NEREUS

Núcleo de Economia Regional e Urbana da Universidade de São Paulo

The University of São Paulo Regional and Urban Economics Lab

CENTRO DE ECONOMÍA Y POLÍTICA REGIONAL

UNIVERSIDAD ADOLFO IBÁÑEZ

Tool Kits in Multi-regional and Multi-sectoral General Equilibrium Modeling for Chile

International Workshop on General Equilibrium Modeling, Universidad Adolfo Ibañez
Viña del Mar, December 4-5, 2018

Eduardo A. Haddad

Research team – NEREUS

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Background

Interregional **I**nput-**O**utput **A**djustment **S**ystem (IIOAS)

- Colombia, Ecuador, Azores, Lebanon, Egypt, Morocco, Brazil, Greece, **Chile**, Mexico

Mediterranean (partnerships for modeling)

- ***Portugal***, Spain, France, *Italy*, ***Greece***, *Turkey*, ***Lebanon***, ***Egypt***, Tunisia, ***Morocco***

REAL/RSAI network (Geoffrey J. D. Hewings)

"Nereids Program" and "CONICYT-FAPESP Project"

Background

EAE 5918 – "Applied General Equilibrium Models"

- Project 2017: Greece
- Part 1 – Input-Output models
- Part 2 – CGE models
- Modeling Marathons (2x)
- Publication process

Enhance broader scientific communication skills

- **Project 2018: Chile**
- Prof. Patricio Aroca

I Modeling Marathon

Date: September 13, 2018
Time: 8:00 – 18:00
Place: NEREUS meeting room

Outcomes

Interregional Input-Output System for Chile

National CGE Model for Chile

Interregional CGE Model for Chile

Eight different applications

"International Workshop on General Equilibrium Modeling: Applications for the Chilean Economy"

Interregional Input-Output System for Chile

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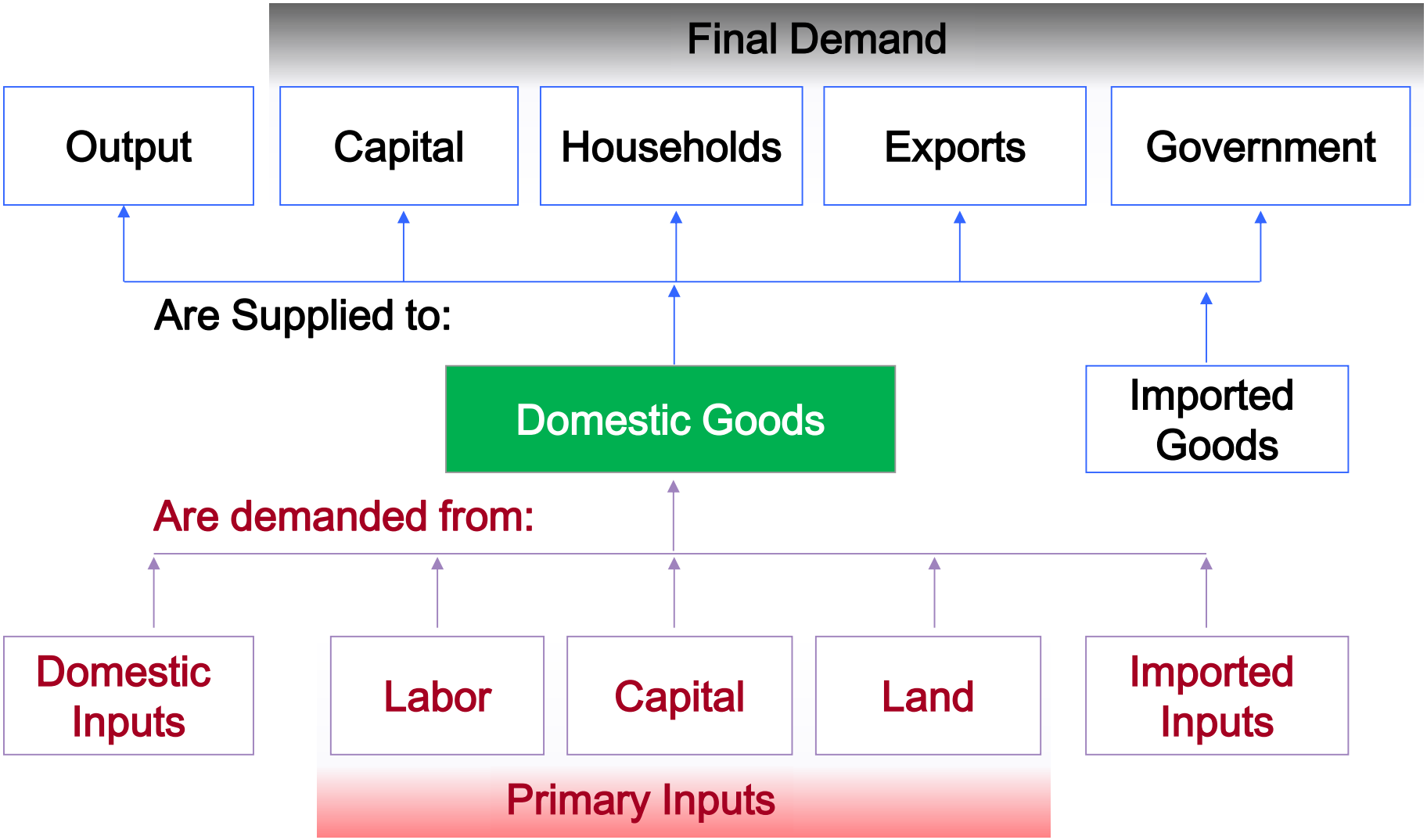
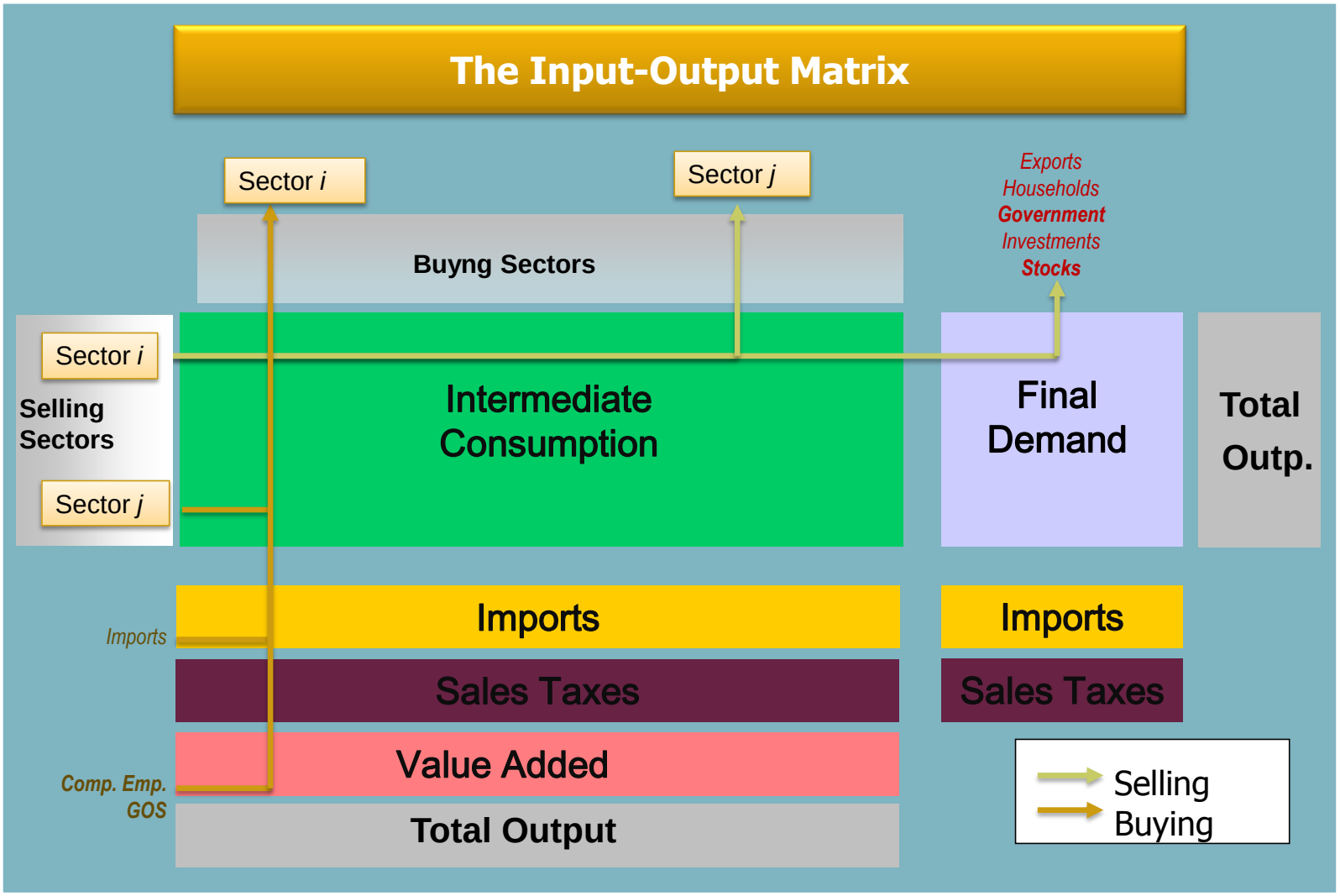
Interregional Input-Output Tables for Chile, 2014

Reference: Haddad, E. A., Aroca, P. A., Arantes, S. M., Dias, L. C. C., Fernandes, R. P., Li, D. L., Pimenta, B. P. P., Rocha, A. A. M., Sass, K. S., Ussami, K. A. (2018). Interregional Input-Output System for Chile, 2014, The University of São Paulo Regional and Urban Economics Lab (NEREUS), mimeo

Input-output flows



Input-output table



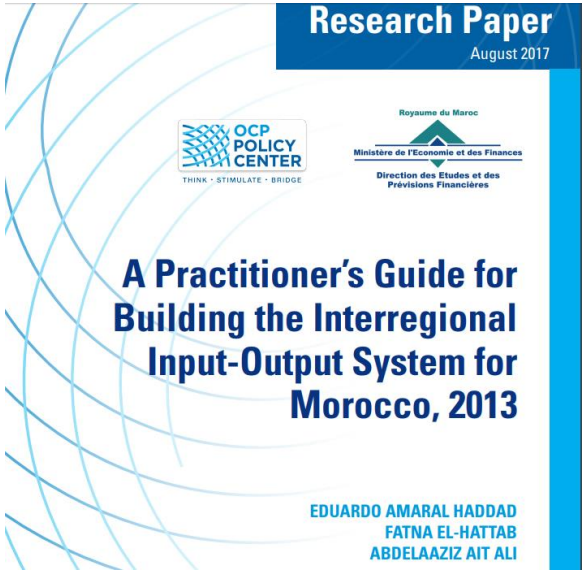
Interregional IO models

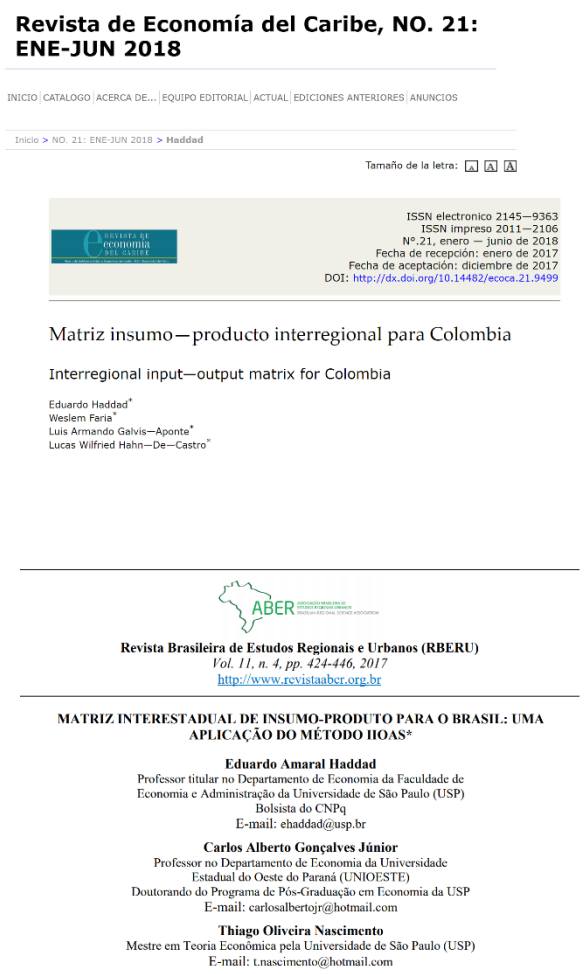
	Buying Sectors Region L	Buying Sectors Region M			
Selling sectors **Region L**	Interindustry Inputs LL	Interindustry Inputs LM	FD LL	FD LM	TO L
Selling sectors **Region M**	Interindustry Inputs ML	Interindustry Inputs MM	FD ML	FD MM	TO M
	Imports from the World	Imports from the World	M	M	M
	Sales Taxes	Sales Taxes	T	T	T
	Value Added	Value Added			
	Total Output L	Total Output M			

Interregional IO models

Interregional IO models

Methodology





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Inicio > NO. 21: ENE-JUN 2018 > Haddad

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Matriz insumo—producto interregional para Colombia

Interregional input—output matrix for Colombia

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MATRIZ INTERESTADUAL DE INSUMO-PRODUTO PARA O BRASIL: UMA APLICAÇÃO DO MÉTODO IIOAS*

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مجلة التنمية والسياسات الاقتصادية

المجلد السادس عشر - العدد الأول (ISSN - 1561 - 0411) يناير 2014

المحتويات

اتجاه التأثير ما بين الصادرات النفطية والنمو الاقتصادي: حالة الجزائر.
قاسم حموري
ساره جندي

العلاقة بين سعر الصرف وأسعار الأسهم في السوق السعودية.
فوزان الفوزان

التجارة والاعتماد المتبادل في لبنان: تحليل المدخلات والمخرجات على أساس إقليمي.
ادوارد حداد

الحوكمة والنمو الاقتصادي: تطبيق على بلدان الشرق الأوسط و شمال افريقيا.
نهى عماره

أثر تقلبات سعر الصرف على أداء الاقتصاد الكلي في السودان.
عبيدالله محجوب

مراجعة كتاب:
" ستجلز، جوزيف، السقوط الحرّ: الولايات المتحدة، والأسواق الحرّة، وهبوط الاقتصاد العالمي ".
أحمد الكواز

Arab Planning Institute
المعهد العربي للتخطيط

National CGE Model for Chile

CRunGEM - ORANIG2

File Copy View Options Help

Picture | Text | Model/Data | Closure | Shocks | Output files | Solve | Results

ORANI-Chile Model

National Computable General Equilibrium Model for Chile

The University of Sao Paulo Regional and Urban Economics Lab - NEREUS

November 2018

What is an applied CGE model ?

Computable, based on data

It has many sectors

And perhaps many regions, primary factors and households

A big database of matrices

Many, simultaneous, equations (hard to solve)

Prices guide demands by agents

Prices determined by supply and demand

Trade focus: elastic foreign demand and supply

What is a CGE model good for?

Analyzing policies that affect different sectors in different ways

The effect of a policy on different:

- ✓ Sectors
- ✓ Regions
- ✓ Factors (Labor, Capital)

Policies that help one sector a lot, and harm all the rest a little

What-if questions

What if productivity in the grape sector decreased due to a temporary climate shock?

What if the climate shock also affected the quality of Chilean wine?

What if productivity in mining decreased by 1%?

What if government imposed a 3% production tax on total output of copper sector?

What if a drought hit Central Chile decreasing productivity in agriculture by 10%?

What if Chile faced (uncertain) commodity price shocks?

What if Central government increased its expenditures?

ORANI-Chile like other GE models

Equations typical of an AGE model, including:

- ✓ market-clearing conditions for commodities and primary factors;
- ✓ producers' demands for produced inputs and primary factors;
- ✓ final demands (investment, household, export and government);
- ✓ the relationship of prices to supply costs and taxes;
- ✓ a few macroeconomic variables and price indices.

Neo-classical flavor:

- ✓ demand equations consistent with optimizing behavior (cost minimization, utility maximization).
- ✓ competitive markets: producers price at marginal cost.

Model Database – Structural coefficients

(miles de millones de pesos de 2014)

	User (1j)	User (2j)	User (3)	User (4)	User (5)	User (6)	TOTAL
i∈G, s∈S	BAS(i,s,(1j))	BAS(i,s,(2j))	BAS(i,s,(3))	BAS(i,s,(4))	BAS(i,s,(5))	B(i,s,(6))	B(i,s,(•))
i∈G, s∈S	MAR(i,s,(1j))	MAR(i,s,(2j))	MAR(i,s,(3))	MAR(i,s,(4))	MAR(i,s,(5))	-	MAR(i,s,(•))
i∈G, s∈S	TAX(i,s,(1j))	TAX(i,s,(2j))	TAX(i,s,(3))	TAX(i,s,(4))	TAX(i,s,(5))	-	TAX(i,s,(•))
s∈F	VA(g+1,s,(1j))	-	-	-	-	-	VA(g+1,s,(•))
TOTAL	VTOT(•,•,(1j))	VTOT(•,•,(2j))	VTOT(•,•,(3))	VTOT(•,•,(4))	VTOT(•,•,(5))	-	VTOT(•,•,(•))

	User (1j)	User (2j)	User (3)	User (4)	User (5)	User (6)	TOTAL
i∈G, s∈S	124,761	32,235	71,195	47,567	18,982	-864	293,877
i∈G, s∈S	5,753	2,102	12,271	1,646	3	-	21,776
i∈G, s∈S	3,109	1,108	10,269	0	95	-	14,581
s∈F	136,170	-	-	-	-	-	136,170
TOTAL	269,793	35,445	93,735	49,213	19,080	-864	466,403

Features of database

Commodity flows are valued at "basic prices" (do not include user-specific taxes or margins)

For each user of each imported good and each domestic good, there are numbers showing:

- ✓ tax levied on that usage
- ✓ usage of several margins (trade, transport)

MAKE multi-production:

- ✓ each commodity may be produced by several industries
- ✓ each industry may produce several commodities

For each **industry** the total cost of production is equal to the total value of output (**column** sums of MAKE).

For each **commodity** the total value of sales is equal to the total value of output (**row** sums of MAKE).

No data regarding direct taxes or transfers. Not a full SAM.

Industries and commodities

- 111 industries:
  - 12 industries - Agriculture and fishing
  - 6 industries – Mining
  - 45 industries – Manufacturing
  - 6 industries – Public Utilities
  - 42 industries – Services
- 179 products
  - 26 products - Agriculture and fishing
  - 10 products – Mining
  - 82 products – Manufacturing
  - 6 products - Public Utilities
  - 55 products - Services

3 - Cultivo de uva

13 - Extracción de carbón
14 - Extracción de petróleo y gas natural
15 - Minería del cobre
16 - Minería del hierro
17 - Minería de otros metalíferos no ferrosos …

7 - Uva vinífera y pisquera
8 - Uva de mesa

27 - Carbón
30 - Cobre
32 – Hierro
(…)

Model Database – Behavioral parameters

SIGMA1PRIM – CES between primary factors: **0.9**

SIGMA1, SIGMA2, SIGMA3 – Armington elasticities:

- ✓ Agriculture and fishing: **1.2**
- ✓ Mining and manufacturing: **0.8**
- ✓ Services: **0.6**

SIGMA1OUT – CET transformation elasticities:

- ✓ Agriculture and fishing: **1.2**
- ✓ Mining and manufacturing: **0.8**
- ✓ Services: **0.6**

Expenditure elasticities – Melo & Cortés (2007)

CUADRO A.1

Grupo de alimentos y productos que los componen

Grupo								
1	2	3	4	5	6	7	8	9
Pan, cereales y productos de cóctel	Carnes, cecinas, embutidos, pescados y mariscos	Lácteos y huevos	Otros consumos del hogar	Azúcares y bebidas estimulantes	Sopas, condimentos y bebidas	Bebidas alcohólicas y alimentos, fuera del hogar	Frutas y verduras	Aceites, grasas y mantecas
Aceitunas	Carne de cerdo	Crema de leche	Vestuario y calzado	Azúcar	Analcohólicas	Cerveza	Frutas frescas	Aceite
Alimentos colados y picados	Carne de cordero	Huevos	Gastos de la vivienda, agua, combustibles y energía eléctrica	Café	Caldo en cubo, extractos	Champagne	Verduras frescas y congeladas	Manteca
Arroz	Carne de vacuno	Leche	Muebles, decoraciones, enseres domésticos y servicios	Calugas y caramelos	Especias	Chicha	Conservas de frutas	Mantequilla
Avena, maíz y sus derivados	Embutidos y cecinas	Leche condensada	Gastos en servicios médicos	Chicle	Ketchup	Otros licores	Conservas de verduras	Margarina
Cereales preparados	Menudencias de ave	Leche en polvo	Transporte y comunicaciones	Chocolate	Levadura y polvos de hornear	Pisco	Legumbres	
Fortificante para leche	Pavo	Queso	Recreación y esparcimiento	Dulce de membrillo y camote	Mayonesa	Vino	Frutas deshidratadas	
Galletas de agua y soda	Pollo	Yogurt	Enseñanza	Helado	Mostaza y otras salsas	Whisky		
Galletas dulces	Atún en conserva		Otros bienes y servicios	Hierbas naturales	Sal	Almuerzo y comida		
Galletas para cóctel	Jurel en conserva			Manjar	Salsa de tomate	Bebida Gaseosa y jugo		
Harina y otros derivados del trigo	Marisco en conserva			Mermelada	Sopas y cremas	Café expreso		
Maní	Marisco fresco y congelado			Miel	Vinagre	Cerveza		
Otros alimentos para niños	Otros pescados en conserva			Postre preparado	Agua Mineral	Combinado		
Pan	Otros productos del mar			Té	Bebida gaseosa	Completo		
Pastas	Pescado congelado, apanado y ahumado				Jugo de fruta	Desayuno		
Pre-pizza y otras masas saladas preparadas	Pescado fresco				Polvo para preparar jalea, budín y flan	Empanadas		
Tortas, pasteles y queques					Polvo para preparar jugo	Lomito, hamburguesa y otros sándwiches		
						Once		
						Papas fritas en porciones		
						Platos preparados Pollo asado		

Expenditure elasticities – Melo & Cortés (2007)

CUADRO A.5

Elasticidades precio compensadas y elasticidades gasto

	Elasticidades precio compensadas propia y cruzadas								
	Grupo 1	Grupo 2	Grupo 3	Grupo 4	Grupo 5	Grupo 6	Grupo 7	Grupo 8	Grupo 9
Grupo 1	–0.9497141*	0.0623478	0.076896	0.6684487*	–0.0497305	0.1406558	0.0223432	0.0303922	–0.0016391
	(0.1601491)	(0.0593656)	(0.0483894)	(0.0581545)	(0.0912752)	(0.0880997)	(0.0443766)	(0.0353085)	(0.1200206)
Grupo 2	0.0581937	–1.006515*	0.0751686*	0.671997*	0.1080661*	–0.0047645	–0.0126273	0.0841292*	0.0263519
	(0.0552598)	(0.0442234)	(0.0345295)	(0.0275487)	(0.0332465)	(0.0440765)	(0.033907)	(0.0258371)	(0.0343825)
Grupo 3	0.1665837	0.172516*	–1.041851*	0.6211044*	0.0023026	–0.0412164	0.0539479	0.0884859	–0.0218729
	(0.1038494)	(0.0792835)	(0.0926305)	(0.0482005)	(0.0623415)	(0.0940439)	(0.0591497)	(0.0502529)	(0.0495205)
Grupo 4	0.06864*	0.0743639*	0.0301886*	–0.3386191*	0.0181034*	0.0363424*	0.0486253*	0.0520556*	0.0102999*
	(0.006005)	(0.003025)	(0.002265)	(0.0048472)	(0.0034653)	(0.0036027)	(0.0026836)	(0.0017231)	(0.0048505)
Grupo 5	–0.1485971	0.3550615*	0.0036194	0.5309373*	–0.7836784*	–0.0461161	–0.083142	0.1776787*	–0.0057633
	(0.2788861)	(0.1091271)	(0.0891279)	(0.1034712)	(0.2339404)	(0.1892983)	(0.0950944)	(0.0667375)	(0.2235709)
Grupo 6	0.2628648	–0.0092489	–0.0359062	0.6527503*	–0.028156	–0.9761824*	0.153559*	–0.1027723	0.0830918
	(0.1634168)	(0.0880677)	(0.0818344)	(0.0655191)	(0.115126)	(0.1857242)	(0.0667661)	(0.0607816)	(0.0881703)
Grupo 7	0.030906	–0.0191067	0.0357704	0.6605733*	–0.037874	0.1161563*	–1.010518*	0.2174435*	0.0066489
	(0.0625085)	(0.0512835)	(0.0389423)	(0.036976)	(0.0437769)	(0.0504347)	(0.0775507)	(0.0523917)	(0.0339081)
Grupo 8	0.0384838	0.109957*	0.0502787	0.6112714*	0.070369*	–0.0672534	0.1879528*	–1.036212*	0.0351528*
	(0.7441296)	(0.0337749)	(0.0286596)	(0.0206278)	(0.0265961)	(0.0397867)	(0.0453017)	(0.0446212)	(0.0158269)
Grupo 9	–0.0080426	0.175699	–0.063745	0.6168296*	–0.0120647	0.2770866	0.0290594	0.1793745*	–1.194197
	(0.7441296)	(0.2290938)	(0.1436894)	(0.2923435)	(0.4533623)	(0.2938811)	(0.1497527)	(0.0808536)	(0.7064214)
Elasticidades	0.6768144*	0.9386683*	0.9202147*	1.049464*	0.9754854*	0.9591301*	1.092167*	0.9165859*	0.8800257*
Gasto	(0.0109929)	(0.0123508)	(0.0149915)	(0.0037972)	(0.0145283)	(0.0139224)	(0.0236223)	(0.0121372)	(0.0182508)

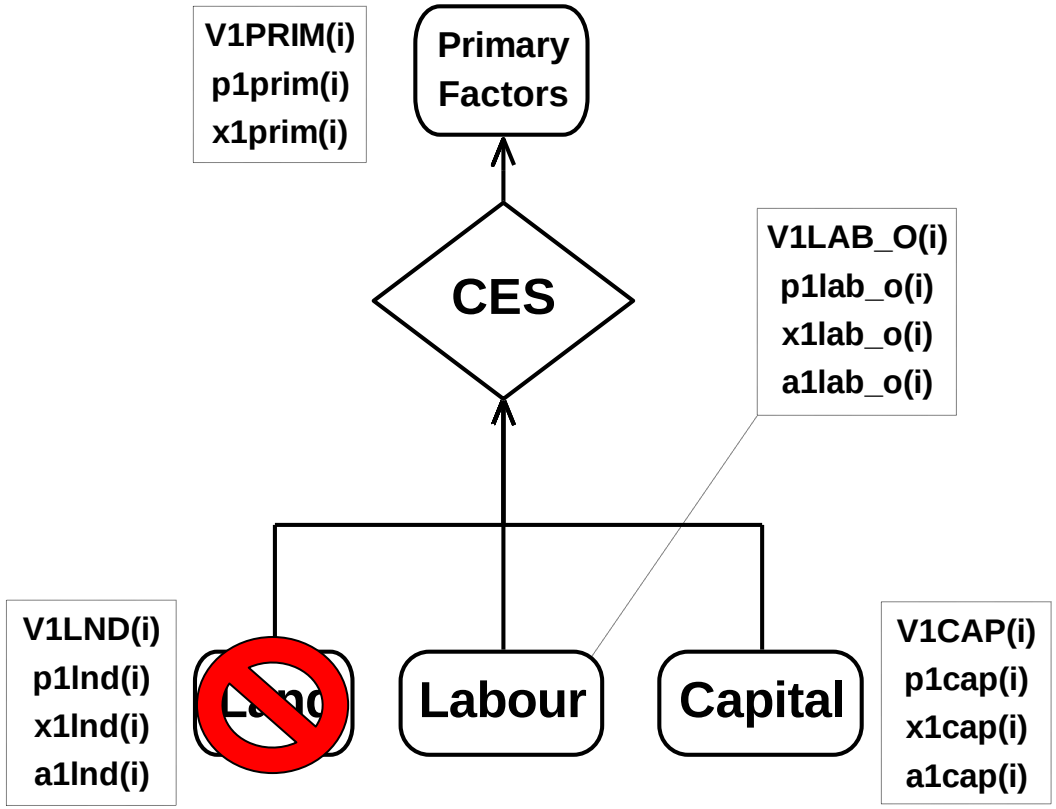
Nota: * significativo al 5%. Errores estándar entre paréntesis.

Export demand elasticities – De Gregorio (1984)

Cuadro 1.– Elasticidades precio de las exportaciones chilenas

Producto	*Modelo*	*Elasticidad precio de corto plazo*	*Elasticidad precio de largo plazo*
Cobre, Gran Minería	I	0,10	0,14
	II	0,06	
Cobre, Mediana y Pequeña Minería	II	0,06	
Molibdeno a/	I	0,15	0,22
	II	0,10	
Hierro a/	I	0,24	0,58
Celulosa	I	0,12	0,47
Harina de pescado a/	I	0,34	0,64
Sector industrial b/	III	0,33	1,77
Sector industrial excluidos algunos productos b/	III	0,44	2,34
Sector agropecuario y del mar b/	III	0,59	3,56

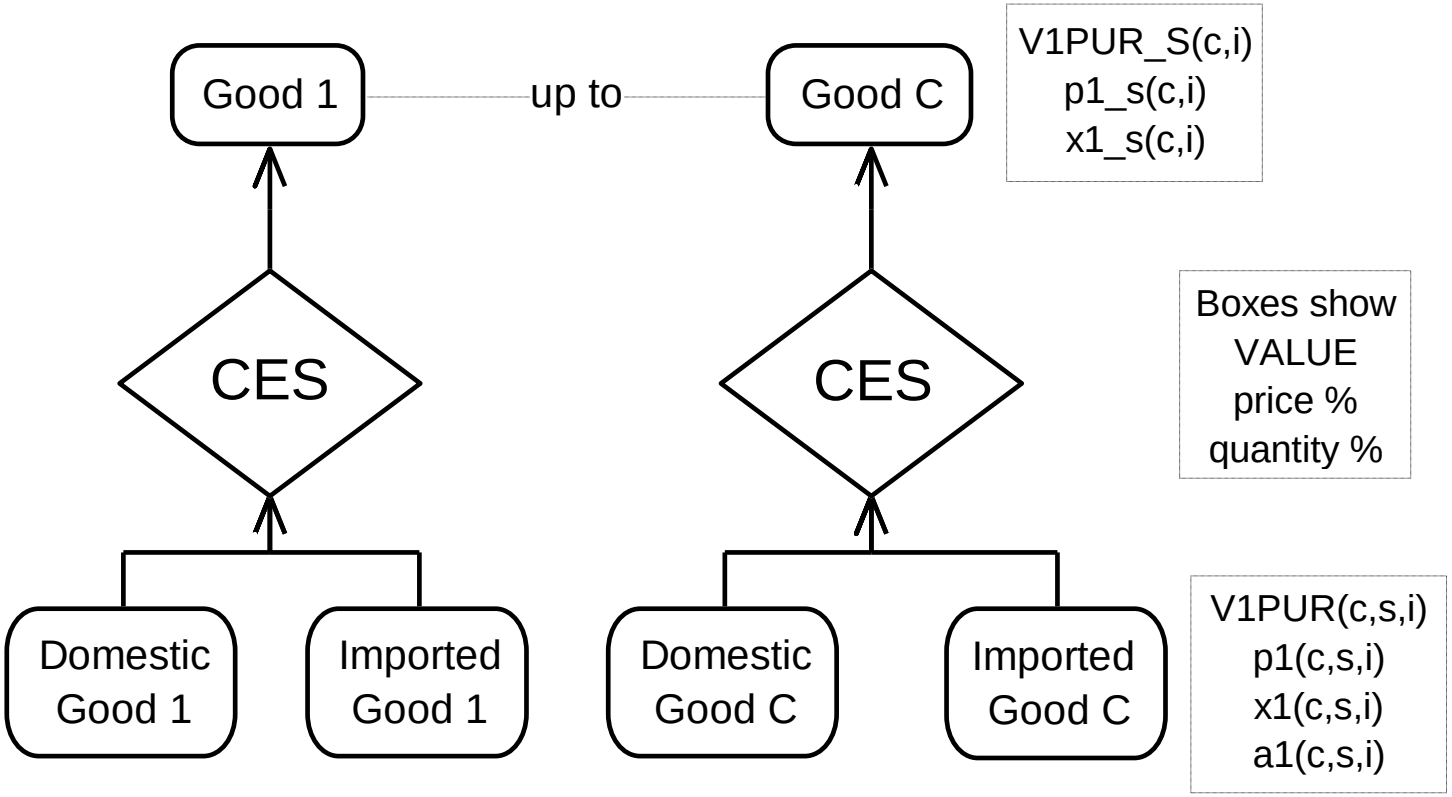
Primary factor mix



X1PRIM(i) = CES (X1LAB_O(i)/A1LAB_O(i),
X1CAP(i)/A1CAP(i),
X1LND(i)/A1LND(i))

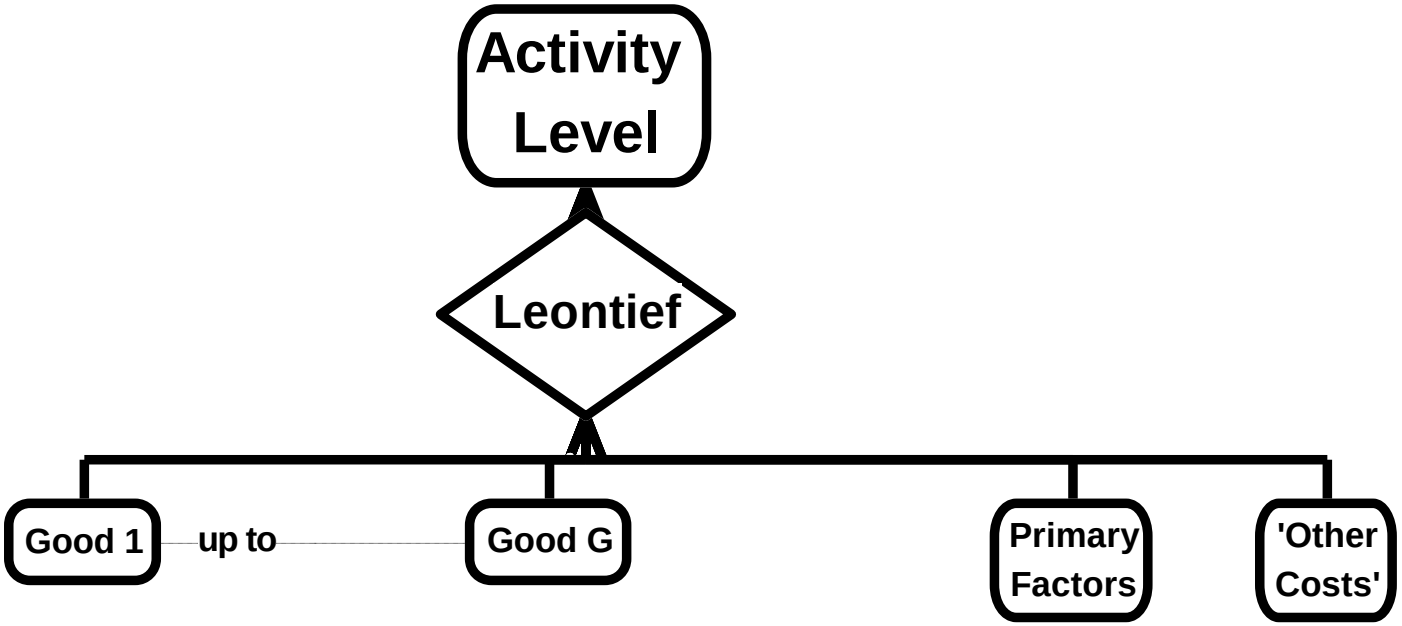
quantity-augmenting technical change

Intermediate sourcing



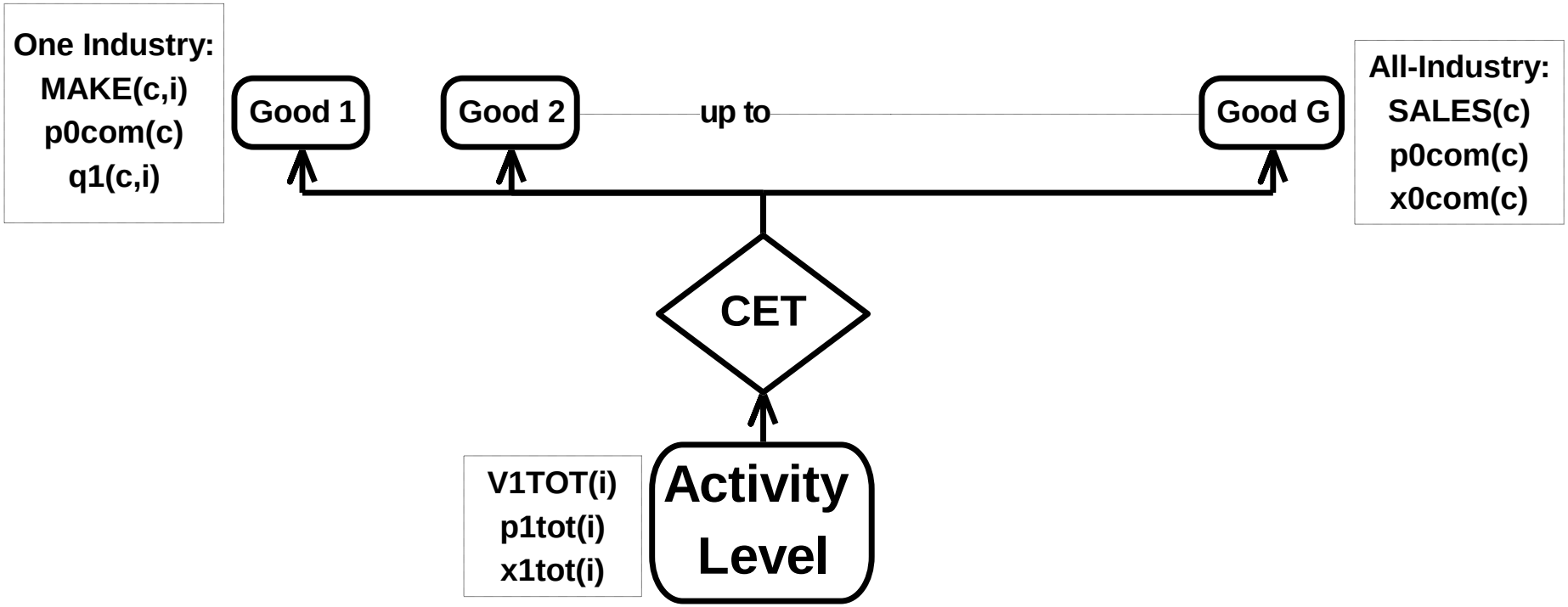
X1_S(c,i) = CES(All,s,SRC: X1(c,s,i)/A1(c,s,i))

Top nest of industry inputs

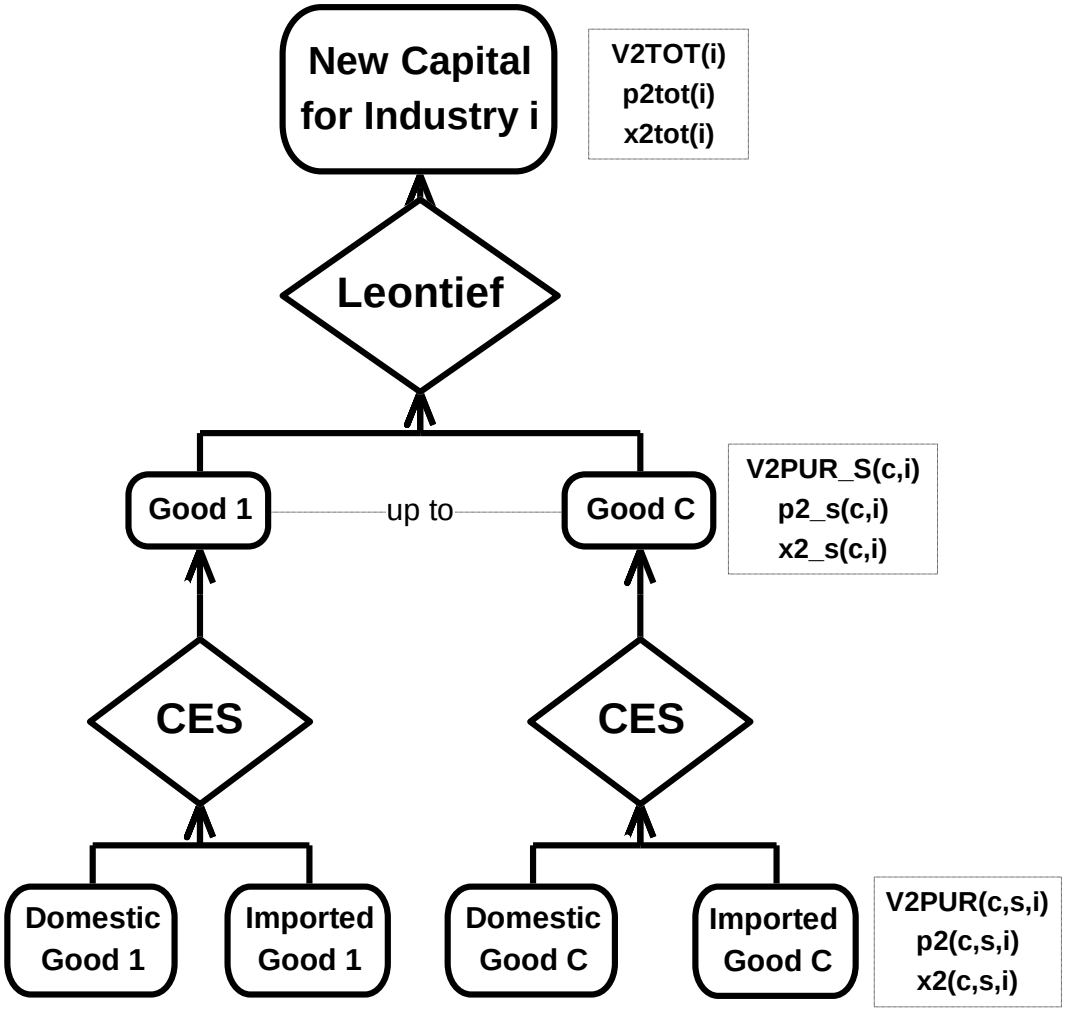


X1TOT(i) =
MIN(All,c,COM: X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)],
X1PRIM(i)/[A1PRIM(i)*A1TOT(i)],
X1OCT(i)/[A1OCT(i)*A1TOT(i)])

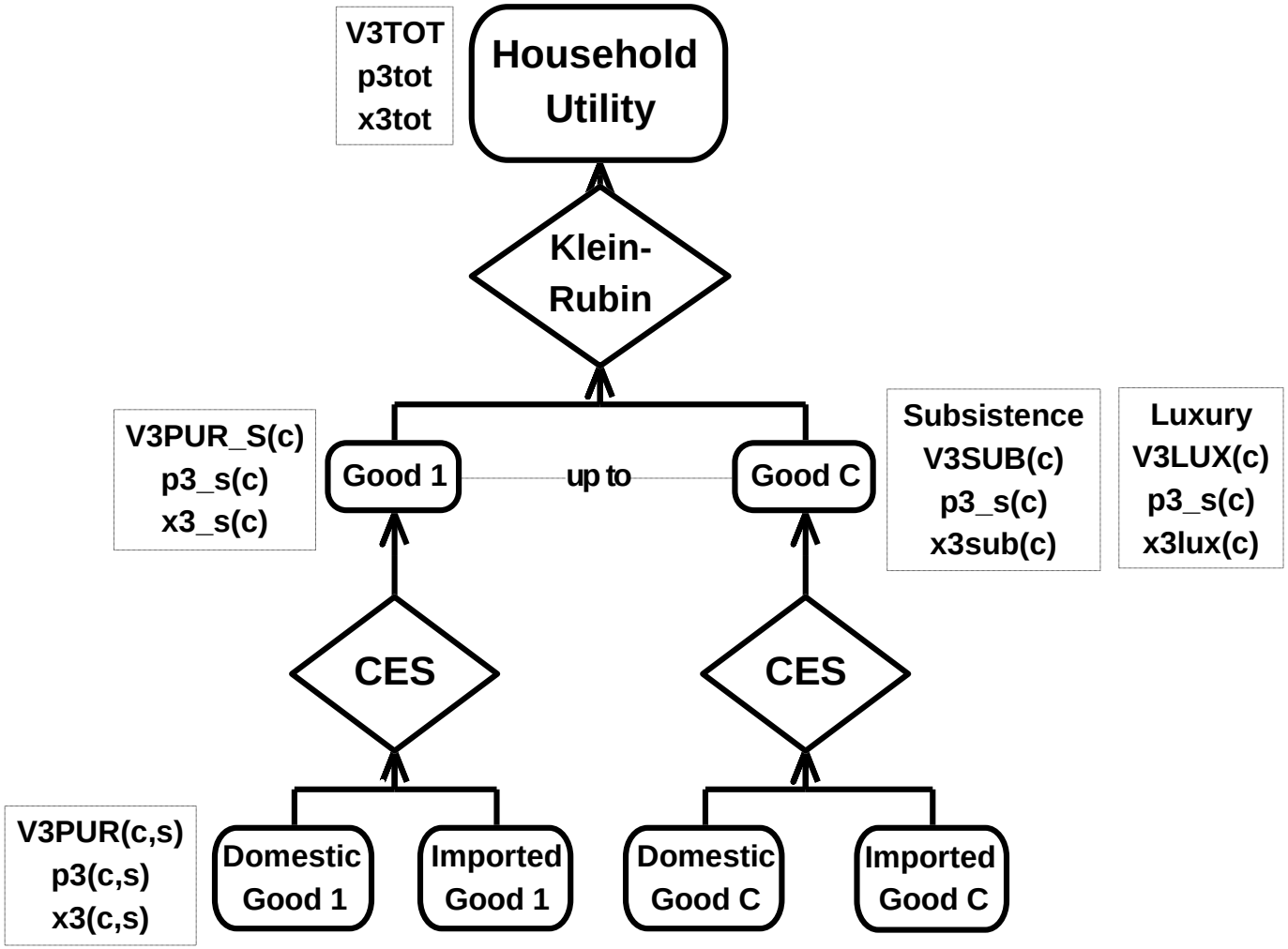
Industry output mix



Composition of investment



Household demand



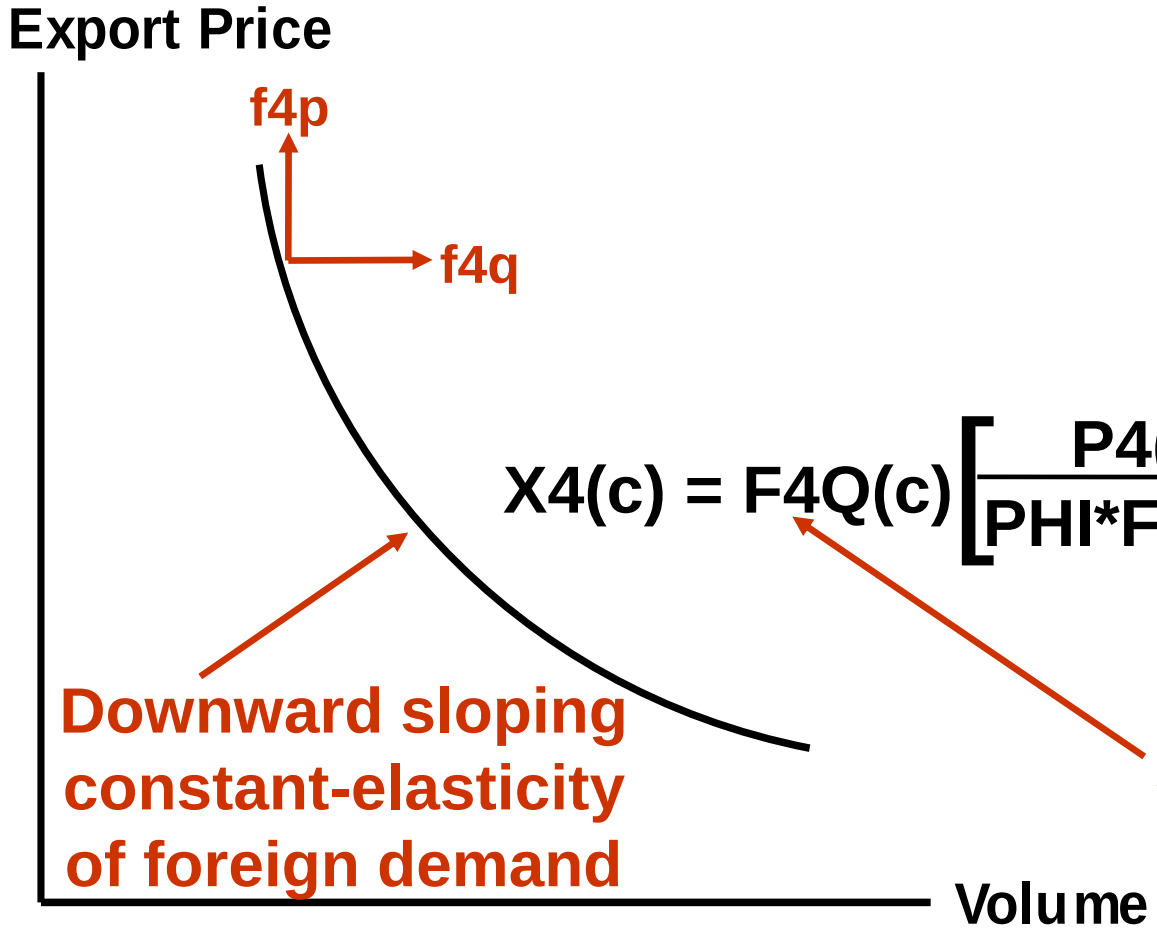
Consumption function

```
Variable
w1prim_i # Aggregate primary factor payments #;
w3tot # Nominal total household consumption #;
f3tot # Ratio, factor income/ consumption #;

Equation E_f3tot # Consumption function #
w3tot = w1prim_i - f3tot;

! note: normally ONE of f3tot and x3tot is exogenous
f3tot exogenous gives x3tot ... hou cons follows factor
income
x3tot  exogenous gives f3tot ... avg propensity to cons
changes  !
```

Individual export demand



$$X4(c) = F4Q(c)\left[\frac{P4(c)}{PHI*F4P(c)}\right]^{EXP_ELAST(c)}$$

Downward sloping constant-elasticity of foreign demand

shift variables

Government demand function

```
Variable
f5tot  # Overall shift term for government demands #;
f5tot2 # Ratio between f5tot and real ind tax rev #;
(all,c,COM)(all,s,SRC) f5(c,s) # Government demand shift #;
w0tax_csi # Aggregate revenue from all indirect taxes #;
p5tot # Government price index #;

Equation
E_x5 # Government demands #
(all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;
E_f5tot # Overall government demands shift #
f5tot = w0tax_csi - p5tot + f5tot2;

! note: normally ONE of f5tot and f5tot2 is exogenous
f5tot2 exogenous ... gov follows real tax rev
f5tot exogenous gives x5(c,s) = f5(c,s) + f5tot ...gov exog!
```

Purchasers prices

All purchaser's price equations have the same basic form:

Purchaser's value of commodity c used by user N

Value of margins associated with the purchase

$$PN_c \,.\, XN_c = P0c \,.\, XN_c \,.\, T_c + \Sigma_{mar}\, X_{mar,\,c} \,.\, P_{mar}$$

value preservation

Basic value of commodity c used by user N

Power of tax (= 1 + rate of tax) Eg. 1.03

. . . linearising (and dropping subscripts) . . .

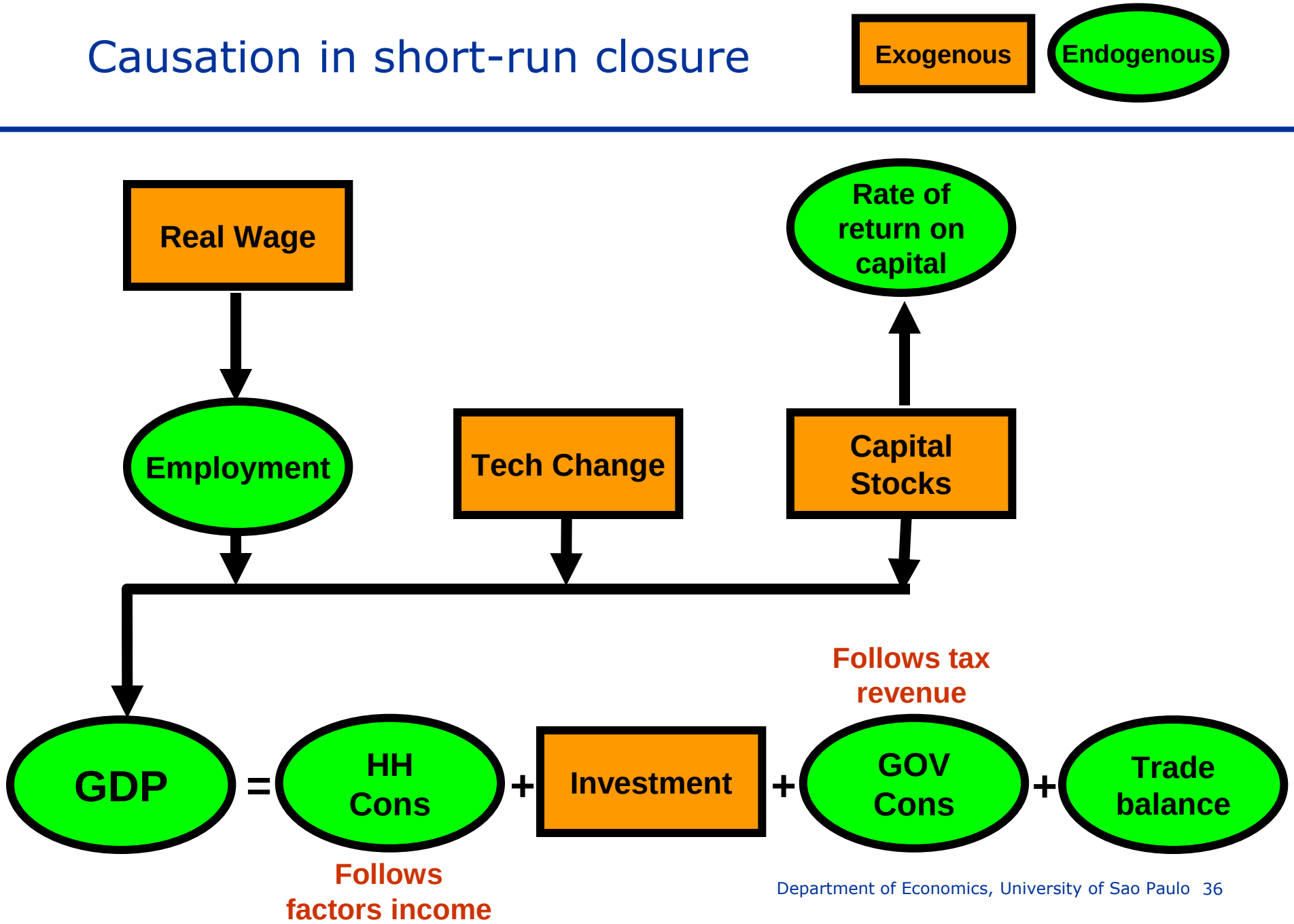
$$[P.X]\,(p + x) = [P0.X.T]\,(p0 + x + t) + \Sigma_{mar}[X_{mar}.P_{mar}]\,(x_{mar} + p_{mar})$$

. . . noting that demand for margins is: $x_{mar} = x + a_{mar}$

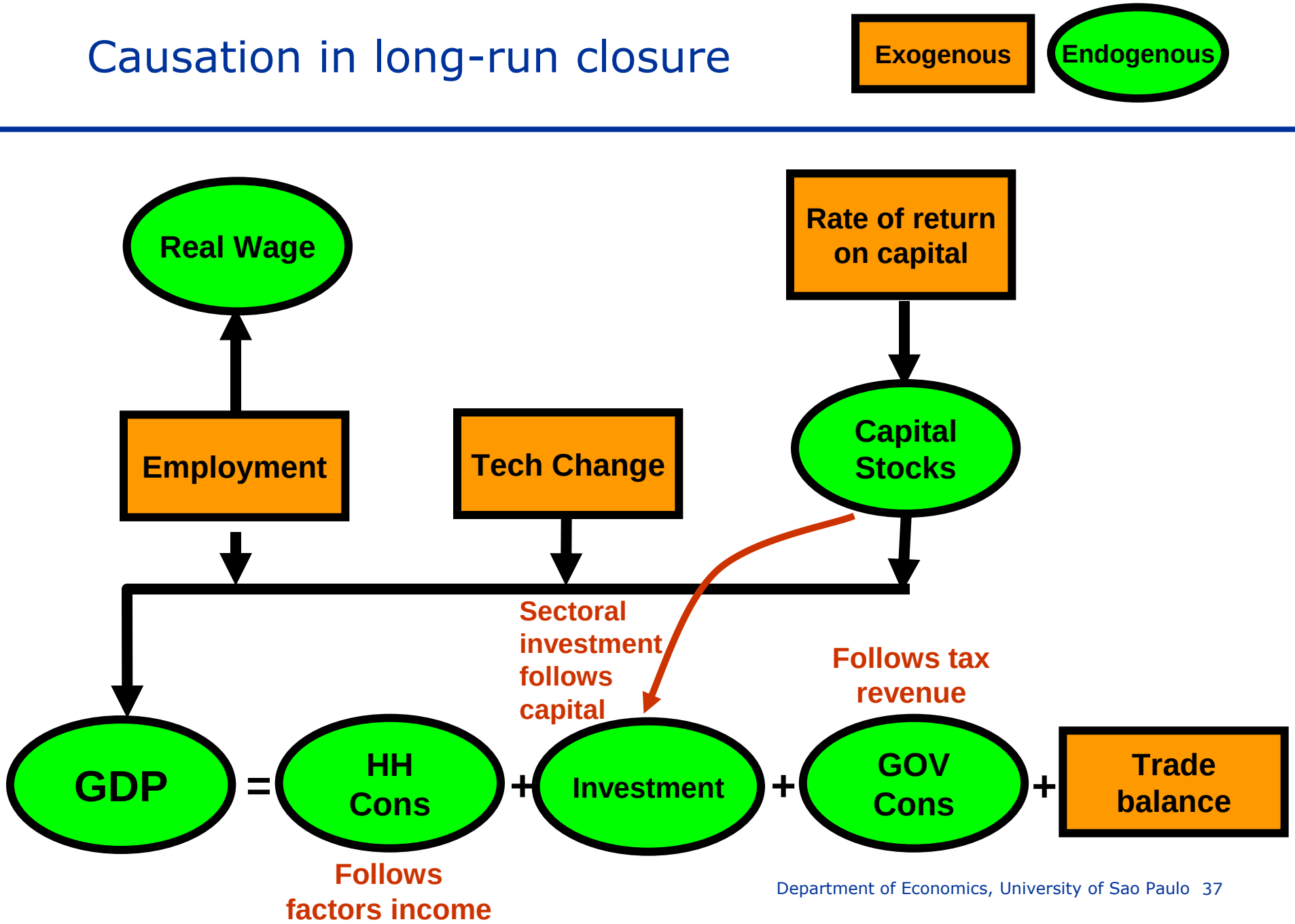
$$[P.X]\,p = [P0.X.T]\,(p0 + t) + \Sigma_{mar}[X_{mar}.P_{mar}]\,(a_{mar} + p_{mar})$$

Standard form

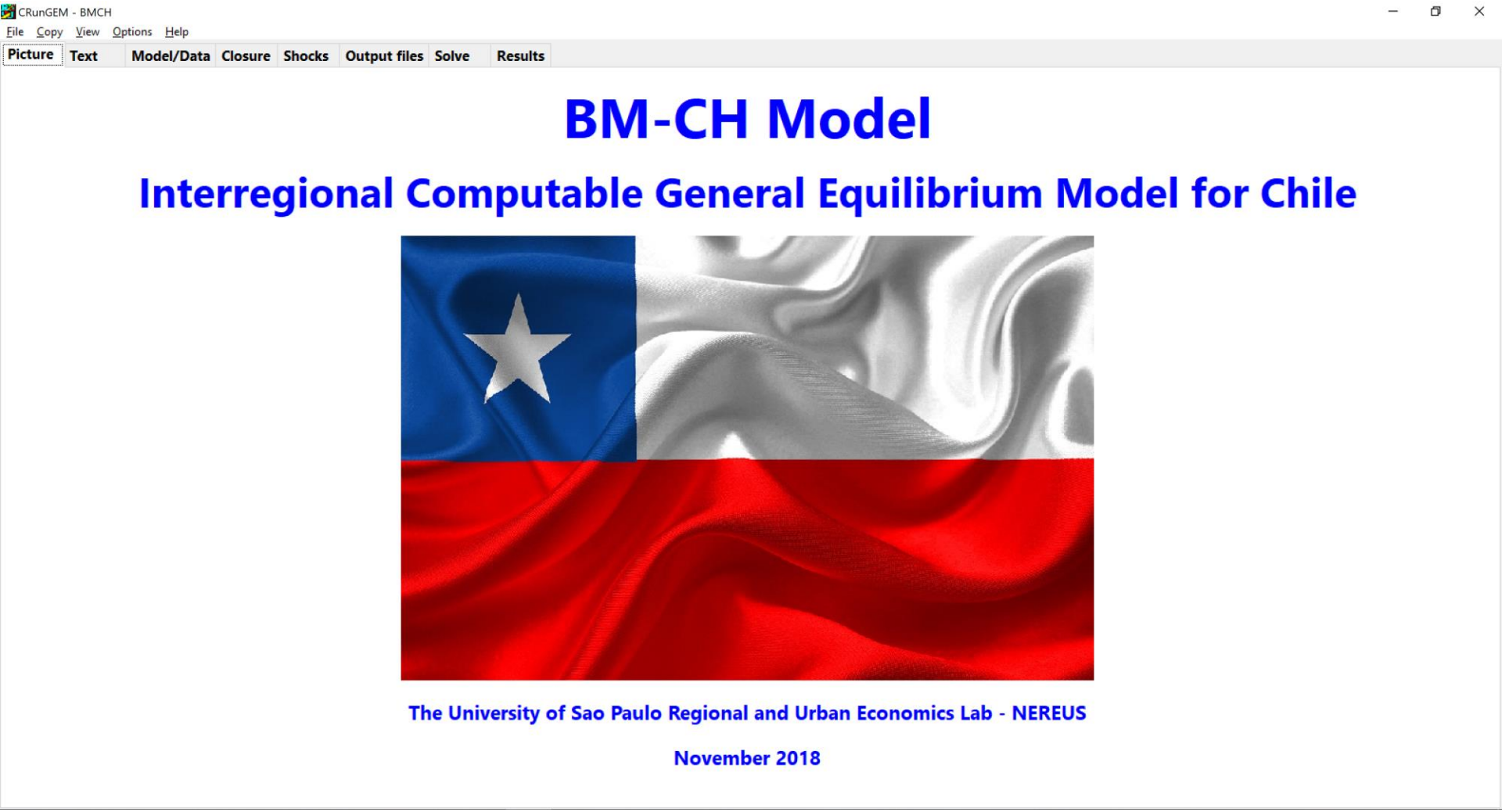
Causation in short-run closure



Causation in long-run closure



Interregional CGE Model for Chile



BM-CH, a bottom-up spatial CGE model of Chile

A multi-sectoral, multi-regional bottom-up CGE model of Morocco's 15 regions

- each region is modeled as an economy in its own right
- region-specific prices
- region-specific industries
- region-specific consumers

Based on the comparative-static B-MARIA and MMRF models

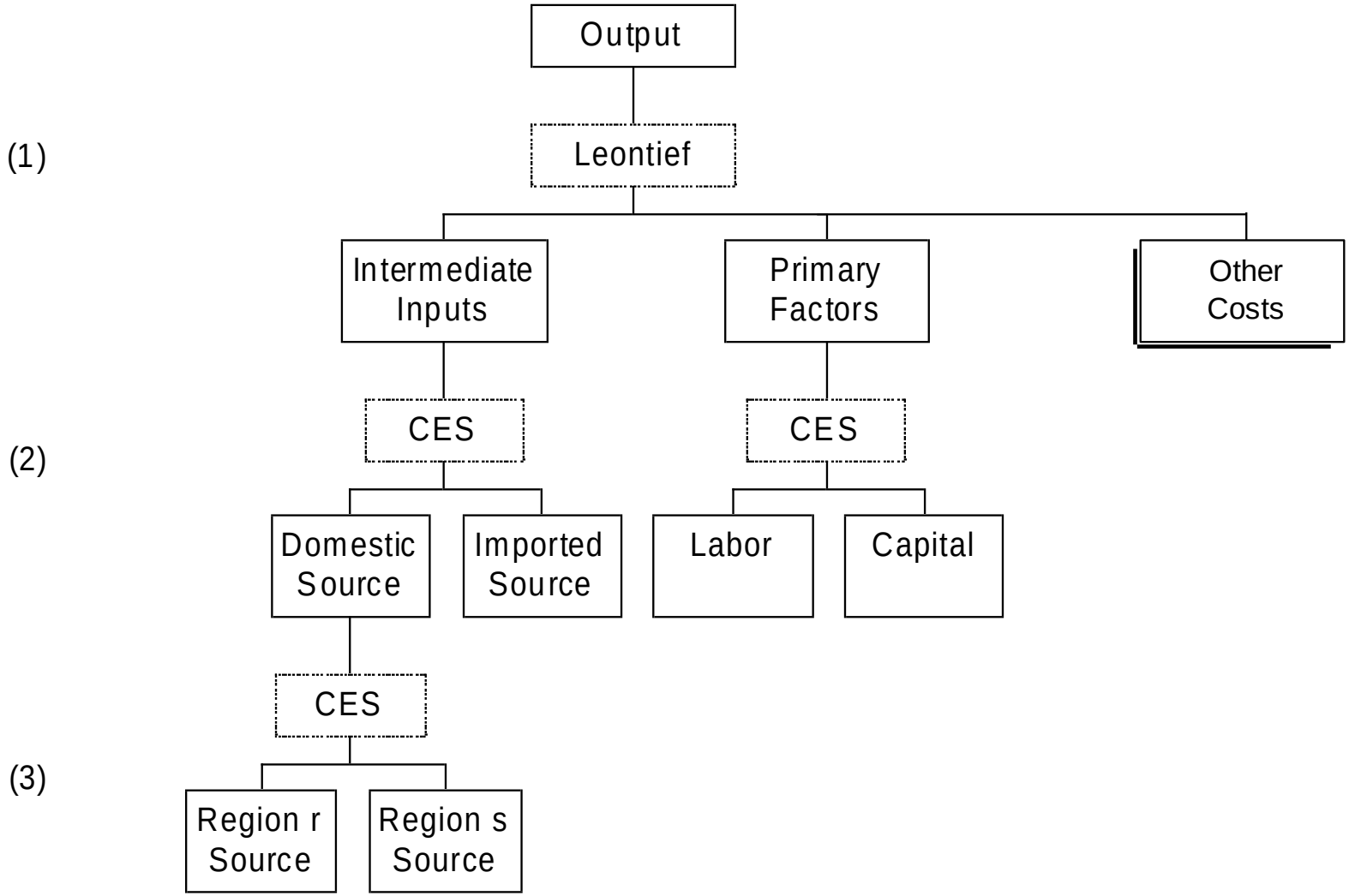
Database makes allowance for interregional, intra-regional and international trade

- Potential for the representation of regional and central government financial accounts

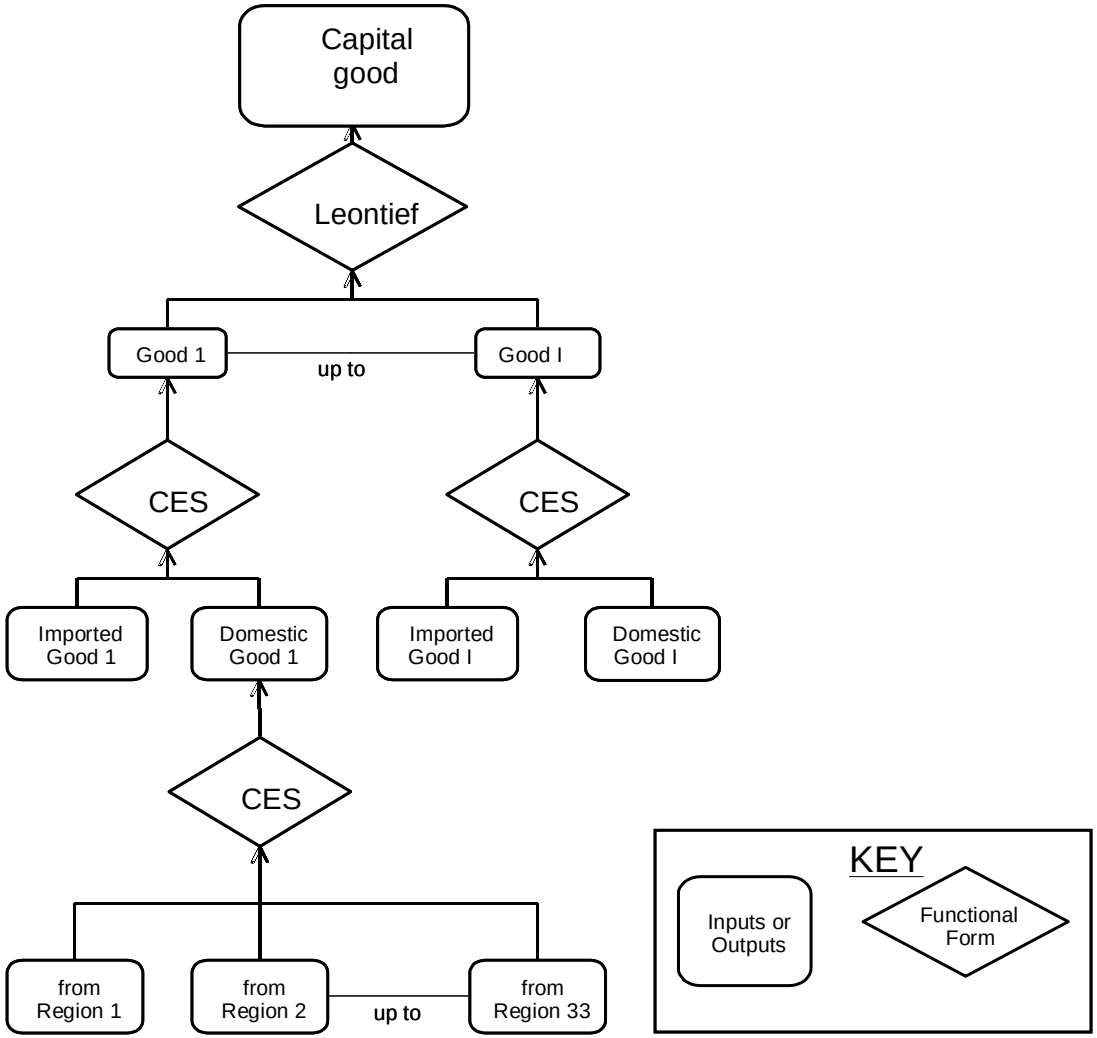
Building blocks

- ✓ Producer's demands for inputs
- ✓ Investor demands
- ✓ Household demands
- ✓ Export demands
- ✓ Government demands
- ✓ Zero pure profits
- ✓ Indirect tax equations
- ✓ Market-clearing
- ✓ Regional and national macroeconomic variables and price indexes
- ✓ Capital accumulation and investment
- ✓ Regional population and labor market

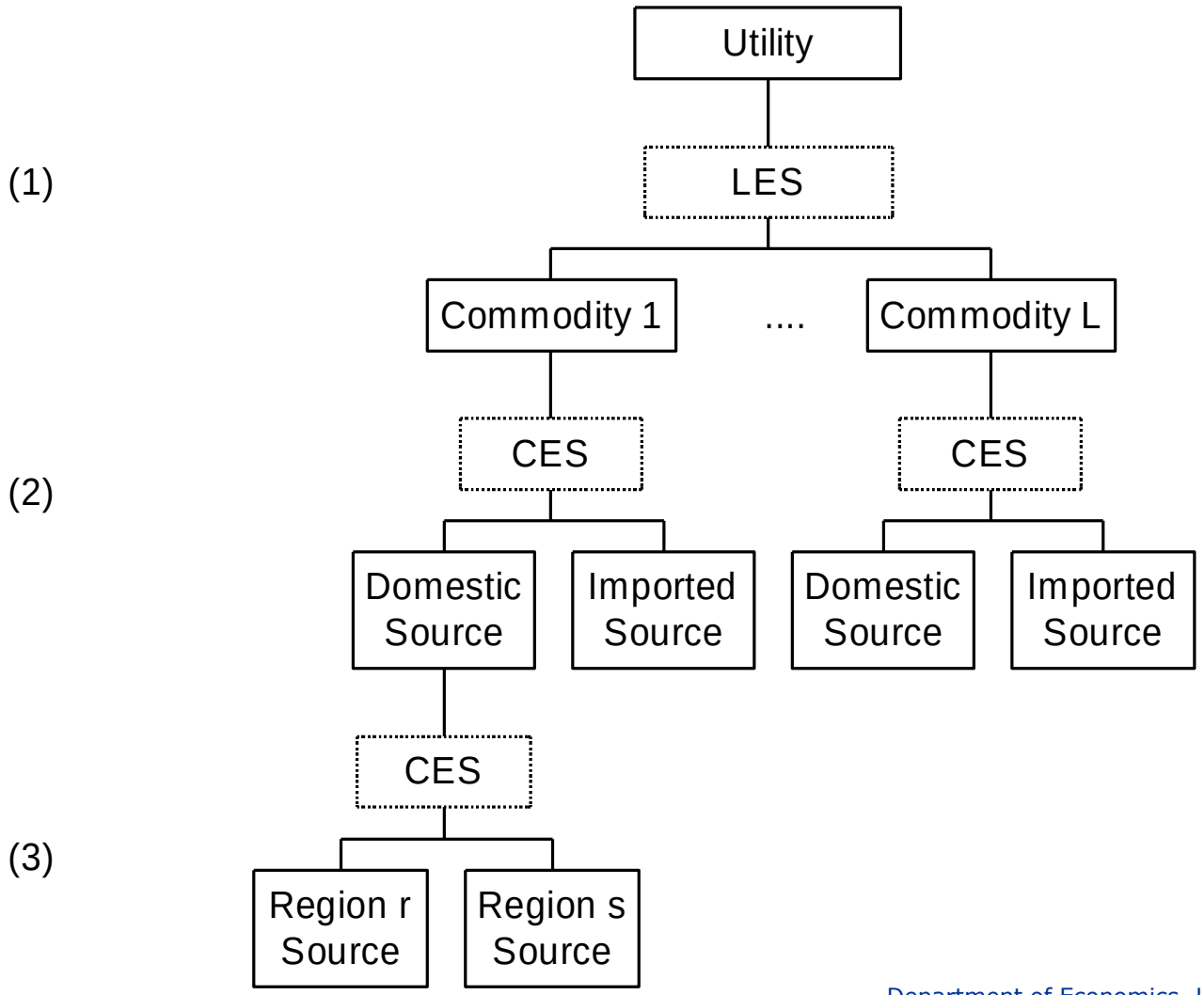
Production nest



Investment demand



Household demand

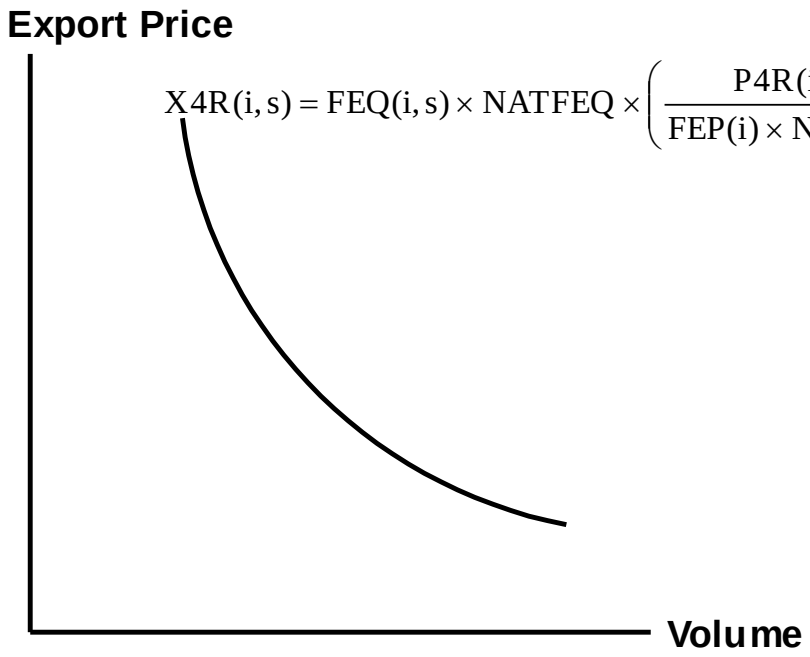


Household demand

Each regional household determines optimal consumption bundle by maximizing a Stone-Geary utility function subject to a budget constraint

A Keynesian-type consumption function determines aggregate regional household expenditure

Foreign export demand



$$X4R(i,s) = FEQ(i,s) \times NATFEQ \times \left(\frac{P4R(i,s)}{FEP(i) \times NATFEP} \right)^{EXP_ELAST(i)}$$

Export commodities face individual downward-sloping foreign export demand functions

Exports of product i from source s are distinguished from exports of i from source r (r not equal s)

Government demand

Recognise regional governments and central government demands for goods and services for current consumption

Default:

- aggregate regional government demand in region q moves with regional government revenue, with structure of demand exogenous
- aggregate central government demand in region q moves with national government revenue, with structure of demand exogenous

Zero pure profits

Critical assumptions

- no pure profits in the production or distribution of commodities
- price received by the producer is uniform across all customers

Zero pure profits in current production imposed by setting unit prices received by producers equal to unit costs

Zero pure profits in distribution imposed by setting the prices paid by users equal to producer price plus commodity tax plus margins

Indirect taxes

Equations have been added to enable flexible handling of indirect taxes on all flows of goods and services

Equations allow for variations in tax rates across commodities, their sources and destinations

Market-clearing

Equations that impose market clearing (demand equals supply) for:

- domestically produced margin and non-margin commodities
- imported commodities

Macro aggregates

Wide range of national and regional macro variables defined…

Two concepts of the real wage rate:

- consumer real wage rate (PLAB/CPI)
- producer real wage rate (PLAB/PGDP)

Investment "dynamics"

Capital, investment and expected rates of return

$$K_{j,q}(t+1) = (1 - DEP_{j,q}) \times K_{j,q}(t) + Y_{j,q}(t)$$

Given starting point for capital (t=0) and an explanation of investment, we can trace out time path for capital

Investment "dynamics"

Investment explained by assuming that:

$$\frac{K_{j,q}(t+1)}{K_{j,q}(t)} - 1 = F_{j,q}^{t}[EROR_{j,q}(t)]$$

Growth in capital related to expected rate of return

- In BM-CH ICGE only assume static expectations, though rational is possible

Rates of return and investment

For static expectations case, the actual rate of return is:

$$RO_t(j,q) = \frac{P_t(j,q)}{\Pi_t(j,q)} - D(j,q)$$

$$ro(j,q) = p_t(j,q) - \pi_t(j,q)$$

$$ro(j,q) = QCOEF\,(j,q)\left[p_t(j,q) - \pi_t(j,q)\right]$$

QCOEF: relationship between gross and net rates of return (> 1)

Rates of return and investment

In long-run comparative-static simulations:

- aggregate capital adjusts to maintain R_{INT} (*natr_tot*)
- capital allocated in line with equation **E_f_rate_xx**
  - industries with relatively large increases in capital require relatively high rates of return
  - industries with relatively small increases in capital require relatively low rates of return
- industry investment determined by fixed ratios of investment to capital (equation **E_y**)

Rates of return and investment

Equalization in the rates of return

$$\left(\frac{K(j,q)}{K(q)}\right)^{-\beta(j,q)} RO(j,q) = R_{\text{int}}$$

$$ro(j,q) - r_{\text{int}} = \beta_t(j,q)\left[k(j,q) - k(q)\right] + f_rate(j,q)$$

beta: risk/return ratio

Short-run: *f_rate* endogenous, *k* exogenous

Long-run: *f_rate* exogenous, *k* endogenous

Investment "dynamics"

Growth rate of capital stocks and investment in the short-run:

$$k_{t+1}(j,q) - k_t(j,q) = 0$$ % change in capital stocks

$$y_t(j,q) = 0$$ % change in investment

Investment "dynamics"

Growth rate of capital stocks and investment in the long-run:

$$\frac{K_{j,q}(t+1)}{K_{j,q}(t)} = \left(\frac{K_{j,q}(t)}{K_{j,q}(0)} \right)^{1/T}$$

$$k_{t+1}(j,q) = \left(1 + \frac{1}{T} \right) k_t(j,q)$$

Investment in the short run

Fixed capital stocks in the base year values:

- *curcap(j,q)* exogenous (=0)
- relationship between sectoral rates of return, *r0(j,q)*, and reference interest rate, *natr_tot*, is endogenous (*f_rate_xx(j,q)* endogenous)

Percentage change in sectoral investment, *y(j,q)* is zero; this can be guaranteed by setting the shift term, *delf_rate(j,q)*, exogenous and zero

By hypothesis, not only the capital stocks are fixed but also firms' investment plans

Investment in the short run

```
E_r0 # Definition of rates of return to capital #
r0(j,q) = QCOEF(j,q)*(p1cap(j,q) - pi(j,q));

E_f_rate_xx # Capital growth rates related to rates of
return #
(r0(j,q) - natr_tot) = BETA_R(j,q)*[curcap(j,q) -
kt(q)] + f_rate_xx(j,q);

E_curcapT1 # Capital stock in period T+1 #
  curcap_t1(j,q) - curcap(j,q) =0;

E_yT # Investment in period T #
curcap(j,q) - y(j,q)- 100*delf_rate(j,q)=0;
```

endog. exog.

Investment in the long run

Capital stocks endogenously determined:

- *curcap(j,q)* endogenous
- relationship between sectoral rates of return, *r0(j,q)*, and reference interest rate, *natr_tot*, is given (*f_rate_xx(j,q)* exogenous)

Percentage change in sectoral investment, *y(j,q)* is endogenous

Firms' investment plans are carried out, reestablishing returns differentials in the base year

Rate of capital accumulation, but **not the level** of capital stock, remains constant

Investment in the long run

```
E_r0 # Definition of rates of return to capital #
r0(j,q) = QCOEF(j,q)*(p1cap(j,q) - pi(j,q));

E_f_rate_xx # Capital growth rates related to rates of
return #
(r0(j,q) - natr_tot) = BETA_R(j,q)*[curcap(j,q) - kt(q)] +
f_rate_xx(j,q);

E_curcapT1 # Capital stock in period T+1 #
curcap_t1(j,q) - K_TERM*curcap(j,q)=0;

E_yT # Investment in period T #
VALK_T1(j,q)*curcap_t1(j,q)= VALKT(j,q)*DEP(j)*curcap(j,q)
+(INVEST(j,q))*y(j,q)-100*(VALK_0(j,q)*(1-DEP(j))
```

endog. exog.

$(DEP(j) = 0.96)$

Regional population and labor market

Critical variables:

- regional population
- regional migration
- regional unemployment
- regional participation rates
- regional wage relativities

Various closures

Regional population and labor market

(1) Fixed
- wage relativities (determining employment by region), participation and unemployment rates (determining population by region)

(1) Endogenous
- regional migration

(2) Fixed
- **regional migration, participation rates, wage relativities**

(2) Endogenous
- **unemployment rates**

(3) Fixed
- regional migration, participation and unemployment rates

(3) Endogenous
- wage relativities

Labor market in the short-run

```
E_wage_diff # Region real-wage diff
#(all,q,REGDEST)

wage_diff(q) = pwage(q) - natxi3 - natrealwage;

E_del_labsup # P-point changes in regional
unemployment rates #(all,q,REGDEST)

C_labsup(q)*del_unr(q)=C_EMPLOY(q)*(labsup(q)-
                                    employ(q));
```

del_unr(q) # *Percentage-point changes in regional unemployment rate* #;

endog. exog.

Labor market in the long-run

```
E_wage_diff # Region real-wage diff
#(all,q,REGDEST)

wage_diff(q) = pwage(q) - natxi3 - natrealwage;

E_del_labsup # P-point changes in regional
unemployment rates #(all,q,REGDEST)

C_labsup(q)*del_unr(q)=C_EMPLOY(q)*(labsup(q)-
                                    employ(q));
```

del_unr(q) # *Percentage-point changes in regional unemployment rate* #;

endog. exog.

Closures

Each equation explains a variable

More variables than equations

Endogenous variables: explained by model

Exogenous variables: set by user

Closure: choice of exogenous variables

Many possible closures

Number of endogenous variables = Number of equations

Length of run, T

T is related to our choice of closure

With short-run closure we assume that:

- T is long enough for price changes to be transmitted throughout the economy, and for price-induced substitution to take place
- T is not long enough for investment decisions to greatly affect the useful size of sectoral capital stocks [new buildings and equipment take time to produce and install]

T might be 2 years. So results mean:

- A 10% consumption increase might lead to employment in 2 years time being 1.2% higher than it would be (in 2 years time) if the consumption increase did not occur.

Different closures

Many closures might be used for different purposes

No unique natural or correct closure

Must be at least one exogenous variable measured in local currency units

Normally just one — called the *numéraire*

Often the exchange rate, *natphi*, or *natxi3*, the CPI.

Some quantity variables must be exogenous, such as:

- primary factor endowments
- final demand aggregates

In honor of those that made this gathering possible!

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