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CGE modelling: introduction and experience at the Centre of Policy Studies since 1975

Presented by

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at the Workshop on

Capturing the potential for greenhouse gas offsets in Indian agriculture

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CGE model are used for many things

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Models built by the Centre of Policy Studies (CoPS) are used in Australia, U.S., China and other countries to study

the effects on

macro, industry, regional, labor-market, distributional and environmental variables

of changes in

taxes, public consumption, social-security payments, environmental policies, technologies, international commodity prices, interest rates, wage setting arrangements and union behavior, immigration, infrastructure and major-project expenditures, and known levels and exploitability of mineral deposits (the Dutch disease).

CoPS' U.S. Model USAGE is applied by

USITC *on import restraints, free trade agreements, baseline forecasting & validation*

U.S. Treasury *on Waxman-Markey greenhouse bill*

Dept. of Commerce *on illegal immigration, stimulus, national export initiative, biofuel policy, environmental regulation*

Dept. of Agriculture *on illegal immigration, biofuels*

Dept. of Homeland Security *on terrorist events and counterterrorism policies, H1N1 epidemic, illegal immigration*

Dept. of Energy *on greenhouse policies, biofuel policies*

Canadian Government *on US jobs from trade with Canada, North American integration*

Cato Institute *on low-skilled immigration*

Mitre Corporation *on airport infrastructure (NextGen)*

Dept. of Transport *on costs/benefits of road infrastructure*

Plan of presentation

1. CGE history and relationship to I-O modelling
2. Building a CGE model
3. Ingredients in a successful long-term CGE project
4. Concluding remarks

Input-output and CGE modelling

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Wassily Leontief (1936 & 1941) made two great contributions:

(a) The input-output table, and

(b) The input-output model that uses I-O table

CGE modelling is another form of modelling that uses the I-O table

- Started with the work of Leif Johansen (1960) in Norway

Distinguishing features of CGE relative to I-O modelling

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(1) CGE emphasizes behaviour by individual agents

(2) CGE introduces resource constraints

(3) CGE emphasizes substitution possibilities and price sensitive behaviour

Similarities between Johansen's CGE and Leontief's I-O models

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Leontief: $X=(I-A)^{-1}*Y$

Johansen: $v_1 = T*v_2$

Leontief was fascinated with his $(I-A)^{-1}$ matrix the typical element of which shows the effect on the output of good i of a unit increase in exogenous demand for good j

Johansen was fascinated with his T matrix part of which shows the effect on the output of good i of a unit increase in exogenous demand for good j

Leontief versus Johansen: the effect on the output of i of a unit increase in exogenous demand for j

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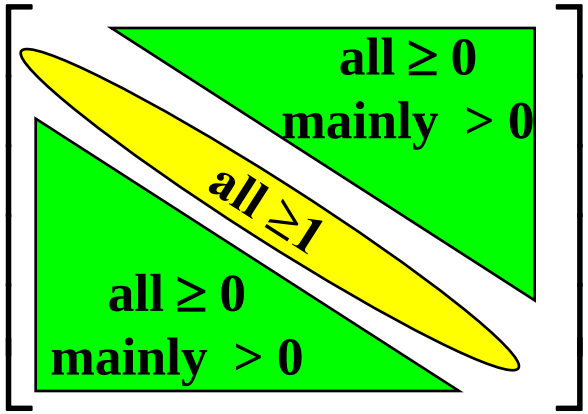
Leontief (I-O)

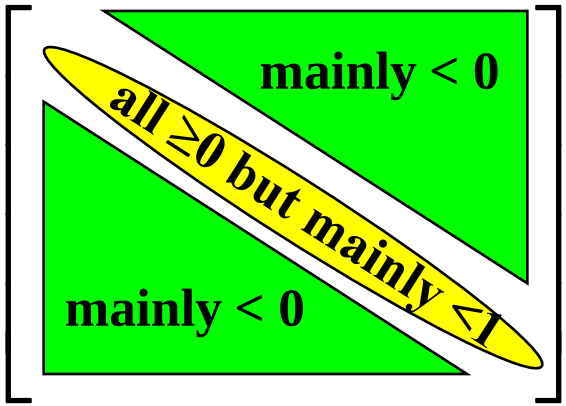
$$(I - A)^{-1} =$$



In Leontief's world (the 1930s) there is high unemployment
⇒ no upward pressure on prices of primary factors from extra demand

Johansen (CGE)

$$T_{X,Y} =$$



In Johansen's world (the 1950s) there is full employment
⇒ upward pressure on prices of primary factors from extra demand

Building a CGE model: the input-output database

		Absorption Matrix				
		1	2	3	4	5
		Prod-ucers	Invest-ors	House-holds	Exports	Govt
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ $C \times S$ ↓	BAS1	BAS2	BAS3	BAS4	BAS5
Margins	↑ $C \times S \times N$ ↓	MAR1	MAR2	MAR3	MAR4	MAR5
Sales Taxes	↑ $C \times S$ ↓	TAX1	TAX2	TAX3	TAX4	TAX5
Labour	↑ M ↓	LAB0CCIND				
Capital	↑ 1 ↓	CAPITAL				

C = Number of commodities
I = Number of industries
S = 2; domestic and imported
M = Number of occupations
N = Number of commodities used as margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

	Import Duty
Size	← 1 →
↑ C ↓	TARIFF

Value of inputs equals value of output

Sum(BAS1) + Sum(MAR1) + Sum(TAX1) +

Sum(LABOCCIND) + Sum(CAPITAL)

= Sum(BAS1)+Sum(BAS2)+Sum(BAS3)+Sum(BAS4)+Sum(BAS5)

+ Sum(MAR1)+Sum(MAR2)+Sum(MAR3)+Sum(MAR4)+Sum(MAR5)

- [Sum(BAS1(imp)) + Sum(BAS2(imp))

+ Sum(BAS3(imp)) + Sum(BAS5(imp))]

Sum(~~BAS1~~) + Sum(~~MAR1~~) + Sum(TAX1) +

Sum(LABOCCIND) + Sum(CAPITAL)

= Sum(~~BAS1~~)+Sum(BAS2)+Sum(BAS3)+Sum(BAS4)+Sum(BAS5)

+ Sum(~~MAR1~~)+Sum(MAR2)+Sum(MAR3)+Sum(MAR4)+Sum(MAR5)

- [Sum(BAS1(imp)) + Sum(BAS2(imp))

+ Sum(BAS3(imp)) + Sum(BAS5(imp))]

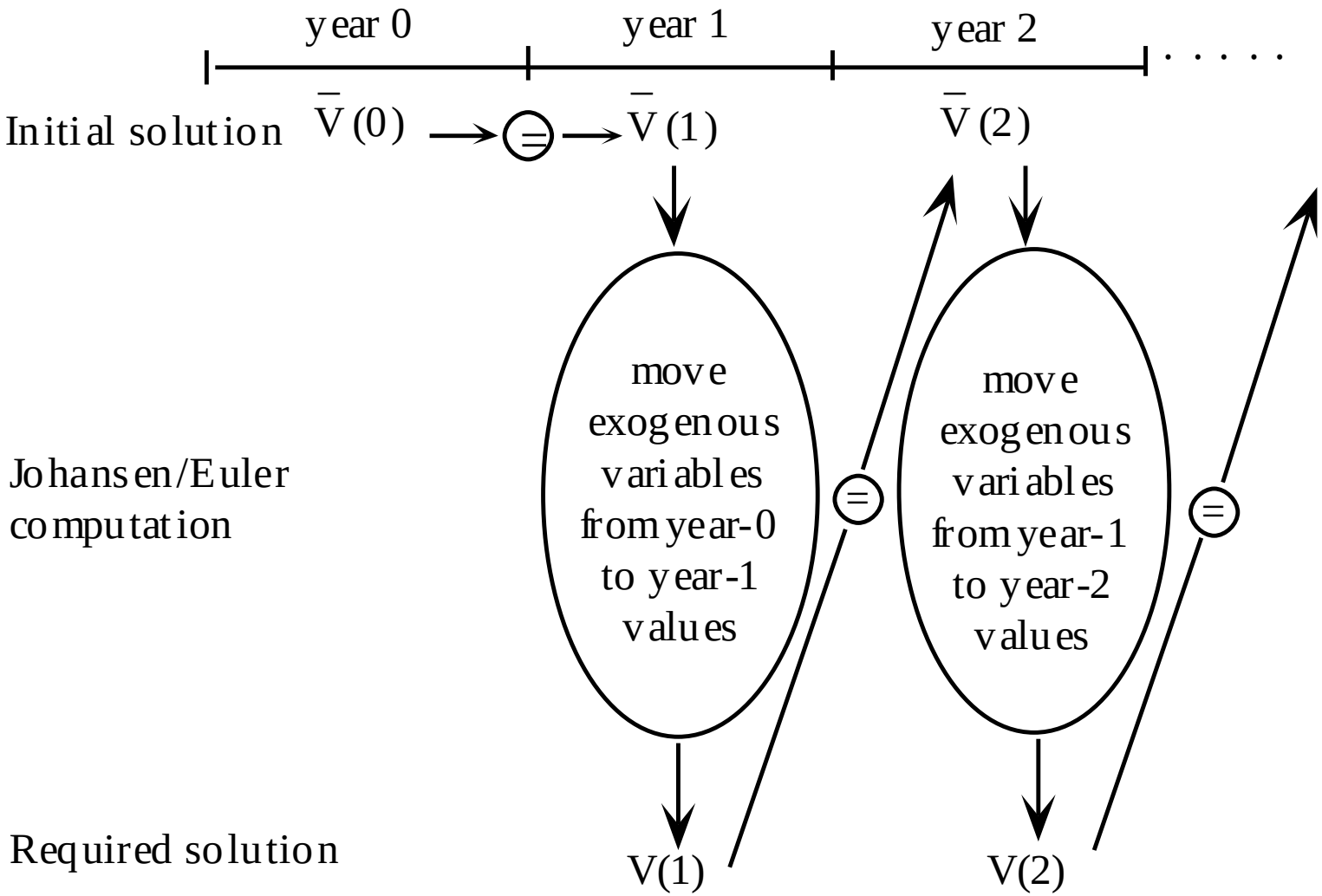
Income and expenditure measures of GDP

$$\text{Sum(LABOCCIND)} + \text{Sum(CAPITAL)} + \text{Sum(TAX1)}$$

$$+ \text{Sum(TARIFF)} + \sum_{\phi=2}^{5} \text{Sum(TAX}\phi\text{)}$$

$$= \text{Sum(BAS2)} + \text{Sum(MAR2)} + \text{Sum (TAX2)}$$
$$+ \text{Sum(BAS3)} + \text{Sum(MAR3)} + \text{Sum(TAX3)}$$
$$+ \text{Sum(BAS4)} + \text{Sum(MAR4)} + \text{Sum(TAX4)}$$
$$+ \text{Sum(BAS5)} + \text{Sum(MAR5)} + \text{Sum(TAX5)}$$
$$- \left[\sum_{\phi=1}^{3,5} \text{Sum(BAS}\phi\text{(imp))} - \text{Sum(TARIFF)} \right]$$

A sequence of solutions using required solution for t-1 as initial solution for t



Ingredients in a successful long-term CGE project

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Success and longevity of CoPS attributed to

- **sharp policy focus, initially tariffs**
- **the leadership of the foundation director Alan Powell who set the standards of openness and collegiality**
- **adaptability of CoPS' models reflecting extensions of Johansen techniques**
- **willingness to respond to clients needs**

Responding to the needs of CGE clients

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(1) up-to-date data

Historical simulations:

Tell the model about movements in observed variables since the last input-output table.

Historical simulations produce up-to-date input-output data that can't be contradicted by available statistics.

Historical simulations produce valuable estimates of trends in technologies, consumer preferences and other unobservables.

What do clients want:
(2) detail in the focus area

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Clients interested in biofuel policy required extension of a 500 commodity model to

- **include as separate commodities: Corn; Switch grass; Crop residue; Cellulosic materials; Organic by-products; Corn ethanol; Dried distillers grains with solubles; Cellulosic ethanol; Advanced ethanol; Gasoline; Diesel; and Other fuels**
- **explicit complementarity conditions specifying the operation of tariff rate quotas on imports of Sugar and other agricultural products**
- **72 types of agricultural land**

What do clients want:
(3) disaggregated results

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CGE results for the U.S.: income changes from an Iron & steel safeguard tariff

Income changes:		Million dollars
Tariff revenue		649.9
Labor income		-386.0
Capital income		-294.3
Iron and steel industry	239.5	
Input suppliers to Iron and steel	67.4	
Other industries (including steel users)	-601.2	
GDP		-30.4

What do clients want: (4) baseline forecasts

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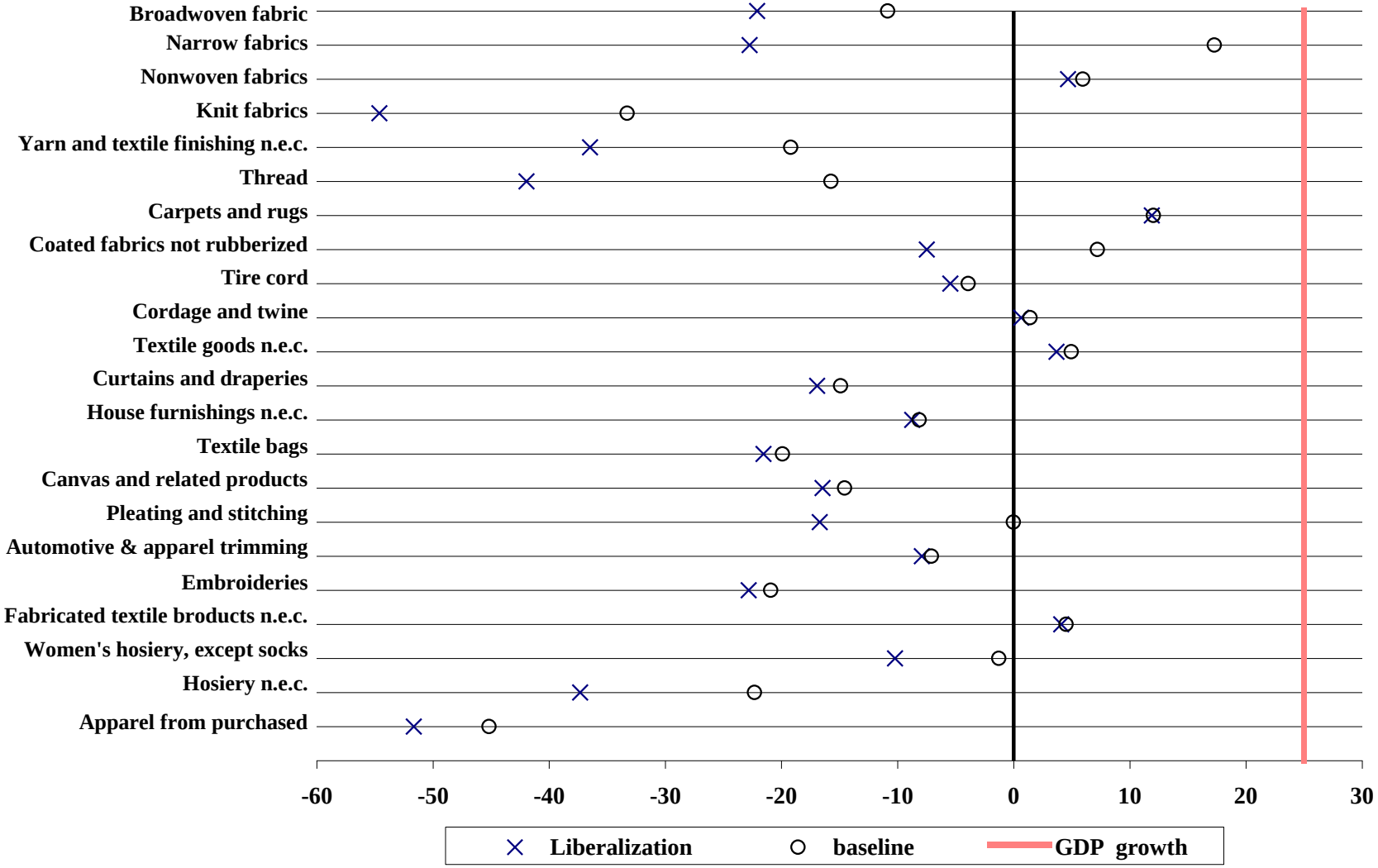
% output changes 2005-13: baseline and liberalization



What do clients want:

(5) historical decomposition

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Output of the Australian Motor vehicle industry, 1987 to 1994

Driving factor	Percentage effect
1. Shifts in foreign demands and import supply curves	-4.8
2. Changes in protection	-5.6
3. Technical change	24.4
4. Growth in aggregate employment	16.7
5. Changes in import/domestic preferences	-4.0
6. Changes in required rates of return	-7.0
7. Other factors	-5.2
Total	14.5

What do clients want:
(6) validation

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(1) **Computing validation**

(2) **Historical validation**

(3) **Forecasting validation**

(4) **Explanation validation**

Vital for assessing

- ***what has been taken into account?***
- ***is the relevant data up-to-date and accurate?***
- ***are the mechanisms built into the model adequate?***

Explanation validation can take many forms, e.g. a diagram

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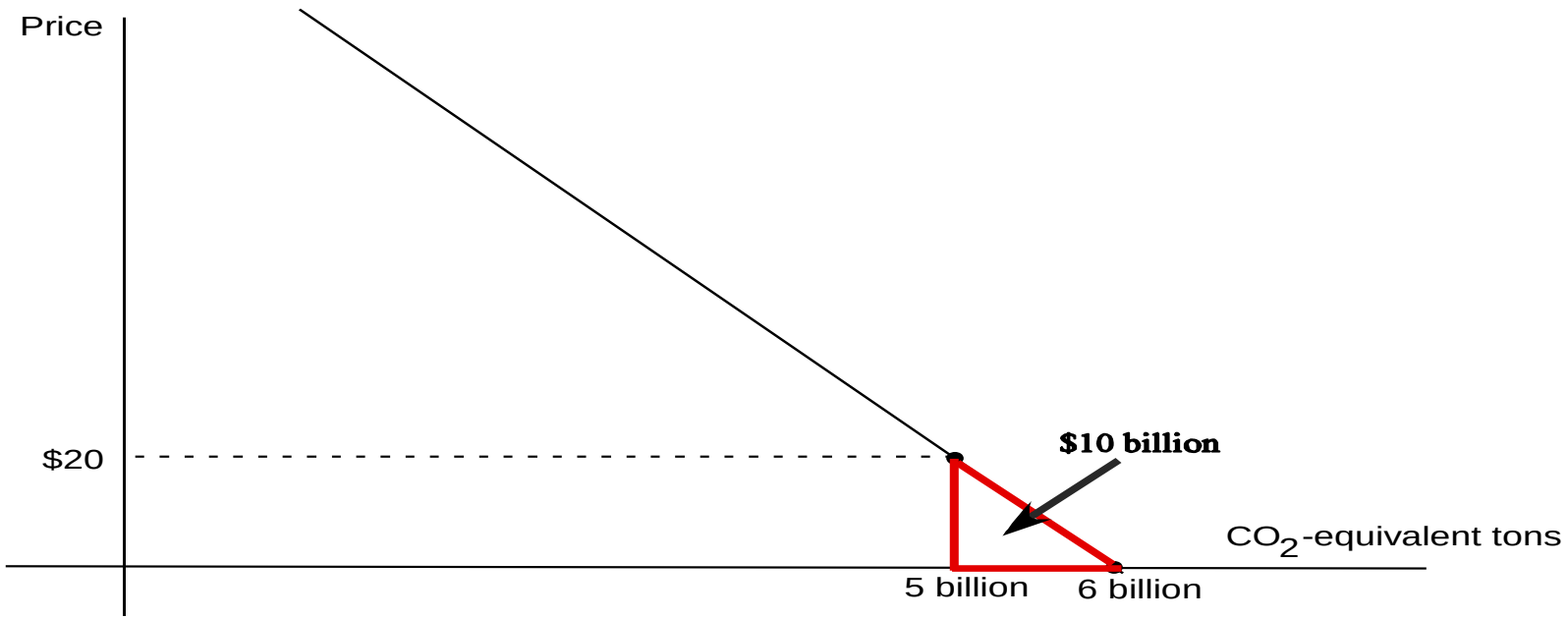
Welfare effect of carbon tax explained via consumer surplus diagram



Concluding remarks

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(1) Disaggregated CGE modelling can produce results that are credible, new, policy-relevant and not available from aggregated models

(2) Johansen (1960) is still worth reading

(3) Derivation from published statistics of a database for a detailed policy-relevant CGE model is highly skilled, painstaking work

Concluding remarks

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(4) Primary purpose of CGE modelling is to assist in policy formation. CGE modellers should respect demands of clients for: up-to-date data; sectoral detail; disaggregated results; baselines; decomposition; and validation

(5) CGE results can be explained convincingly to economists without CGE backgrounds

(6) CGE modelling benefits from an enduring team environment allowing specialization and accumulation of knowledge across generations