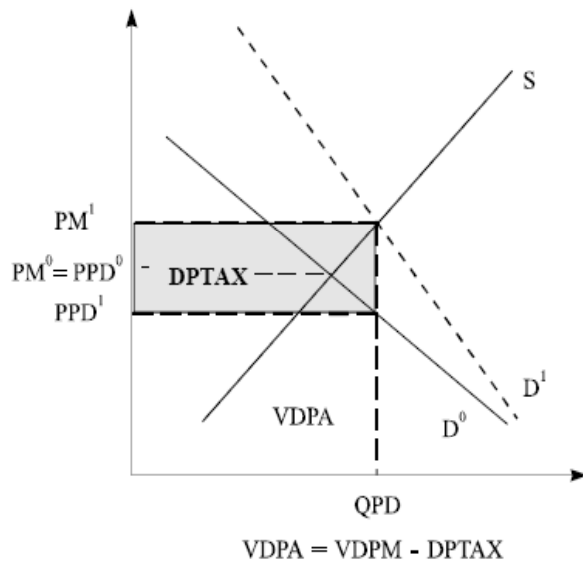
4.1 Tax on Private Household's Purchases



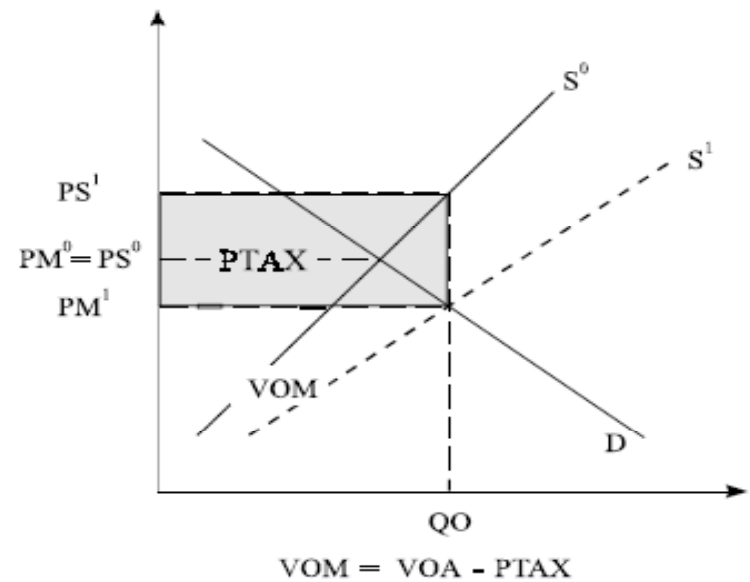
5.1 Tax on Output



4.2 Subsidy on Private Household's Purchases



5.2 Subsidy on Output



Tax on Firm's Output

- If VOA is the Value of Output at Agent's (i.e. Firm's) price and VOM is the same output but at Market price, then the Tax on Production is

$$PTAX = VOM - VOA.$$

The power of this tax is :

$$TOUT = VOA/VOM$$

Note that in this case the power of the tax is less than 1 (in contrast to the case when tax is levied on demand rather than supply).

Tax on Exports

- If $VXMD$ is the Value of Exports at domestic Market by Destination price and $VXWD$ is the Value of Exports at World price by Destination, then the value of the Tax on Export is $XTAXD = VXWD - VXMD$.
- The power of this bilateral export tax is:
$$TXS = VXMD/VXWD$$
which is less than 1.

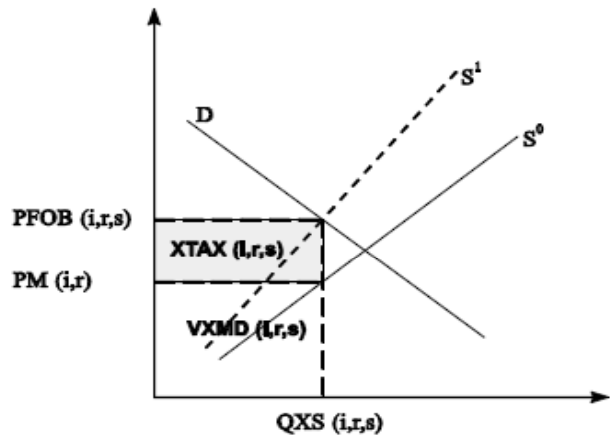
Tax on Imports

- If VIMS is the Value of Imports at domestic Market prices by Source and VIWS is the Value of Imports at World prices by Source, then the value of the Tax on Imports is $MTAX = VIMS - VIWS$.
- The power of this bilateral import tax is:

$$TMS = VIMS/VIWS$$

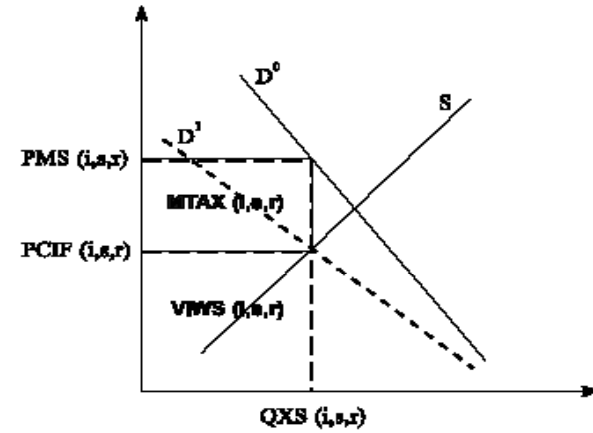
which is greater than 1.

7.1 Export Tax



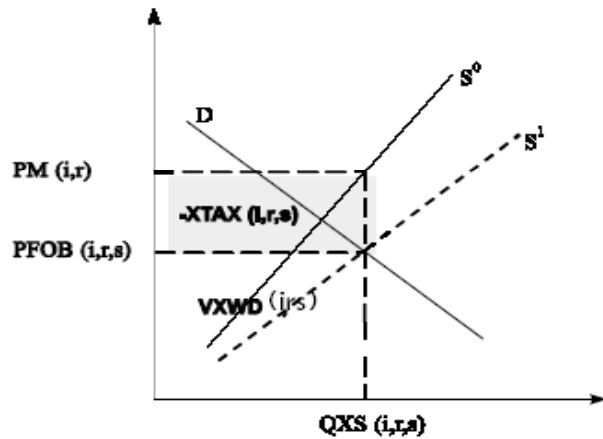
$$VXWD(i,r,s) = VXMD(i,r,s) + XTAX(i,r,s)$$

8.1 Import Tax



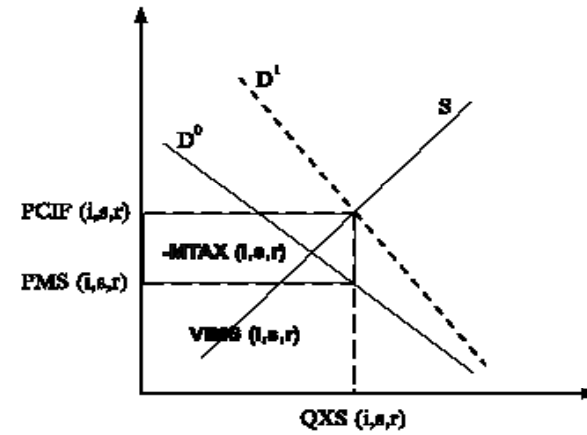
$$VIMS(i,s,r) = VIWS(i,s,r) + MTAX(i,s,r)$$

7.2 Export Subsidy



$$VXWD(i,r,s) = VXMD(i,r,s) + XTAX(i,r,s)$$

8.2 Import Subsidy



$$VIMS(i,s,r) = VIWS(i,s,r) + MTAX(i,s,r)$$

Applications using GTAP

Trade Policy as a vehicle for
Adaptation to Global Warming
Hertel and Randhir (1999)

Applications using GTAP-E

European Union studies

Japan, South Africa

Asia-Pacific countries?