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AN ESTIMATION METHOD OF OD TABLE OF INTERNATIONAL CONTAINER CARGO

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ABSTRACT

The key issue for developing port facilities and evaluating network structure is information about inter-port container cargo movement which usually represented by origin-destination (OD) table or matrix. The purpose of this paper is to propose estimation method of OD table of international container cargo. This paper consists of two stages methods. The first is method for estimating the benchmark years OD matrix in 2000. The second is method for forecasting the future OD volume in 2015 and 2020. In estimating the benchmark years OD matrix in 2000, as the existing data of OD is very few and there is high correlation between container cargo flow and trade flow which provided by monetary value, we can estimate the blank cell by using rate distribution of trade statistics published by IMF. The result shows proposed method gives good accuracy and it can be applied for empirical use. To estimate the future OD Table, Durbin-Watson test was done to estimate factors affecting the container cargo movement test and time series analysis of ARIMA model was performed to estimate the future economic value. Finally, by applying Fratar method and distribution pattern in benchmark OD table in 2000, we estimated the OD table in 2015 and 2020.

1. INTRODUCTION

Over the last decades, the Asian economies have increasingly relied on international trade as the primary engine of economic growth and development, since the more industrialized countries of the region succeeded in moving into the production of higher value-added export items and diversified their market. Keeping pace with economic development, the Asian container trade has been growing rapidly. According to Containerisation International Yearbook[1)], East Asian container trade has significant changes from 31.6 million TEU in 1990 to 129.9 million TEU in 2002, or equal to 36.9% in 1990 to 48.8 percent in 2002 of the world container trade. This means that share of East Asian container trade is almost half of world container trade. The substantial growth in container trade due to further economic development, in particular in China, and in ASEAN countries.
The significant change of Asia container trade has become the development of port facilities have been priority issues of the countries in the region. Moreover, this development has become liner shipping have to re-evaluate their network structure. The key issue for developing port facilities and evaluating network structure is information about inter-port container cargo movement which usually represented by origin-destination (OD) table or matrix. Unfortunately, information about OD table is very few and also limited only for specific area. Even, study in this field is very few. One of the studies which concern with this topic area is study done by Kannami, et el, 2004[2)]. The study estimated international maritime container cargo flow. However, this study did not estimate the future OD cargo.
The purpose of this paper is to propose an estimation method of OD table of international container cargo. This paper consists of two stages methods. The first is method for estimating the benchmark years OD matrix in 2000. The second is method for forecasting the future OD volume in 2015 and 2020.

2. STUDY AREA AND DATA

Study area of this paper consists of Asian countries, America, and Europe. The detail of country area study and their representative port is shown in Table 1. We separate Taiwan and Hong Kong from China mainland because this two area have huge container cargo handled on their ports. The choice of countries and their representative port is based on total export and import, frequency direct call of liner shipping and total container cargo handled.
Data was taken from various resources. The main data was taken from PIERS, IMF, Containerisation International Yearbook, and Ocean Shipping Consultant. PIERS (Port Import Export Reporting Service) 2000[3)] is a published data

presented in yearly and collected by United States Department of Commerce. It includes information on container cargo movement (export and import) from and to U.S. The format of data is based on TEU and Ton. However, it does not include the empty container movement.
International Monetary Fund (IMF)[4] published Direction of Trade Statistics Year Book. It includes trade statistics among countries which represented by monetary value. From this data we can calculate rate distribution of trade which is useful in performing OD table. Beside that, the data also provide historical information data about GDP for each country. The historical data of GDP is used in time series analysis.
Containerisation International Yearbook which is the most popular data used in maritime study gives so many data regarding port, liner shipping, container traffic, shipper, etc. However, it does not provide data of container cargo movement country to country. In this study, we use only data related to container handled on each port. Container handled data from this book will be useful in validation test that compare output form model and statistic data. Ocean Shipping Consultants Ltd[5] gives statistics data of container cargo movement from Japan to others countries. This data includes empty container and transshipment cargo.

Table 1: Countries and theirs port representative

Country	Port
Japan	Keihin: Tokyo + Yokohama Chukyo: Nagoya + Yokkaichi Hanshin: Osaka + Kobe North Kyushu: Kitakyushu + Hakata
Korea	Busan
Taiwan	Keelung Kaohsiung
China	Dalian Tianjin Qingdao Shanghai Guangzhou
Hong Kong (China)	Hong Kong

Country	Port
Malaysia	Port Klang + Tanjung Pelepas
Thailand	Laem Chabang + Bangkok
Singapore	Singapore
Indonesia	Tanjung Priok
Phillippines	Manila
Amerika	East Coast (U.S.): NY/NJ + Charleston + savanna + Virginia West Coast (U.S.): LA+LB+ Oakland + Tacoma + Seattle + Vancouver
Europe	Mediterranean: Algeciras + Genoa + Barcelona + Valencia Northern Europe: Rotterdam + Hamburg + Antwerp + Felixstowe + Bremen + Le Havre

3. METHODOLOGY

As mentioned previously, this paper consists of two stage of method, i.e. estimating the benchmark OD table in 2000 and forecasting future OD. At first, we will describe a method to estimate OD in 2000 table as benchmark OD. PIERS data gives imperfect OD matrix, i.e. OD matrix from and to U.S. The problem is how to fill the others blank cells. To solve this problem, we adopted the IMF data and calculate rate distribution from country to country. However, IMF data provides OD statistics by monetary value, not in TEU. So, correlation test between TEU and monetary value is needed. If there is strong correlation between TEU and monetary value, than rate distribution of IMF data can be adopted to fill the blank cells. To calculate rate distribution of IMF data and to fill the blank cell, we use the following formulation.

$$h_{rs} = \frac{D_{rs}^{out}}{\sum_s D_{rs}^{out}}, \qquad \sum_s h_{rs} = 1, \qquad (r \neq s) \tag{1}$$

$$h_{ra} = \frac{D_{ra}^{out}}{\sum_s D_{ra}^{out}} \tag{2}$$

$$Q_{rs} = h_{rs} \sum_s Q_{rs}, \qquad \sum_s Q_{rs} = \frac{Q_{ra}}{h_{ra}}\ ; \qquad (r \neq s) \tag{3}$$

where:

h_{rs} = rate distribution from country r to country s

D_{rs}^{out} = export from country r to country s (in monetary value)
D_{ra}^{out} = export from country r to country U.S (in monetary value)
h_{ra}^{out} = total export from country r to US
Q_{rs} = total container from country r to country s

After the completing the OD table, the next step is to validate the result by comparing with statistical data. The above procedure is illustrated in Figure 1 as follows.

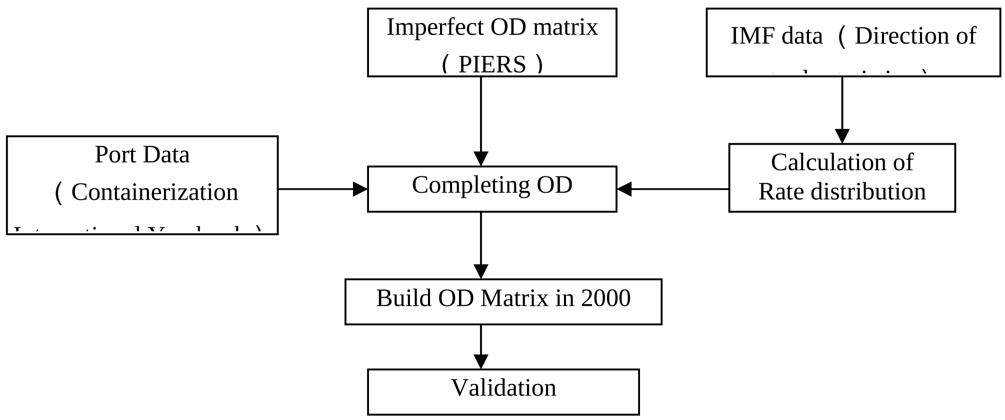

Figure 1: Procedure for estimating OD table in 2000

The second step is how to forecast the future OD table. Econometric modeling can be used to predict trends in container flow by considering which factors are likely to influence cargo movements and how they are likely to impact on growth. Container movements are essentially a direct result of cargo flows, which depend on the economic activities occurring within the areas of origin and destination of the cargoes. The key measure of economic activity is GDP. Most of industrial countries use GDP as their main measure of economic activity. The implication is that the volumes of exports and imports have some form of relationship with GDP.
In this research, factors which have influence in container cargo movement were listed. Durbin-Watson test (see Maddala, 1992[6)]) was performed to see autocorrelation between explanatory variable and total container cargo. Time series analysis of ARIMA model was used to forecast the future economic value. By using regression model and time series analysis, total amount of container cargo in future can be estimated. Finally, by applying Fratar method (see Ortuzar[7)]) and export and import rate in 2000, we can estimate the future OD table. The procedure for forecasting the future OD table is shown in Figure 2.

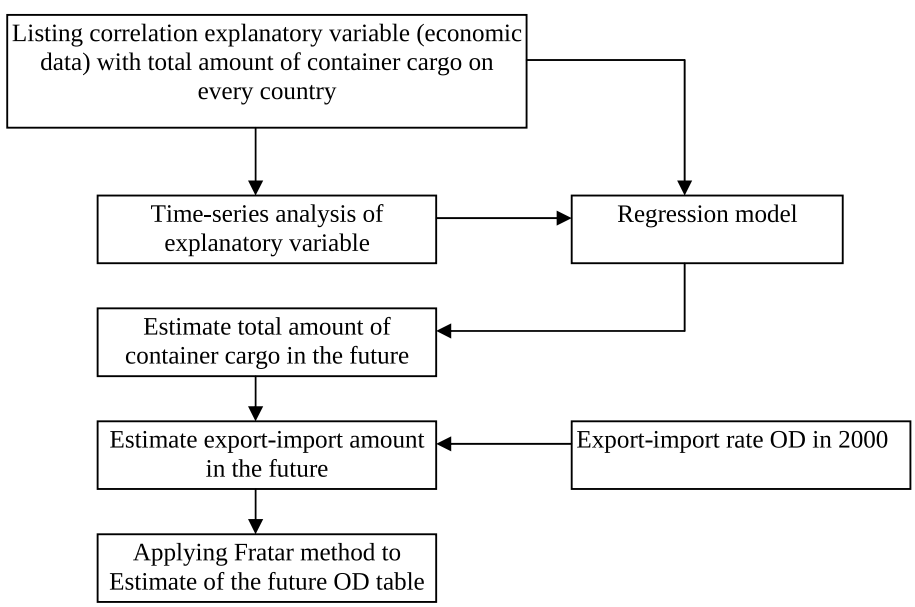

Figure 2: Procedure for forecasting the future OD Table

4. AUTOREGRESSIVE INTEGRATED MOVING-AVERAGE (ARIMA) MODEL

In this section we describe the time series analysis. In practice, most time series are nonstationary. One procedure that is often used to convert a nonstationary series to a stationary series is successive differencing. Therefore, if we have to difference a time series *d* times to make it stationary and then apply the ARMA(*p*,*q*) model to it, we say that the original time series is ARIMA(*p*,*d*,*q*), that is an autoregressive integrated moving average time series, where *p* denotes the number of autoregressive terms, *d* the number of time series has to be differenced before it becomes stationary, and *q* the number of moving average terms.
The ARIMA approach was first popularized by Box and Jenkins, and ARIMA models are often referred to as Box-Jenkins models. The Box-Jenkins approach is one of the most widely used methodology for the analysis of time series data. It is popular because of its generality; it can be handle any series, stationary or not, with or without seasonal elements. The basic steps in the Box-Jenkins methodology are (1) identification of a tentative model, (2) estimation of the model, (3) diagnostic checking, and (4) Forecasting (see Gujarati[8)]).

(1) Identification
In the identification step a tentative ARIMA model is specified for a given sample of data on the basis of estimation autocorrelation and partial autocorrelation functions.

(2) Estimation
Once a tentative specification of the ARIMA model has been made, the parameters of the process are estimated. If a pure AR process is identified then the parameters can be estimated by using least squares. If any MA terms are identified then maximum likelihood or least square estimation can be used.

(3) Diagnostic Checking
The third step in Box_Jenkins model building is to check the model adequacy using diagnostic tests. The suggested tests included residual analysis and model overfitting. By oberfitting we mean that if an ARIMA (p,d,q) model is specified and estimated, then we could estimate an ARIMA (p+1,d,q) model and an ARIMA (p,d,q+1) model and check the significance of the additional parameters. If the model is ARIMA (p,d,q), then additional parameters introduced by the larger model should not be significantly different from zero. A residual analysis is based on the fact that if an ARIMA(p,d,q) model is an adequate representation of the data-generation process, then the residuals should be uncorrelated random disturbances. Thus, a plot of the residuals should show no patterns, and there should be no “unusual value”, or outliers. Furthermore, an autocorrelation function fit to the residuals should reveal no significant autocorrelations. Residual autocorrelation may be checked for significance by comparing them to $\pm 2/\sqrt{T}$.

To check the overall acceptability of the residual autocorrelation, we use the test statistics.

$$Q = T(T+2)\sum_{k=1}^{m} \frac{1}{T-k} r_k^2 \tag{4}$$

Which was developed by Ljung and Box. T is number of observation, the r_k is the autocorrelation of the estimated residual and *m* is the number of autocorrelation that are included in the test statistics. Value of Q for various value of m may be computed during the residual analysis. If the ARIMA(p,d,q) model is correctly specified, then the statistics Q, computed from the calculated residuals, is approximately χ^2 distributed with m-p-q degrees of freedom.

(4) Forecasting
One of the reasons for the popularity of the ARIMA modeling is its success in forecasting. In many cases, the forecasts obtained by this method are more reliable than those obtained from the traditional econometrics modeling, particularly for short-term forecast.

In this research, the process of ARIMA model was calculated by using software “R”[9)].

5. RESULT

5.1 Estimation of OD Table in 2000

In order to produce future OD table of international container cargo, at first, we build OD table in 2000 as benchmark.

Currently, International Transportation Handbook [10] gives OD table of container cargo. Unfortunately, the data is only container OD within Asia. Because the data is not covered the study area, we did not adopt this data. Since the OD table of the TEU base does not exist, it is necessary to generate OD table by others data, in this research we use PIERS data. However, PIERS data only provide data from and to US. Therefore, we need additional data which give trade movement country to country. Direction of Trade Statistics published by IMF (International Money Found) has given historical data of trade statistics among countries by monetary value. This data expresses the trade volume between each country in OD table of monetary base. The OD table in 2000 based on monetary value and its ratio is shown in Table 2.

Table 2: OD Table based on monetary value in 2000 (million dollars)

	Japan	Korea	Taiwan	China	Hong Kong	Indonesia	Singapore	Thailand	Philippines	Malaysia	US	Europe	Total
Japan	-	30,703	35,977	30,356	27,187	7,604	20,830	13,634	10,257	13,886	144,009	78,457	412900
ratio		0.0744	0.0871	0.0735	0.0658	0.0184	0.0504	0.0330	0.0248	0.0336	0.3488	0.1900	1
Korea	20466	–	8027	18455	10708	3505	5648	2015	3360	3515	37806	23460	136965
ratio	0.1494		0.0586	0.1347	0.0782	0.0256	0.0412	0.0147	0.0245	0.0257	0.2760	0.1713	1
Taiwan	16,517	3,888	-	4,195	31,183	1,726	5,954	2,550	3,021	2,786	34,643	22,048	128511
ratio	0.1285	0.0303	0.0000	0.0326	0.2426	0.0134	0.0463	0.0198	0.0235	0.0217	0.2696	0.1716	1
China	41654	11293	5040	-	44520	3062	5761	2243	1464	2565	52162	38230	207994
ratio	0.2003	0.0543	0.0242		0.2140	0.0147	0.0277	0.0108	0.0070	0.0123	0.2508	0.1838	1
Hong Kong	11,195	3,827	5,112	69,744	–	950	4,717	1,837	2,011	1,806	47,084	30,845	179128
ratio	0.0625	0.0214	0.0285	0.3894	0.0000	0.0053	0.0263	0.0103	0.0112	0.0101	0.2629	0.1722	1
Indonesia	14,415	4,318	2,378	2,768	1,554	–	6,562	1,026	820	1,972	8,489	8,681	52983
ratio	0.2721	0.0815	0.0449	0.0522	0.0293	0.0000	0.1239	0.0194	0.0155	0.0372	0.1602	0.1638	1
Singapore	10,404	4,916	8,225	5,377	10,841	3,421	–	5,872	3,387	25,041	23,891	18,244	119619
ratio	0.0870	0.0411	0.0688	0.0450	0.0906	0.0286		0.0491	0.0283	0.2093	0.1997	0.1525	1
Thailand	10,164	1,265	2,415	2,806	3,474	1,338	5,997	–	1,082	2,813	14,706	10,877	56937
ratio	0.1785	0.0222	0.0424	0.0493	0.0610	0.0235	0.1053		0.0190	0.0494	0.2583	0.1910	1
Philippines	5,606	1,173	2,861	663	1,907	183	3,124	1,206	–	1,377	11,406	6,826	36332
ratio	0.1543	0.0323	0.0787	0.0182	0.0525	0.0050	0.0860	0.0332		0.0379	0.3139	0.1879	1
Malaysia	12,780	3,235	3,729	3,028	4,440	1,707	18,050	3,550	1,727	–	20,162	13,435	85843
ratio	0.1489	0.0377	0.0434	0.0353	0.0517	0.0199	0.2103	0.0414	0.0201		0.2349	0.1565	1
US	64,538	27,338	23,833	15,964	14,567	2,479	17,497	6,538	8,677	10,830	–	164,593	356854
ratio	0.1809	0.0766	0.0668	0.0447	0.0408	0.0069	0.0490	0.0183	0.0243	0.0303		0.4612	1
Europe	41,279	14,869	13,673	23,295	18,826	4,058	13,534	5,907	4,037	7,682	213,388	–	360548
ratio	0.1145	0.0412	0.0379	0.0646	0.0522	0.0113	0.0375	0.0164	0.0112	0.0213	0.5918		1

Source: IMF: Direction of Trade Statistics, 2000

In order to find correlation between monetary value and ton base, we compare total export from US to others countries with monetary value (from IMF) and ton base (from PIERS) as shown in Table 3. From statistical test we found that there is high correlation between monetary value and ton base with coefficient correlation of 0.943. Due to OD table of international container cargo represented in TEU base, we still need to calculate the correlation between ton base and TEU base. To do this, we compared export and import from and to U.S with TEU base and Ton base as shown in Table 4. From this table and after statistics test calculation we got that correlation between TEU and Ton is high, with coefficient correlation of 0.866.

Table 3: Export from US

	Million dollars	TON
Japan	64,538	59,287,927
Korea	27,338	16,972,537
Taiwan	23,833	9,442,193
China	15,964	20,595,454
Hong Kong	14,567	5,752,463
Malaysia	10,830	785,792
Thailand	6,538	1,915,751
Singapore	17,497	2,220,096
Indonesia	2,479	1,064,280
Philippines	8,677	3,006,571

Table 4: Correllation between TEU and Ton

	Export From US		Import to US	
	TEU	TON	TEU	TON
Japan	961,789	59,287,927	816,500	14,073,071
Korea	431,141	16,972,537	461,999	11,604,523
Taiwan	310,436	9,442,193	610,132	5,748,060
China	524,944	20,595,454	1,365,118	20,686,701
Hong Kong	454,360	5,752,463	1,816,081	9,073,062
Malaysia	67,339	785,792	241,650	4,333,743
Thailand	118,753	1,915,751	362,994	7,105,827
Singapore	116,939	2,220,096	91,795	1,789,077
Indonesia	149,387	1,064,280	256,829	4,625,218
Philippines	99,513	3,006,571	164,392	1,763,022

Source: IMF and PIERS *Source: PIERS*

Although we calculated correlation between monetary value versus ton and TEU versus Ton based on only export and import from/to U.S; we can assume this type correlation also occurs in others country. Therefore, if we refer to ratio distribution of container cargo as shown in Table 2 and PIERS data as shown in Table 4, we can calculate the complete OD Table. The result of this calculation is represented in Table 5.

Table 5: Country to country OD Table of container cargo in 2000 (TEU)

	Japan	Korea	Taiwan	China	HK	Malaysia	Thai.	Sing.	Ind.	Phil.	US	EU	Total
Japan	0	174,079	203,982	172,112	154,144	78,731	77,302	118,102	43,113	58,155	816,500	444,834	2,341,054
Korea	250,100	0	98,092	225,525	130,855	42,832	69,020	24,624	41,060	42,954	461,999	286,687	1,673,749
Taiwan	290,897	68,475	0	73,882	549,195	30,398	104,862	44,911	53,206	49,067	610,132	388,309	2,263,335
China	1,090,115	295,546	131,900	0	1,165,121	80,135	150,770	58,701	38,314	67,128	1,365,118	1,000,507	5,443,354
Hong Kong	431,803	147,612	197,175	2,690,101	0	36,643	181,940	70,855	77,566	69,659	1,816,081	1,189,725	6,909,160
Malaysia	104,202	26,377	30,405	24,689	36,202	0	28,945	147,172	13,918	14,081	164,392	109,543	699,925
Thailand	63,444	7,896	15,075	17,515	21,685	17,559	0	37,433	8,352	6,754	91,795	67,895	355,403
Singapore	158,076	74,693	124,969	81,697	164,716	380,467	89,218	0	51,978	51,461	362,994	277,195	1,817,463
Indonesia	410,341	122,917	67,693	78,795	44,237	56,135	29,206	186,796	0	23,342	241,650	247,116	1,508,228
Philippines	126,230	26,412	64,421	14,929	42,940	31,006	27,155	70,343	4,121	0	256,829	153,701	818,087
US	961,789	431,141	310,436	524,944	454,360	67,339	118,753	116,939	149,387	99,513	0	1,399,000	4,633,600
Europe	249,387	89,831	82,605	140,737	113,737	46,411	35,687	81,766	24,516	24,390	1,788,000	0	2,677,068
Total	4,136,386	1,464,979	1,326,753	4,044,926	2,877,190	867,655	912,858	957,640	505,531	506,504	7,975,490	5,564,512	

As we want to find the OD table between port to port, not only between country to country, the next task is how to extract the above OD table to become OD table between port to port. In this research we solved this problem by using additional data from Containerisation International Yearbook (CIY) and Ocean Shipping Consultant (OSC). The data consist of the amount of container cargo handled on each port and also information about the amount of transshipment cargo. By using these data and simple interpolation, we can make distribution of container cargo on each port. However, the OD table from this calculation does not represent the real container cargo movement, since PIERS data which we used is not included empty container; as consequence, we have to generate the OD table which consider empty container. Again, the data from Containerization International Yearbook and Ocean Shipping Consultant are needed as these data already considered the empty container which handled at each port. Based on OD table pattern represented in Table I and data from CIY and OSC, we can upgrade the OD table as shown in Appendix of Table 1.

In order to know the accuracy of the method, we have to validate the model by comparing the estimation output and real data. In this case, we compared the amount of container cargo handled (export and import) at each port from estimation and data from CIY and OSC. The result is shown in Table 6 and Figure 3. From statistics test we found the value of coefficient determination (R^2) is 0.959. It means that the estimation method gives good accuracy.

Table 6: Comparison between estimation and data of container handled

	Estimation	Data
Keihin	4,429,346	4,614,500
Chukyo	1,812,474	1,950,346
Hanshin	2,911,808	3,440,000
Kanmon	787,847	907,000
Busan	4,655,581	5,150,400
Kaohsiung	1,921,176	1,859,600
Keelung	3,322,978	3,460,200
Dalian	1,066,374	1,011,000
Tianjin	1,936,836	1,708,000
Qingdao	2,512,368	2,120,000
Shanghai	6,627,210	5,613,100
Guangzhou	1,768,613	1,080,000
Hong Kong	14,204,679	11,763,000
Malaysia	2,476,212	2,038,700
Thailand	2,930,173	3,184,500
Singapore	2,819,996	3,712,100
Indonesia	3,056,978	3,368,700
Philippines	1,515,970	2,291,700

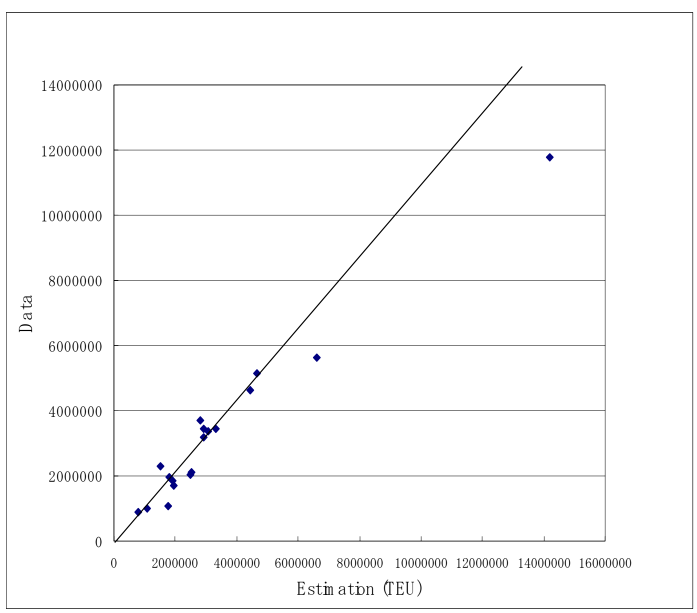

Figure 3: Comparison between estimation and data of container handled

Source: Data taken from Containerisation International Yearbook and OSC

At final step, with total container cargo handled from statistical data as shown in Table 6, we need to fix or update OD table represented in Appendix of Table 1. By applying Fratar method and distribution pattern in the previous table, we can calculate the final estimation of OD table of container cargo as shown in Table 7.

Table 7: Port to port OD table of container cargo calculating by Fratar Method in 2000 (TEU)

		Japan				Korea	Taiwan		China				
		Keihin	Chukyo	Hanshin	Kanmon	Busan	Kaohsiung	Keelung	Dalian	Tianjin	Qingdao	Shanghai	Guangzhou
Japan	Keihin	-	-	-	-	124,900	46,984	82,878	9,907	15,606	17,991	48,246	6,513
	Chukyo	-	-	-	-	57,017	21,448	37,834	4,523	7,124	8,213	22,025	2,973
	Hanshin	-	-	-	-	106,900	40,213	70,934	8,479	13,357	15,398	41,293	5,575
	Kanmon	-	-	-	-	28,193	10,605	18,707	2,236	3,523	4,061	10,890	1,470
Korea	Busan	189,700	76,166	157,925	40,554	-	57,777	101,917	33,197	52,293	60,282	161,663	21,825
Taiwan	Kaohsiung	62,669	25,162	52,172	13,397	35,684	-	-	3,089	4,866	5,609	15,042	2,031
	Keelung	142,125	57,065	118,319	30,384	80,927	-	-	7,005	11,035	12,721	34,114	4,605
China	Dalian	62,770	25,203	52,256	13,419	41,165	5,898	10,404	-	-	-	-	-
	Tianjin	97,952	39,329	81,545	20,940	64,238	9,204	16,235	-	-	-	-	-
	Qingdao	116,048	46,594	96,610	24,809	76,105	10,904	19,234	-	-	-	-	-
	Shanghai	309,993	124,465	258,069	66,270	203,296	29,127	51,379	-	-	-	-	-
	Guangzhou	42,574	17,094	35,443	9,101	27,920	4,000	7,056	-	-	-	-	-
Hong Kong		252,712	101,466	210,383	54,024	208,970	89,611	158,071	305,532	481,290	554,816	1,487,890	200,869
Malaysia		79,196	31,798	65,931	16,930	48,492	17,945	31,654	3,641	5,736	6,613	17,733	2,394
Thailand		179,484	72,064	149,420	38,370	54,035	33,117	58,417	9,616	15,148	17,462	46,828	6,322
Singapore		37,987	15,252	31,624	8,121	43,418	23,320	41,136	3,810	6,002	6,919	18,554	2,505
Indonesia		308,020	123,672	256,426	65,848	223,188	39,459	69,604	11,478	18,081	20,843	55,897	7,546
Philippines		81,257	32,625	67,646	17,371	41,127	32,203	56,805	1,865	2,938	3,387	9,082	1,226
US	East coast	140,319	62,344	102,234	12,649	216,460	49,147	112,826	5,905	5,044	76,507	140,240	49,432
	West coast	618,201	191,691	338,323	107,045	515,445	131,372	182,733	16,767	17,256	111,427	192,714	80,279
Europe		336,505	135,110	280,140	71,937	293,203	86,556	152,681	36,853	58,053	66,921	179,468	24,229
Total		3,057,512	1,177,100	2,354,465	611,169	2,490,683	738,890	1,280,504	463,905	717,353	989,168	2,481,681	419,794

		Hong Kong	Malaysia	Thailand	Singapore	Indonesia	Philippines	US		Europe	
								East coast	West coast		Total
Japan	Keihin	83,178	21,263	79,551	67,037	39,884	75,395	116,047	519,661	249,600	1,604,642
	Chukyo	37,971	9,707	36,315	30,603	18,207	34,418	35,248	272,302	113,943	749,871
	Hanshin	71,190	18,198	68,086	57,375	34,136	64,529	69,982	219,408	213,627	1,118,682
	Kanmon	18,775	4,799	17,956	15,132	9,003	17,018	8,070	78,086	56,340	304,866
Korea	Busan	180,564	54,172	42,414	153,060	75,118	100,550	149,726	620,766	411,355	2,741,024
Taiwan	Kaohsiung	215,242	17,576	21,972	66,048	15,142	37,007	89,849	314,155	158,250	1,154,961
	Keelung	488,143	39,860	49,829	149,789	34,340	83,927	122,363	420,735	358,892	2,246,176
China	Dalian	122,051	6,427	7,676	25,382	10,669	7,123	13,592	50,710	108,983	563,728
	Tianjin	190,459	10,029	11,978	39,609	16,649	11,115	56,558	184,935	170,066	1,020,839
	Qingdao	225,645	11,882	14,191	46,926	19,725	13,168	67,826	174,127	201,484	1,165,278
	Shanghai	602,753	31,740	37,908	125,350	52,689	35,176	157,367	603,058	538,212	3,226,849
	Guangzhou	82,781	4,359	5,206	17,215	7,236	4,831	70,731	270,965	73,917	680,432
Hong Kong		-	67,786	94,170	311,315	49,585	146,563	561,767	1,816,421	1,317,168	8,470,409
Malaysia		50,055	-	49,958	327,027	24,459	34,552	73,214	209,098	157,495	1,253,920
Thailand		111,604	82,594	-	309,618	54,631	61,687	179,365	417,836	363,349	2,260,966
Singapore		72,010	152,020	48,687	-	28,881	39,926	30,942	158,429	126,010	895,551
Indonesia		60,409	70,063	49,786	409,951	-	56,570	124,746	292,191	350,904	2,614,684
Philippines		50,286	33,186	39,697	132,389	6,133	-	101,733	273,689	187,166	1,171,812
US	East coast	228,381	32,440	98,487	62,581	112,802	65,053	-	-	559,600	2,132,451
	West coast	373,853	49,722	107,336	174,093	145,624	159,786	-	-	839,400	4,353,067
Europe		279,196	104,125	109,353	322,568	76,489	106,250	715,200	1,072,800	-	4,507,636
Total		3,544,548	821,949	990,555	2,843,068	831,402	1,154,644	2,744,325	7,969,370	6,555,760	

5.2 Forecasting The Future OD Table

Based on OD table in 2000 as discussed in the previous sub-section and by ARIMA model, this sub-section will forecast OD table in 2015 and 2020. At first, we have to determine the factors which affecting total container cargo handling. As mentioned previously, econometric modeling can be used to predict trends in container flow by considering which factors are likely to influence cargo movements and how they are likely to impact on growth.

In this research, to obtain which factor affecting the container cargo movement in study area, autocorrelation analysis was performed by Durbin-Watson (DW) test. GDP data (from IMF) of each country from 1991 to 2000 was analyzed. Beside that, total of export and import also analyzed. The result indicated, the key measures of economic activity which influencing cargo movement in study area is GDP and total of export and import as shown in Appendix of Table 2. In Taiwan case, since IMF only release few data in this country, we was not able to perform the Durbin-Watson test. To find the future total container cargo handled on each country we performed regression analysis. The result is shown in Appendix of Table 3.

In order to obtain future value of economic variable, we performed time series analysis. Based on the candidate economic variable in Appendix of Table 2 we performed the ARIMA model test by Box-Jenkins approach. The ARIMA model result is shown in Appendix of Table 4. Finally, after performing ARIMA model and regression analysis, by applying Fratar method and export/import rate in 2000, we can estimate the future OD table in 2015 and 2020 as shown in Table 8 and 9.

Table 8: OD Table 2015

	Japan	Korea	Taiwan	China	Hong Kong	Malaysia	Thailand	Singapore	Indonesia	Philippines	US	Total
Japan	-	414,370	366,213	776,819	89,457	95,376	315,189	192,714	114,541	314,923	1,474,323	4,153,924
Korea	541,781	-	228,007	1,253,640	104,133	118,255	82,751	220,677	108,500	206,376	1,103,304	3,967,425
Taiwan	585,619	195,199	-	390,259	394,802	129,159	142,897	314,345	71,969	253,364	1,360,330	3,837,944
China	3,259,370	1,195,253	418,093	-	1,373,147	240,195	259,923	652,053	275,205	252,821	4,220,503	12,146,562
Hong Kong	194,489	101,878	98,390	3,946,987	-	47,184	56,426	128,161	20,302	93,274	956,737	5,643,827
Malaysia	340,118	117,216	105,685	193,581	45,879	-	141,248	697,535	52,399	102,504	601,618	2,397,785
Thailand	642,575	110,411	163,088	440,580	82,816	221,069	-	555,420	98,261	155,815	1,066,105	3,536,139
Singapore	100,091	66,688	85,086	135,615	37,539	311,539	88,778	-	38,666	76,652	251,065	1,191,719
Indonesia	851,304	359,819	150,770	427,614	33,003	150,980	95,302	575,603	-	113,995	579,181	3,337,571
Philippines	308,002	88,741	167,704	89,783	39,736	93,603	100,667	251,037	11,662	-	708,600	1,859,536
US	1,522,045	1,018,852	565,862	2,286,910	277,317	153,810	341,309	286,145	312,327	392,832	-	7,157,409
Total	8,345,394	3,668,427	2,348,899	9,941,787	2,477,831	1,561,170	1,624,490	3,873,691	1,103,832	1,962,556	12,321,765	49,229,841

Table 9: OD Table 2020

	Japan	Korea	Taiwan	China	Hong Kong	Malaysia	Thailand	Singapore	Indonesia	Philippines	US	Total
Japan	-	399,949	392,595	804,901	91,778	96,709	332,665	197,792	114,439	337,902	1,448,156	4,216,886
Korea	530,170	-	257,245	2,818,904	91,652	154,085	107,065	255,247	135,459	267,586	1,093,512	5,710,925
Taiwan	654,855	229,572	-	877,371	350,253	165,722	180,458	357,472	89,331	318,603	1,310,995	4,534,631
China	3,526,830	2,768,888	931,550	-	2,253,072	618,313	666,094	1,473,520	668,479	652,636	8,232,879	21,792,262
Hong Kong	198,438	87,427	83,000	6,011,430	-	44,336	53,347	109,169	18,437	88,593	704,095	7,398,273
Malaysia	364,982	159,646	134,935	508,792	46,068	-	208,615	921,039	75,127	151,343	677,182	3,247,729
Thailand	687,978	143,096	198,254	1,095,279	79,722	314,220	-	698,460	134,170	218,602	1,142,485	4,712,265
Singapore	105,651	78,764	94,738	303,220	33,272	403,029	113,710	-	48,162	98,120	246,162	1,524,827
Indonesia	899,047	470,386	186,300	1,063,109	32,176	216,510	135,414	732,458	-	162,028	629,696	4,527,124
Philippines	347,259	119,501	210,415	232,620	39,822	138,033	146,303	327,217	16,548	-	785,040	2,362,758
US	1,517,031	1,013,813	530,475	4,290,160	208,445	167,414	367,752	277,160	327,978	422,796	-	9,123,023
Total	8,832,240	5,471,043	3,019,507	18,005,785	3,226,261	2,318,371	2,311,423	5,349,534	1,628,130	2,718,209	16,270,200	69,150,705

6. CONCLUSION

The key issue for developing port facilities and evaluating network structure is information about inter-port container cargo movement which usually represented by origin-destination (OD) table or matrix. In this paper, we propose an estimation method of OD table of international container cargo. First, we propose a method to estimate the benchmark years OD matrix in 2000. As the existing data of OD is very few and there is high correlation between container cargo flow and trade flow which provided by monetary value, we can estimate the blank cell by using rate distribution of trade statistics published by IMF. The result shows proposed method gives good accuracy and it can be applied for empirical use. Second, we propose a method to estimate the future OD Table. Durbin-Watson test was done to estimate factors affecting the container cargo movement test and time series analysis of ARIMA model was performed to estimate the future economic value. Finally, by applying Fratar method and distribution pattern in benchmark OD table in 2000, we estimated the OD table in 2015 and 2020.

APPENDIX

Table 1: Port to port OD Table of container cargo in 2000 (TEU)

		Japan				Korea	Taiwan		China				
		Keihin	Chukyo	Hanshin	Kanmon	Busan	Kaohsiung	Keelung	Dalian	Tianjin	Qingdao	Shanghai	Guangzhou
Japan	Keihin	-	-	-	-	103,897	45,828	75,916	9,006	15,214	18,884	49,999	9,619
	Chukyo	-	-	-	-	46,506	20,513	33,981	4,031	6,810	8,453	22,380	4,306
	Hanshin	-	-	-	-	78,686	34,708	57,495	6,820	11,522	14,302	37,867	7,285
	Kanmon	-	-	-	-	20,960	9,245	15,315	1,817	3,069	3,810	10,087	1,941
Korea	Busan	154,469	61,708	113,451	29,618	-	53,039	87,861	28,400	47,979	59,554	157,677	30,336
Taiwan	Kaohsiung	58,017	23,177	42,610	11,124	31,761	-	-	3,004	5,076	6,300	16,680	3,209
	Keelung	121,650	48,597	89,347	23,326	66,598	-	-	6,300	10,642	13,210	34,975	6,729
China	Dalian	59,025	23,580	43,351	11,318	37,217	6,252	10,357	-	-	-	-	-
	Tianjin	99,720	39,836	73,240	19,121	62,876	10,563	17,498	-	-	-	-	-
	Qingdao	123,772	49,445	90,905	23,732	78,041	13,111	21,718	-	-	-	-	-
	Shanghai	327,713	130,916	240,690	62,837	206,631	34,714	57,504	-	-	-	-	-
	Guangzhou	63,058	25,191	46,313	12,091	39,760	6,680	11,065	-	-	-	-	-
Hong Kong		266,695	106,540	195,875	51,137	212,031	106,614	176,610	338,764	572,302	710,368	1,880,802	361,851
Malaysia		94,605	37,793	69,483	18,140	55,694	24,166	40,032	4,570	7,721	9,583	25,374	4,882
Thailand		154,952	61,901	113,805	29,711	44,851	32,232	53,393	8,722	14,735	18,290	48,425	9,317
Singapore		24,690	9,863	18,133	4,734	27,132	17,088	28,306	2,602	4,395	5,456	14,444	2,779
Indonesia		269,358	107,604	197,831	51,647	187,650	38,901	64,441	10,546	17,816	22,114	58,550	11,265
Philippines		49,903	19,936	36,652	9,569	24,284	22,296	36,934	1,203	2,033	2,523	6,681	1,285
US	East coast	85,193	37,661	54,760	6,888	126,354	33,639	72,522	3,767	3,451	56,355	101,987	51,230
	West coast	614,917	189,711	296,892	95,501	492,940	147,317	192,434	17,523	19,340	134,469	229,606	136,306
Europe		367,094	146,648	269,614	70,387	307,525	106,450	176,339	42,239	71,357	88,572	234,507	45,117
Total		2,934,831	1,120,104	1,992,951	530,879	2,251,393	763,357	1,229,722	489,313	813,463	1,172,243	2,930,042	687,457

		Hong Kong	Malaysia	Thailand	Singapore	Indonesia	Philippines	US		Europe	
								East coast	West coast		Total
Japan	Keihin	91,999	25,732	70,487	46,137	34,709	46,989	70,777	513,827	265,494	1,494,515
	Chukyo	41,180	11,518	31,551	20,651	15,536	21,033	21,079	264,003	118,839	692,370
	Hanshin	69,675	19,488	53,384	34,941	26,287	35,587	37,769	191,969	201,071	918,857
	Kanmon	18,560	5,191	14,220	9,307	7,002	9,479	4,399	69,005	53,560	256,967
Korea	Busan	187,961	61,700	35,370	99,141	61,524	58,979	85,944	577,676	411,800	2,404,188
Taiwan	Kaohsiung	254,735	22,759	20,831	48,638	14,100	24,679	58,635	332,374	180,111	1,157,820
	Keelung	534,133	47,721	43,679	101,986	29,565	51,747	73,830	411,560	377,660	2,093,255
China	Dalian	146,719	8,453	7,392	18,986	10,091	4,825	9,009	54,495	125,990	577,060
	Tianjin	247,873	14,281	12,488	32,075	17,048	8,151	40,588	215,162	212,852	1,123,373
	Qingdao	307,659	17,726	15,501	39,812	21,160	10,117	50,995	212,242	264,191	1,340,126
	Shanghai	814,595	46,932	41,041	105,411	56,026	26,787	117,274	728,590	699,505	3,697,168
	Guangzhou	156,744	9,031	7,897	20,283	10,780	5,154	73,850	458,661	134,598	1,081,156
Hong Kong		-	100,059	101,777	261,340	52,634	111,417	417,916	2,190,718	1,708,932	9,924,379
Malaysia		76,439	-	61,117	310,748	29,388	29,732	61,652	285,456	231,296	1,477,870
Thailand		123,172	99,736	-	212,626	47,439	38,363	109,158	412,250	385,649	2,018,728
Singapore		59,832	138,203	32,408	-	18,881	18,693	14,177	117,679	100,690	660,183
Indonesia		67,533	85,698	44,587	285,168	-	35,635	76,899	292,012	377,255	2,302,510
Philippines		39,480	28,507	24,967	64,675	3,789	-	44,043	192,091	141,316	752,167
US	East coast	177,258	27,548	61,237	30,224	68,886	28,451	-	-	559,600	1,587,013
	West coast	475,388	69,178	109,341	137,748	145,695	114,490	-	-	839,400	4,458,196
Europe		389,364	158,881	122,170	279,914	83,929	83,494	715,200	1,072,800	-	4,831,602
Total		4,280,300	998,343	911,445	2,159,813	754,468	763,803	2,083,195	8,592,571	7,389,810	

Table 2: Correlation analysis between explanatory variable and total container handled

	Coef. of det.	Variable	Observation	t value	Standard Error	F value	DW value
Japan	0.779	Total of export&import ($US)	11	6.034	6.92	1.509	1.067
Korea	0.687	Total of export&import ($US)	11	4.792	1.39	1.533	1.051
Taiwan	0.402	Total of export&import ($US)	7	2.243	8.72	-	-
China	0.685	GDP ($US)	10	4.177	3.92	13.48	0.737
Hong Kong	0.946	Total of export&import ($US)	11	13.333	9.13	2.566	1.533
Malaysia	0.942	GDP（Ringgit）	10	10	2.87	1.473	0.771
Thailand	0.74	GDP (baht)	10	5.165	3.39	0.127	0.567
Singapore	0.795	Total of export&import ($US)	10	6	1.65	3.537	0.551
Indonesia	0.802	GDP（rupiah）	10	6.126	3.86	0.346	1.808
Philippines	0.874	GDP (peso)	10	7.991	2.2	1.459	2.192
US	0.972	GDP ($US)	11	18.619	1.84	0.413	1.724

Table 3: Table 2: Correlation analysis between explanatory variable and total container handled

		variable	Constant
Japan	Variable name	Total of export&import ($US)	Positive
	Regression coefficient	14.33	3.40(10+6)
Korea	Variable name	Total of export&import ($US)	Negative
	Regression coefficient	46.41	2.32(10+6)
Taiwan	Variable name	Total of export&import ($US)	Positive
	Regression coefficient	75.66	2.38(10+6)
China	Variable name	GDP (US dollar)	Negative
	Regression coefficient	2.08(10-5)	7.75(10+6)
Hong Kong	Variable name	Total of export&import ($US)	Negative
	Regression coefficient	64.43	4.16(10+6)
Malaysia	Variable name	GDP （Ringgit）	Negative
	Regression coefficient	1.69(10-5)	1.47(10+6)
Thailand	Variable name	GDP (baht)	Negative
	Regression coefficient	6.65(10-7)	5.9(10+5)
Singapore	Variable name	Total of export&import ($US)	Negative
	Regression coefficient	1.75(10-4)	1.06(10+6)
Indonesia	Variable name	GDP （rupiah）	Positive
	Regression coefficient	2.14(10-9)	7.87(10+5)
Philippines	Variable name	GDP (peso)	Positive
	Regression coefficient	6.26(10-7)	6.95(10+5)
US	Variable name	GDP （$US）	Positive
	Regression coefficient	7.94(10-5)	5.56(10+8)

Table 4: ARIMA model result

	The candidate for analysis	p	q	AIC	Flexibility	P value	m-p-q degree of freedom
Japan	Total of export&import ($US)	1	1	277.995	4	0.831	0.588
Korea	Total of export&import ($US)	2	1	238.997	3	0.967	0.710
Taiwan	Total of export&import ($US)	1	1	133.896	3	0.771	0.469
China	GDP (US dollar)	1	1	526.893	10	0.993	0.974
Hong Kong	Total of export&import ($US)	4	1	449.058	7	0.996	0.896
Malaysia	GDP （Ringgit）	2	1	68.822	3	0.778	0.355
Thailand	GDP (baht)	2	2	111.550	2	0.671	0.133
Singapore	Total of export&import ($US)	2	0	437.489	10	0.997	0.987
Indonesia	GDP （rupiah）						
Philippines	GDP (peso)	1	1	138.609	4	0.970	0.856
US	GDP （$US）	1	0	570.825	11	0.963	0.939

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