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**Gravity Analysis of Regional Economic Interdependence:
In case of Japan**

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New Age of Input-Output Database

The development in International input-output table such as IDE-JETRO's AIIO (Asia International Input-Output) table or WIOD (World Input-Output Database) by European Joint Project have made us forward in the field of the research of international connectivity by industry level. Such international input-output tables are useful in comparing in same criteria and in measuring the mutual connectivity internationally. Even though the standalone national input-output tables made us limited in usage, it is quite useful in applying the developed tools to revitalize the description of the domestic economic activity in an international view point. Using the international input-output tables, this paper shows the Skyline Chart for the representative economies. Skyline Chart shows us the bird-eye view of its economic activity, but only illustrated domestically. There has no description of international connectivity by industry. International input-output table which has trade matrix by itself lead us to be flexible in analyzing in both ways, domestically and internationally. In all analysis of Gravity model, GDP or GNP has been used as a proxy of economic size in regressing trade flows. In this paper, we introduce the data of output aggregated in the international input-output table as the economic size in estimating the gravity equation.

In the above analysis, we use WIOD database. WIOD database has provided with the annual Intercountry Input-Output Table until 2009 for 40 countries plus the rest of the world (ROW), in current prices, (industry-by-industry, in millions of US\$). The economies provided in WIOD table are as follows;

Coverage of Economies in WIOD Database

European Union: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak, Republic, Slovenia, Spain, Sweden, United Kingdom

North America: Canada, United States

Latin America: Brazil, Mexico

Asia and Pacific: China, India, Japan, South Korea, Australia, Taiwan, Turkey, Indonesia, Russia

+ ROW (the rest of the world)

Economic Structure in usage of Skyline Chart

The Skyline Chart shows the comparative proportion of output by industry and the comparative size of self-sufficiency, output and import by industry. In the input-output table, domestic demand (DDM) is equal to output (OUT) minus export (EXP) plus import (IMP);

$$\text{DDM} = \text{OUT} - \text{EXP} + \text{IMP}.$$

What we need in making Skyline Chart for the specific economy is the data of the domestic demand, export and import for each industry. The ratios of the domestic demand and the import to the output are measured with the vertical axis. Each sector's output share in the economy's total output are shown along with the horizontal axis in the following chart. The area colored in light grey shows the output for each industry. The line at 100% in the vertical axis means the self-sufficiency. The area colored in dark grey shows the import the industry. As the representative economies in WIOD table, we constructed Skyline Chart for some major economies of Japan, China, Russia and USA.¹

¹ For the reference of many Asian economies' Skyline Charts, refer to Toshiaki Hasegawa (2013 forthcoming), "Industrial Structure and Interdependence in Asia Pacific region," in I. Yamazawa et al. (eds.), *New Trade Order in Asia Pacific*, Keiso-Shobo (in Japanese). In generating Skyline Charts, we referred to the following material; Kenjiro UDA (2011), "An Introduction to skyline chart generating tool "Ray" Version2", *Research of Economy Statistics*, 34(4), pp.41-57, Economy, Trade and Industry Statistics Association.

Figure 1 Skyline Chart of Japanese Economy 2009 (calculated with WIOD Table)

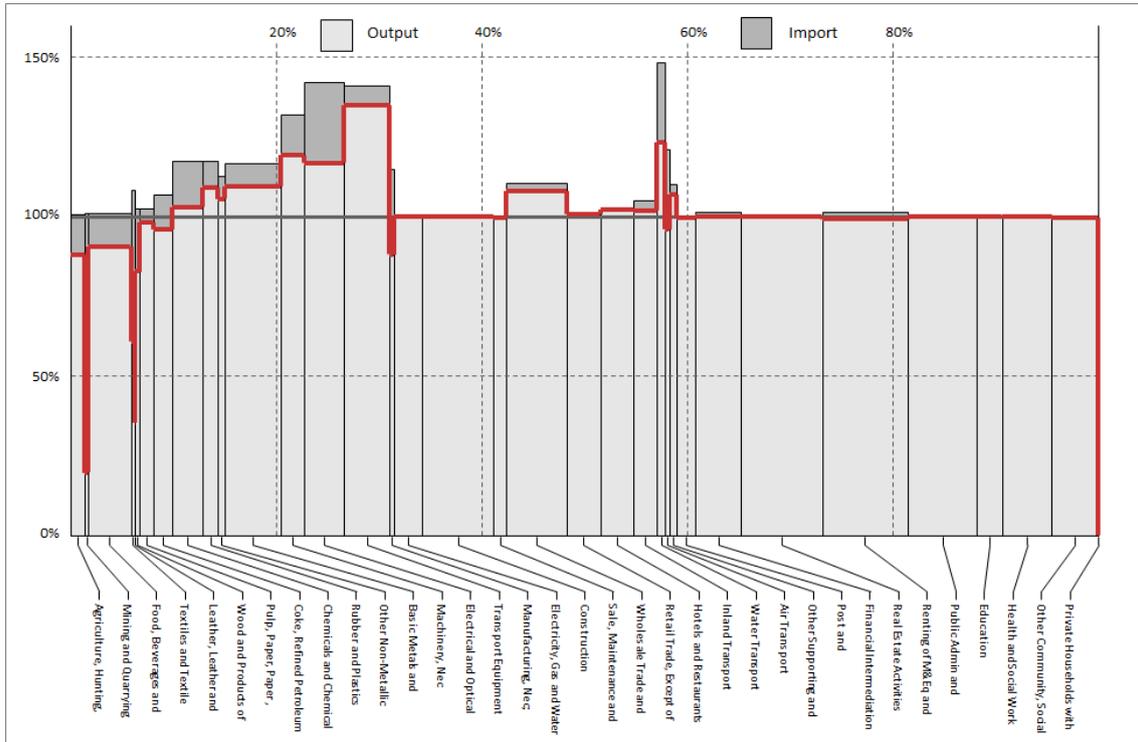


Figure 2 Skyline Chart of Chinese Economy 2005 (calculated with OECD IO Table)

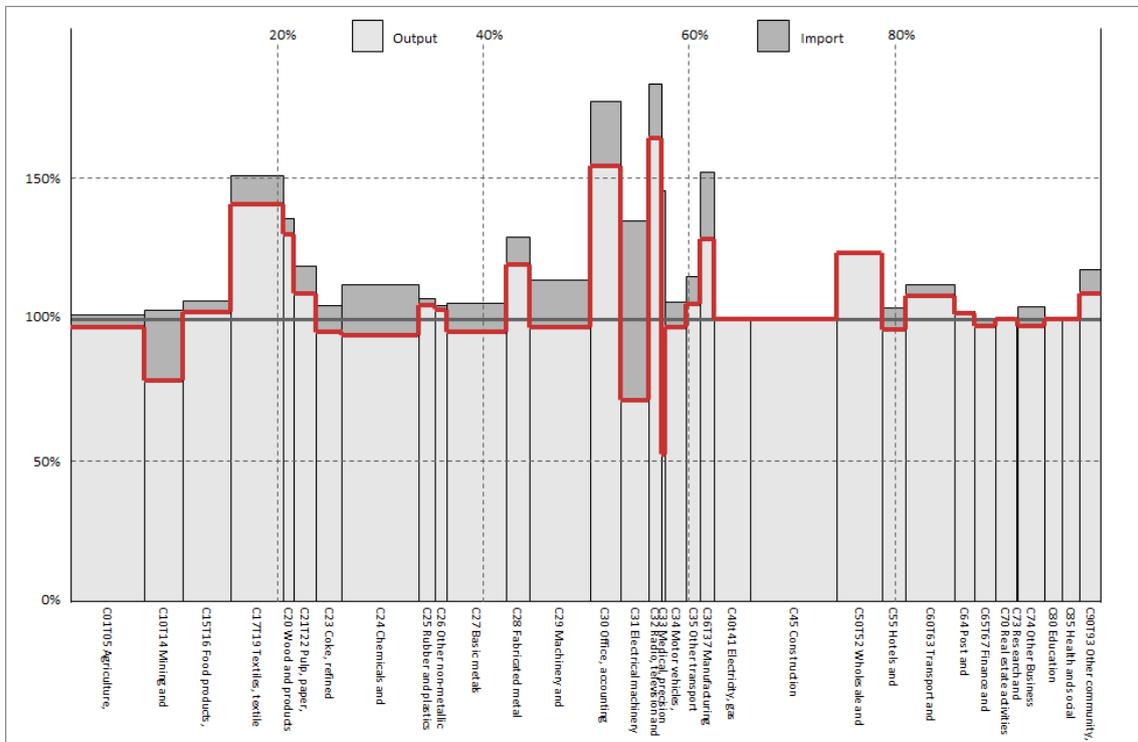


Figure 3 Skyline Chart of Russian Economy 2005 (calculated with OECD IO Table)

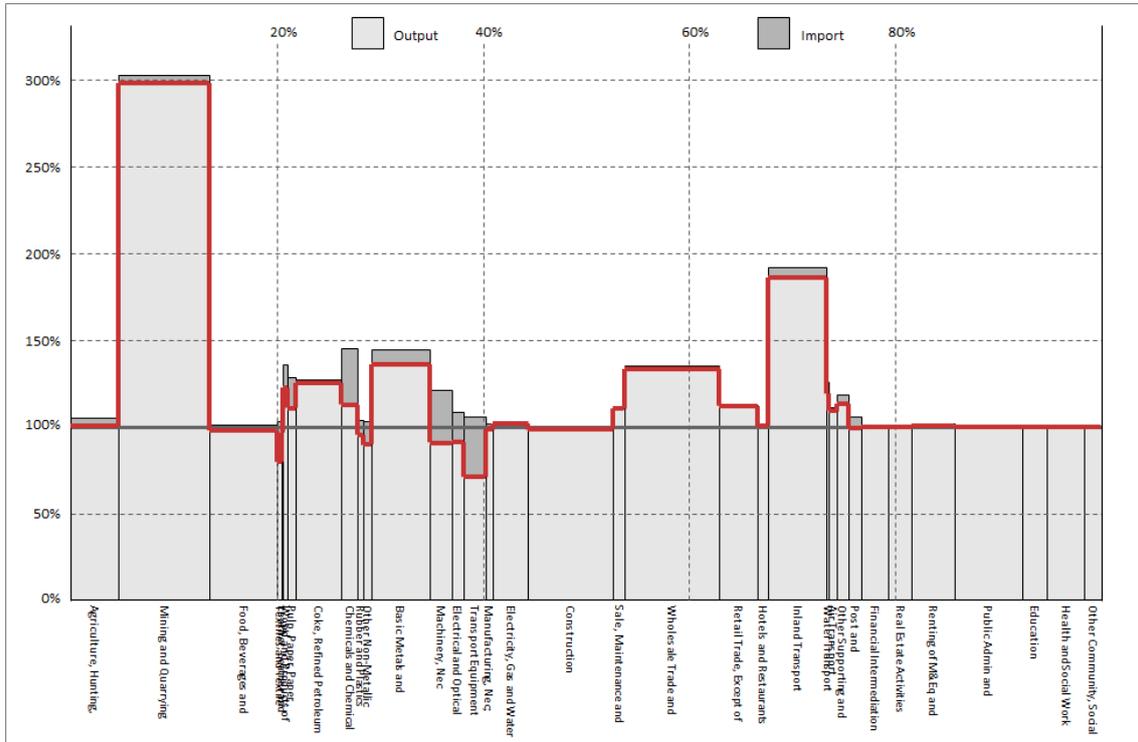
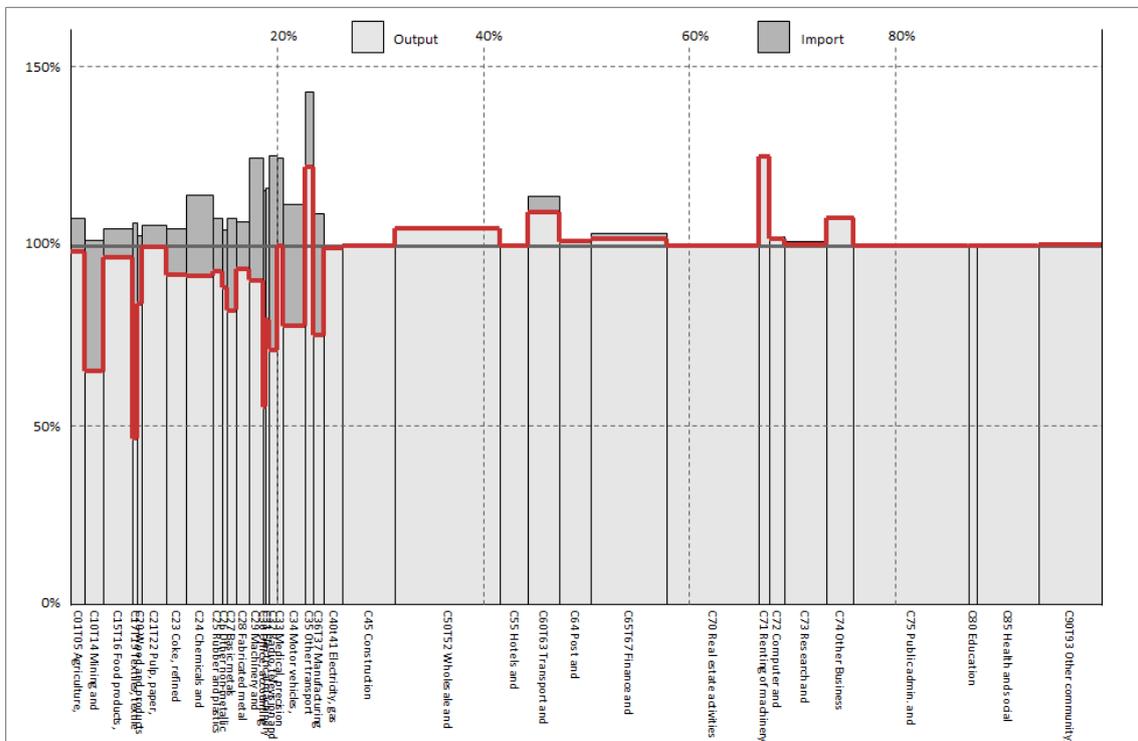


Figure 4 Skyline Chart of USA Economy 2005 (calculated with OECD IO Table)



Gravity Model of International Trade

The standard equation of Gravity model² is regressed in the following form;

$$\ln TRADE_{ij} = \alpha_0 + \alpha_1 \ln OUT_i + \alpha_2 \ln OUT_j + \alpha_3 \ln GEDST_{ij},$$

where $TRADE_{ij}$ is the sum of export and import of intermediate goods between the i -th economy and the j -th economy, and OUT_i and OUT_j is are the output in the i -th economy and the j -th economy, and $GEDST_{ij}$ is the geographic distance (measured in mile) between the i -th economy and the j -th economy. In this paper, the i -th economy denotes Japan and the above all variables were transformed in legalism. Among 40 economies and a ROW, we extract the trade data directly related to Japan only. In such case, the data of OUT_i is the unchanged variable, to be omitted. The equation to be estimated becomes simple as follows;

$$\ln TRADE_{ij} = \alpha_0 + \alpha_1 \ln OUT_j + \alpha_2 \ln GEDST_{ij},$$

The result of this equation³ in terms of the method of the ordinary least squares is described as follows;

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Estimation of Gravity Model

Method of estimation = Ordinary Least Squares

Dependent variable: $\ln TRADE$

Current sample: 1 to 39

Number of observations: 39

Mean of dep. var. = 8.33779

LM het. test = .160999 [.688]

Std. dev. of dep. var. = 1.43858

Durbin-Watson = 1.75219 [<.311]

Sum of squared residuals = 13.2150

Jarque-Bera test = .786040 [.675]

² For the broader review of Gravity literature, refer to Anderson, E. J. (1979), "A Theoretical Foundation for the Gravity Equation," *American Economic Review*, 69 (1): pp.106-116.

³ The data source in our estimation are as follows;

Data of geographic distance was from *Time and Date AS 1995-2013*, timeanddate.com.
<http://www.timeanddate.com/information/copyright.html>

Input-Output table was obtained from WIOD Database;
<http://www.wiod.org/database/iot.htm>

Variance of residuals = .367084	Ramsey's RESET2 = 1.94865 [.172]
Std. error of regression = .605875	F (zero slopes) = 89.1171 [.000]
R-squared = .831960	Schwarz B.I.C. = 39.7309
Adjusted R-squared = .822624	Log likelihood = -34.2356

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	8.61698	1.98582	4.33926	[.000]
<i>ln</i> OUT	.656869	.059444	11.0503	[.000]
<i>ln</i> GEDST	-1.07224	.197265	-5.43551	[.000]

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Our anticipation in regressing the gravity equation of trade flow between Japan and the trading partners were well examined by the supposed variables, the trading partners' outputs with positive sign and the geographic distance with negative sign.

The economic interdependence among the economies will be amplified or damped by the change in the institutional framework or in the political and social atmospheres. If we could obtain enough numbers of Asian economies in using WIOD database, we would extend our analysis to the examination of the influence caused by Regional Trade Agreement (RTA). In WIOD database, there are only a limited numbers of Asian economies, in which there are only two economies, Indonesia and Mexico, settled the RTA with Japan as for in 2009. Instead, although AIIO (Asia International Input-Output) tables by IDE which was used in our former analysis⁴ covered much more Asian economies closely related to Japanese trade. However, AIIO database has not been available since 2000, unavailable for 2005 table. 2000 AIIO table is the last updated one we can get. Further growing data coverage in WIOD and IDE will be useful for such researches in what the global value chains in business activities has been widely developed, especially in Asia-Pacific region.

⁴ Toshiaki Hasegawa (2012), "External Backward Linkage and External Forward Linkage in Asian International Input-Output Table," The 20th NFORUM World Conference Firenze, Italy.

Appendix

WIOD IO table classification		OECD IO table classification	
1	Agriculture, Hunting, Forestry and Fishing	1	Agriculture, hunting, forestry and fishing
2	Mining and Quarrying	2	Mining and quarrying (energy)
3	Food, Beverages and Tobacco	3	Mining and quarrying (non-energy)
4	Textiles and Textile Products	4	Food products, beverages and tobacco
5	Leather, Leather and Footwear	5	Textiles, textile products, leather and footwear
6	Wood and Products of Wood and Cork	6	Wood and products of wood and cork
7	Pulp, Paper, Paper, Printing and Publishing	7	Pulp, paper, paper products, printing and publishing
8	Coke, Refined Petroleum and Nuclear Fuel	8	Coke, refined petroleum products and nuclear fuel
9	Chemicals and Chemical Products	9	Chemicals excluding pharmaceuticals
10	Rubber and Plastics	10	Pharmaceuticals
11	Other Non-Metallic Mineral	11	Rubber & plastics products
12	Basic Metals and Fabricated Metal	12	Other non-metallic mineral products
13	Machinery, Nec	13	Iron & steel
14	Electrical and Optical Equipment	14	Non-ferrous metals
15	Transport Equipment	15	Fabricated metal products, except machinery & equipment
16	Manufacturing, Nec; Recycling	16	Machinery & equipment, nec
17	Electricity, Gas and Water Supply	17	Office, accounting & computing machinery
18	Construction	18	Electrical machinery & apparatus, nec
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	19	Radio, television & communication equipment
20	Retail Trade, Except of Motor Vehicles and Motorcycles	20	Medical, precision & optical instruments
21	Repair of Household Goods	21	Motor vehicles, trailers & semi-trailers
22	Hotels and Restaurants	22	Building & repairing of ships & boats
23	Inland Transport	23	Aircraft & spacecraft
24	Water Transport	24	Railroad equipment & transport equip nec.
25	Air Transport		
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies		
27	Post and Telecommunications		
28	Financial Intermediation		
29	Real Estate Activities		
30	Renting of M&Eq and Other Business Activities		
31	Public Admin and Defence; Compulsory Social Security		
32	Education		
33	Health and Social Work		
34	Other Community, Social and Personal Services		
35	Private Households with Employed Persons		
		25	Manufacturing nec; recycling (include Furniture)
		26	Production, collection and distribution of electricity
		27	Manufacture of gas; distribution of gaseous fuels through mains
		28	Steam and hot water supply
		29	Collection, purification and distribution of water
		30	Construction
		31	Wholesale & retail trade; repairs
		32	Hotels & restaurants
		33	Land transport; transport via pipelines
		34	Water transport
		35	Air transport
		36	Supporting and auxiliary transport activities; activities of travel agencies
		37	Post & telecommunications
		38	Finance & insurance
		39	Real estate activities
		40	Renting of machinery & equipment
		41	Computer & related activities
		42	Research & development
		43	Other Business Activities
		44	Public admin. & defence; compulsory social security
		45	Education
		46	Health & social work
		47	Other community, social & personal services
		48	Private households with employed persons & extra-territorial organisations & bodies