Trade and Environment Modeling with GTAP and AIM/CGE

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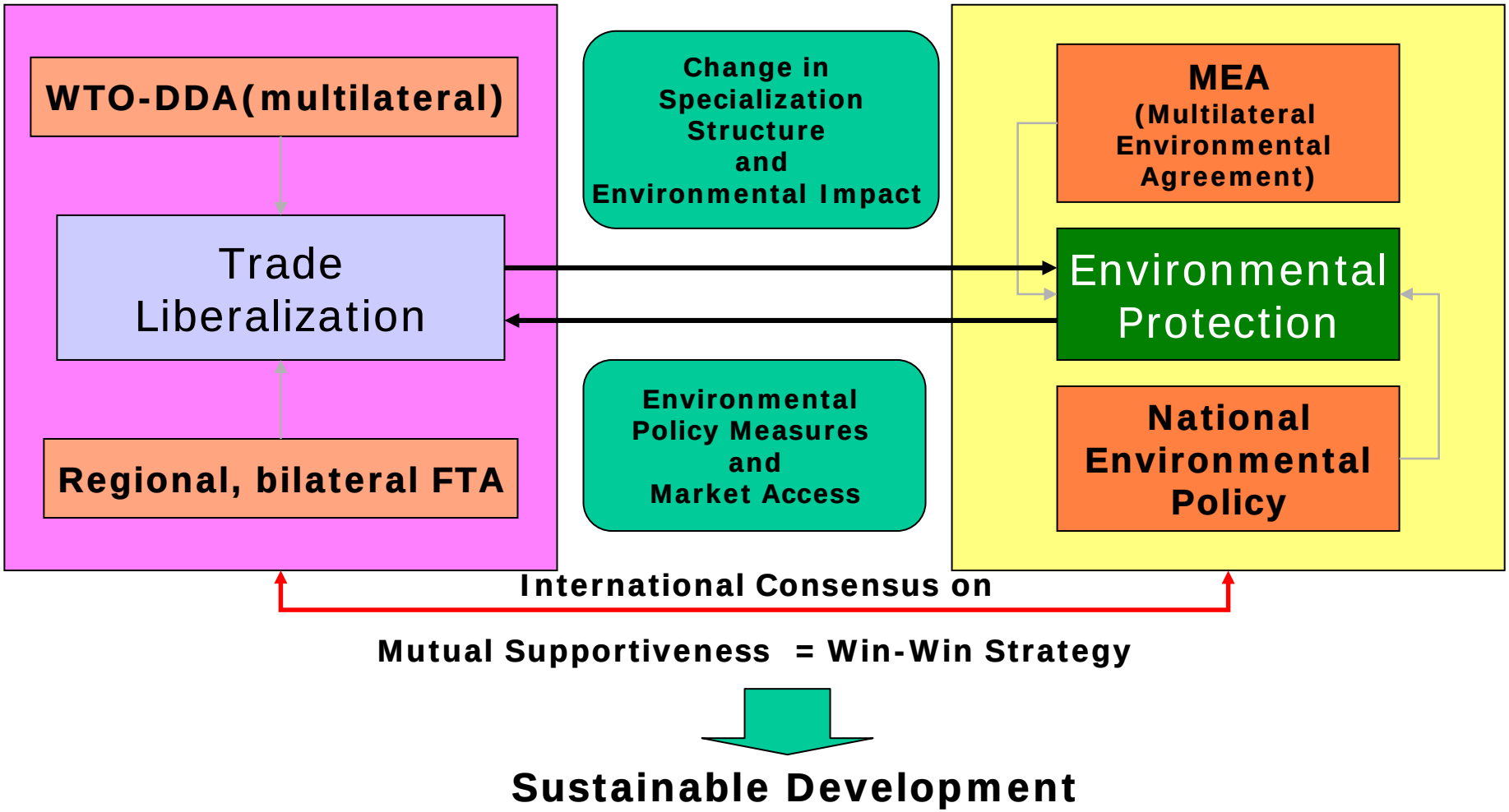
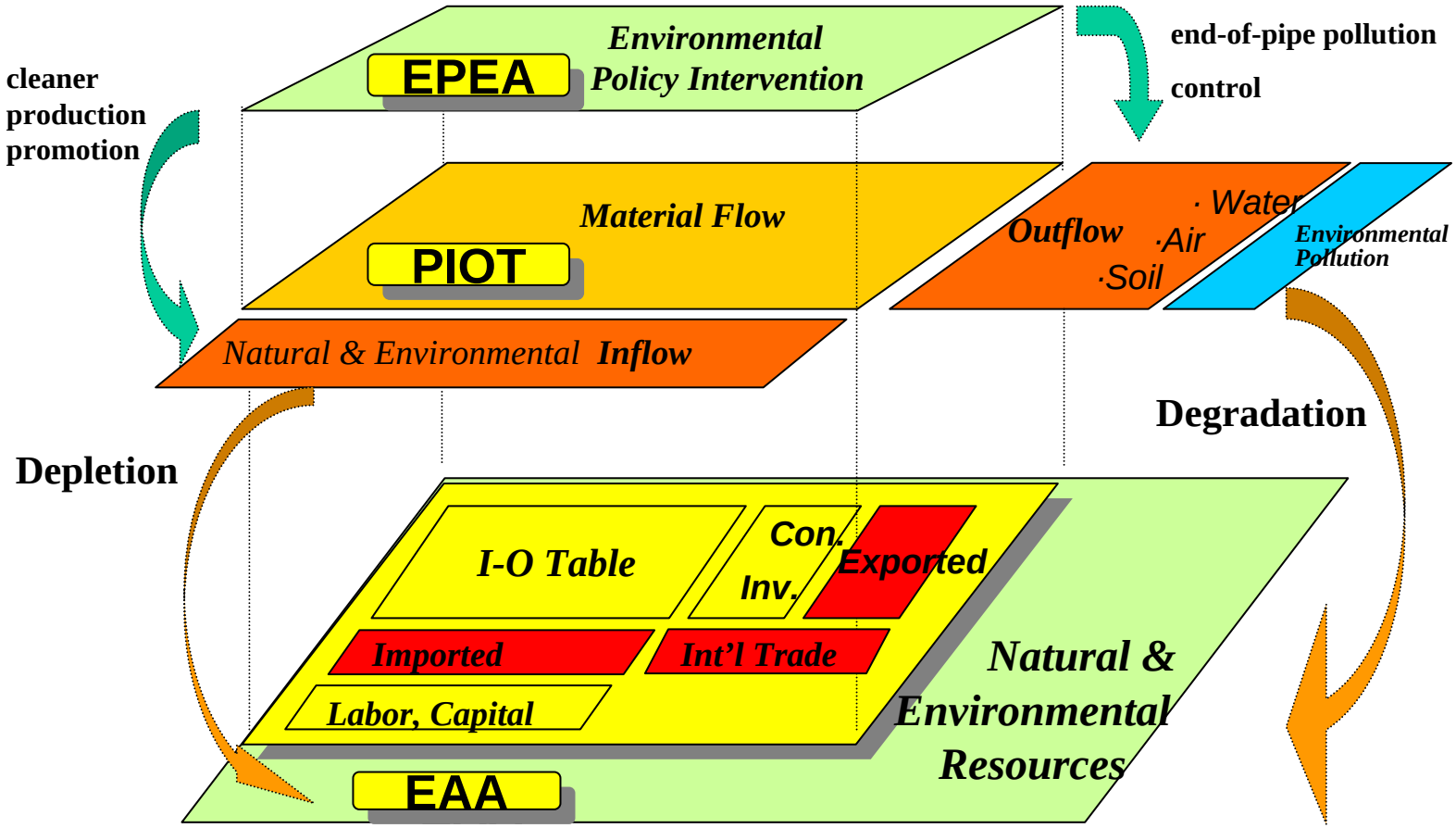
I. Introduction

❑ Trade and Environment



I. Introduction

❑ Trade, Economy and Environment



System of Economic and Environmental Accounts

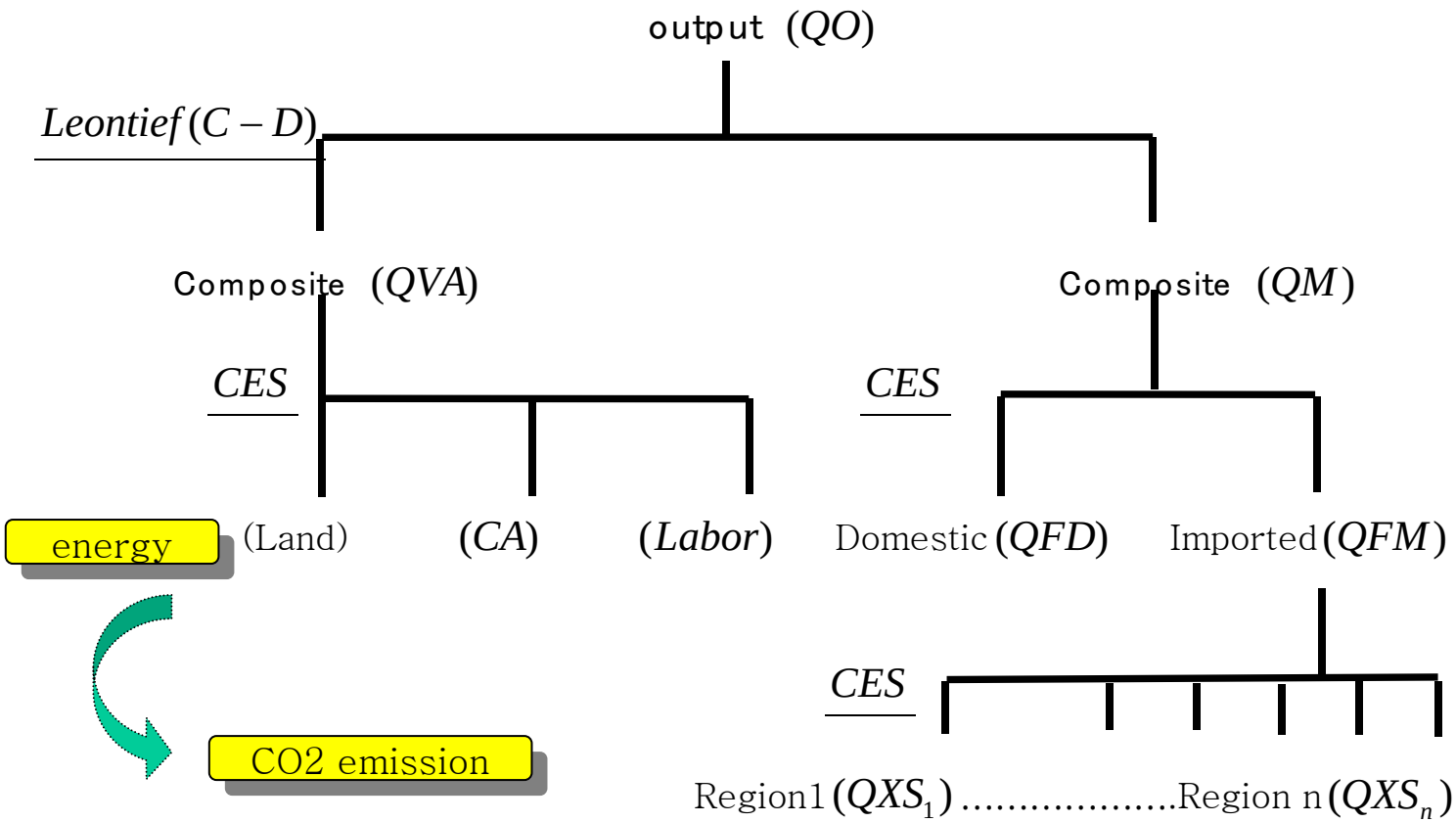
II. Application of GTAP

❑ Global Trade Analysis Project ?

- GTAP is a global network of researchers and policy makers conducting quantitative analysis of international policy issues
- provide quantitative analysis tools within an economy-wide framework including 87 regions and 57 sectors
- current version(GTAP 6) is based on updated database corresponds to the global economy in 2001 and IEA-based energy use data
- multi-regional computable general equilibrium model provided in comparative static and dynamic framework
- possibility of quantitative analysis of global climate change issues in multi-regional CGE(GTAP-E)
  - energy used as input and carbon dioxide emission inventory
- difficult to deal with local environmental issues as the DB does not include inventories of other pollutants → national model…

II. Application of GTAP

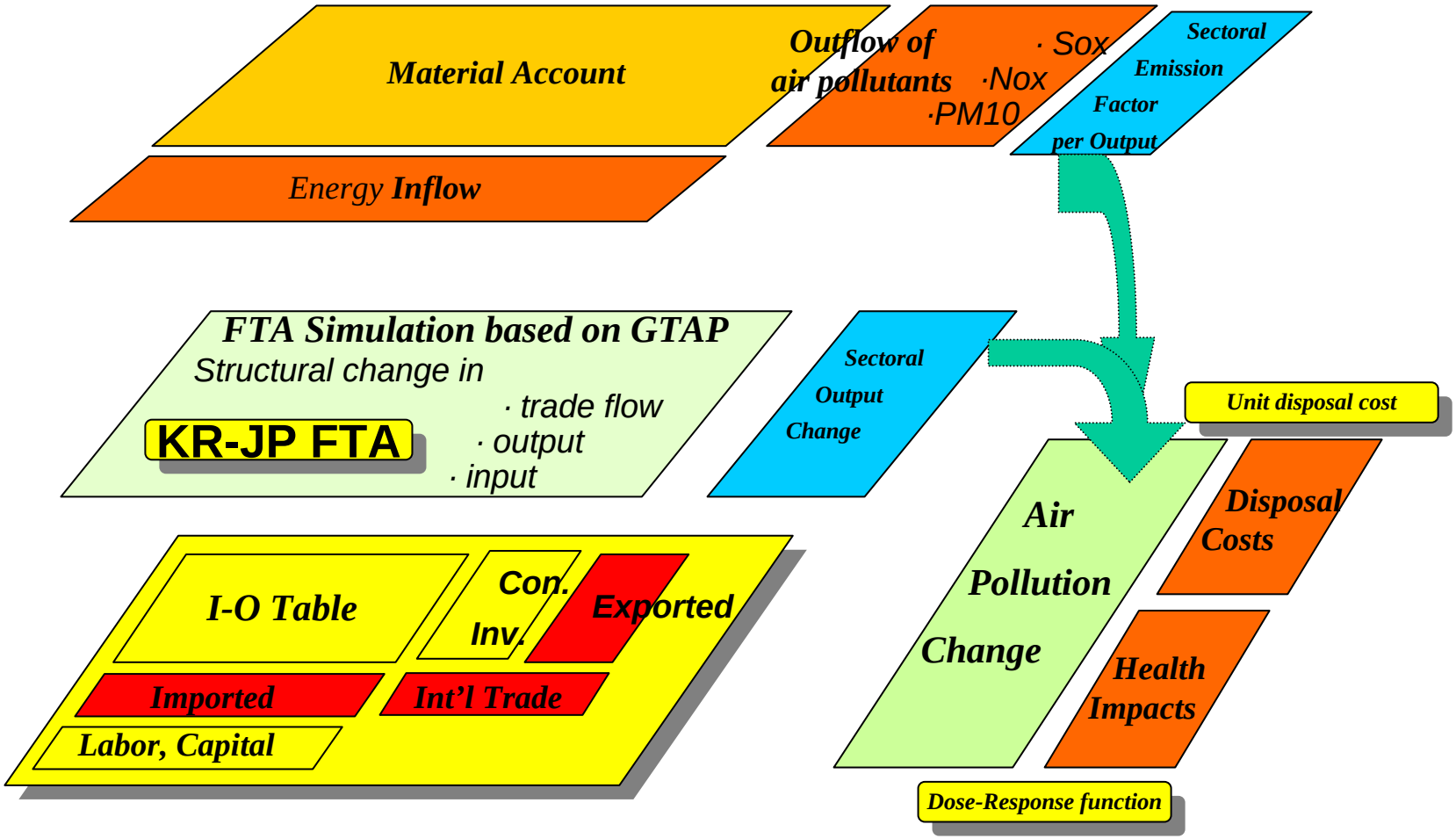
❑ Production structure of GTAP-E



Standard GTAP model

II. Application of GTAP

❑ Scheme of analysis for EIA on Korea-Japan FTA



Scheme of Analysis

II. Application of GTAP

❑ Model and Data sources

- Comparative study based on Korea - Japan FTA simulation with GTAP and on National emission factors in KR & JP for 1995, 2000(Korea only)

  Consider Bilateral trade flow change, Industrial output change, Air pollution and disposal cost change

- Model: comparative static standard multi-regional CGE
- Simulation: removal of import tax between KR and JP (equivalent to tariff and NTBs)
- Data sources:
  - GTAP DB version5 – 1995 based, GTAP DB 6Beta, 2000 based.
  - Industry structure: I-O Table 1995, 2000(Korea, Japan)
  - Bilateral trade data: the office of custom administration for Korea, Ministry of Finance for Japan, 1990~2002
  - Air pollution emission factors:
    - Korea -KEI(2003) for 1995, 2000
    - Japan –NIES(2004) for 1995(93 sectors)

II. Application of GTAP

❑ Aggregation

Regional Aggregation(1995, 2000)

- 7 regions:Kor, Jpn, Chn, NAFTA, EU, Oth_ASIA, ROW from 87 regional disaggregation

26 Sectoral aggregation

- based on Japanese and Korean I-O table, and sum-up to 6 Groups

Sectoral emission factor aggregation

- made by simple weighted average with output

Environmental factors

- Korea
  - Pollutant: SOx, NOx, TSP(1995), Nox, PM_{10}(2000)
  - Emission Factor(ton/output in MUS$ for 26 sectors, 1995,2000)
  - Unit disposal cost (MUS$/ton, Fixed and Maintenance, 1995)
- Japan
  - Pollutant: Sox, Nox, SPM(1995)
  - Emission Factor(ton/output in MUS$ for 26 sectors, 1995)

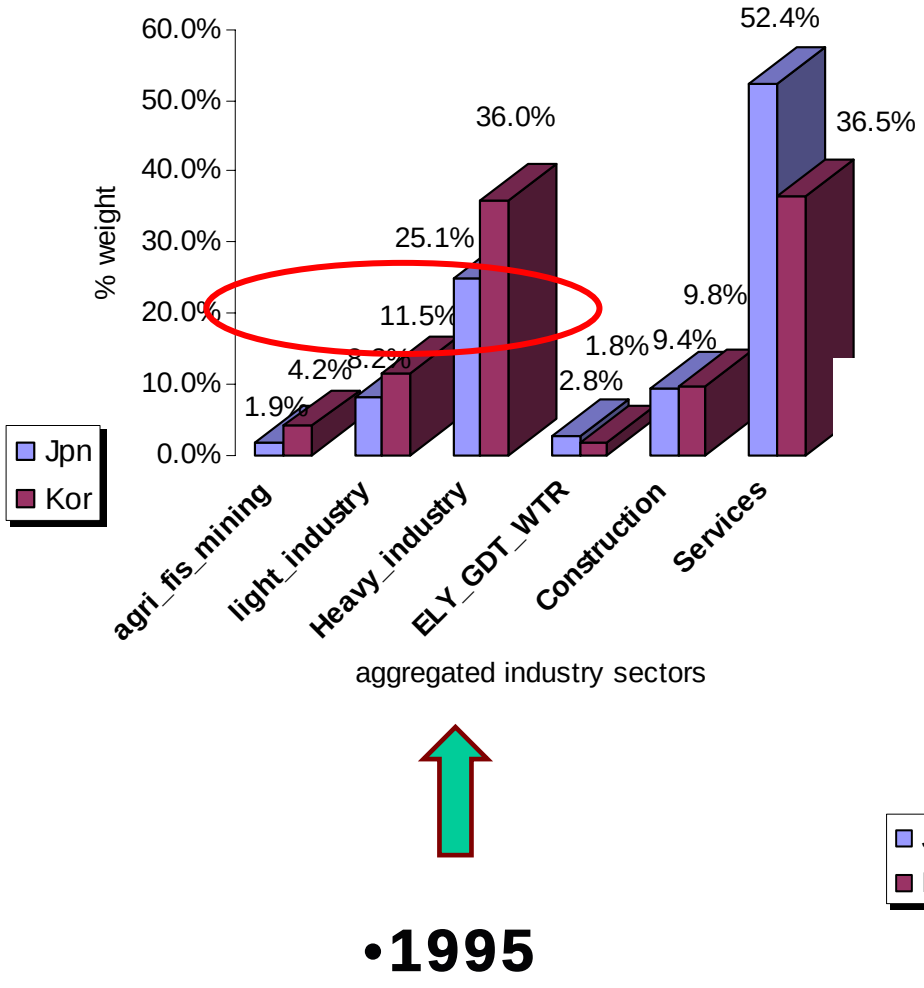
II. Application of GTAP

❑ Sectors

Sectors	A-Sectors	GTAP code	Sectors	A-Sectors	GTAP code
Agri_Fi_For_Min	AG_FI_FO	1-6, 8-14	**Heavy Industry**	OME	41
	Mining	15-18		ELE	40
Light Industry	Food	19-26		MVH	38
	TEX	7,27		OTN	39
	WAP	28		OMF	42
	LEA	29	**Ely_GDT_Wtr**	ELY	43
	LUM	30		GDT_WTR	44-45
	PPP	31	**Construction**	Cons	46
Heavy Industry	P_C	32	**Services**	TRD	47
	CRP	33		OTP	48-50
	NMM	34		CMN	51
	I_S	35-36		OFI_ISR	52-53
	FMP	37		Others	54-57

II. Application of GTAP

❑ KR and JP in Industrial structure

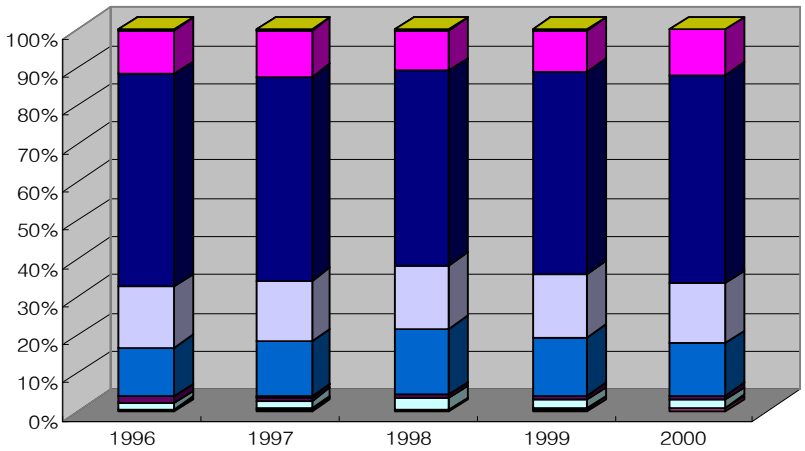


II. Application of GTAP

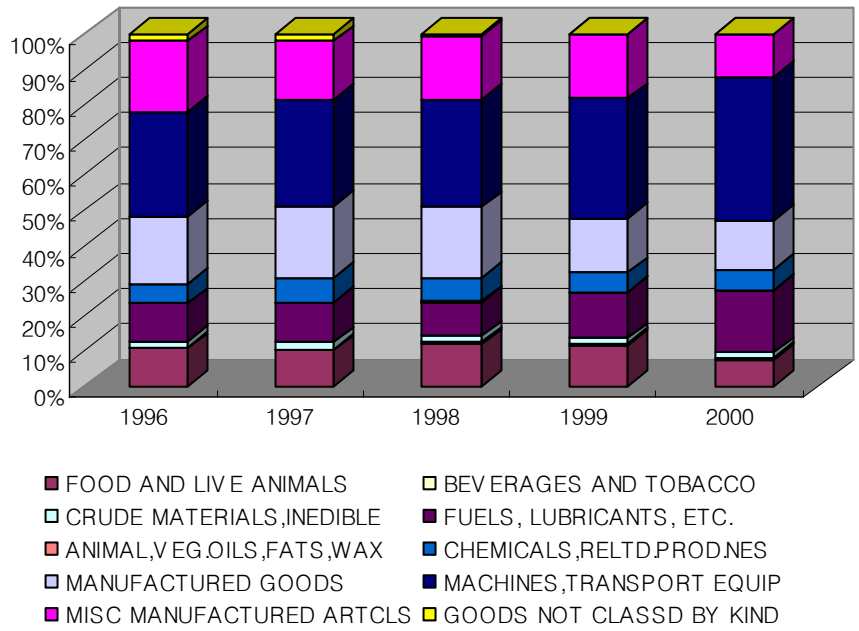
❑ KR-JP Bilateral trade structure

- **Korea's Comparative advantage sector in export to Japan**
  - Agriculture_fishing_forest, light industry – textile, food, leather, Heavy industry – ELE(semiconductors, TV, office equipment)
- **Japan's Comparative advantage sector in export to Korea**
  - Heavy industry – semiconductors, steel, automotive parts, chemical products

import

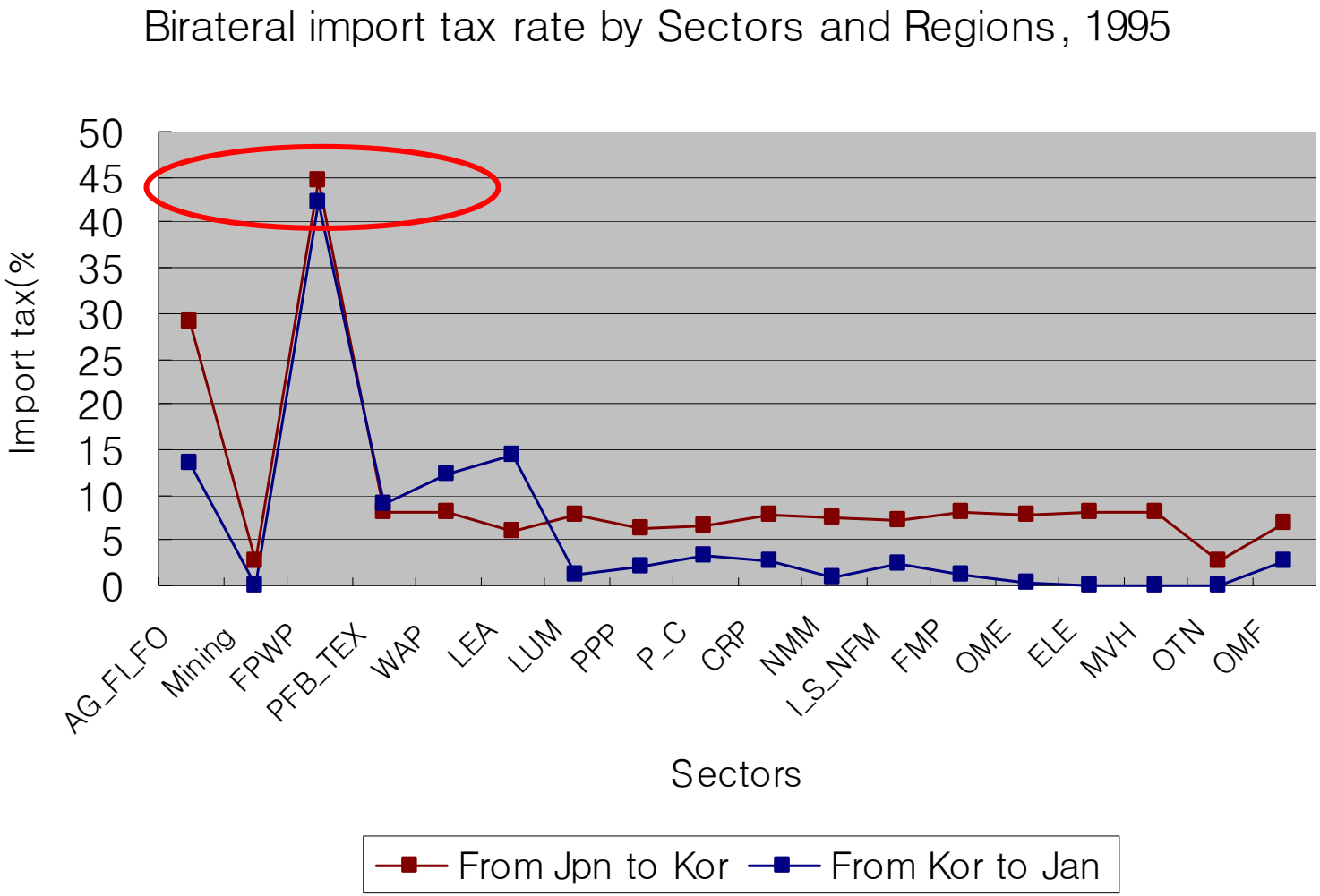


export



II. Application of GTAP

❑ Bilateral trade barriers(import tax rate in 1995)



II. Application of GTAP

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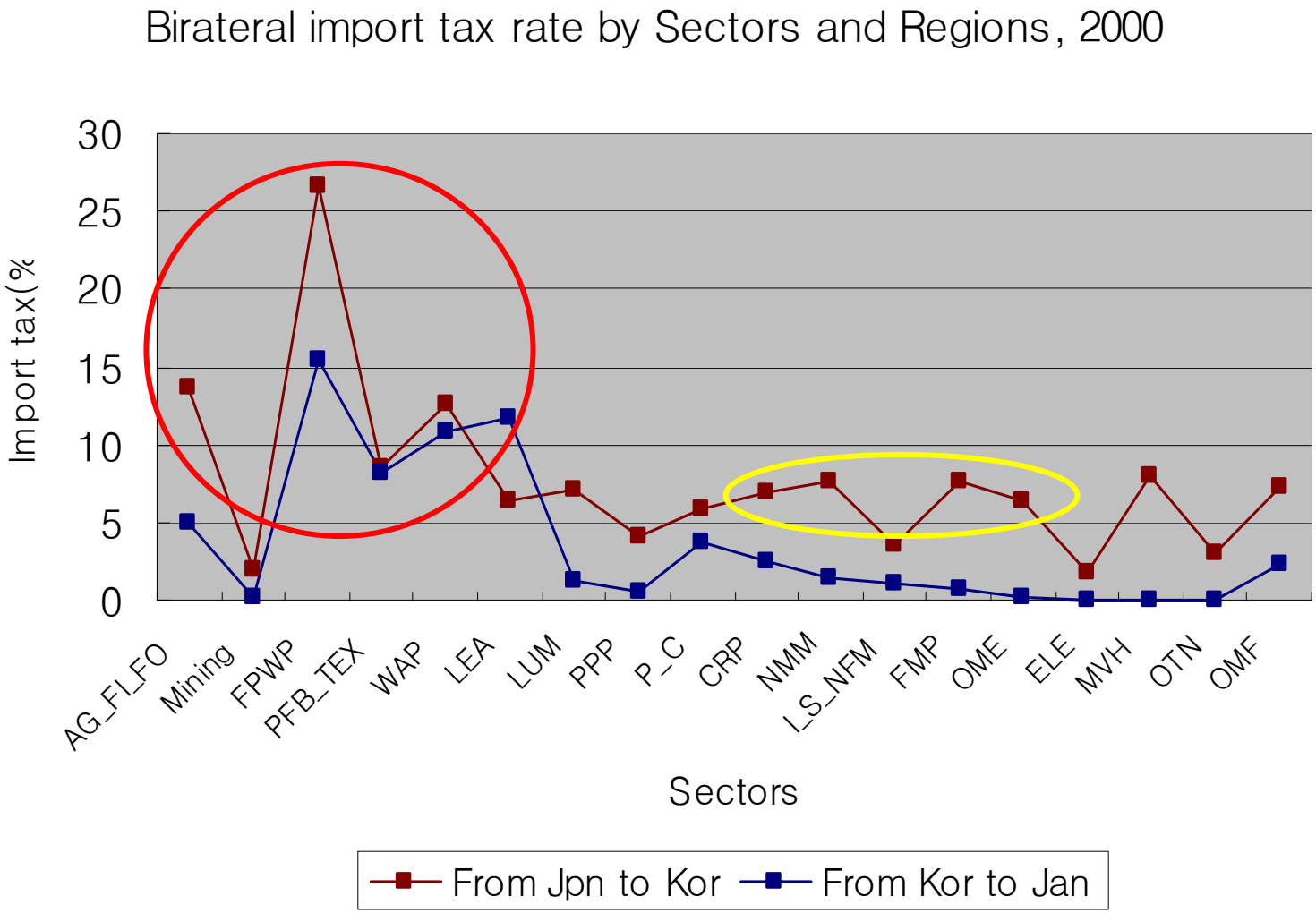
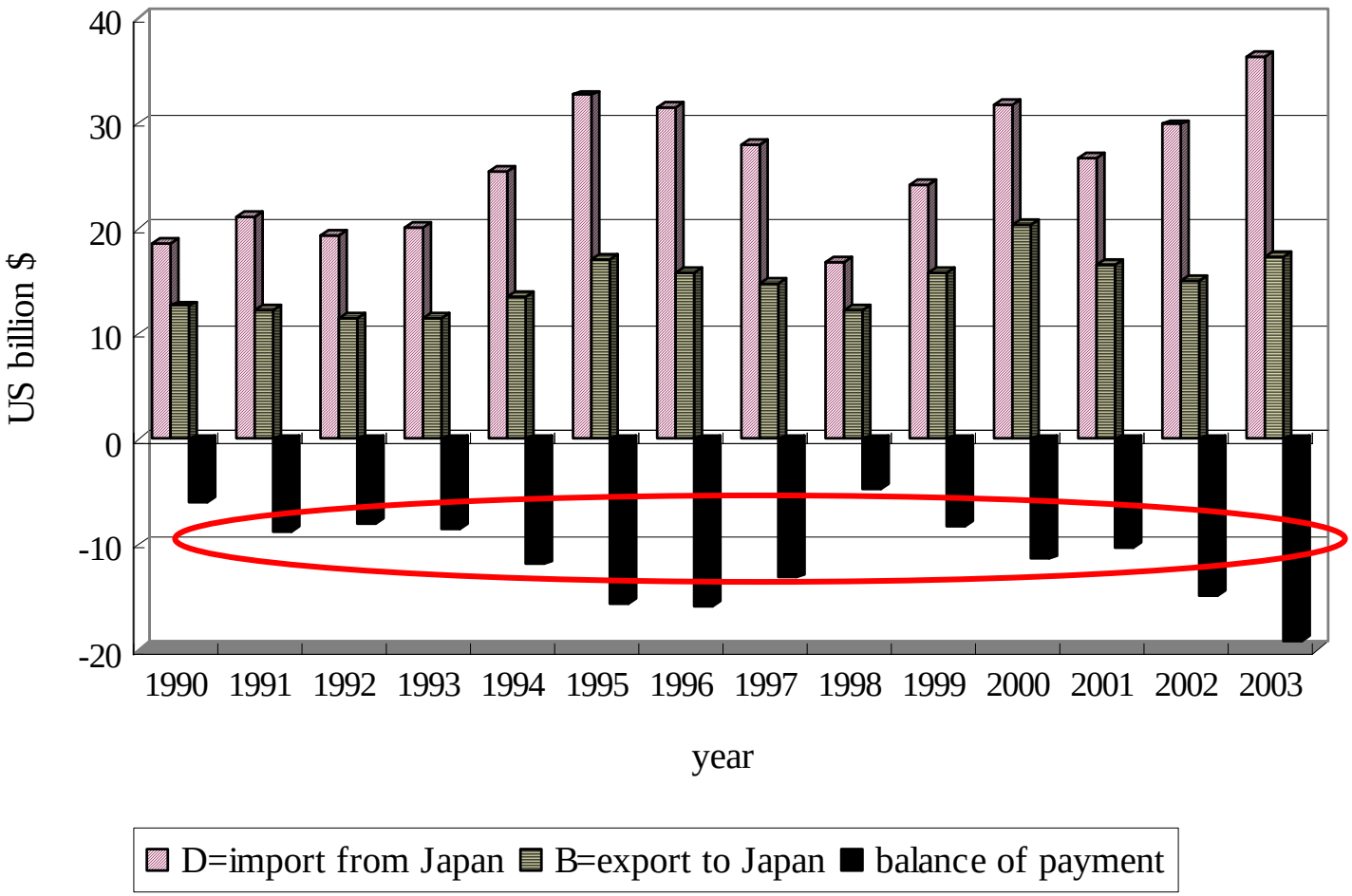


II. Application of GTAP

- Bilateral trade balance (X, M, BOP(X-M) for



II. Application of GTAP

❑ KR and JP in Emission Factors(1995)

Top five Sox and Nox intensive sectors of KR and JP

Sox — UNIT= EMISSION TON/ US MILLION $ — **Nox**

Korea			Japan		
19	ELY	22.75	23	OTP_WA	1.87
9	P_C	9.52	19	ELY	1.84
23	OTP_WA	6.45	1	AG_FI_FO	1.17
12	I_S_NFM	5.74	9	P_C	1.13
11	NMM	4.50	4	PFB_TEX	0.98

Korea			Japan		
19	ELY	9.25	23	OTP_WA	4.38
12	I_S_NFM	4.69	11	NMN	1.84
11	NMM	2.99	19	ELY	1.54
23	OTP_WA	2.53	1	AG_FI_FO	1.45
20	GDT_WTR	2.22	9	P_C	0.53

- **Direct emission intensity vs. Embodied emission intensity**
- **Pollution intensive sectors**
  - Heavy industry – transportation services, Non metallic products, Electricity

II. Application of GTAP

❑ Change in Emission Factor of Korean(1995-2000)

	1995y			2000y		
	sox	nox	tsp	nox	2000-1995	PM10
1 AG_FI_FO	0.0014610	0.0005050	0.0000990	0.0003544	-0.0001506	0.0008585
2 Mining	0.0002840	0.0003600	0.0001900	0.0001784	-0.0001816	0.0005357
3 FPWP	0.0013432	0.0003437	0.0001073	0.0001053	-0.0002384	0.0000456
4 PFB_TEX	0.0026410	0.0005230	0.0002320	0.0002502	-0.0002728	0.0000539
5 WAP	0.0001500	0.0000630	0.0000150	0.0000045	-0.0000585	0.0000012
6 LEA	0.0016760	0.0003500	0.0001210	0.0000406	-0.0003094	0.0000091
7 LUM	0.0006230	0.0001590	0.0000550	0.0002249	0.0000659	0.0000563
8 PPP	0.0028385	0.0005042	0.0002175	0.0003720	-0.0001323	0.0001636
9 P_C	0.0122800	0.0020290	0.0009230	0.0003647	-0.0016643	0.0000666
10 CRP	0.0017593	0.0004756	0.0002113	0.0002672	-0.0002084	0.0002670
11 NMM	0.0058090	0.0038490	0.0017760	0.0028071	-0.0010419	0.0109064
12 I_S_NFM	0.0074010	0.0060440	0.0029130	0.0025235	-0.0035205	0.0128206
13 FMP	0.0003010	0.0001010	0.0000230	0.0000521	-0.0000489	0.0000082
14 OME	0.0000641	0.0000245	0.0000053	0.0000124	-0.0000121	0.0000035
15 ELE	0.0004720	0.0000951	0.0000348	0.0000066	-0.0000886	0.0000002
16 MVN	0.0003080	0.0000670	0.0000230	0.0000194	-0.0000476	0.0000012
17 OTN	0.0000160	0.0000050	0.0000010	0.0000199	0.0000149	0.0000056
18 OMF	0.0001600	0.0001000	0.0000190	0.0000094	-0.0000906	0.0000207
19 ELY	0.0293290	0.0119270	0.0119730	0.0170574	0.0051304	0.0806504
20 GDT_WTR	0.0014210	0.0028620	0.0001340	0.0027268	-0.0001352	0.0000763
21 CONS	0.0000960	0.0000480	0.0000080	0.0000268	-0.0000212	0.0000025
22 TRD	0.0003103	0.0000921	0.0000205	0.0000521	-0.0000400	0.0000314

Increasing sectors for Nox

- wood products
- Transport equipment
- Electricity

II. Application of GTAP

❑ Free Trade Simulation

- Elimination of Tariff and Tariff equivalent of NTB on imports

$$pms(i,r,s) = tm(i,s) + \underline{tms(i,r,s)} + pcif(i,r,s)$$

- GTAP Experiment

Shock tms(TRAD_COMM, "Jpn", "Kor") = select from file tms.shk; ! within Kor and Jpn !

Shock tms(TRAD_COMM, "Kor", "Jpn") = select from file tms.shk; ! within Kor and Jpn !

II. Application of GTAP

❑ Macro-economic impacts(in GTAP 5, GTAP 6)

o Overall economic impact of K-J FTA 1995 base, unit = %, US million $

	pGDP	qGDP	vGDP	u	y	tot	EV
Korea	0.90	0.274	1.17	0.52	1.31	0.36	2026.39
Japan	0.21	-0.002	0.21	0.07	0.21	0.26	2502.44

	consumptio	investment	government	exports	import	gdp expendi
Korea	1.31%	1.57%	1.31%	3.39%	4.06%	1.18%
Japan	0.21%	0.32%	0.21%	0.90%	1.36%	0.21%

o Overall economic impact of K-J FTA 2000 base, unit = %, US million $

	pGDP	qGDP	vGDP	u	y	tot	EV
Korea	0.21	0.087	0.29	0.08	0.33	-0.04	282.22
Japan	0.24	0.004	0.24	0.07	0.25	0.25	2323.71

	consumption	investment	government	exports	import	gdp expenditure
Korea	0.33%	0.98%	0.33%	2.14%	3.03%	0.29%
Japan	0.25%	0.32%	0.25%	0.62%	0.90%	0.24%

II. Application of GTAP

❑ Trade Flow Change(GTAP 5, 1995)

Change of Bilateral Trade Flow From Korea to Japan

Unit: US million $

Aggregated sectors	Export		Import		Balance of trade	
Agri_Fi_For_Min	**618.29**	(46.69%)	**200.01**	(179.96%)	**418.28**	(19.49%)
Light Industry	**9102.73**	(200.80%)	**2219.86**	(118.54%)	**6882.87**	(242.37%)
Heavy Industry	**11322.44**	(6.15%)	**33173.26**	(34.77%)	**-21850.8**	(56.65%)
Ely_GDP_Wtr	**0.97**	(-5.11%)	**1.39**	(1.15%)	**-0.42**	(19.30%)
Construction	**1.76**	(-3.07%)	**1.54**	(0.55%)	**0.22**	(-22.52%)
Services	**988.86**	(-3.58%)	**1362.15**	(0.37%)	**-373.30**	(12.61%)

II. Application of GTAP

❑ Trade Flow Change(GTAP 6, 2000)

Change of Bilateral Trade Flow From Korea to Japan

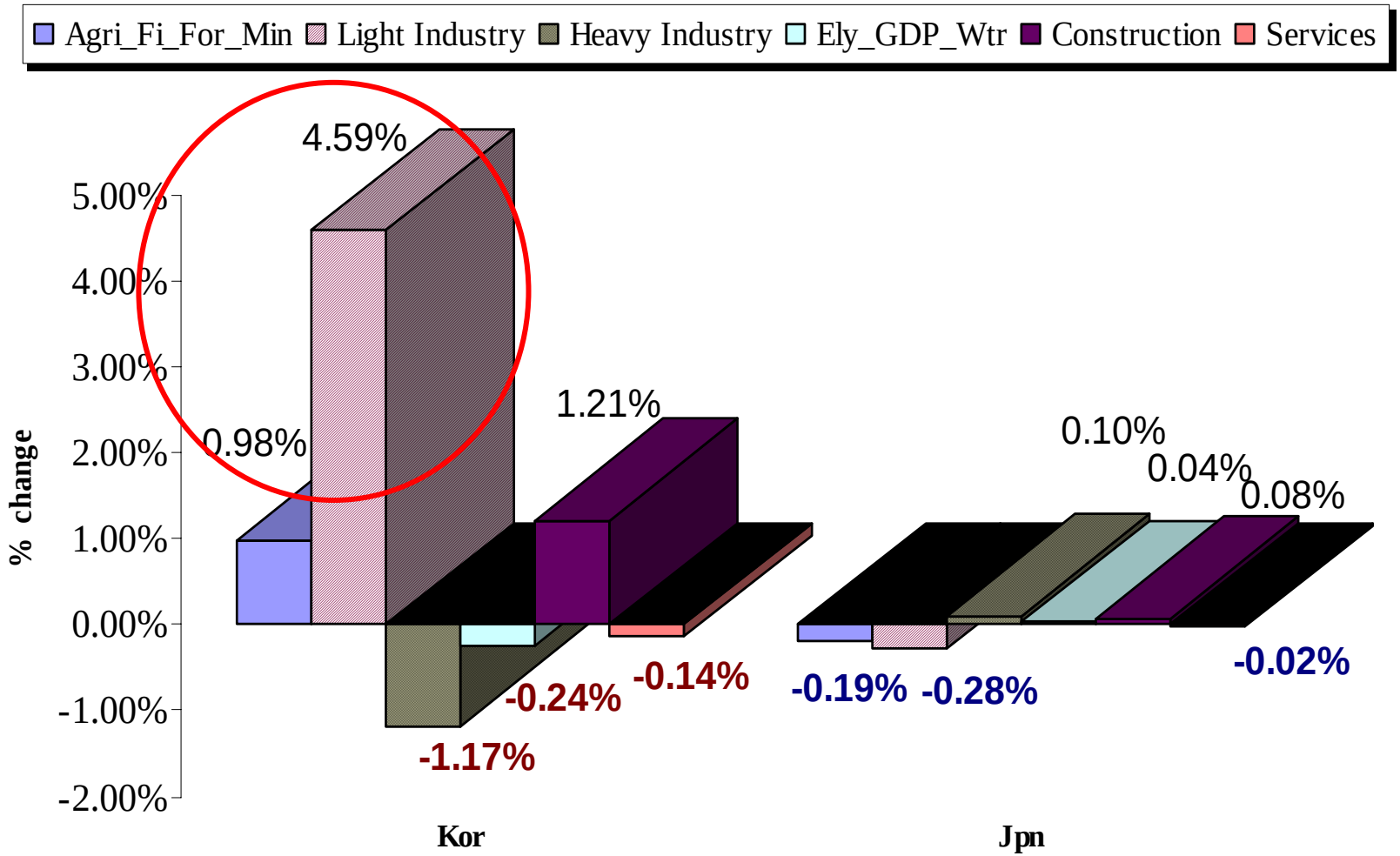
Unit: US million $

Aggregated sectors	Export		Import		Balance of trade	
Agri_Fi_For_Min	**549.71**	(20.82%)	**216.06**	(77.37%)	**333.65**	(0.14%)
Light Industry	**4639.52**	(89.61%)	**1894.28**	(99.65%)	**2745.24**	(83.24%)
Heavy Industry	**13560.25**	(7.25%)	**3275.67**	(29.60%)	**-19315.43**	(51.81%)
Ely_GDP_Wtr	**1.59**	(-1.85%)	**0.23**	(-0.44%)	**-1.36**	(-2.08%)
Construction	**13.95**	(-0.75%)	**2.48**	(0.20%)	**11.46**	(-0.95%)
Services	**1120.32**	(-1.29%)	**1053.09**	(-0.52%)	**-67.23**	(11.96%)

II. Application of GTAP

❑ Change in sectoral output (GTAP 5, 1995)

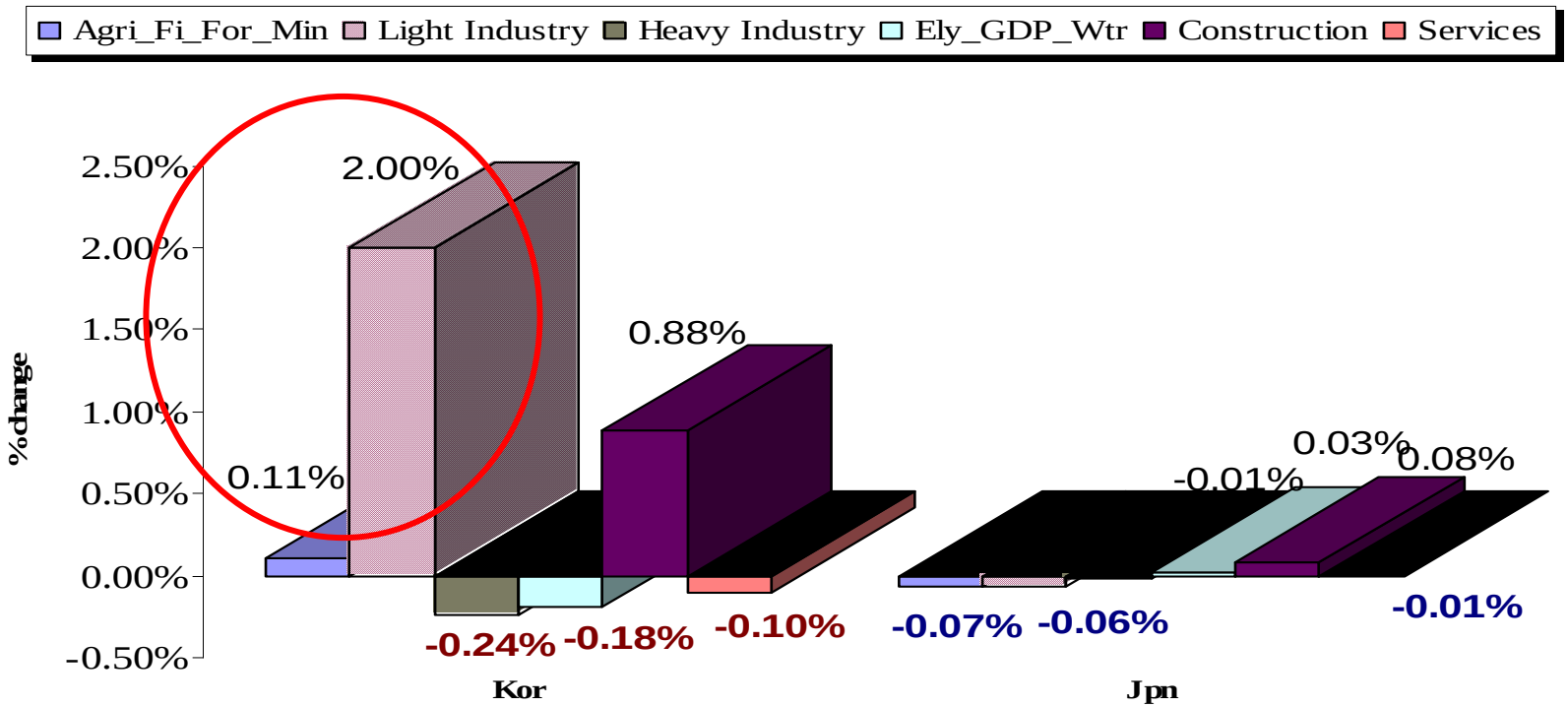
Based on GTAP ver5



II. Application of GTAP

❑ Change in sectoral output (GTAP 6, 2000)

Based on GTAP ver6



II. Application of GTAP

❑ Emission effects(GTAP 5, 1995)

- **output(qo)**
  - **Korea**(+0.18%) ↑
  - **Japan**(-0.004%) ↓
- **emission**
  - **Korea** ↓
  - **Japan** ↓

Interindustrial difference of emission intensity and changes in specialization structure play a key role determining total emission change in both countries!

	KOR			JPN		
	Sox	Nox	TSP	Sox	Nox	Spm
1 AG_FI_FO	483.05	166.97	32.73	-211.95	382.80	-61.41
2 Mining	-13.31	-16.88	-8.91	0.80	3.30	0.20
3 FPWP	4,070.70	1,041.65	325.25	-155.69	-61.63	-10.62
4 PFB_TEX	283.04	56.05	24.86	-9.97	-6.41	-1.02
5 WAP	65.32	27.43	6.53	-11.17	-13.66	-1.46
6 LEA	952.55	198.92	68.77	-12.89	-6.10	-1.05
7 LUM	-9.97	-2.54	-0.88	-1.16	-1.84	-0.36
8 PPP	-76.80	-13.64	-5.88	-11.38	-8.57	-2.24
9 P_C	868.16	143.44	65.25	-24.21	-27.68	-2.07
10 CRP	-667.02	-180.32	-80.13	132.32	122.44	15.79
11 NMM	-945.37	-626.39	-289.03	89.52	468.56	24.84
12 I_S_NFM	-5,047.05	-4,121.65	-1,986.49	351.24	450.33	51.95
13 FMP	-19.29	-6.47	-1.47	3.28	7.93	0.72
14 OME	-111.12	-42.46	-9.99	23.88	49.22	5.69
15 ELE	205.06	41.33	15.14	4.12	6.19	0.41
16 MVN	-182.69	-39.74	-13.64	-22.23	-47.80	-5.59
17 OTN	-3.03	-0.95	-0.19	-19.62	-17.75	-2.67
18 OMF	-7.16	-4.48	-0.85	-0.38	-0.41	-0.07
19 ELY	-1,123.42	-456.85	-458.61	103.68	121.14	11.63
20 GDT_WTR	3.08	6.19	0.29	-1.65	-1.68	-1.38
21 CONS	79.51	39.76	6.63	8.68	94.09	8.82
22 TRD	17.95	5.33	1.18	4.66	3.40	0.31
23 OTP_WA	-1,631.51	-641.42	-108.70	-781.11	-1,703.72	-114.26
24 CMN	-1.15	-0.34	-0.06	-0.49	-1.32	-0.09
25 OFI_ISR	-0.92	-0.42	-0.03	-0.11	-0.51	-0.04
26 Others	-21.09	-5.16	-3.50	-13.20	-18.95	-2.28
total	-2,832.51	-4,432.65	-2,421.74	-555.03	-974.25	-86.22

II. Application of GTAP

❑ Emission effects (GTAP 6, 2000)

- **output(qo)**
  - **Korea**(+0.13%) ↑
  - **Japan**(-0.01%) ↓
- **emission(Nox, PM10)**
  - **Korea** ↓

Interindustrial difference of emission intensity and change in specialization structure determine the volume of total emission.

The total emission change of Nox in Korea with GTAP 6 is less important than that with GTAP 5. This comes from smaller change in production and improved emission factors. Technical progress contributes to mitigate environmental pressure from trade liberalization.

	Nox	PM110
1 AG_FI_FO	20.07	48.61
2 Mining	−5.24	−15.74
3 FPWP	55.06	23.84
4 PFB_TEX	97.65	21.03
5 WAP	1.59	0.41
6 LEA	11.29	2.52
7 LUM	0.07	0.02
8 PPP	−16.98	−7.47
9 P_C	43.70	7.99
10 CRP	−68.70	−68.63
11 NMM	−377.82	−1,467.95
12 I_S_NFM	−907.12	−4,608.54
13 FMP	−4.14	−0.65
14 OME	−11.36	−3.22
15 ELE	6.80	0.25
16 MVN	−1.07	−0.06
17 OTN	−0.10	−0.03
18 OMF	0.02	0.04
19 ELY	−475.54	−2,248.46
20 GDT_WTR	−1.70	−0.05
21 CONS	10.24	0.96
22 TRD	1.28	0.77
23 OTP_WA	−830.84	−40.96
24 CMN	−0.13	−0.01
25 OFI_ISR	−0.15	−0.03
26 Others	−3.16	−1.05
total	−2456.27	−8356.42

II. Application of GTAP

❑ Aggregated Emission effects

			1995 base				2000base	
		Korea			Japan		Korea	
	Sox	Nox	TSP	Sox	Nox	Spm	Nox	PM10
Agri_Fi_For_	469.73	150.09	23.83	-211.16	-379.50	-61.20	14.83	32.88
	1.20%	1.05%	0.77%	-0.22%	-0.21%	-0.22%	0.18%	0.16%
Light Industr	5,284.81	1,307.87	418.65	-202.26	-98.21	-16.74	148.68	40.35
	3.37%	3.88%	3.28%	-0.21%	-0.17%	-0.13%	1.12%	0.86%
Heavy Indus	-5,909.42	-4,837.68	-2,301.40	537.91	1,011.01	89.00	-1,319.78	-6,140.82
	-0.84%	-1.36%	-1.37%	0.25%	0.28%	0.28%	-1.07%	-1.23%
Ely_GDP_W	-1,120.34	-450.66	-458.32	102.03	119.46	10.26	-477.24	-2,248.51
	-0.27%	-0.27%	-0.28%	0.04%	0.04%	0.03%	-0.20%	-0.21%
Construction	79.51	39.76	6.63	8.68	94.09	8.82	10.24	0.96
	1.21%	1.21%	1.21%	0.08%	0.08%	0.08%	0.88%	0.88%
Services	-1,636.80	-642.04	-111.11	-790.24	-1,721.11	-116.36	-833.01	-41.28
	-0.52%	-0.53%	-0.49%	-0.08%	-0.09%	-0.09%	-0.28%	-0.25%
total	-2,832.50	-4,432.67	-2,421.74	-555.04	-974.26	-86.22	-2,456.27	-8,356.42
	-0.17%	-0.64%	-0.65%	-0.03%	-0.03%	-0.03%	-0.36%	-0.51%

II. Application of GTAP

❑ Environmental cost effects (Korea Case, 1995)

- **Emission and its disposal costs (1995)**

description	code	Emission factor		
		Sox	Nox	TSP
9. Petroleum, coil product	P_C	0.012280	0.002029	0.000923
11. Mineral product	NMM	0.005809	0.003849	0.001776
12. Ferrous Metals	I_S_NFM	0.007401	0.006044	0.002913
19. Electricity	ELY	0.029329	0.011927	0.011973
23. Transport service	OTP_WA	0.008315	0.003269	0.000554

description	code	Unit disposal cost		
		Sox	Nox	TSP
2. Mining	MINING	0.891	287.074	1.639
7. Wood product	LUM		70.294	
15. Electronic equipments (=13,14)	ELE		95.155	
18. Furniture and Manufactures n.e.c	NMM		211.842	
21. Construction	CONS		180.353	

II. Application of GTAP

❑ Changes of Emission and Disposal Cost

(Unit: MKR¥, ton, %)

Commodities	Base Total cost	Emission(ton change)			Cost	
		Sox	Nox	Tsp	%change	Add_cost
1. Agriculture_fishing_forest	692,718	668	231	45	1.25	8,687
3. Food product	**644,154**	**5,632**	**1,441**	**450**	**7.69**	**49,750**
4. Textiles	415,432	392	78	34	0.58	2,420
6. Leather product	**63,397**	**1,318**	**375**	**95**	**13.37**	**8,480**
9. Petroleum, coal product	785,935	1,201	199	90	0.41	3,228
15. Electricity equipment	557,568	284	57	21	1.03	5,728
21. Construction	**826,607**	**110**	**55**	**9**	**1.21**	**10,034**
10. Chemical, rubber, plastic	452,774	-923	-250	-111	-0.78	-3,530
11. Mineral product	**1,101,623**	**-1,308**	**-867**	**-400**	**-1.21**	**-13,288**
12. Ferrous metal	**1,387,386**	**-6,983**	**-5,703**	**-2,749**	**-1.74**	**-24,138**
14. Machinery and equipment	194,630	-154	-59	-14	-2.95	-5,750
16. Motor vehicles and parts	239,664	-253	-55	-19	-1.63	-3,907
19. Electricity	1,344,073	-1,554	-632	-635	-0.28	-3,712
23. Transport	**3,032,651**	**-2,258**	**-888**	**-150**	**-0.57**	**-17,404**

II. Application of GTAP

❑ Total Emission and Disposal Cost Effects

(Unit: MKR¥, ton, %)

	Pre FTA				Post FTA			
	Sox	Nox	Tsp	Total	Sox	Nox	Tsp	Total (change)
Cost	2,013,742	10,134,550	845,521	12,993,813	2,010,252 (-3,490)	10,151,203 (+16,653)	840,029 (-5,492)	13,001,484 (+0.06%) (+7,671)
Emission	2,260,951	964,958	515,898	3,741,807	2,257,032 (-3,919)	958,824 (-6,134)	512,547 (-3,351)	3,728,403 (-0.36%) (+13,404)
Unit cost	0.891	10.503	1.64		0.891	10.587	1.64	

- ❑ **Total Emission decreases (-0.36%), but Disposal Costs increase(+0.06%).**
- ❑ **Structural(Substitution) Effects dominates Volume(Income) effects, in Air-Pollution Impact Assessment of Korea Japan FTA**

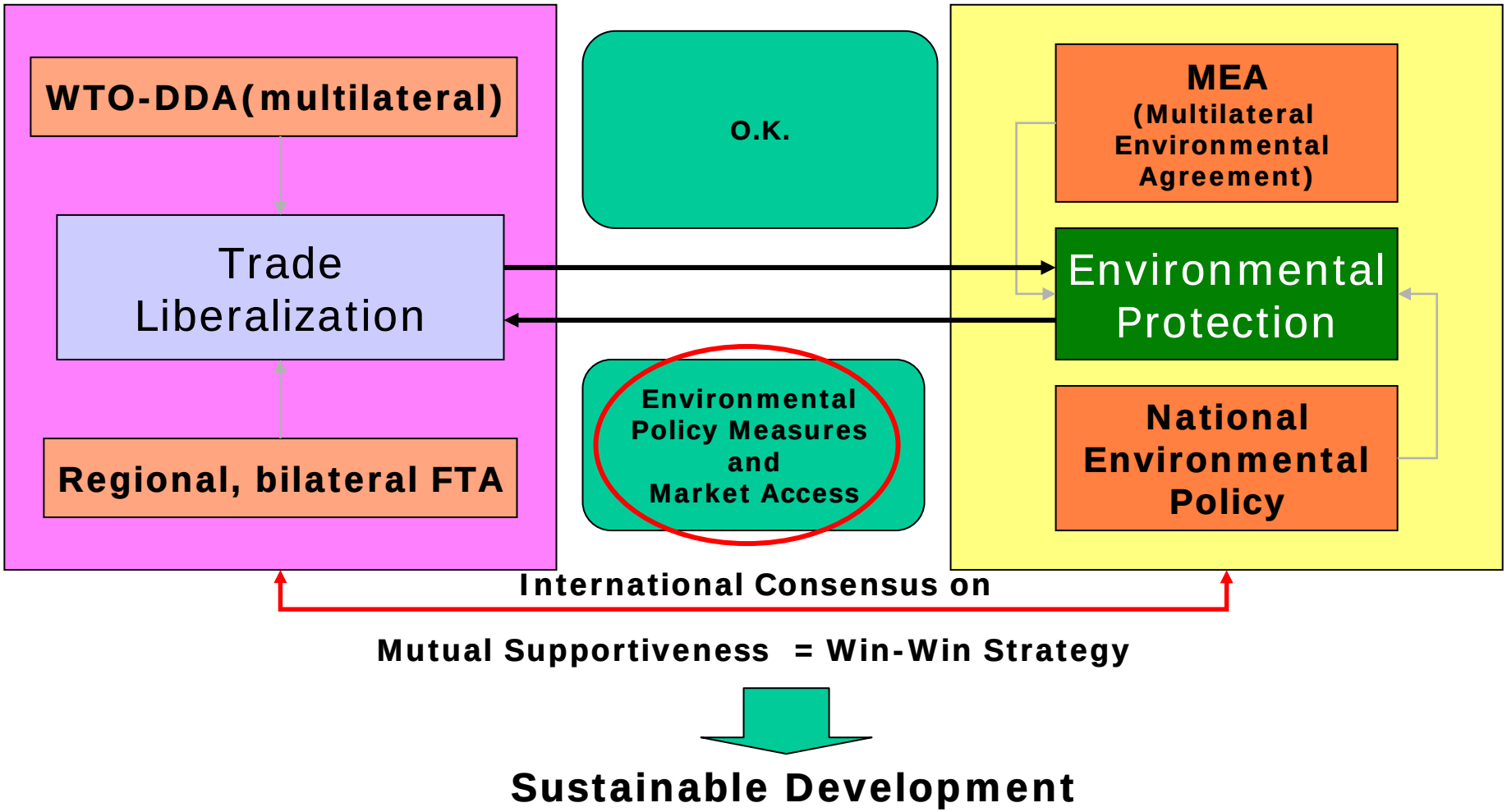
II. Application of GTAP

❑ Results

- **Free Trade with Japan gives KR** **1995** **2000**
  - Economic gains in “qgdp” : +0.27% +0.087%
  - Reduction of air pollution : -0.36% -0.36%(for Nox)
  - Increase of disposal costs : +0.06%
- **Origin**
  - Removal of bilateral trade distortion gives economic gains
  - Favorable change in output structure in environmental point of view
  - Sectoral difference of unit disposal cost(Nox) plays a key role
- **Policy implication**
  - detailed sectoral approach to EIA of FTA recommended
  - consider international and interindustrial difference of emission factor
  - take note of the disposal costs effects and complementary environmental policy intervention
- **Future work**
  - include environmental policy measures for feedback effect
  - link global CGE approach with national CGE modeling efforts

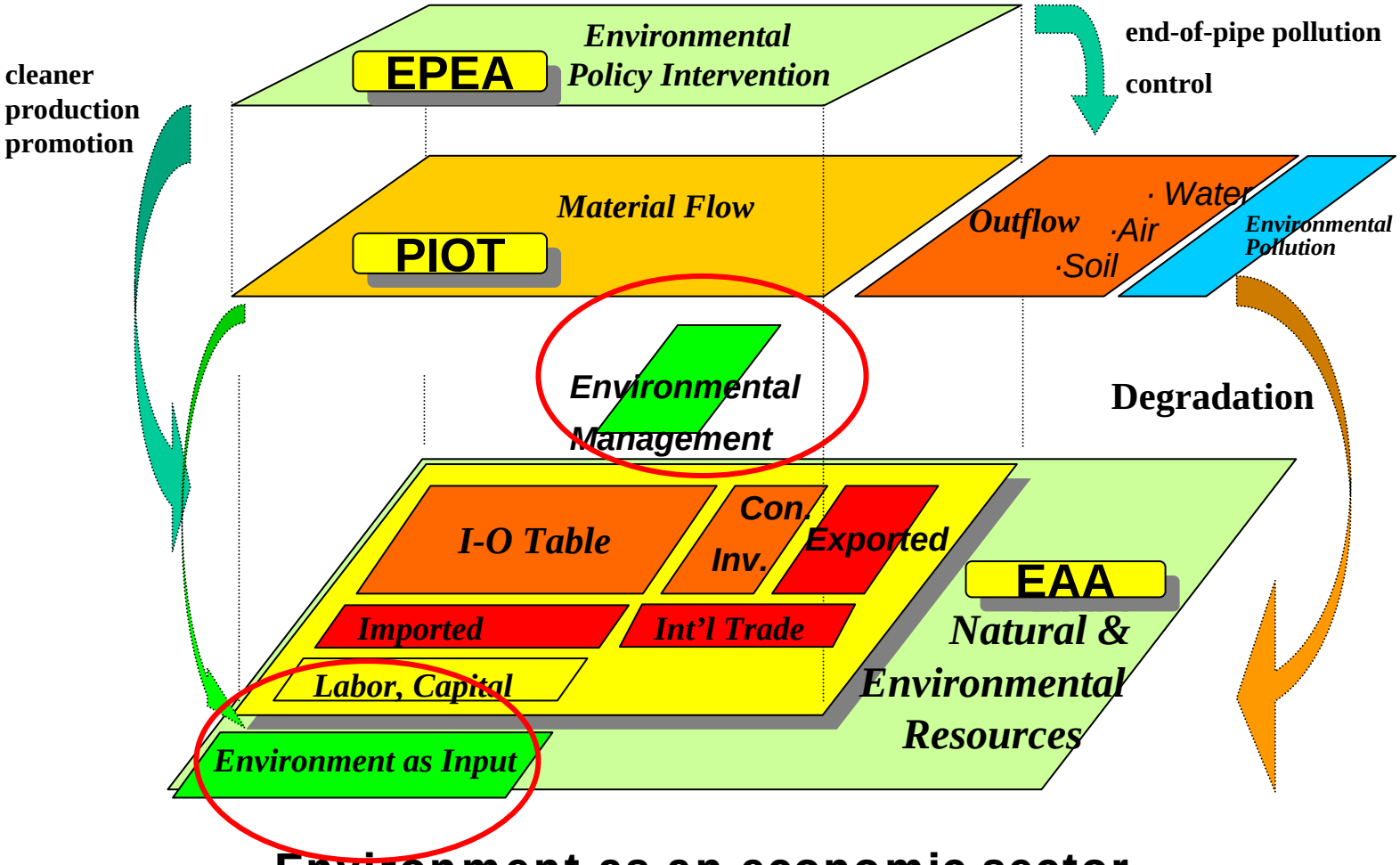
III. Limits of GTAP

- Only deal with flow from trade to environment



III. Limits of GTAP

❑ Environment Embodied CGE Framework



Environment as an economic sector

IV. CGE Modeling for Small Open Economy

❑ Properties of AIM/CGE

- **National CGE assuming small open economy**
  - Fixed international prices
  - Import and export as a endowment
  - Auxiliary variables to match demand and supply of import(export)
- **Environmental policy measures**
  - Environmental Tax for the mitigation of CO2 and other local pollutants
  - Tradable Permit System...
- **Waste management sector**
  - Closed material flow and “Zero emission”
  - Waste recycling as an economic activity
  - Use(U) and Make(V) matrix
- **Recursive dynamic structure**
  - Investment calculated outside and distributed by expected cap. income
  - Efficiency changes capturing technical progress
  - Capital stock estimated from growth rate of GDP, K, L and Investment

IV. CGE Modeling for Small Open Economy

❑ Application of AIM/CGE in Korean case

- **National CGE model set up**

-32 sector, 37 Commodities

-Base model + waste flow+air pollution

-Small open economy

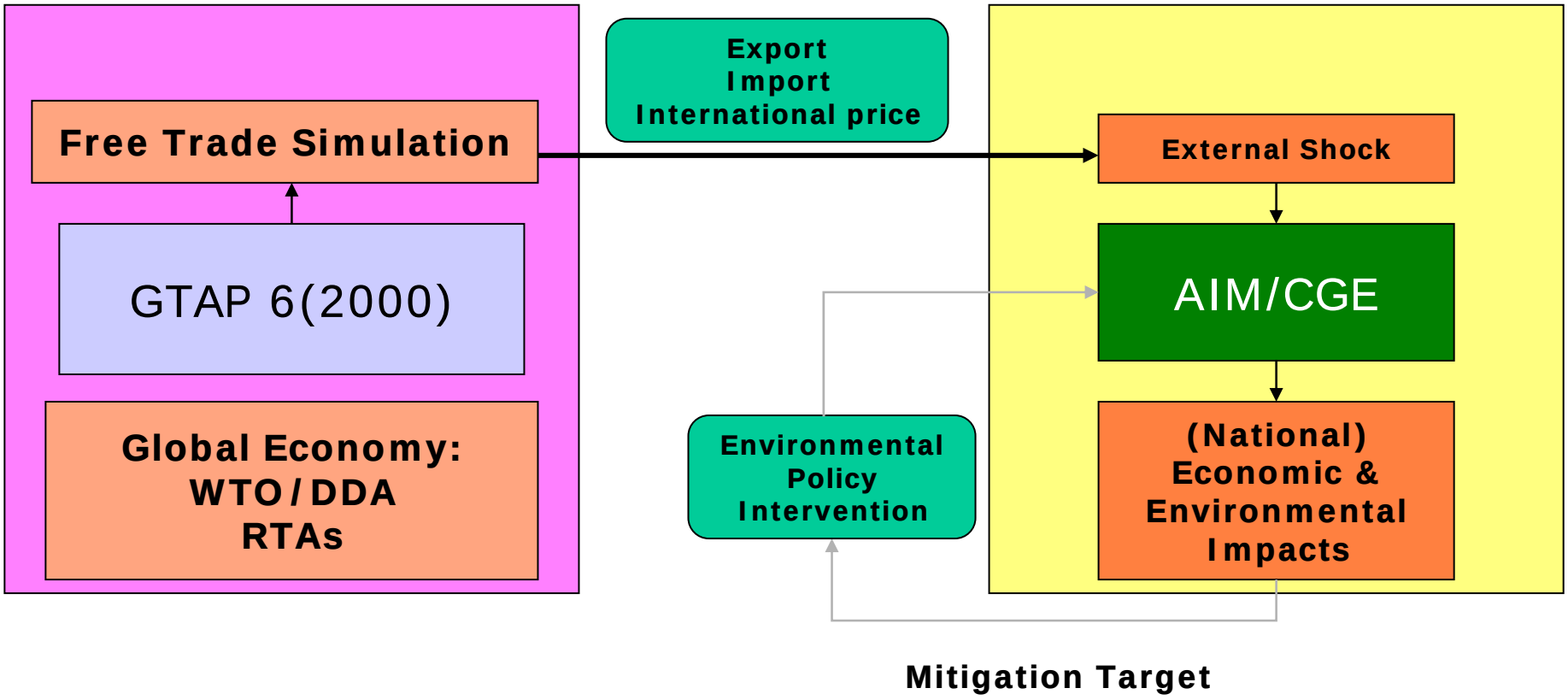
- **Data mining- Economic part**

U matrix	V matrix	U_D	U_M	FCF	TAX	ENE	ER	air pollution	Waste
○	○	○	○	○	△	△	△	△	x

○: **ready,** △: to be checked, x : not available at the moment

V. GTAP and AIM/CGE

- How to link GTAP and AIM CGE in Trade & Env.



Green Growth...

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