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Compilation and Application of Real Global Input-Output Tables

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Abstract

This paper attempts to estimate the Global Input-Output tables in real terms using Inter Country Input-Output tables published by OECD, industry-specific producers price indices (for 14 manufacturing industries), Consumers Price indices (for two non-manufacturing industries), and exchange rates with respect to base year 2005. We also conduct basic input-output analysis to see the inter continent (Asia, North America, and Europe) linkage subject respective final demand and output based on reorganized nominal and real inter-continent input-output tables for 2020.

Keywords: Global Input-Output tables in constant price, Production inducements, Economic impact

JEL classifications: C45, F60

1. Introduction

Recently Input-Output (IO) analysis has been popularly used in various fields related to Economics. Estimation of directly unobserved phenomena, known as indirect or induced effects, numerically is one of the major reasons for the popularity. Specifically in global context, international economic linkages can be assessed precisely because of its capability to address complex interactions among countries and industries. As such, various input-output datasets with international coverage are available. A few examples of the datasets are Inter Country Input-Output (ICIO) Tables published by OECD, Asian Development Bank's (ADB) Multi Regional Input-Output (MRIO) tables, and World Input-Output Database (WIOD) by the WIOD project among others.[1]

In general IO tables are valued in current price or in nominal terms, which means that the price factor remains unaddressed. Moreover, in international economic framework an exchange rate factor, which is directly related to price in international trade, is also overlooked. However, comparison of economic phenomena over time or country or region in nominal terms may mislead the outcome of an analysis due to change in price and exchange rate over the period or area of concern.

In this paper, we attempt to estimate Global Input-Output (GIO) tables in constant price and exchange rate or in real terms by incorporating price and exchange rate to overcome the critical issue stated above. ADB estimates and provides constant price MRIO by assigning Consumers Price indices (CPI) to all industries as price factor despite different industrial characteristics and pricing mechanism. We associate 14 industry-

[1] See details on OECD (https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm), ADB (https://www.adb.org/what-we-do/data/regional-input-output-tables), and WIOD (https://www.rug.nl/ggdc/valuechain/wiod/?lang=en) in respective links.

specific Producers or Wholesale Price indices (PPI or WPI) for manufacturing industries (primarily collected to estimate Industry-Specific Real Effective Exchange Rates (IREER) for Research Institute of Economy, Trade and Industry (RIETI) project)[2], CPI for non-manufacturing industries, and exchange rates with the OECD ICIO tables to get 30 countries (excluding Rest of the World, ROW), 16 industries (14 manufacturing industries, 6 final demand categories, and one value added category GIO tables with respect to constant price and exchange rate in 2005[3]. The annual Real GIO tables cover 26 years starting from 1995 to 2020 and the amounts are presented in Million US$.

As an application of the Real GIO tables, we first reorganize 2020 Nominal and Real GIO table into three continent-three sector inter continent IO tables and conduct a basic production inducement analysis to calculate Production Inducement Coefficients (PIC) and Production Inducement Shares (PIS) showing linkage between industrial production activities with final demand and gross output respectively. The result shows that the price and exchange rate effects are more prominent in PIC due to magnifying nature of complex interactions of price and exchange rate from the demand-side aspect.

The remaining of the paper is organized as follows. Section 2 describes estimation strategy with respect to basic relationship of variables in nominal and real terms. We provide details of data used and compilation procedures in Sections 3 and 4 respectively. Section 5 conducts and discusses IO based production inducement analysis and its results. Finally, the paper is concluded in Section 6.

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[2] See https://www.rieti.go.jp/users/eeri/en/ for RIETI's IREER project. Also see Sato et al. (2013, 2015) for the details on IREER.

[3] See Appendices 1, 2 and 3 for list of countries, industries, and final demand categories.

2. Estimation strategy

Here, we try to establish relationship of an economic variable[4], say Y, in nominal and real terms. Nominal Y (say Y^N) is defined as product of price (P), exchange rate (E) and quantity (Q) all in current year $T=t$ as shown in equation (1), whereas real Y (say Y^R) is product of price and exchange rate in base year $B=0$, and quantity in current year T as expressed in equation (2).

$$Y^N = P^{T=t} E^{T=t} Q^{T=t} \tag{1}$$

$$Y^R = P^{T=0} E^{T=0} Q^{T=t} \tag{2}$$

Here, Y is expressed in UD dollars, P in local currency, E in US dollar per unit local currency, and Q in quantity measure. Using equations (1) and (2), we can derive real valued Y as equation (3).

$$Y^R = \left[\frac{P^{T=0}}{P^{T=t}} \frac{E^{T=0}}{E^{T=t}} \right] Y^N \tag{3}$$

Where $\left[\frac{P^{T=t}}{P^{T=0}} \frac{E^{T=t}}{E^{T=0}} \right]$ is price and exchange rate deflator.

Based on equation (3), for the given base year and target year prices and exchanges rates, single sector nominal priced GIO table (shown in Figure 1-1) with two countries A and B can be represented by real priced GIO table as given in Figure 1-2.

[4] In this paper we deal with economic variables of different countries expressed in US dollars and price variables in local currencies. It means that further treatment of price in local currency is necessary with the bilateral exchange rates with respect to US dollar.

Figure 1-1: GIO Table in Nominal Term

	Intermediate demand		Final demand		Gross output
	C_A	C_B	C_A	C_B	
C_A	Z_{AA}	Z_{AB}	F_{AA}	F_{AB}	X_A
C_B	Z_{BA}	Z_{BB}	F_{BA}	F_{BB}	X_B
Value-added	V_A	V_B			
Total input	X_A	X_B			

Figure 1-2: GIO Table in Real Term

	Intermediate demand		Final demand		Gross output
	C_A	C_B	C_A	C_B	
C_A	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]Z_{AA}$	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]Z_{AB}$	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]F_{AA}$	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]F_{AB}$	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]X_A$
C_B	$\left[\frac{E_{S/LCB}^{T=0}}{E_{S/LCB}^{T=t}}\frac{P_B^{T=0}}{P_B^{T=t}}\right]Z_{BA}$	$\left[\frac{E_{S/LCB}^{T=0}}{E_{S/LCB}^{T=t}}\frac{P_B^{T=0}}{P_B^{T=t}}\right]Z_{BB}$	$\left[\frac{E_{S/LCB}^{T=0}}{E_{S/LCB}^{T=t}}\frac{P_B^{T=0}}{P_B^{T=t}}\right]F_{BA}$	$\left[\frac{E_{S/LCB}^{T=0}}{E_{S/LCB}^{T=t}}\frac{P_B^{T=0}}{P_B^{T=t}}\right]F_{BB}$	$\left[\frac{E_{S/LCB}^{T=0}}{E_{S/LCB}^{T=t}}\frac{P_B^{T=0}}{P_B^{T=t}}\right]X_B$
Value-added	V_A^R	V_B^R			
Total input	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]X_A$	$\left[\frac{E_{S/LCA}^{T=0}}{E_{S/LCA}^{T=t}}\frac{P_A^{T=0}}{P_A^{T=t}}\right]X_B$			

Notes:

1. *Z, F, V and X represents intermediate goods transactions, final goods transactions, value-added and gross output respectively expressed in US dollar.*
2. *In double letter country suffix, First represents the country of production and second represents the country of use subject to intermediate and final goods.*
3. *E, P, T = 0 and T = t represents exchange rate ($ per unit local currency), price index, values at base year and target year respectively.*
4. *Value-added in real term is estimated as the difference of respective gross output and total of intermediate inputs.*

3. Data

We use 2022 version of inter-country input-output (ICIO)[5] tables published by Organization for Economic Co-operation and Development (OECD) consisting annual tables from 1995 to 2020, 77 countries and regions (including Rest of the World, ROW), and 45 industrial classifications expressed in current basic price to estimate the new constant price GIO tables.

[5] See https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm (accessed on 2023/08/29) for the details of OECD ICIO tables.

Industry-specific price indices necessary to convert nominal values into real values are borrowed from the Research Institute of Economy, Trade and Industry (RIETI) project named "Industry-Specific Nominal and Real Effective Exchange Rates of 25 Countries Worldwide".[6] The RIETI project uses monthly Producers Price Indices (PPI) or Wholesale Price indices (WPI) for 28 countries and 13 manufacturing industries starting from January 2001 to latest published month (December 2022 as of 2023/03/23) with year 2005 as base year. We extend the existing price data for 30 countries and 14 industries to comply with our research objectives.[7]

Further, we use annual exchange rates provided by UNSD, National Accounts for the 29 countries except Taiwan and National Statistics, Republic of China (Taiwan) for Taiwanese exchange rate.

4. Compilation of GIO Tables in Real Terms

First, we convert price data for manufacturing industries (borrowed from RIETI project) with monthly frequency to annual frequency by taking simple average. For non-manufacturing industries and a few manufacturing industries price data, which are unfortunately unavailable[8], we use annual Consumer Price Indices (CPI) of respective country as the price data. Using these annual price and exchange rate information, we then calculate the annual price and exchange rate deflator $\left[\frac{P^{T=t}}{P^{T=0}}\frac{E^{T=t}}{E^{T=0}}\right]$ as defined in section 2.

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[6] See https://www.rieti.go.jp/users/eeri/en/ (accessed on 2023/03/03) for the details on Industry-specific Real Effective Exchange Rates.

[7] See Appendices 1 and 2 for the list of newly estimated Real GIO table's country and industry coverage.

[8] See Appendix 4 for the list of countries and industries for which price data are unavailable.

Second, the most crucial part of estimation process, we attempt to convert basic price valuation of ICIO variables into producers' price valuation in following three steps. 1) Country and industry-specific gross output in producers' price valuation is calculated as difference between that valued at basic price and taxes less subsidies. 2) We assume the intermediate input structure is independent of valuation system, so we deduct taxes less subsidies from intermediate and final goods amount with equal proportion. And 3) we subtract total of intermediate inputs from gross output, both valued in producers' price, to get the value-added in producers' price.

Third, we reorganize producers' price valued ICIO tables into 30 countries and 16 industries (out of which Producers Price Index data are available for 14 manufacturing industries and remaining two industries use Consumers Price Index) as per price data availability to get the real priced GIO tables.

Finally, we deflate the nominal GIO tables into Real GIO tables using the price and exchange rate deflator. Note that the price data for ROW is not available and assumed to be unit, our annual real priced GIO tables starts from 1995 to 2020 and consist of 30 countries (excluding ROW), 16 industries (two nonmanufacturing and 14 manufacturing industries), and six final demand categories with 2005 as base year for price and exchange rate.

Once we compile the Real GIO tables for 1995 to 2020, for this paper, we summarize and present the latest year 2020 transactions within and between three continents (Asia, North America, and Europe) and three industries (Agriculture, Manufacturing and Services) in Tables 1 and 2 for nominal and real (base year 2005) tables respectively.

The difference between values in nominal and real terms attributes to the change in price and exchange rate level in target year with respect to base year. Positive value in

nominal minus real term values imply that the aggregate price and exchange rate level in target year is higher than that in base year. In general, region with same price and exchange rate level as base year must be same for both real term and nominal term values. However, ROW+ in Tables 1 and 2 includes Australia and New Zealand that results in distinct values.

Table 1: 2020 Nominal inter-continent GIO Table

		Asia			North America			Europe			ROW+			Final Demand				Total
		AGR	MFG	SER	AGR	MFG	SER	AGR	MFG	SER	AGR	MFG	SER	Asia	N. America	Europe	ROW+	Output
Asia	AGR	715	2,128	542	1	4	1	1	2	0	2	6	2	1,059	2	2	6	4,474
	MFG	820	9,671	5,107	11	152	170	7	160	122	58	358	260	5,568	388	263	509	23,625
	SER	606	3,844	7,252	3	28	102	2	49	141	20	64	150	18,037	168	127	160	30,755
N. America	AGR	6	39	9	135	390	125	2	14	7	5	25	5	10	274	5	13	1,063
	MFG	7	109	55	121	1,275	1,438	2	61	44	14	98	65	84	2,942	83	136	6,535
	SER	8	68	104	268	1,541	9,709	3	65	183	13	52	98	74	17,981	94	100	30,359
Europe	AGR	2	34	10	2	9	4	131	351	116	7	33	15	2	3	254	14	986
	MFG	14	195	98	8	85	78	107	1,835	1,412	36	263	185	164	216	2,460	364	7,520
	SER	9	86	155	4	31	128	202	1,867	7,849	27	101	293	115	127	12,474	218	23,686
ROW+	AGR	32	578	136	16	75	25	8	102	43	955	1,181	460	24	9	30	981	4,655
	MFG	18	215	89	7	102	82	9	196	120	329	1,777	1,572	116	238	276	2,666	7,809
	SER	9	76	104	4	30	66	6	83	241	585	1,491	5,781	87	103	195	10,651	19,513
Gross Value-added		2,231	6,580	17,095	482	2,813	18,431	507	2,735	13,408	2,603	2,359	10,626					
Total Output		4,474	23,625	30,755	1,063	6,535	30,359	986	7,520	23,686	4,655	7,809	19,513					

Notes:

1. *Source: Authors' reorganization from OECD ICIO2022 tables*
2. *Units in Billion US$*
3. *ROW+ includes Australia and New Zealand*
4. *AGM: Agriculture and Mining, MFG: Manufacturing, SER: Services*

Table 2: 2020 Real inter-continent GIO Table

		Asia			North America			Europe			ROW+			Final Demand				Total
		AGR	MFG	SER	AGR	MFG	SER	AGR	MFG	SER	AGR	MFG	SER	Asia	N. America	Europe	ROW+	Output
Asia	AGR	506	1,500	379	1	3	1	0	2	0	2	4	2	726	1	1	4	3,131
	MFG	617	8,157	4,022	9	140	155	6	142	107	49	327	234	4,796	366	231	469	19,828
	SER	433	2,862	5,467	2	21	72	2	37	102	14	47	106	13,562	119	91	114	23,049
N. America	AGR	5	30	7	104	303	98	1	11	5	4	19	4	8	209	4	10	824
	MFG	5	108	49	92	1,025	1,199	2	51	38	12	85	59	81	2,557	75	121	5,558
	SER	6	52	79	207	1,176	7,393	2	49	139	10	40	74	56	13,708	71	76	23,140
Europe	AGR	1	30	9	2	8	4	118	319	106	6	29	13	2	2	228	13	890
	MFG	14	235	108	8	89	83	108	1,860	1,474	35	281	199	181	230	2,606	388	7,901
	SER	8	77	142	4	28	119	180	1,673	7,126	25	91	267	104	116	11,351	197	21,509
ROW+	AGR	30	554	129	16	75	25	8	101	42	949	1,165	455	23	9	30	974	4,586
	MFG	17	208	87	7	101	81	8	195	120	327	1,766	1,554	112	236	275	2,642	7,736
	SER	9	74	102	4	30	66	6	83	240	566	1,472	5,612	86	102	194	10,414	19,058
Gross Value-added		1,481	5,941	12,469	366	2,559	13,845	448	3,378	12,009	2,586	2,410	10,480					
Total Output		3,131	19,828	23,049	824	5,558	23,140	890	7,901	21,509	4,586	7,736	19,058					

Notes:

1. *Source: Authors' estimation*
2. *2005 as base year*
3. *Units in Billion US$*
4. *ROW+ includes Australia and New Zealand*
5. *AGR: Agriculture and Mining, MFG: Manufacturing, SER: Services*

5. Production Inducement Analysis with new data sets

In this section we use the conventional production inducement analysis based on the newly estimated nominal and real GIO tables for 2020. The conventional total production inducement vector **X** can be estimated from the basic IO equation[9] as shown in equation (4) with respect to GIO table presented in Table 1-1.

$$\mathbf{X} = \begin{pmatrix} X_A \\ X_B \\ X_C \end{pmatrix} = \begin{pmatrix} L_{AA} & L_{AB} & L_{AC} \\ L_{BA} & L_{BB} & L_{BC} \\ L_{CA} & L_{CB} & L_{CC} \end{pmatrix} \begin{pmatrix} F_A \\ F_B \\ F_C \end{pmatrix} \tag{4}$$

Where $\mathbf{L} = \begin{pmatrix} L_{AA} & L_{AB} & L_{AC} \\ L_{BA} & L_{BB} & L_{BC} \\ L_{CA} & L_{CB} & L_{CC} \end{pmatrix} = \begin{pmatrix} 1-\frac{Z_{AA}}{X_A} & -\frac{Z_{AB}}{X_B} & -\frac{Z_{AC}}{X_C} \\ -\frac{Z_{BA}}{X_A} & 1-\frac{Z_{BB}}{X_B} & -\frac{Z_{BC}}{X_C} \\ -\frac{Z_{CA}}{X_A} & -\frac{Z_{CB}}{X_B} & 1-\frac{Z_{CC}}{X_C} \end{pmatrix}^{-1}$ is the Leontief inverse matrix and $\mathbf{F} = \begin{pmatrix} F_A \\ F_B \\ F_C \end{pmatrix} = \begin{pmatrix} F_{AA}+F_{AB}+F_{AC} \\ F_{BA}+F_{BB}+F_{BC} \\ F_{CA}+F_{CB}+F_{CC} \end{pmatrix}$ is the final demand vector. We can easily express equation (4) as bilateral transactions of production inducements given be equation 5 without any loss of generality.

$$\begin{pmatrix} x_{AA} & x_{AB} & x_{AC} \\ x_{BA} & x_{BB} & x_{BC} \\ x_{CA} & x_{CB} & x_{CC} \end{pmatrix} = \begin{pmatrix} L_{AA} & L_{AB} & L_{AC} \\ L_{BA} & L_{BB} & L_{BC} \\ L_{CA} & L_{CB} & L_{CC} \end{pmatrix} \begin{pmatrix} f_{AA} & f_{AB} & f_{AC} \\ f_{BA} & f_{BB} & f_{BC} \\ f_{CA} & f_{CB} & f_{CC} \end{pmatrix} \tag{5}$$

Such that $\mathbf{X} = \begin{pmatrix} x_{AA} & x_{AB} & x_{AC} \\ x_{BA} & x_{BB} & x_{BC} \\ x_{CA} & x_{CB} & x_{CC} \end{pmatrix} \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$ is the gross output vector. Here, any bilateral production inducements represent the production induced directly and indirectly in country with prior subscripts because of final demand in country of post subscripts. For example, x_{BC} is the directly and indirectly generated production inducements in country

[9] See Miller and Blair (2009) for the derivation of basic IO equation (4).

B because of the final demands f_{AC}, f_{BC} and f_{CC} that are produced in countries *A*, *B* and *C* respectively and then supplied to country *C*.

Table 3 shows the production inducements calculated from the Nominal (Table 1) and Real (Table 2) GIO tables, and the differences between inducements in nominal and real terms in 2020. The results illustrated in last column of Table 3 clearly show significant increase in combined price and exchange rate effects across continents and industries specifically in Asia (highest difference of 7.7 trillion US$ is recorded for service sector in Asia) except for manufacturing industries in Europe that marked -0.4 trillion US$ in 2020.

Table 3: Production Inducements in 2020

		Production Inducements														
		Asia			N. America			Europe			ROW+			Total		
		Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.
Asia	AGR	3,864.6	2,678.6	1,186.0	190.2	143.3	46.9	145.5	105.0	40.5	273.8	204.3	69.5	4,474.0	3,131.1	1,342.9
	MFG	18,732.3	15,467.1	3,265.2	1,535.2	1,390.8	144.5	1,166.1	1,007.6	158.5	2,191.5	1,962.3	229.2	23,625.2	19,827.8	3,797.4
	SER	28,314.6	21,218.5	7,096.1	766.4	577.1	189.3	674.6	498.9	175.8	999.2	754.4	244.8	30,754.8	23,048.8	7,706.0
N. America	AGR	96.0	75.4	20.6	831.7	642.3	189.4	52.2	40.7	11.5	83.5	65.3	18.1	1,063.4	823.7	239.7
	MFG	354.3	322.4	31.9	5,493.5	4,641.7	851.8	272.1	233.8	38.3	415.0	360.3	54.7	6,534.9	5,558.1	976.8
	SER	531.3	411.1	120.1	28,686.5	21,855.0	6,831.5	580.7	443.4	137.2	560.4	430.4	130.0	30,358.8	23,140.0	7,218.8
Europe	AGR	94.6	85.5	9.0	61.8	56.8	4.9	691.7	623.0	68.7	138.0	124.1	13.9	986.0	889.5	96.5
	MFG	695.5	766.1	-70.6	612.1	644.9	-32.8	5,071.0	5,283.9	-212.9	1,141.5	1,206.1	-64.5	7,520.2	7,901.0	-380.8
	SER	830.3	760.9	69.5	704.0	643.2	60.9	20,810.9	18,891.4	1,919.5	1,340.3	1,213.3	127.0	23,685.6	21,508.8	2,176.8
ROW+	AGR	976.5	930.1	46.4	344.6	344.7	-0.1	413.4	410.7	2.6	2,920.2	2,900.1	20.1	4,654.6	4,585.6	69.0
	MFG	703.2	681.5	21.8	662.2	659.0	3.2	837.1	834.8	2.2	5,606.3	5,560.2	46.1	7,808.8	7,735.5	73.3
	SER	750.0	722.4	27.6	548.6	542.1	6.5	976.3	967.3	9.1	17,237.7	16,826.4	411.4	19,512.6	19,058.1	454.5
Total		55,943.1	44,119.4	11,823.8	40,436.8	32,141.0	8,295.8	31,691.6	29,340.6	2,351.0	32,907.3	31,607.1	1,300.2	160,978.8	137,208.1	23,770.8

Notes:

1. *Source: Authors' estimation based on equation* (5)
2. *2005 is base year for Real term values*
3. *Units in Billion US$*
4. *Diff. is difference of Nominal and Real values of production inducement*
5. *ROW+ includes Australia and New Zealand*
6. *AGR: Agriculture and Mining, MFG: Manufacturing, SER: Services*

Now, we calculate two conventional measures of production inducements namely "Inducement Coefficient, **PIC**" indicating the extent of production inducements per unit of final demand and "Inducement Share, **PIS**" showing the extent of inducements per unit gross output as given in equations (6) and (7) respectively and present in Tables 4 and 5.

$$\mathbf{PIC} = \begin{pmatrix} \frac{x_{AA}}{f_{AA}+f_{BA}+f_{CA}} & \frac{x_{AB}}{f_{AB}+f_{BB}+f_{CB}} & \frac{x_{AC}}{f_{AC}+f_{BC}+f_{CC}} \\ \frac{x_{BA}}{f_{AA}+f_{BA}+f_{CA}} & \frac{x_{BB}}{f_{AB}+f_{BB}+f_{CB}} & \frac{x_{BC}}{f_{AC}+f_{BC}+f_{CC}} \\ \frac{x_{CA}}{f_{AA}+f_{BA}+f_{CA}} & \frac{x_{CB}}{f_{AB}+f_{BB}+f_{CB}} & \frac{x_{CC}}{f_{AC}+f_{BC}+f_{CC}} \end{pmatrix} \quad (6)$$

$$\mathbf{PIS} = \begin{pmatrix} \frac{x_{AA}}{X_{AA}+X_{AB}+X_{AC}} & \frac{x_{AB}}{X_{AA}+X_{AB}+X_{AC}} & \frac{x_{AC}}{X_{AA}+X_{AB}+X_{AC}} \\ \frac{x_{BA}}{X_{BA}+X_{BB}+X_{BC}} & \frac{x_{BB}}{X_{BA}+X_{BB}+X_{BC}} & \frac{x_{BC}}{X_{BA}+X_{BB}+X_{BC}} \\ \frac{x_{CA}}{X_{CA}+X_{CB}+X_{CC}} & \frac{x_{CB}}{X_{CA}+X_{CB}+X_{CC}} & \frac{x_{CC}}{X_{CA}+X_{CB}+X_{CC}} \end{pmatrix} \quad (7)$$

PIC and **PIS** measures the relationship between production inducement subject to final demand and gross output respectively. Here, it is important to notice that these measures account for complex interactions among industries and countries, which is impossible to address with the direct observations. Higher value of **PIC** (or **PIS**) indicates higher dependence on final demand (or gross output)

Table 4: Production Inducement Coefficients (**PIC**) in 2020

		Production Inducement Coefficients (Inducement/FD Total)														
		Asia			N. America			Europe			ROW+			Total		
		Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.
Asia	AGR	15.3	13.6	1.7	0.8	0.8	0.0	0.9	0.7	0.2	1.7	1.3	0.4	5.6	4.6	1.0
	MFG	73.9	78.4	-4.4	6.8	7.9	-1.0	7.2	6.6	0.5	13.9	12.7	1.1	29.6	29.2	0.4
	SER	111.7	107.5	4.2	3.4	3.3	0.1	4.1	3.3	0.9	6.3	4.9	1.4	38.5	33.9	4.6
N. America	AGR	0.4	0.4	-0.0	3.7	3.6	0.1	0.3	0.3	0.1	0.5	0.4	0.1	1.3	1.2	0.1
	MFG	1.4	1.6	-0.2	24.5	26.3	-1.8	1.7	1.5	0.1	2.6	2.3	0.3	8.2	8.2	0.0
	SER	2.1	2.1	0.0	127.8	123.8	4.0	3.6	2.9	0.6	3.5	2.8	0.8	38.0	34.0	4.0
Europe	AGR	0.4	0.4	-0.1	0.3	0.3	-0.0	4.3	4.1	0.1	0.9	0.8	0.1	1.2	1.3	-0.1
	MFG	2.7	3.9	-1.1	2.7	3.7	-0.9	31.2	34.9	-3.7	7.2	7.8	-0.6	9.4	11.6	-2.2
	SER	3.3	3.9	-0.6	3.1	3.6	-0.5	128.0	124.6	3.3	8.5	7.9	0.6	29.7	31.6	-2.0
ROW+	AGR	3.9	4.7	-0.9	1.5	2.0	-0.4	2.5	2.7	-0.2	18.5	18.8	-0.3	5.8	6.7	-0.9
	MFG	2.8	3.5	-0.7	2.9	3.7	-0.8	5.1	5.5	-0.4	35.4	36.1	-0.6	9.8	11.4	-1.6
	SER	3.0	3.7	-0.7	2.4	3.1	-0.6	6.0	6.4	-0.4	109.0	109.1	-0.1	24.4	28.0	-3.6
Total		220.8	223.5	-2.8	180.1	182.0	-1.9	194.9	193.6	1.3	208.0	205.0	3.1	201.6	201.9	-0.3

Notes:

1. *Source: Authors' estimation based on equation* (6)
2. *2005 is base year for Real term values*
3. *Units in percent of total final demand*
4. *Diff. is difference of Nominal and Real values of production inducement*
5. *Shaded cells indicate the difference below -1.0% and above 1%*
6. *ROW+ includes Australia and New Zealand*
7. *AGR: Agriculture and Mining, MFG: Manufacturing, SER: Services*

Production inducement coefficients (**PIC**), as illustrated in Table 4 and observe the results in vertical direction, measure the extent of gross production induced in continent-

industry due to final demand structure of the continent. For example, regional and imported final demand in Asia induces 223.5% in real term (or equivalently, 220.8% in nominal term) production activity all over the World. In the meantime, manufacturing industry within Asia enjoys production inducement of 78.4% (73.9% in nominal term) in real term. The difference of -4.4% may be attributed to collective effect of price and exchange rate decrease in 2020 compared to the base year 2005. It is important to note that the variation in differences (shaded cells in Table 4) in real term and nominal term production inducement coefficients evidently indicate that the composite price and exchange rate effect works differently for production inducements (very few negative differences in Table 3) and its coefficients with significant number of negative differences in Table 4.

Table 5: Production Inducement Shares (**PIS**) in 2020

		Production Inducement Shares (Inducement/Gross Output)														
		Asia			N. America			Europe			ROW+			Total		
		Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.	Nominal	Real	Diff.
Asia	AGR	86.4	85.5	0.8	4.3	4.6	-0.3	3.3	3.4	-0.1	6.1	6.5	-0.4	100.0	100.0	0.0
	MFG	79.3	78.0	1.3	6.5	7.0	-0.5	4.9	5.1	-0.1	9.3	9.9	-0.6	100.0	100.0	0.0
	SER	92.1	92.1	0.0	2.5	2.5	-0.0	2.2	2.2	0.0	3.2	3.3	-0.0	100.0	100.0	0.0
N. America	AGR	9.0	9.2	-0.1	78.2	78.0	0.2	4.9	4.9	-0.0	7.8	7.9	-0.1	100.0	100.0	0.0
	MFG	5.4	5.8	-0.4	84.1	83.5	0.6	4.2	4.2	-0.0	6.4	6.5	-0.1	100.0	100.0	0.0
	SER	1.7	1.8	-0.0	94.5	94.4	0.0	1.9	1.9	-0.0	1.8	1.9	-0.0	100.0	100.0	0.0
Europe	AGR	9.6	9.6	-0.0	6.3	6.4	-0.1	70.2	70.0	0.1	14.0	14.0	0.0	100.0	100.0	0.0
	MFG	9.2	9.7	-0.4	8.1	8.2	-0.0	67.4	66.9	0.6	15.2	15.3	-0.1	100.0	100.0	0.0
	SER	3.5	3.5	-0.0	3.0	3.0	-0.0	87.9	87.8	0.0	5.7	5.6	0.0	100.0	100.0	0.0
ROW+	AGR	21.0	20.3	0.7	7.4	7.5	-0.1	8.9	9.0	-0.1	62.7	63.2	-0.5	100.0	100.0	0.0
	MFG	9.0	8.8	0.2	8.5	8.5	-0.0	10.7	10.8	-0.1	71.8	71.9	-0.1	100.0	100.0	0.0
	SER	3.8	3.8	0.1	2.8	2.8	-0.0	5.0	5.1	-0.1	88.3	88.3	0.1	100.0	100.0	0.0
Total		34.8	32.2	2.6	25.1	23.4	1.7	19.7	21.4	-1.7	20.4	23.0	-2.6	100.0	100.0	0.0

Notes:

1. *Source: Authors' estimation based on equation* (7)
2. *2005 is base year for Real term values*
3. *Units in percent of gross output*
4. *Diff. is difference of Nominal and Real values of production inducement*
5. *Shaded cells indicate the difference below -1.0% and above 1%*
6. *ROW+ includes Australia and New Zealand*
7. *AGM: Agriculture and Mining, MFG: Manufacturing, SER: Services*

Production inducement shares (**PIS**) are presented in Table 5 along horizontal direction, and it tells us about the share of gross production with respect to different continents. According to the table, direct and indirect contribution of Asia, North America,

Europe, and ROW+ are 78.0%, 7.0%, 5.1% and 9.9% in real term on the gross output of manufacturing industry in Asia. If we carefully check the difference between nominal and real term **PIS**, the magnitude is not so large as compared to **PIC** in Table 4. As **PIS** indicates the supply structure of an industry-continent, only a single price and exchange rate is associated with the result and hence the difference becomes marginal. However, in case of **PIC**, demand structure of production is associated with complex interactions of price and exchange rate of various industries and continents, which magnifies the effect of price and exchange rate and hence the difference becomes prominent.

6. Concluding remarks

This paper attempts to compile Global Input-Output Tables in real terms from the nominal based Inter-Country Input-Output tables published by OECD (Version 2022). We use producers price (or wholesale price) indices of 30 countries (listed in Appendix 1) and 14 manufacturing industries (see Appendix 2), consumers price indices for same 30 countries and two non-manufacturing industries (namely, Agriculture and Services), and exchange rates to estimate the Global Input-Output tables in real terms with 30 countries (10 countries in Asia, 2 countries each in Oceania and North America, and 16 European countries), and 16 industries (14 manufacturing, an agriculture, and a service sectors) for the period 1995 to 2020. It is a unique and contributing attempt of this paper to use the price data in disaggregated level as existing constant price international input-output tables (for example, MRIO published by Asian Development Bank) uses CPI as price factor and it is not clear whether they address foreign exchange rates or not.

A simple example, illustrated in this paper, of inter-continent input-output analysis shows that the composite effect of price and exchange rate works differently in supply-

side and demand-side aspect. The supply-side aspect shows a composite marginal effect of price and exchange rate. In contrast, the demand-side aspect tends to magnify the complex interactions of price and exchange rate among industries and countries.

Existence of Real Global Input-Output tables enable us to address price and exchange rate factor in economic analyses that most of the existing data sets are not capable of. Further, without loss of generality, assuming the values expressed in real terms as a hypothetical volume, we can apply it in other field of studies such as environment analysis.

7. References

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Data Sources

PPI or WPI for manufacturing industries:

Country	Code	Data source	Link
Japan	JPN	Bank of Japan	http://www.boj.or.jp/
Korea	KOR	The Bank of Korea	http://eng.bok.or.kr/eng/engMain.action
China	CHN	1. CEIC 2. *China Monthly Statistic* 3. *China Statistical Yearbook*	
Taiwan	TWN	CEIC (include output data)	
Singapore	SGP	Statistics Singapore	http://www.singstat.gov.sg/
Malaysia	MYS	CEIC	
Thailand	THA	CEIC	
Indonesia	IDN	1. BPS, *Economic Indicators* 2. CEIC	
Philippines	PHL	1. National Statistics Office 2. *Philippine Yearbook*	http://www.census.gov.ph
India	IND	Office of Economic Adviser	http://eaindustry.nic.in/
Australia	AUS	Australian Bureau of Statistics	http://www.abs.gov.au/
New Zealand	NZL	CEIC	
USA	USA	1. FEDSTATS 2. Bureau of Labor Statistics (BLS)	http://www.bls.gov/ppi/#data
Canada	CAN	Statistics Canada	http://www5.statcan.gc.ca
UK	GBR	CEIC	
Germany	DEU	GENESIS-Online Database	https://www-genesis.destatis.de
France	FRA	National Institute of Statistics and Economic Studies	http://www.bdm.insee.fr
Italy	ITA	CEIC	
Spain	ESP	National Statistics Institute	http://www.ine.es
Austria	AUT	CEIC	
Belgium	BEL	CEIC	
Denmark	DNK	CEIC	
Finland	FIN	CEIC	
Greece	GRC	1.CEIC 2.National Statistical Service	http://www.statistics.gr
Ireland	IRL	CEIC	
Netherlands	NLD	Statistics Netherlands Statline Database	http://statline.cbs.nl/StatWeb/?LA = en
Norway	NOR	Statistics Norway	http://statbank.ssb.no
Sweden	SWE	CEIC	
Switzerland	CHE	CEIC	
Russia	RUS	CEIC	

Other Data:

Data	Data source	Link
Consumer Price Indices	CEIC	
Input -Output Tables	OECD Inter-Country Input-Output (ICIO) Tables	https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm
Exchange Rates	UNSD National Accounts	https://unstats.un.org
Exchange Rate (Taiwan)	National Statistics, Republic of China (Taiwan)	https://eng.stat.gov.tw

Appendix 1: List of Country Coverage (with country codes) in GIO table

Asia		Europe	
1	Japan (JPN)	15	United Kingdom (GBR)
2	Korea (KOR)	16	Germany (DEU)
3	China (CHN)	17	France (FRA)
4	Taiwan (TWN)	18	Italy (ITA)
5	Singapore (SGP)	19	Spain (ESP)
6	Malaysia (MYS)	20	Austria (AUT)*
7	Thailand (THA)	21	Belgium (BEL)
8	Indonesia (IDN)	22	Denmark (DNK)
9	Philippines (PHL)	23	Finland (FIN)
10	India (IND)	24	Greece (GRC)
North America		11	Ireland (IRL)*
13	United States (USA)	26	Netherlands (NLD)
14	Canada (CAN)	27	Norway (NOR)
Rest of the World+ (ROW+)		14	Sweden (SWE)
11	Australia (AUS)	29	Switzerland (CHE)
12	New Zealand (NZL)	30	Russian Federation (RUS)
31	Rest of the World (ROW)		

Note:

1. *Numbers represent the order of a country in the GIO Tables*
2. *Countries without RIETI coverage are indexed * .*

Appendix 2: List of Industry Coverage of Real GIO table

Real GIO	Details	Code
Y01	Agriculture and Mining	Agriculture
Manufacturing		
Y02	Food products, beverages and tobacco	Food
Y03	Textiles, textile products, leather and footwear	Textiles
Y04	Wood and products of wood and cork	Wood
Y05	Pulp, paper, paper products, printing and publishing	Paper
Y06	Coke, refined petroleum products and nuclear fuel	Petroleum
Y07	Chemicals and pharmaceuticals	Chemicals
Y08	Rubber and plastics products	Rubber
Y09	Other non-metallic mineral products	Non-metal
Y10	Basic and fabricated metals	Basic metal
Y11	Machinery and equipment, nec	Machinery
Y12	Computer, electronic and optical products	Office
Y13	Electrical equipment	Electrical
Y14	Motor vehicles, trailers and semi-trailers	Motor
Y15	Other transport equipment	Other transport
Y16	Manufacturing nec; Services and Others	Others

Notes:

1. *Y01 and Y16 are not covered by RIETI industrial classifications.*
2. *Y14 and Y15 are combined as Transport Equipment in RIETI industry coverage.*

Appendix 3: Final demand coverage

Final Demand List	FD Code
Household Final Consumption Expenditure	HFCE
Non-Profit Institutions Serving Households	NPISH
General Government Final Consumption	GGFC
Gross Fixed Capital Formation	GFCF
Changes in Inventories and Valuables	INVNT
Direct purchases abroad by residents	DPABR

Appendix 4: List of countries and industries for which price data are unavailable

Y03	Textiles, textile products, leather and footwear	
	Singapore (SGP)	
Y06	Coke, refined petroleum products and nuclear fuel	
	India (IND)	Austria (AUT)
	Finland (FIN)	Ireland (IRL)
Y13	Computer, electronic and optical products	
	Denmark (DNK)	
	Switzerland (CHE)	