Ejercicio Práctico de Aplicación

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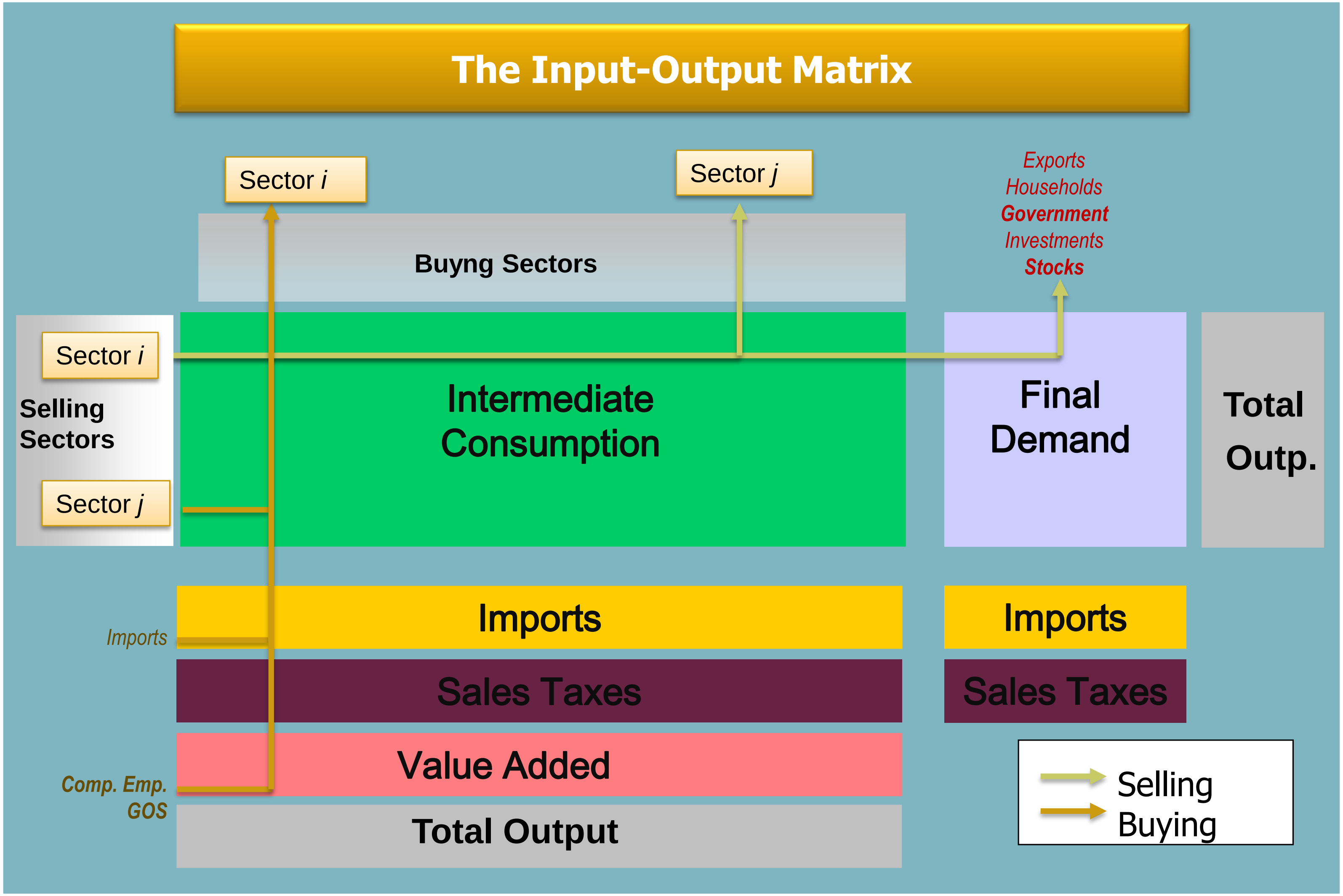
Input-output table



Input-output model

The input-output table is basically an accounting system – a double entry one similar to that prepared for a business in which sales and purchases or assets and liabilities will be shown but, in this case, for an economy.

The next step is to **prepare an economic model** so that we can trace the impact of changes in one sector on the rest of the economy.

We do this because the nature of interdependence among sectors varies.

Input-output model

Key assumptions

We assume that each sector produces goods and services according to a fixed recipe (formally known as a **production function**)

$$a_{ij} = \frac{z_{ij}}{x_j} \quad \forall \quad i, j = 1, 2, \ldots, n$$

- Fixed technical coefficient
- Constant returns to scale
- Sectors use inputs in fixed proportions

Production function

$$x_j = f\left(z_{1j},\ldots,z_{nj},W_j,M_j\right)$$

$$x_j = \min\left(\frac{z_{1j}}{a_{1j}},\ldots,\frac{z_{nj}}{a_{nj}}\right)$$

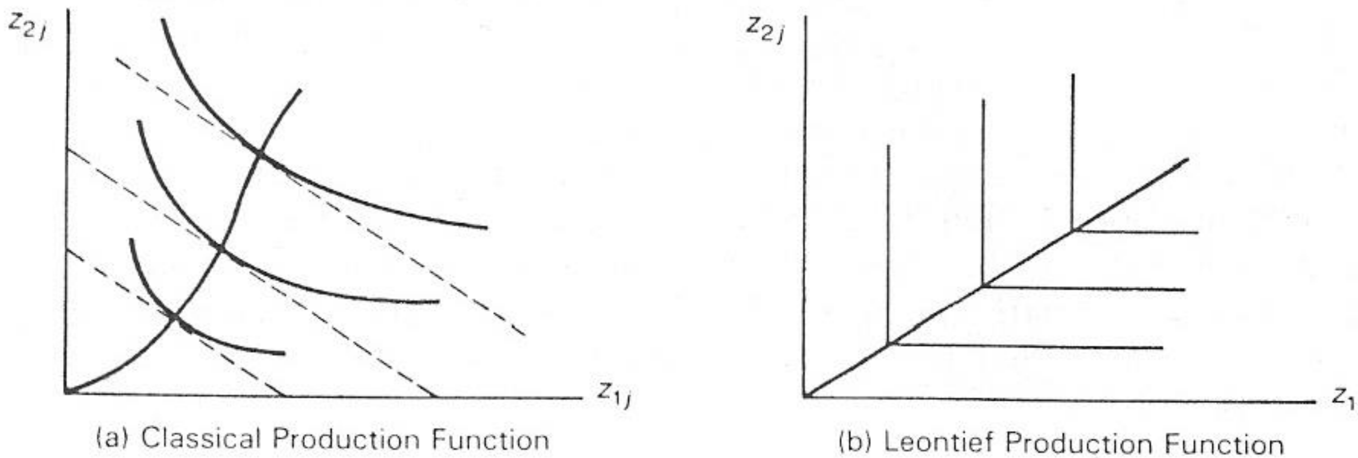


FIGURE 2-1 Production functions in input space.

Input-output model

Key assumptions

Inputs are expressed in monetary terms since it would be difficult to combine tons of iron ore with megawatts of electricity, or hours of labor in some consistent fashion.

This fixed recipe enables us to express the transactions in proportional form, also known as *direct coefficients*.

Input-output model

Key assumptions

The final assumption is that the **economy is driven by signals emanating from final demand** (consumers, government, exports); this is the *exogenous* part of the economy, while the interindustry transactions respond to these signals and are therefore *endogenous*.

Input-output model

Basic relations

$$\sum_{j=1}^{n} z_{ij} + y_i \equiv x_i \quad \forall \ i,j = 1,2,\ldots,n$$

z_{ij} = flows of intermediate consumption from sector *i* to sector *j*
y_i = final demand of sector *i*
x_i = total supply of sector *i*

Input-output model

Basic relations

Replacing $a_{ij} = \frac{z_{ij}}{x_j}$ in the previous equation, we have:

$$\sum_{j=1}^{n} a_{ij} x_j + y_i = x_i \quad \forall \; i, j = 1, 2, \ldots, n$$

$$\mathbf{A}x + y = x$$
$$x = (\mathbf{I} - \mathbf{A})^{-1} y$$
$$\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$$

A = matrix of technical direct coefficients
B = Leontief inverse matrix

Input-output model

Basic relations

The Leontief inverse matrix **B** shows the coefficients (economic multipliers) that measure the successive effects on the economy as a result of the initial increase in production of an economic activity branch:

$$x = (\mathbf{I} - \mathbf{A})^{-1} y$$

$$\begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nn} \end{bmatrix} \begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} b_{11}y_1 & \cdots & b_{1n}y_n \\ \vdots & \ddots & \vdots \\ b_{n1}y_1 & \cdots & b_{nn}y_n \end{bmatrix}$$

The entries reveal the direct and indirect impacts on a sector when final demand in the sector at the top of the column changes by $1 (or $1 million or $100 million). The sum of the elements in a column generate the **output multipliers**.

Output multipliers

Calculation of the output multiplier (backward linkages)

$$o_j = \sum_{i=1}^{n} b_{ij} \; , \qquad i, j = 1, \ldots, n$$

Output multipliers

Decomposition of the output multiplier

Total effect: $ET_j = o_j$

Indirect effect: $EID_j = o_j - \sum_i a_{ij}$ - 1

Direct effect: $ED_j = \sum_i a_{ij}$

Initial effect: $EI_j = 1$

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

Interregional model

$$A = \begin{bmatrix} A^{LL} & \vdots & A^{LM} \\ \cdots & \cdots & \cdots \\ A^{ML} & \vdots & A^{MM} \end{bmatrix} \quad y = \begin{bmatrix} y^{L} \\ \cdots \\ y^{M} \end{bmatrix} \quad x = \begin{bmatrix} x^{L} \\ \cdots \\ x^{M} \end{bmatrix}$$

$$\left\{ \begin{bmatrix} I & \vdots & 0 \\ \cdots & \cdots & \cdots \\ 0 & \vdots & I \end{bmatrix} - \begin{bmatrix} A^{LL} & \vdots & A^{LM} \\ \cdots & \cdots & \cdots \\ A^{ML} & \vdots & A^{MM} \end{bmatrix} \right\} \begin{bmatrix} x^{L} \\ \cdots \\ x^{M} \end{bmatrix} = \begin{bmatrix} y^{L} \\ \cdots \\ y^{M} \end{bmatrix}$$

$$(I - A)x = y \longrightarrow x = (I - A)^{-1} y$$

Multipliers in interregional IO models

$$A = \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \rightarrow B = (I - A)^{-1} = \begin{bmatrix} B^{LL} & B^{LM} \\ B^{ML} & B^{MM} \end{bmatrix}$$

<u>Intraregional effects</u>: $B^{LL}, B^{MM} \rightarrow O_j^{LL}, O_j^{MM}$

<u>Interregional effects</u>: $B^{ML}, B^{LM} \rightarrow O_j^{ML}, O_j^{LM}$

<u>National effects</u>: $O_j^{L} = O_j^{LL} + O_j^{ML}$ e $O_j^{M} = O_j^{MM} + O_j^{LM}$

<u>Sectoral effects</u>: $O_{ij}^{L} = \alpha_{ij}^{LL} + \alpha_{ij}^{ML}$ e $O_{ij}^{M} = \alpha_{ij}^{MM} + \alpha_{ij}^{LM}$

Multipliers in interregional IO models

Multipliers vary not only across sectors but also across regions.

A small regional economy, with a modest representation of industry, may not be able to provide all the necessary inputs required by local industry. Thus, there will be considerable importation of inputs (sometimes referred to as leakages).

In general, the larger the value of the imports, the lower the value of the multiplier.

We would expect multipliers to decrease as we move from the country as a whole to a macro-region, an individual province, a metropolitan region and finally to a municipality.

Mexican interregional input-output system, 2013

NEREUS

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The University of São Paulo Regional and Urban Economics Lab

IBERO PUEBLA ®

IIMA
Instituto de Investigaciones en Medio Ambiente Xavier Gorostiaga, S.J. /

CENTRO ITAM
ENERGÍA Y RECURSOS NATURALES

Interregional Input-Output Tables for Mexico, 2013

Reference: Haddad, E. A., Araújo, I. F., Ibarrarán, M. E., Boyd, R., Elizondo, A., Liedo, P., Belausteguigoitia, J. C., and Menchero, M. (2019). Interregional Input-Output System for Mexico, 2013, *TD NEREUS 07-2019* , The University of São Paulo Regional and Urban Economics Lab (NEREUS).

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https://www.researchgate.net/publication/344121142_Interstate_input-output_model_for_Mexico_2013

List of sectors

Id	Cod. SUT*	Sectors
S1	111	Agriculture
S2	112	Animal production
S3	113	Forestry and logging
S4	114	Fishing and aquaculture
S5	115	Agriculture, farming, forestry and fishing support service activities
S6	211	Extraction of crude petroleum and natural gas
S7	212-213	Mining and support service activities
S8	221	Electric power generation, transmission and distribution
S9	222	Water and gas supply by pipelines to the final consumer
S10	236-238	Construction
S11	311	Manufacture of food products
S12	312	Manufacture of beverages and tobacco products
S13	313-314	Manufacture of textiles
S14	315-316	Manufacture of wearing apparel
S15	321	Manufacture of wood and of products of wood and cork, except furniture
S16	322-323	Manufacture of paper and paper products; Printing and reproduction of recorded media
S17	324-326	Manufacture of coke and refined petroleum products; Manufacture of chemicals and chemical products; Manufacture of rubber and plastics products
S18	327	Manufacture of other non-metallic mineral products
S19	331-332	Manufacture of basic metals; Manufacture of fabricated metal products, except machinery and equipment
S20	333-336	Manufacture of machinery and equipment n.e.c.; Manufacture of computer, electronic and optical products; Manufacture of electrical equipment; Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment
S21	337	Manufacture of furniture
S22	339	Other manufacturing
S23	431	Wholesale trade
S24	461	Retail trade
S25	481-493	Transportation and storage
S26	511-519	Information and communication
S27	521-524	Financial and insurance activities
S28	531-533	Real estate activities
S29	541	Professional, scientific and technical activities
S30	551	Activities of head offices; management consultancy activities
S31	561-562	Administrative and support service activities
S32	611	Education
S33	621-624	Human health and social work activities
S34	711-713	Arts, entertainment and recreation
S35	721-722	Accommodation and food service activities
S36	811-814	Other service activities
S37	931	Public administration and defense; compulsory social security; Activities of extraterritorial organizations and bodies

Aggregate trade flows in Mexico

Annex 4.A. Interregional Trade in Mexico, 2013 (in MXN billions)

ORIGIN \ DESTINATION	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	ROW	TOTAL
R1	159	2	0	6	4	1	2	4	20	1	7	1	1	10	6	2	1	1	8	1	2	3	1	4	1	2	4	3	0	4	1	5	91	355
R2	2	456	3	29	11	1	6	12	27	2	3	1	1	7	7	1	1	1	13	1	3	2	2	2	3	16	14	4	0	9	2	3	256	899
R3	1	8	84	11	5	0	2	4	13	1	2	0	0	2	3	0	0	0	7	0	1	1	0	1	1	4	5	2	0	3	0	1	8	170
R4	1	5	0	164	8	0	15	4	45	1	26	0	13	23	47	3	6	1	32	13	6	11	1	6	1	4	44	41	2	42	2	1	347	915
R5	5	13	2	20	478	1	5	28	39	5	9	2	2	15	15	4	2	1	93	3	7	5	3	6	5	12	12	17	1	13	3	5	448	1279
R6	1	2	0	5	3	73	1	2	12	0	2	0	0	6	3	1	0	0	4	0	1	1	0	1	0	2	3	1	0	2	0	1	8	139
R7	2	8	1	16	7	1	233	7	39	2	5	2	2	7	11	2	1	1	13	2	5	3	3	2	2	6	20	5	1	13	4	1	33	462
R8	3	13	1	18	21	1	5	416	32	5	6	1	1	11	11	3	2	1	29	2	5	3	2	4	4	14	11	8	1	10	2	4	330	979
R9	22	46	6	59	58	6	21	59	2566	12	68	18	44	69	256	25	28	7	73	21	72	49	8	34	15	41	60	51	13	92	10	14	166	4088
R10	2	5	1	8	12	0	2	11	20	148	4	1	1	7	7	2	1	1	18	1	2	2	1	3	3	5	5	5	0	5	1	3	31	317
R11	11	12	2	18	17	2	5	16	99	4	556	3	4	32	28	9	3	2	28	3	10	16	3	12	5	10	13	13	1	16	3	7	187	1151
R12	2	4	0	11	6	0	2	6	58	1	4	138	1	5	11	1	3	0	10	1	5	3	1	2	1	3	8	3	1	7	1	1	19	318
R13	2	4	1	7	5	1	2	5	101	1	6	2	179	7	18	2	2	1	8	1	9	5	1	3	1	3	6	4	2	10	1	1	33	435
R14	18	22	3	36	30	6	9	28	145	7	38	4	6	897	44	18	5	6	50	4	15	17	5	17	10	19	24	23	2	27	5	11	306	1855
R15	9	17	3	26	24	3	8	22	659	5	27	8	13	34	1052	12	13	3	43	7	31	25	5	13	6	15	23	19	5	35	5	5	300	2475
R16	5	8	1	10	12	1	2	10	63	2	14	1	3	30	21	246	2	1	18	2	6	8	1	5	2	7	8	7	1	10	2	2	51	562
R17	1	2	0	5	3	0	1	3	51	1	3	2	1	4	11	1	157	0	5	1	5	2	1	1	1	2	4	2	1	5	1	1	62	338
R18	1	2	0	4	4	0	1	3	15	1	2	0	0	6	3	1	0	78	6	0	1	1	0	1	1	2	3	2	0	2	0	1	7	154
R19	11	29	4	44	118	3	11	52	89	9	20	4	4	30	27	7	4	3	1148	5	13	10	5	15	10	25	28	64	2	27	6	12	388	2226
R20	2	6	1	18	7	1	5	6	51	1	5	1	2	6	11	2	2	1	12	189	8	3	2	2	2	5	12	4	1	13	2	2	27	409
R21	4	7	1	21	9	1	7	9	149	2	11	3	8	14	36	4	7	1	17	6	428	8	3	5	2	6	18	7	7	36	3	2	164	1006
R22	4	5	1	11	8	1	3	7	74	2	16	2	3	13	22	4	2	1	13	2	7	289	1	7	2	4	8	6	1	10	2	3	119	651
R23	1	6	0	33	8	0	2	8	35	1	4	0	1	3	6	1	1	0	14	1	3	2	144	2	1	5	12	6	0	6	3	1	10	320
R24	7	5	1	10	11	1	3	8	46	2	13	1	2	16	14	3	2	1	22	2	5	8	1	272	2	4	7	10	1	9	1	6	113	611
R25	3	14	1	17	18	1	3	15	36	4	5	1	1	13	9	2	1	1	23	1	4	3	1	3	241	15	10	7	1	8	2	3	34	500
R26	3	33	3	33	19	2	8	23	42	3	8	2	2	17	16	5	3	2	27	3	7	4	3	4	9	458	18	7	1	18	4	4	244	1035
R27	3	13	2	33	11	1	18	11	56	3	18	3	9	18	34	5	4	1	25	9	10	8	6	6	5	11	303	23	2	40	9	2	177	878
R28	5	13	2	23	26	2	5	18	51	4	11	2	3	15	16	4	2	1	66	2	6	6	2	9	5	11	13	404	1	14	3	6	230	980
R29	1	1	0	3	2	0	1	2	26	0	2	0	1	2	6	1	1	0	3	1	9	2	0	1	0	1	2	1	69	5	1	0	20	164
R30	6	17	3	30	18	2	11	18	149	4	18	6	10	24	44	7	6	2	33	8	31	11	6	8	6	15	31	17	5	706	7	4	142	1404
R31	1	4	0	35	4	0	3	4	18	1	2	1	1	4	5	1	1	0	7	1	2	1	5	1	1	3	15	3	0	6	186	1	22	341
R32	4	2	0	5	6	0	1	4	16	1	5	0	1	6	5	2	1	0	12	0	2	2	0	4	1	2	3	3	0	5	1	100	33	228
ROW	96	215	16	139	369	15	73	269	603	37	229	26	70	330	450	60	66	15	492	51	233	146	26	133	48	247	153	226	29	230	38	37	0	5167
TOTAL	398	1000	143	907	1341	128	477	1092	5445	274	1148	235	391	1678	2256	439	328	133	2372	343	955	661	245	590	394	979	902	999	150	1440	311	250	4407	32809

Interregional linkages

The conventional input-output model is given by the system of matrix equations:

$$x = (I - A)^{-1} f = Bf$$

where x and f are respectively the vectors of gross output and final demand; A consists of input coefficients a_{ij} defined as the amount of product i required per unit of product j (in monetary terms), for i, j = 1,…, n; and B is known as the Leontief inverse.

Interregional input-output model

In an interregional context, with *R* different regions, we have:

$x = \begin{bmatrix} x^1 \\ \vdots \\ x^R \end{bmatrix}$; $A = \begin{bmatrix} A^{11} & \cdots & A^{1R} \\ \vdots & \ddots & \vdots \\ A^{R1} & \cdots & A^{RR} \end{bmatrix}$; $f = \begin{bmatrix} f^1 \\ \vdots \\ f^R \end{bmatrix}$; and $B = \begin{bmatrix} B^{11} & \cdots & B^{1R} \\ \vdots & \ddots & \vdots \\ B^{R1} & \cdots & B^{RR} \end{bmatrix}$

and

$$x^1 = B^{11} f^1 + \cdots + B^{1R} f^R$$
$$\vdots$$
$$x^R = B^{R1} f^1 + \cdots + B^{RR} f^R$$

Interregional input-output model

Let us also consider different components of *f*, which include demands originating in the specific regions, v^{rs}, $s = 1,\ldots, R$, and abroad, *e*. We obtain information of final demand from origin *s* in the IIOM-MEX, allowing us to treat *v* as a matrix which provides the monetary values of final demand expenditures from the domestic regions in Mexico and from the foreign region.

$$v = \begin{bmatrix} v^{11} & \cdots & v^{1R} \\ \vdots & \ddots & \vdots \\ v^{R1} & \cdots & v^{RR} \end{bmatrix};\ e = \begin{bmatrix} e^{1} \\ \vdots \\ e^{R} \end{bmatrix}$$

Thus:

$$x^1 = B^{11}(v^{11} + \cdots + v^{R1} + e^1) + \cdots + B^{1R}(v^{1R} + \cdots + v^{RR} + e^R)$$
$$\vdots$$
$$x^R = B^{R1}(v^{11} + \cdots + v^{R1} + e^1) + \cdots + B^{RR}(v^{1R} + \cdots + v^{RR} + e^R)$$

Spatial propagation of final demand shocks (…)

Table 2. Components of Decomposition of Regional Output Based on the Sources of Final Demand: Mexico, 2013 (in %)

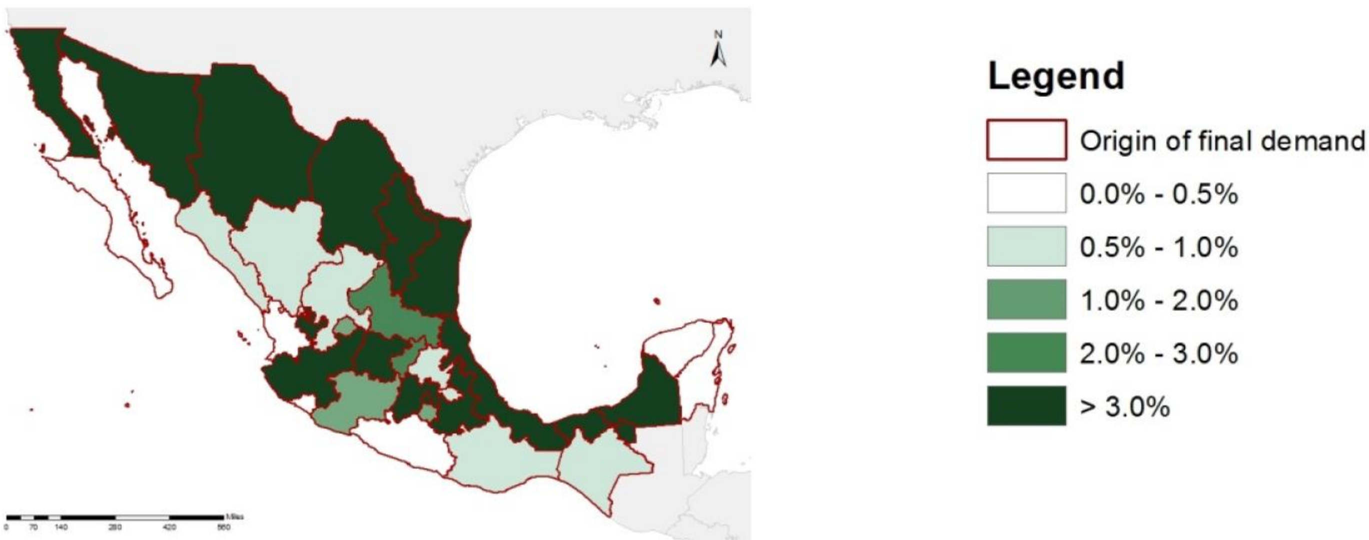
		ORIGIN OF FINAL DEMAND																																
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	ROW
REGIONAL OUTPUT	R1	34.43	0.65	0.09	1.86	0.94	0.14	0.45	0.97	6.43	0.22	1.31	0.12	0.17	1.71	1.18	0.34	0.15	0.13	1.98	0.17	0.45	0.53	0.17	0.70	0.22	0.40	1.18	0.80	0.06	1.09	0.16	1.06	39.75
	R2	0.17	39.09	0.22	3.57	0.96	0.06	0.67	1.12	3.43	0.12	0.31	0.06	0.07	0.48	0.58	0.12	0.08	0.06	1.26	0.09	0.32	0.17	0.14	0.18	0.21	1.12	1.65	0.42	0.03	0.93	0.13	0.33	41.84
	R3	0.46	4.78	39.70	7.88	2.70	0.08	1.38	2.39	9.69	0.38	0.92	0.10	0.22	1.04	1.63	0.22	0.17	0.09	3.96	0.16	0.83	0.50	0.17	0.50	0.31	1.81	3.72	1.23	0.09	2.13	0.24	0.65	9.87
	R4	0.45	1.04	0.18	18.52	1.25	0.18	0.84	1.11	8.28	0.26	1.01	0.24	0.25	1.46	1.93	0.43	0.30	0.16	2.42	0.26	0.84	0.58	0.40	0.53	0.45	0.87	2.47	0.70	0.12	1.74	0.48	0.43	49.83
	R5	0.23	0.75	0.11	1.75	23.40	0.08	0.40	1.29	3.54	0.23	0.45	0.09	0.09	0.66	0.71	0.17	0.11	0.09	4.26	0.13	0.30	0.23	0.17	0.26	0.27	0.48	1.01	0.85	0.04	0.80	0.15	0.30	56.59
	R6	0.77	1.46	0.10	4.30	1.70	44.73	0.85	1.82	10.76	0.24	1.32	0.14	0.24	3.29	1.96	0.45	0.24	0.19	2.93	0.19	0.79	0.67	0.20	0.65	0.30	1.07	2.49	1.06	0.10	1.73	0.26	0.73	12.29
	R7	0.45	1.80	0.25	4.03	1.52	0.16	40.04	1.69	11.79	0.32	1.03	0.30	0.33	1.40	2.00	0.41	0.30	0.16	3.11	0.37	1.02	0.67	0.71	0.49	0.47	1.13	4.04	1.08	0.14	2.17	0.79	0.28	15.54
	R8	0.23	1.10	0.10	1.97	1.33	0.07	0.43	31.77	3.68	0.22	0.45	0.08	0.09	0.65	0.70	0.16	0.10	0.08	2.18	0.12	0.31	0.23	0.15	0.24	0.25	0.80	1.09	0.60	0.04	0.82	0.15	0.33	49.45
	R9	0.56	1.28	0.14	1.75	1.34	0.14	0.56	1.50	58.06	0.29	1.54	0.33	0.84	1.53	4.97	0.51	0.58	0.16	2.06	0.44	1.48	1.07	0.22	0.73	0.33	0.88	1.58	1.21	0.26	2.17	0.29	0.33	10.86
	R10	0.71	1.86	0.23	3.44	3.10	0.15	0.76	3.33	9.65	34.10	1.28	0.18	0.26	1.85	1.91	0.38	0.26	0.21	5.54	0.24	0.79	0.64	0.31	0.73	0.68	1.27	2.06	1.59	0.10	1.70	0.30	0.99	19.40
	R11	0.80	1.04	0.15	2.12	1.19	0.18	0.52	1.32	10.96	0.27	35.69	0.20	0.29	2.11	1.99	0.60	0.24	0.17	2.42	0.22	0.76	1.10	0.24	0.82	0.36	0.71	1.42	1.08	0.10	1.41	0.24	0.58	28.70
	R12	0.56	1.49	0.09	4.22	1.78	0.09	0.83	1.85	20.99	0.21	1.17	35.14	0.40	1.46	2.97	0.30	0.69	0.10	3.19	0.26	1.34	0.84	0.21	0.57	0.20	0.96	2.89	1.15	0.16	2.26	0.33	0.42	10.90
	R13	0.45	0.98	0.14	2.56	1.03	0.15	0.67	1.13	26.85	0.23	1.17	0.29	29.01	1.44	3.34	0.45	0.41	0.13	2.03	0.31	1.66	0.90	0.28	0.53	0.33	0.68	1.84	0.82	0.25	2.26	0.31	0.37	17.01
	R14	0.87	1.32	0.17	2.45	1.45	0.29	0.56	1.62	10.38	0.31	1.81	0.18	0.29	35.19	2.06	0.80	0.25	0.29	2.92	0.23	0.77	0.84	0.26	0.78	0.44	0.89	1.60	1.32	0.10	1.50	0.26	0.59	27.21
	R15	0.36	0.80	0.11	1.53	0.89	0.12	0.41	0.94	28.16	0.18	1.02	0.26	0.43	1.20	32.08	0.41	0.44	0.11	1.85	0.26	0.98	0.85	0.22	0.44	0.25	0.54	1.20	0.79	0.15	1.46	0.23	0.23	21.13
	R16	0.83	1.42	0.14	2.69	1.71	0.19	0.55	1.78	14.69	0.26	2.02	0.20	0.37	3.53	2.75	33.48	0.32	0.21	3.36	0.25	0.92	1.16	0.25	0.72	0.33	0.95	1.85	1.32	0.13	1.70	0.29	0.47	19.13
	R17	0.30	0.70	0.09	2.13	0.80	0.09	0.52	0.79	16.84	0.15	0.71	0.34	0.29	0.88	2.44	0.26	35.79	0.08	1.49	0.21	1.11	0.53	0.17	0.34	0.20	0.48	1.47	0.58	0.13	1.53	0.19	0.26	28.10
	R18	0.78	1.66	0.13	3.74	2.41	0.17	0.75	2.28	12.43	0.49	1.61	0.14	0.30	3.10	2.13	0.47	0.22	42.66	4.18	0.18	0.84	0.87	0.19	0.70	0.44	1.31	2.17	1.42	0.10	1.72	0.22	0.61	9.54
	R19	0.38	1.15	0.15	2.59	3.33	0.12	0.59	1.84	5.30	0.32	0.70	0.14	0.13	1.00	0.99	0.26	0.15	0.11	38.21	0.18	0.46	0.35	0.22	0.45	0.36	0.75	1.51	1.93	0.05	1.22	0.23	0.54	34.28
	R20	0.49	1.50	0.18	5.49	1.66	0.14	1.30	1.59	15.94	0.27	1.11	0.28	0.38	1.35	2.39	0.39	0.36	0.13	3.09	34.82	1.76	0.77	0.38	0.52	0.38	0.97	3.56	1.06	0.19	3.07	0.44	0.44	13.59
	R21	0.32	0.74	0.12	2.70	0.78	0.12	0.78	0.85	16.40	0.16	0.90	0.27	0.48	1.10	2.41	0.36	0.46	0.12	1.70	0.46	30.69	0.63	0.29	0.38	0.24	0.48	2.13	0.68	0.39	3.20	0.30	0.27	29.06
	R22	0.53	0.77	0.12	2.25	1.00	0.14	0.58	1.01	13.30	0.21	1.77	0.20	0.33	1.51	2.44	0.49	0.27	0.13	1.95	0.24	0.82	31.28	0.22	0.72	0.28	0.54	1.54	0.89	0.11	1.59	0.24	0.44	32.10
	R23	0.51	1.87	0.08	11.15	2.37	0.07	0.77	2.60	12.97	0.41	1.31	0.12	0.40	1.00	2.07	0.24	0.19	0.07	4.91	0.24	0.98	0.80	35.59	0.61	0.21	1.34	3.88	1.85	0.14	2.16	1.11	0.23	7.73
	R24	0.83	0.84	0.13	2.36	1.36	0.16	0.58	1.21	9.17	0.27	1.59	0.17	0.23	1.74	1.71	0.41	0.22	0.15	3.14	0.22	0.64	0.88	0.23	31.63	0.30	0.54	1.52	1.34	0.08	1.44	0.22	0.84	33.83
	R25	0.58	3.07	0.27	4.29	3.08	0.15	0.81	3.10	9.90	0.54	1.12	0.16	0.25	2.02	1.75	0.36	0.23	0.23	4.91	0.22	0.77	0.64	0.30	0.58	38.34	2.52	2.43	1.50	0.10	1.72	0.32	0.62	13.10
	R26	0.26	2.48	0.27	3.66	1.09	0.14	0.79	1.69	5.20	0.23	0.60	0.14	0.13	1.06	1.07	0.28	0.16	0.16	1.98	0.20	0.48	0.30	0.30	0.28	0.66	29.26	1.93	0.63	0.06	1.43	0.27	0.38	42.45
	R27	0.48	1.64	0.27	4.85	1.38	0.21	1.19	1.53	10.06	0.37	1.07	0.35	0.31	1.58	2.09	0.51	0.32	0.18	2.57	0.33	1.10	0.63	0.70	0.56	0.62	1.18	26.21	0.83	0.15	2.21	0.99	0.40	33.15
	R28	0.44	1.25	0.16	2.78	2.08	0.14	0.59	1.59	6.83	0.31	0.82	0.17	0.16	1.18	1.23	0.32	0.16	0.13	5.06	0.16	0.57	0.44	0.23	0.61	0.40	0.82	1.55	29.12	0.07	1.28	0.26	0.56	38.52
	R29	0.37	0.88	0.12	2.38	0.90	0.12	0.68	1.03	18.46	0.18	0.98	0.26	0.59	1.21	2.63	0.36	0.41	0.12	1.95	0.42	3.18	0.74	0.29	0.42	0.25	0.59	1.95	0.78	30.69	2.78	0.33	0.28	23.65
	R30	0.44	1.35	0.19	2.80	1.20	0.15	0.78	1.40	13.97	0.27	1.07	0.32	0.43	1.45	2.39	0.43	0.37	0.15	2.48	0.40	1.65	0.71	0.43	0.51	0.41	0.88	2.36	1.00	0.22	39.29	0.48	0.32	19.73
	R31	0.30	1.31	0.16	12.47	1.22	0.09	1.13	1.30	7.73	0.19	0.74	0.17	0.23	0.98	1.38	0.25	0.21	0.10	2.45	0.29	0.71	0.45	1.46	0.36	0.26	0.73	5.17	0.99	0.10	1.83	44.08	0.24	10.93
	R32	1.32	1.00	0.12	2.54	1.74	0.14	0.60	1.62	8.78	0.38	1.45	0.16	0.23	1.79	1.72	0.38	0.24	0.14	3.86	0.19	0.73	0.72	0.22	1.03	0.29	0.66	1.55	1.16	0.09	1.52	0.23	36.23	27.17
TOTAL		0.92	2.49	0.40	3.35	2.53	0.37	1.30	2.54	18.55	0.65	2.54	0.62	0.80	3.63	4.91	1.08	0.74	0.38	5.50	0.78	2.00	1.41	0.70	1.23	1.04	1.88	2.58	2.06	0.32	3.58	0.85	0.71	27.55

Source: Calculations by the authors.

Spatial propagation of final demand shocks (…)

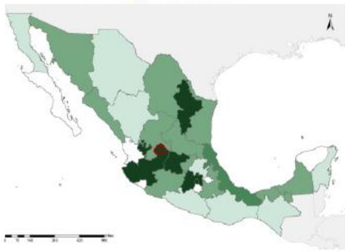
Figure 3. Identification of Regions Relatively More Affected by a Specific Regional Demand, by Origin of Final Demand (cont.)

Rest of the World

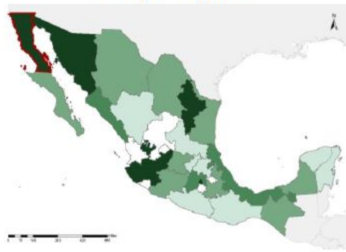


Spatial propagation of final demand shocks (…)

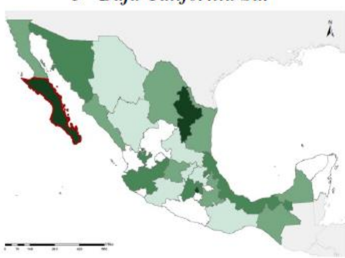
1 - Aguascalientes



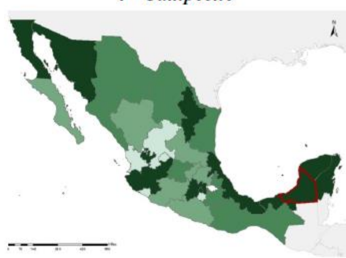
2 - Baja California



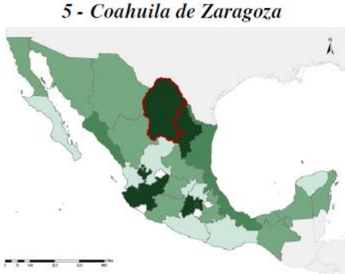
3 - Baja California Sur



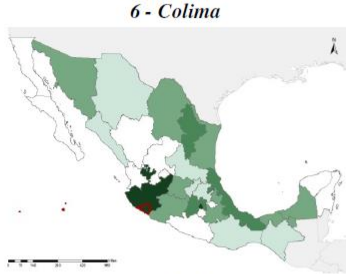
4 - Campeche



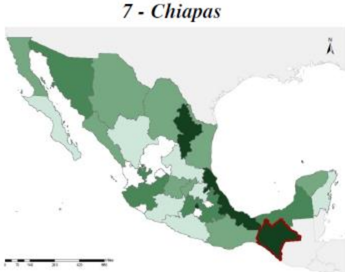
5 - Coahuila de Zaragoza



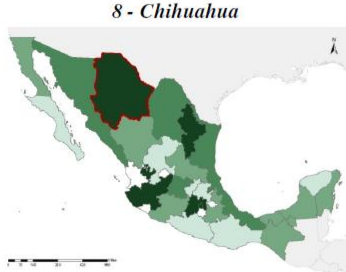
6 - Colima



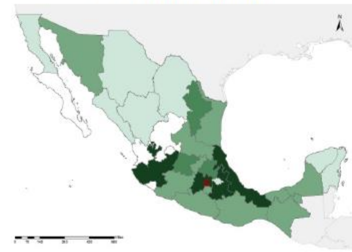
7 - Chiapas



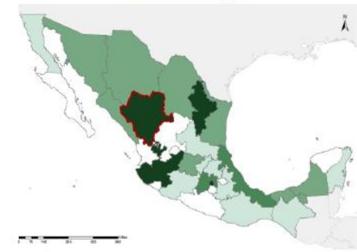
8 - Chihuahua



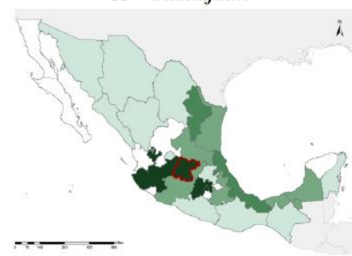
9 - Ciudad de México



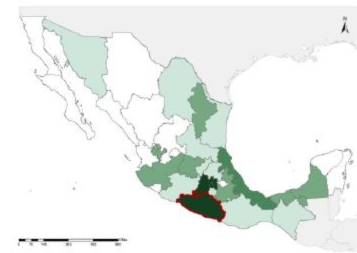
10 - Durango



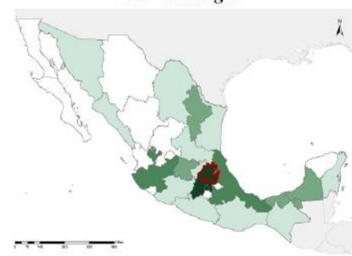
11 - Guanajuato



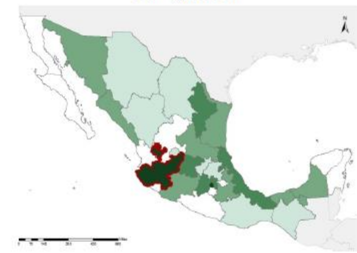
12 - Guerrero



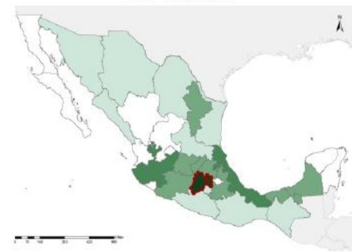
13 - Hidalgo



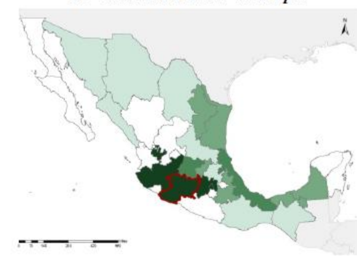
14 - Jalisco



15 - Mexico

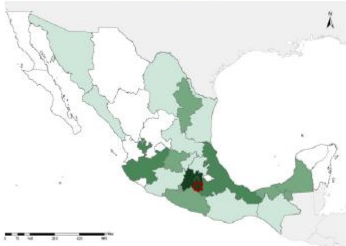


16 - Michoacan de Ocampo

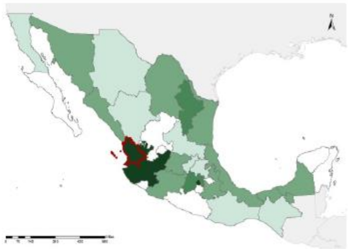


Spatial propagation of final demand shocks

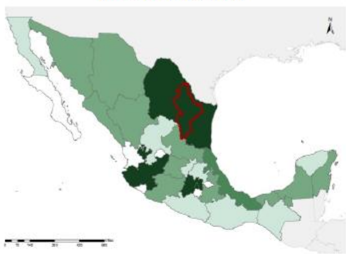
17 - Morelos



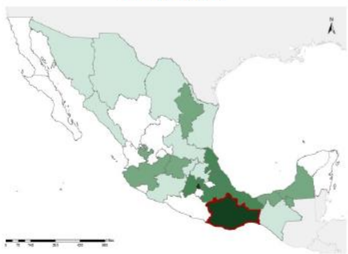
18 - Nayarit



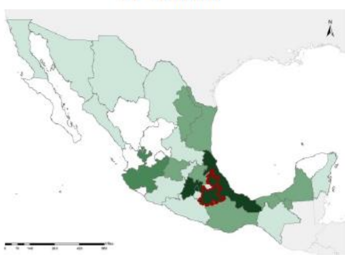
19 - Nuevo Leon



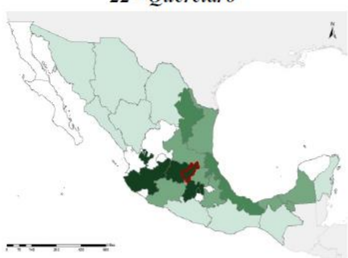
20 - Oaxaca



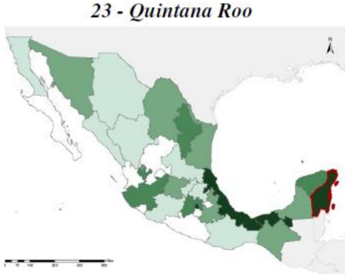
21 - Puebla



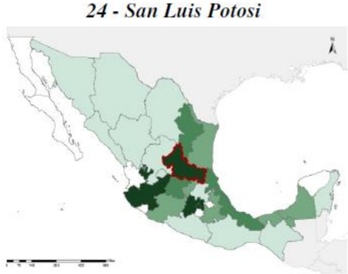
22 - Queretaro



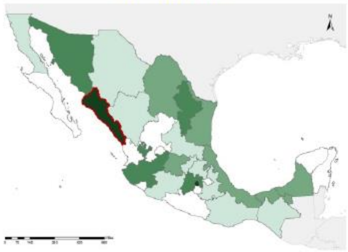
23 - Quintana Roo



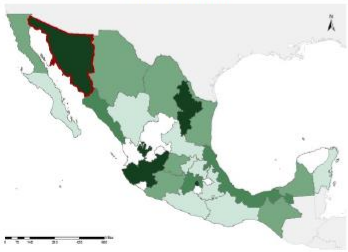
24 - San Luis Potosi



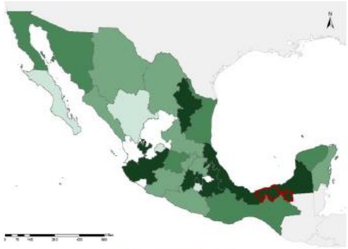
25 - Sinaloa



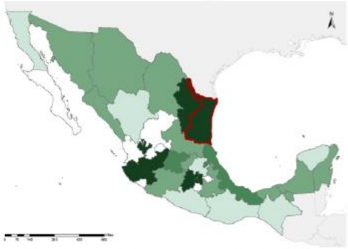
26 - Sonora



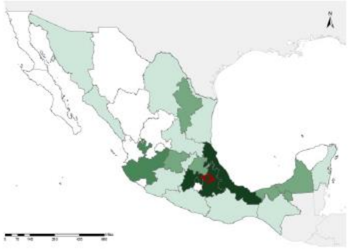
27 - Tabasco



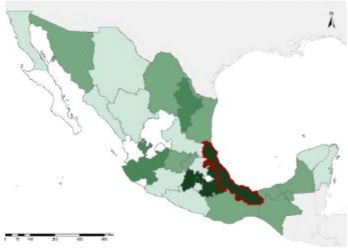
28 - Tamaulipas



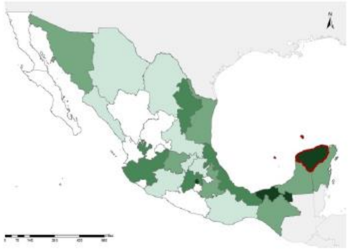
29 – Tlaxcala



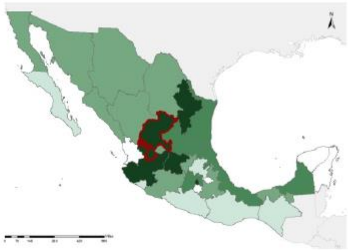
30 - Veracruz de Ignacio de la Llave



31 - Yucatan



32 - Zacatecas



Many potential applications!

Input-output applications

- Mexican regions (how do they relate?), structural decomposition analysis (historical estimation, updating), main drivers of sectoral and regional growth, impact of interregional government transfers, impact analysis…

Interregional CGE applications

- Economic impacts of drought, regional impacts of climate change (agriculture), specific transportation projects (accessibility), simulate TFP-enhancing policies (sectors and regions), other usual CGE applications, ...

Exercise – Interregional IO (decomposition of multiplier effects)

Data: Mexican 32-region interregional input-output table, 2013

1. **Agriculture (S1) in Sinaloa (R25)**
2. Mexican exports and KIBS

Excel files (…)

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Interstate input-output model for Mexico, 2013[1]

Modelo interestatal de insumo-producto para México, 2013

(Received: 03/March/2020; accepted: 09/July/2020; published: 04/September/2020)

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Juan Carlos Belausteguigoitia[******2]

Interregional CGE Model for Mexico

CRunGEM - BMMX

File Copy View Options Help

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

BM-MX Model

Interregional Computable General Equilibrium Model for Mexico

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

May 2019

BMMX ICGE, a bottom-up spatial CGE model of Mexico

A multi-sectoral, multi-regional bottom-up CGE model of Mexico's 32 regions

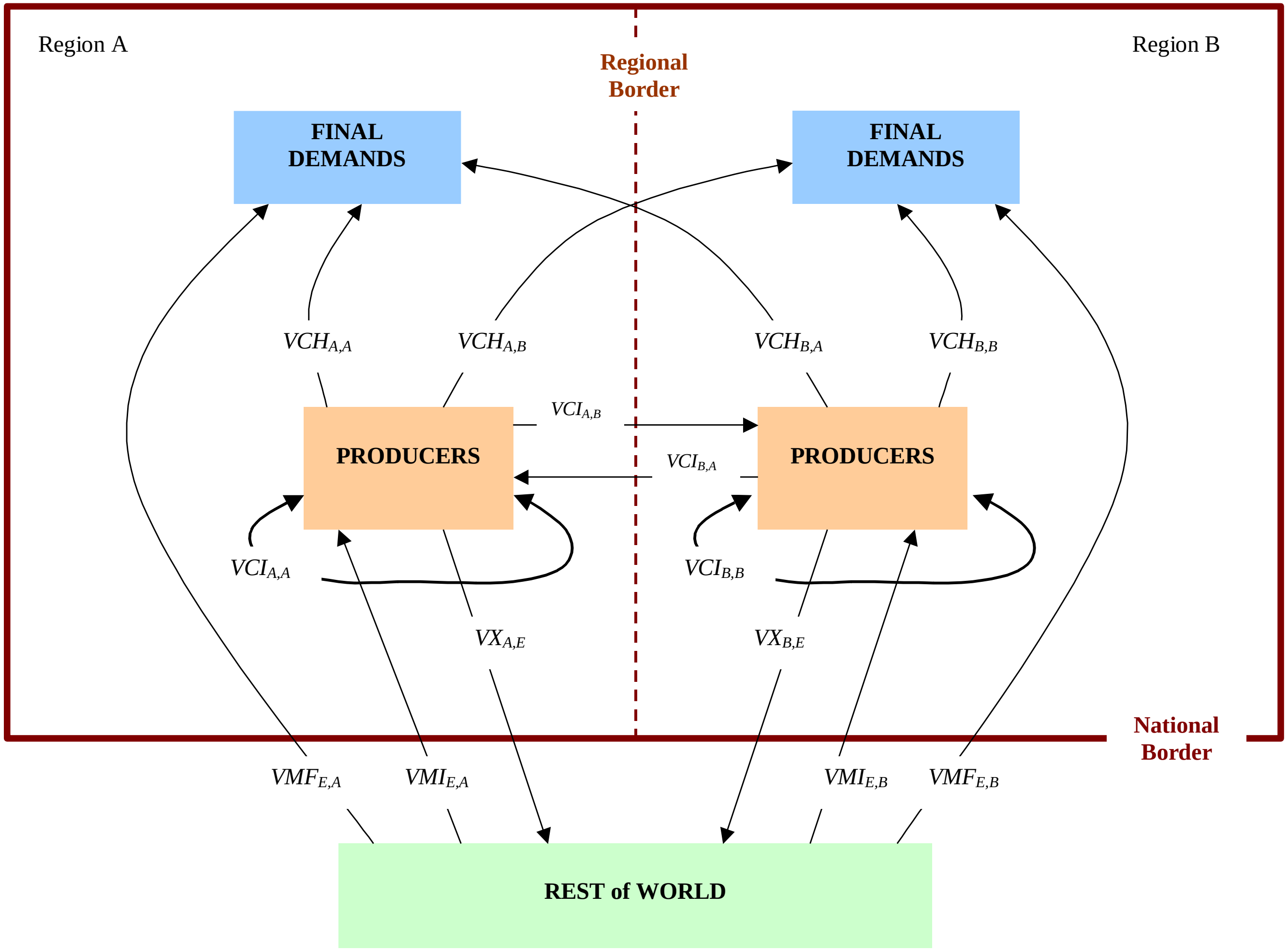
- each region is modeled as an economy in its own right
- region-specific prices
- region-specific industries
- region-specific consumers

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 Federal government financial accounts

Stylized flows



Core database

	Size	ABSORPTION MATRIX					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Regional Govt.	Federal Govt.
	Size	J x Q	J x Q	Q	1	Q	Q
Basic Flows	I x S	BAS1	BAS2	BAS3	BAS4	BAS5	BAS6
Margins	I x S x R	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6
Taxes	I x S	TAX1	TAX2	TAX3	TAX4	TAX5	TAX6
Labor	1	LABR					
Capital	1	CPTL					
Other	1	OCTS					

I = number of commodities
J = number of industries
R = number of commodities used as margins
Q = number of regions
S = Q domestic regions + 1 foreign import

Features of database

Commodity flows are valued at “basic prices” (**BAS**):

- 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 (**TAX**)
- usage of margins – transport (**MAR**)*

Single-production:

- each commodity may be produced by one industry
- each industry may produce one commodity

For each industry the total cost of production is equal to the total value of output

For each commodity the total value of sales is equal to the total value of output

Features of database (cont.)

Domestic producers

- J industries in Q regions

Investors

- J industries in Q regions

Households

- one representative household for each of the Q regions

Each of the I commodity types can be obtained from the region, from other regions, or imported from overseas

Features of database (cont.)

Aggregate foreign purchaser of exports

Other demand category corresponding to the Q regional governments

Other demand category corresponding to the central government in the Q regions

Commodity taxes and margins explicitly recognised

Building blocks

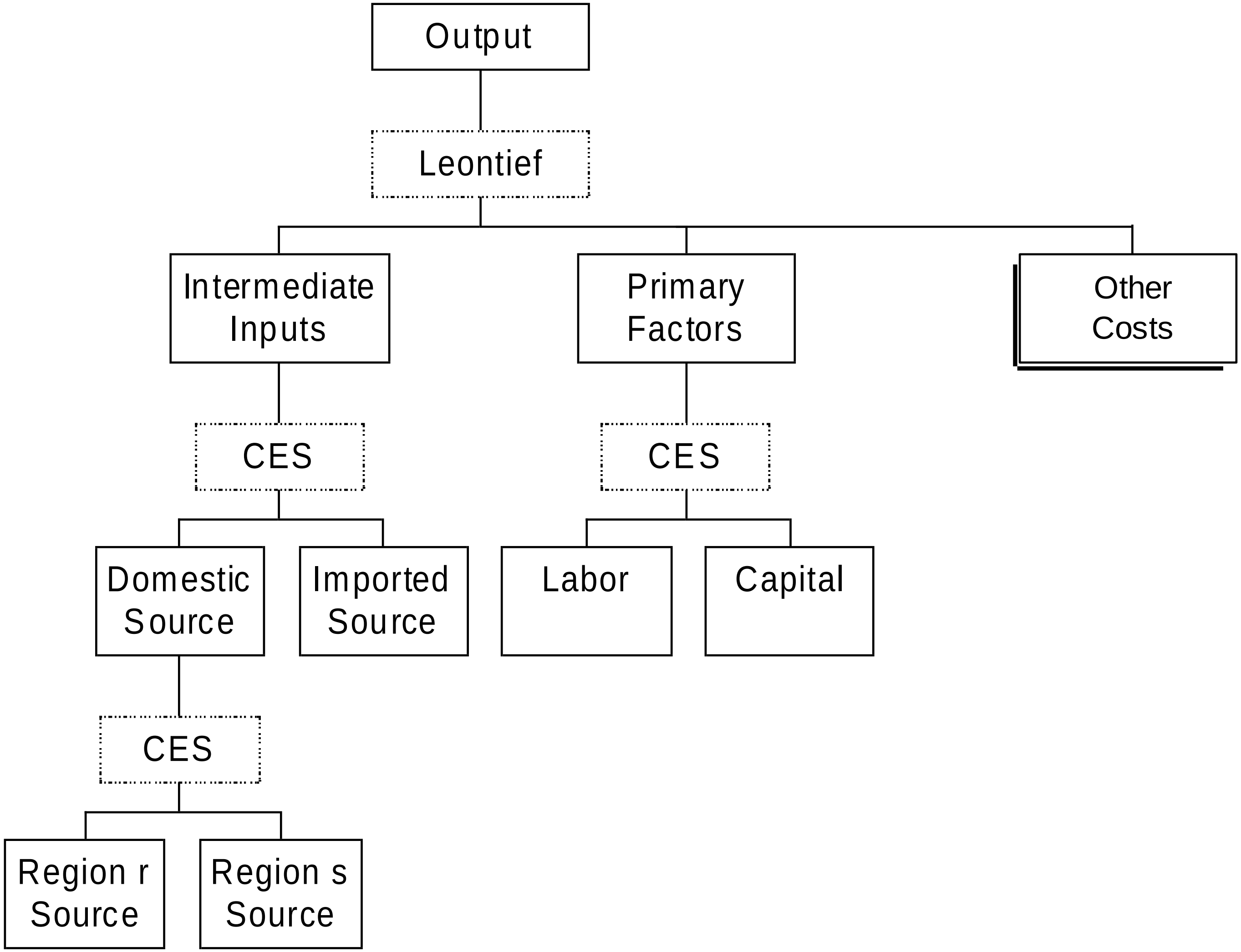
- ✓ **Producer's demands for inputs**
- ✓ Investor demands
- ✓ Household demands
- ✓ Export demands
- ✓ Government demands
- ✓ Margins demands
- ✓ Zero pure profits
- ✓ Indirect tax equations
- ✓ Market-clearing
- ✓ Regional and national macroeconomic variables and price indexes
- ✓ Capital accumulation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

Production nest

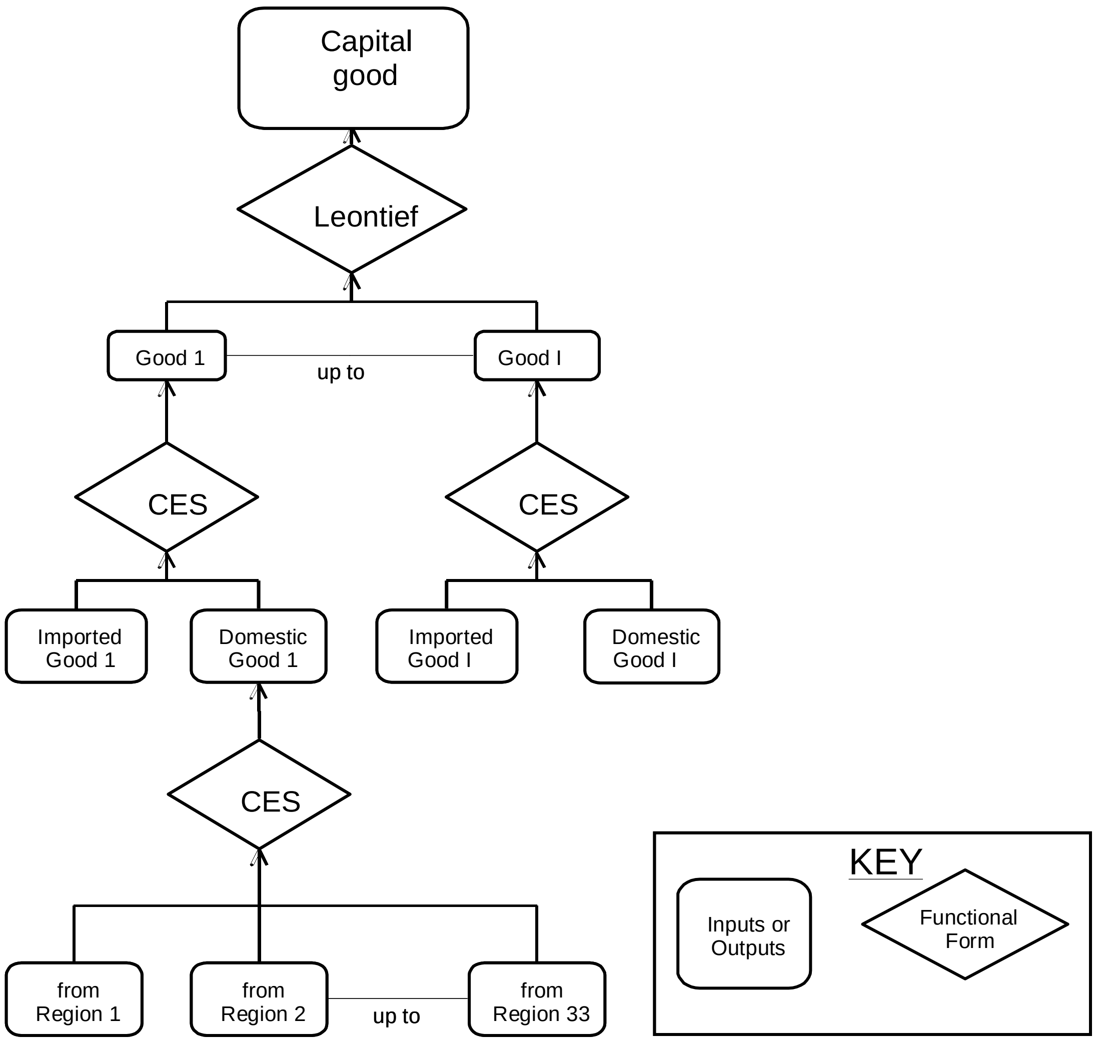
(1)

(2)

(3)



Investment demand

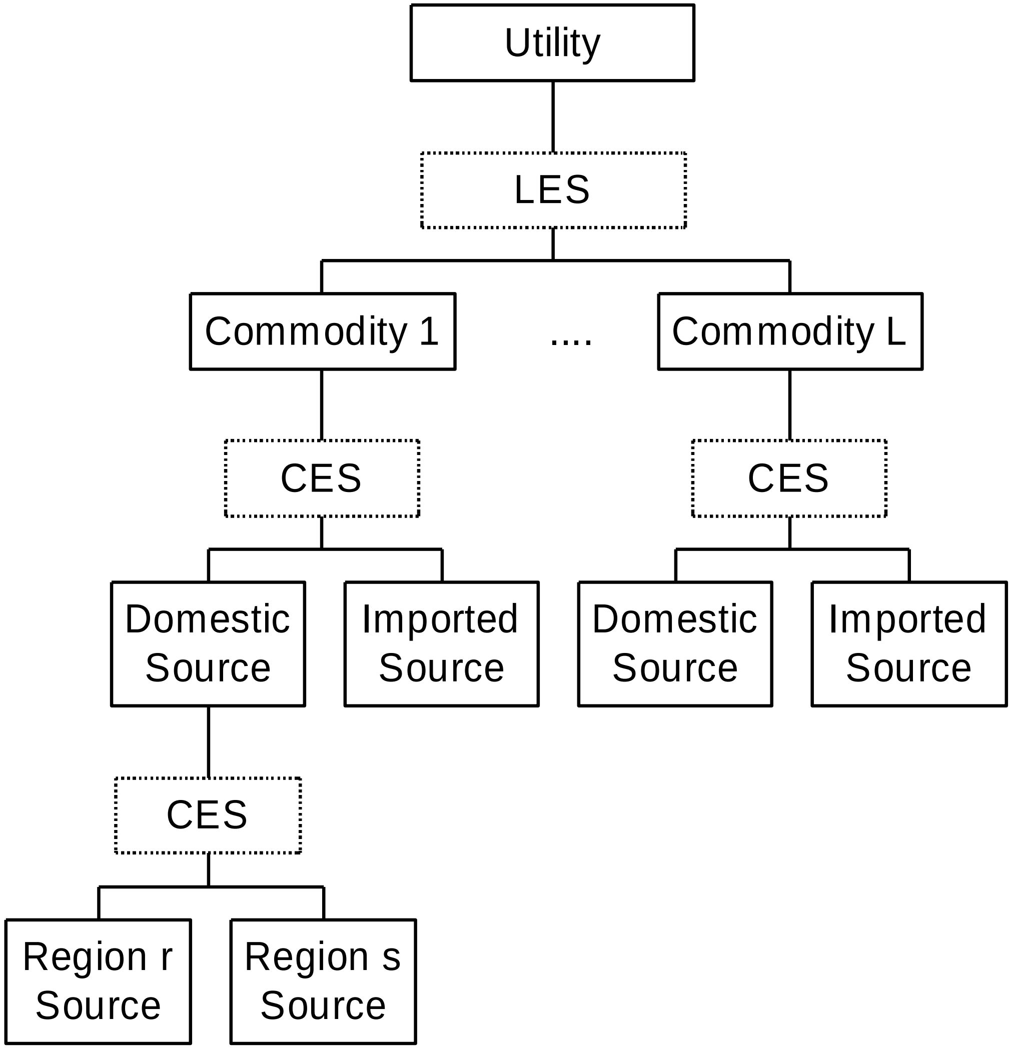


Household demand

(1)

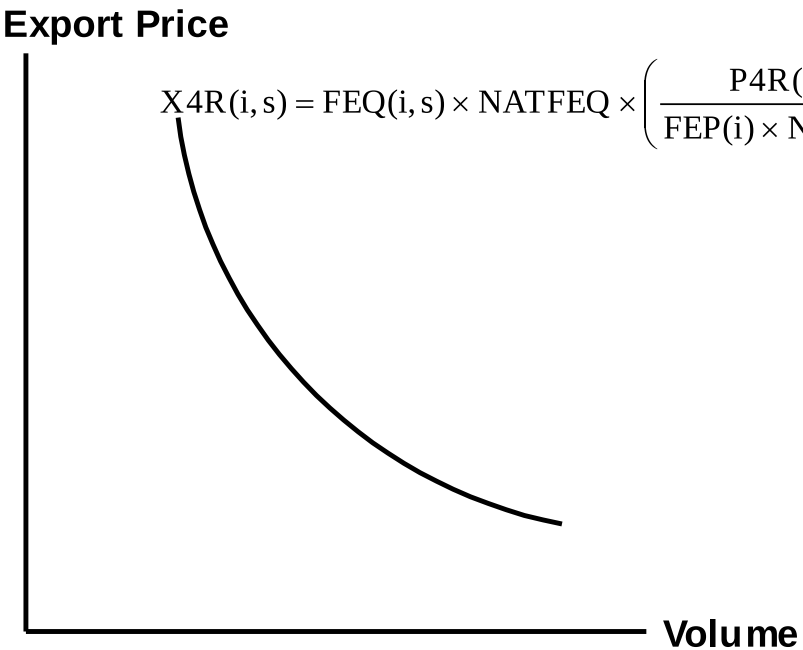
(2)

(3)



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 Federal government demands for goods and services for current consumption (not properly calibrated yet!)

Neither modelled explicitly

Default:

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

Demand for margin (transportation) services*

Margins commodities (identified in the set MARGCOM) provide freight services

- these commodities are consumed directly and used indirectly to facilitate the movements of products
- latter type of use is margins demand

Margins demand for margin commodity i is assumed to be proportional to the volume of the underlying flow

- e.g., margins use of transportation services in taking agricultural products to manufacturing is modelled as proportional to the volume of agricultural product used in manufacturing

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 BMMX 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: relação entre taxa bruta e taxa líquida de retorno (> 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 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

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

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

Exercise – CGE model (simulating the short-run effects of a drought in Northern Mexico)

1. Most years, one or more regions of Mexico suffer from low rainfall. As a continuing result of climate change, during 2020 an unusually severe drought in Sinaloa is expected to affect farmers all over the region. Agricultural outputs will fall sharply, with an expected loss of 10% (what if climate variability would also affect cattle raising output?). We will simulate the effects of such a drought using the BMMX ICGE model.

Guide for the BMMX Interregional CGE Model for Mexico Using Customized RunGEM

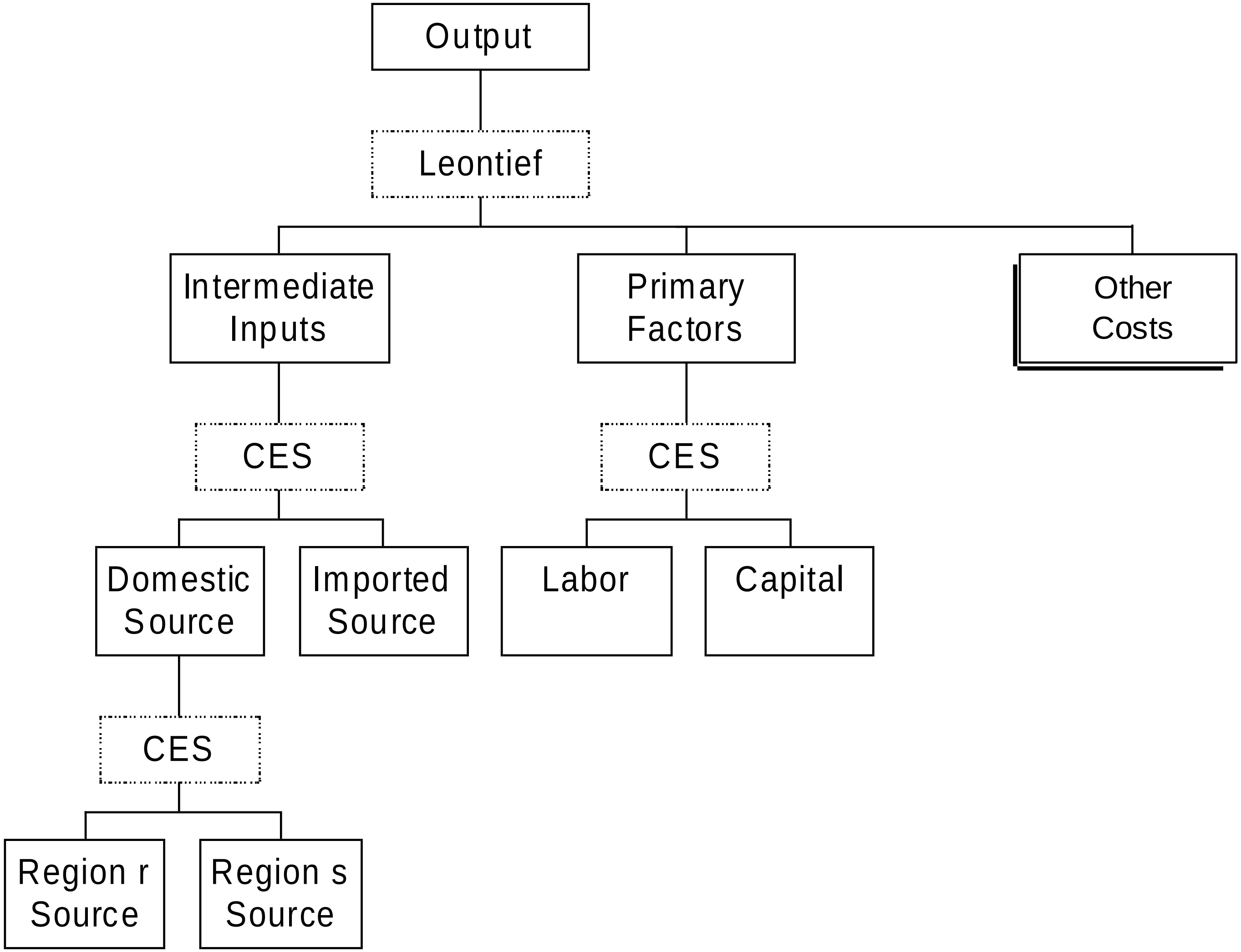
GEMPACK…

Production nest

(1)

(2)

(3)



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