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Product lifecycle and choice of transportation modes: Japan's evidence of import and export

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Abstract

Here we test the hypothesis that commodities at their peak valuation are transported by air and those at their birth and maturity are shipped by sea, and that shippers would choose air for transporting high-valued commodities. We empirically investigated how the product lifecycle of commodities is reflected by shippers' choices of air transportation rather than seaborne transportation. We also assumed that the commodities that achieved substantial innovation in their lifecycles would be moved by air transportation so that these commodities could reach the targeted markets as quickly as possible to avoid the opportunity costs that might be generated by missed business chances. We constructed two unbalanced panel data of 18 commodities (the case of import) and 14 commodities (the case of export) for 24 years from Japan's custom, demographic, and international statistics. By estimating structural equation systems that consisted of commodity-specific import/export and import/export air ratio functions, we found that the product lifecycle of cargo outgoing from Japan exactly matched the upward and downward move of the air ratio, whereas since incoming commodities are raw materials that have little to do with product lifecycle or matured phase in their lifecycle stage, the peak of commodities' valuations and the use of air transportation were not necessarily synchronized.

Key words: product lifecycle, modal choice, structural equations

1. Introduction

Japan has experienced several economic phases over the past 20 years, including the "bubble" economy (around the year 1990), followed by a long-term recession that was described as a "lost twenty years" including a "deflation-spiral," the "inflation of crude oil (early in 2008)" and the "Lehman shock in 2008" during which many companies that had led industries in Japan went bankrupt or re-organized. During this "lost twenty years," stock prices fell and the Japanese yen became stronger with time.

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These trends were followed by an increase in Japanese companies' foreign investments in Asian countries such as China, Thailand, Indonesia, and Vietnam, and by the re-location of some companies' headquarters and/or factories in foreign countries. During the same period, Japan's economy became dependent on imports rather than exports, and its international trading balance became negative due to the increase in imports, especially from East Asian countries.

In accord with these shifts of Japanese economic activities from domestic to international markets, manufacturers and their relevant companies had to construct international logistics systems which have played important roles in their supply chain management: some companies have relegated the operation of their international logistics or supply chain management (SCM) to third-party logistics providers, while other companies have internalized these operations. For example, Toyota Motor Corp. manufactures and assembles car parts that are commonly used over its product lineup such as wire harnesses, brake pedals, and antennas, in Vietnam. The in-process goods are then imported into Japan to finalize the cars' assemblies.[1] It is commonly known that some manufacturers relegate these logistics activities to the logistics-service providers (LSPs) that originate in shipping companies, freight forwarders, and airlines. Air freighters such as FedEx and UPS have constructed high-quality SCM systems called integrators, but not many manufacturers that produce middle-or lower-quality goods use integrators; instead, in light of the valuations of their cargo, they use LSPs.

In any case, regardless of whether a manufacturer chooses an LSP or an integrator, the manufacturer must decide which transportation mode to use for trans-ocean and/or trans-continental exports or imports, by negotiating with LSPs. Focusing on Japan's case, the transportation modes for international export/import are limited to air and seaborne transportation, since Japan has no land-based link to the continents.

The shippers must bear higher expenditures when they need to have products shipped quickly, since short-time delivery needs the speed afforded by air transportation, which generally costs more than sea shipping. According to traditional international trade theories such as the Heckscher–Ohlin model, a commodity with comparative cost competitiveness is exported to a foreign country. In such a case, it is natural to expect that this commodity will be exported by sea in order to take advantage of comparatively low tariff rates. However, it is possible for the generalized cost of seaborne transportation to exceed that of air transportation due to the opportunity costs of missing business chances, high interest rates, and high insurance costs that

[1] The author's interview at Toyota Motor Vietnam, Hanoi, Vietnam in July 2008.

accompany long voyages. Shippers may thus choose air transportation when the generalized cost of air transportation is cheaper than that of seaborne transportation. If we think of shippers' choices of air or seaborne transportation based on the idea of generalized costs mentioned above, the valuation of a commodity is not the absolute determinant of air or seaborne transportation.

In this paper we reduce the idea of a product lifecycle to the overtime changes in the valuations of commodities, and we then analyze whether the product lifecycles match the changes in air ratios for the cases of import and export. The methodologically outstanding features of our analyses are having bridged the following three ideas: the idea of ordinary export/import functions, the air ratio that is much concerned with conditional factors demanded of air transportation, and the idea of the product lifecycle. We regressed the air-ratio variable on cargo-valuation dummy variables as well as other variables common for supply and factor demand scenarios.

The cargo valuation variables are a series of dummy variables, and "peak year dummy" takes the value 1 when a certain type of commodity is at its peak valuation, and the "one-year post-peak dummy" takes the value 1 for the next year of the peak year. The series of peak year dummies consists of five types: two years before, one year before, the peak, one year after, and two year after the peak. By estimating and testing the hypothesis of the coefficients of these dummies, we can approximate how long each stage of the product lifecycle lasts for exports and imports in Japan's case. In the following section we review previous studies of the pricing (i.e., freight rate) theory of cargoes and product lifecycle management. In Sections 3 and 4 we demonstrate our empirical model and the dataset, respectively, and in Section 5 we carry out the econometric analysis based on the models and data in Section 3. We also evaluate the empirical results, and in Section 6 we summarize the contributions and limitations of our study.

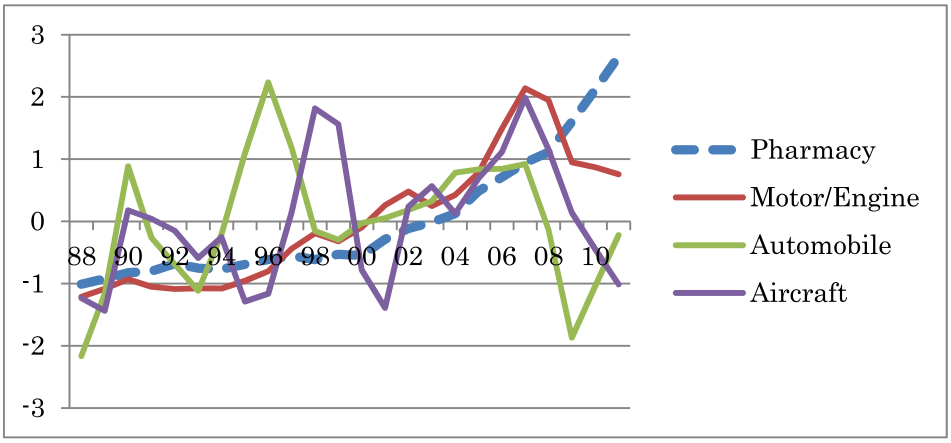
2. Literature review of cargo pricing theory and product lifecycle management

The pricing rule for air and seaborne cargoes is explained by traditional microeconomics theory. Benathan and Walters (1969) showed that the price elasticity of cargo demand could be derived by multiplying the "price elasticity of a commodity in a destination market" by the "freight rate that traffic can bear." The freight rate that traffic can bear is the generalized cost of transportation divided by the valuation of the cargo. That study implied that the prices of cargoes are determined by the price-discrimination rule and the handling costs of commodities.

Klepper (1996) developed a model that explained the industry's evolution from its birth to maturity and theoretically showed the mechanism underlying how the product lifecycle takes place and is terminated. He pointed out that the size of the firms play an important role in the next innovation; e.g., a large firm that had sufficient budget would supply products with lifecycles. Miyashita (2009) stated, based on the results of his several empirical studies, that shippers chose seaborne logistics only, or both seaborne and air in a complementary manner, or air only. He bridged these modal choice behaviors with the product lifecycle theory.

Before Miyashita (2009), Miyashita (1988) in an early study assumed that the nominal price indices include the time trend while actual price indices convey a cyclical movement of prices. He also assumed that while the small amount of high valuation and time-sensitive goods was transported by air, the large amount of low-valuation goods are more commonly moved by a seaborne service. In this sense, Miyashita (1988) assumed that each commodity or bundle of commodities followed a different lifecycle track. Figure 1 illustrates that cargo valuations change cyclically for certain cases (except for medicines) that show an exponential trend only (dotted line). We thus partially accept and partially do not Miyashita's contentions as we survey the time-series dimension of our dataset. In this paper, we will assume Klepper's idea that the commodities of large industries follow the product lifecycles. We then highlight the characters of lifecycles of specific commodities, and we test the hypothesis that the commodities at their peak valuation are transported by air and those at their birth and maturity are shipped by sea.

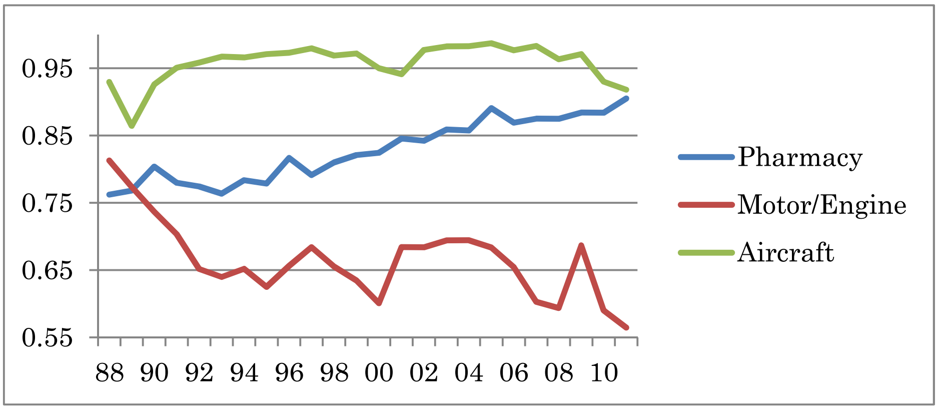
Fig. 1. Time series changes in commodities' valuations (import case).



The vertical axis shows the standardized (mean=0) valuations. The horizontal axis shows the fiscal years.

In addition, although Miyashita (1988) stated that the air ratio itself has a characteristic of a cyclical change in a particular level between 0 and 1, Figure 2 shows that the air ratio (see Section 3) also has both cyclical and time-trend characteristics (especially medicine with positive trend and motor with negative trend).

Fig. 2. Changes in the air ratio with/without trend (import case).



The virtual axis shows the standardized valuations. The horizontal axis shows the fiscal years.

In summary, we have four categories concerning the relationship between commodity valuations and the air ratio (Table 1).

Table 1. Classification of commodity samples with/without trend or cycle

	Cycle	No cycle
Trend	Pharmacy (air ratio), Engines (valuation, air ratio)	Pharmacy (valuation)
No Trend	Aircraft (air ratio, valuation) Automobile (valuation)	

Commodities indifferent of peaks/off-peaks such as gold precious stones are omitted from the present analysis. The words in parentheses at the top-left partition indicate the air ratio of pharmacy changes with cycles and trends. Engines' air ratio and valuation also change with cycles and trends.

Regarding the commodities in Table 1, we can imply that air and seaborne service are substitutes for commodities with cycles and no trend, and complement for commodities with both cycles and trend. In this case, the up-slope trend is caused by technical progress and/or increases in individual income or the GDP. Considering these facts regarding commodities' characteristics, we will have to incorporate the idea of commodity-specific analyses into our empirical models such as commodity-fixed effects.

Vernon (1966)'s product lifecycle theory followed by Vernon (1979 consists of three stages: new product, maturing product, standardized product. Miyashita (1994) added one more stage to this theory: rationalized product. He empirically studied the systems of inter-regional cargo flows by associating the idea of product differentiation with the air ratio. However, the relationships between the peak of the air ratio and the product lifecycle were not analyzed. Here we try to analyze how and to what extent the product lifecycle will be reflected by the air ratio for commodities. We do not perform an origin/destination-specific analysis, in order to maintain a sufficient number of samples in a sense of statistics.

3. The model

In this section, we first construct the export/import air ratio functions together with traditional export/import functions. The definition of the air ratio (AR_{it}^{k}) is as follows:

$$AR_{it}^{k} = \frac{\mathrm{ACV}_{it}^{k}}{\mathrm{ACV}_{it}^{k}+\mathrm{SCV}_{it}^{k}} \quad (k = import\ or\ export, i = commodity, t = year) \tag{1}$$

where ACV_{it}^{k} and SCV_{it}^{k} are the commodity valuations that are exported/imported by air or sea. The determinants of this air ratio can be approximated by deriving the conditional factor demand, because both air and seaborne services are input demands of shippers. Assuming that competitive Japanese shippers (here, importers) minimize their costs subject to a certain fixed amount of cargo, the conditional factor demands can be obtained by taking the first order condition of Lagrange function (Eq. (2)) in terms of inputs ($x_i{}'s$) and a Lagrange multiplier(φ), and a second-order condition such that the Hessian matrix composed of the second-order differentiated terms is positive definite.

$$\min_{x_1,\cdots,x_j,\varphi} L = \sum_{i=1}^{j} w_i x_i + \varphi\{Q^*(x_i)\} \tag{2}$$

The conditional factor demands for x_j can be written in the generalized form:

$$x_j = f\{(+)Q,\ (-)w_j, (+)\textstyle\sum_{-j} w_{-j}\} \tag{3}$$

where Q is the cargo traffic, and w_j and w_{-j} are the input prices. The plus and minus in the parentheses are expected signs assuming that an input is a substitute for the others. In our study, w_j and w_{-j} are assumed to be the valuations of air and seaborne services, that is, ACV_{it}^{k} and SCV_{it}^{k}, and the determinants of the air ratio will be Q, w_j and w_{-j}. In the case of exports, the air ratio function is similar to that of imports; it is a conditional factor demand function from the viewpoint of other countries. Next, we will specify the sign of w_j in the air ratio function. Again,

$$AR_{it}^{k} = \frac{\mathrm{ACV}_{it}^{k}}{\mathrm{ACV}_{it}^{k}+\mathrm{SCV}_{it}^{k}} = \frac{w_j}{w_j+w_{-j}} \tag{1'}$$

and if we assume that the production technology follows the Cobb-Douglas form, such as:

$$Q^* = x_j x_{-j} \tag{4}$$

From the first-order condition of Lagrange function (Eq. (2)), we obtain:

$$w_j = \varphi x_{-j} \text{ and } w_{-j} = \varphi x_j \tag{5}$$

The conditional factor demands that we obtain by the first-order condition of Eqs. (2) and (4) are as follows:

$$x_j = \left(\frac{Qw_{-j}}{w_j}\right)^{\frac{1}{2}} \text{ and } x_{-j} = \left(\frac{Qw_j}{w_{-j}}\right)^{\frac{1}{2}} \tag{6}$$

Substituting Eqs. (5) and (6) into Eq. (1)', we obtain:

$$AR_{it}^k = \frac{x_{-j}}{x_j + x_{-j}} = \left(\frac{RefP_t^{\frac{air}{sea}}}{RefP_t^{\frac{air}{sea}} + \frac{1}{RefP_t^{\frac{air}{sea}}}}\right)^{\frac{1}{2}} \tag{7}$$

where $RefP_t^{air/sea}$ is the ratio of air/sea cargo valuations $\left(that\ is, w_j/w_{-j}\right)$.

Taking the derivative of Eq. (7) with respect to $RefP_t^{air/sea}$, we obtain:

$$\frac{\partial AR_{it}^k}{\partial RefP_t^{\frac{air}{sea}}} = \left\{1 + \left(RefP_t^{\frac{air}{sea}}\right)^2\right\}^{-\frac{3}{2}} > 0 \tag{8}$$

Therefore, the sign of air valuation variable is positive in the air-ratio function.

Our import and export functions are constructed by following ordinary microeconomic theory. The import function can be derived by assuming that Japan maximizes its utility subject to the budget constraint in each year. The explanatory variables are imported commodities' prices, domestic prices, income (the nation's buying power), and the exchange rate as a control variable. The import function of general form goes as follows:

$$Q_{it}^k = \left\{(+)\frac{JGDP_t}{PJ_{it}^k}, (-)\frac{JPNyen_t}{USD_t}, (+)\frac{PJ_{it}^k}{PW_{it}^k}\right\} \tag{9}$$

where QI_{it}^k is the imported cargo of commodity i in year t, $JGDP_t$ is Japan's GDP in year t deflated by the retail price index, $JPNyen_t$ is the Japanese yen in year t, USD_t is the U.S. Dollar in year t, PJ_{it}^k is the price of domestic goods in year t deflated by the retail price index, and PW_{it}^k is that of foreign goods in year t. "K" denotes either import or export, and here "K" means import. As for $\frac{PJ_{it}^k}{PW_{it}^k}$, we used the import price index for PW_{it}^k. As for PJ_{it}^k, we prepared Japan's retail price index and Nikkei stock price index, and used the one better fitted from the statistical viewpoint.

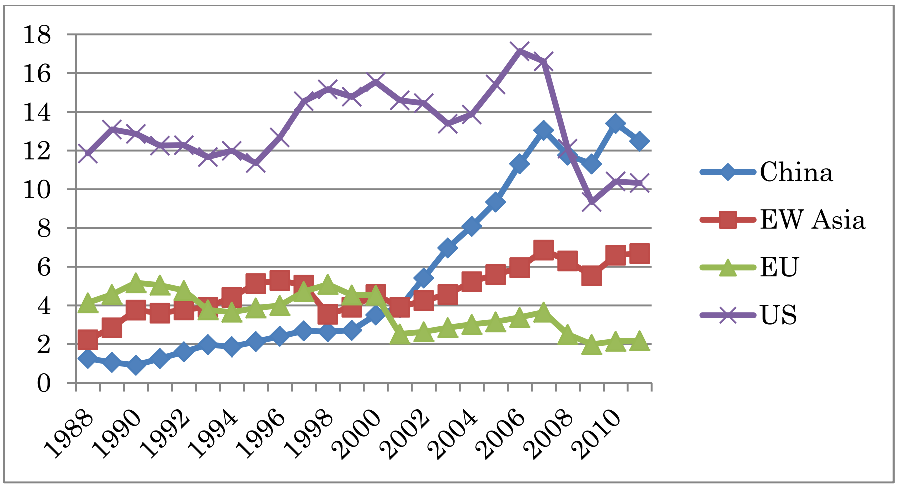
In Eq. (9), the sign of PJ_{it}^k cannot be specified if we take the logarithm, since one is in the denominator and the other is in the numerator. Therefore, this is the empirical issue.

The typical export function can be derived just by replacing Japan's "J" with world's "W", and here "*K*" means the export.

$$Q_{it}^{k} = \left\{(+)\frac{WGDP_t}{PJ_{it}^{k}}, (-)\frac{JPNyen_t}{USD_t}, (+)\frac{PW_{it}^{k}}{PJ_{it}^{i}}\right\} \quad (10)$$

In Eq.(10), $WGDP_t$ is the "system-wide" GDP in the world exempting Japan in year *t*. Japan used to export goods mainly to the U.S. and Europe, and has more recently been exporting to China and South-East Asian countries (Fig. 3).

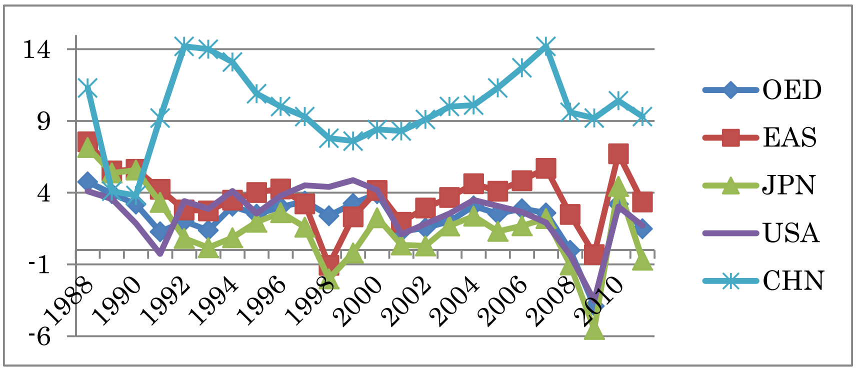
Fig. 3. Changes in total valuations of commodities exported from Japan



The vertical axis indicates U.S. dollars (billion) and the horizontal axis is fiscal years. Source: Ministry of the Treasury, Japan.

The GDPs of Japan's "long-run" trading partners have moved almost the same ways, but China has shown a different growth rate curve (Fig. 4). The correlations among these countries or regions' GDP grows rates are shown in Table 2.

Fig. 4. GDP growth rates of each country/region



OED, OECD countries; EAS, Eastern Asia; JPN, Japan; USA, the United States; CHIN, China. Source: World Bank.

Table 2. Correlation coefficients among countries/regions' GDP growth rates

	OED	EAS	JPN	USA	CHN
OED	1.000				
EAS	0.648**	1.000			
JPN	0.783**	0.902**	1.000		
USA	0.881**	0.293	0.446*	1.000	
CHN	−0.068	0.068	−0.159	0.060	1.000

**: significant at 1% level, *: at 5% level. Abbreviations are explained in Fig. 4.

With this replacement, Eq. (10) will be Japan's supply function to the world. The modified version of Eq. (10) is as follows:

$$Q_{it}^{k}=\left\{(+)\frac{JGDP_t}{PJ_{it}^{k}},(-)\frac{JPNyen_t}{USD_t},(+)\frac{PW_{it}^{k}}{PJ_{it}^{i}}\right\} \tag{11}$$

and again let PW_{it}^{k} be a numeraire. Eq. (6) will be rewritten as follows:

$$Q_{it}^{k}=\left\{(+)\frac{JGDP_t}{PJ_{it}^{k}},(-)\frac{JPNyen_t}{USD_t},(-)PJ_{it}^{i}\right\} \tag{12}$$

Unlike Eq. (9), the sign of PJ_{it}^{k} will be specified as being negative if we take the logarithm.

When Japan's shippers think of trading goods with foreign countries, they have to consider which transportation mode they choose, air or seaborne. Following this simultaneous decision-making by shippers, we construct system-equation models that go as follows:

(1) System of import function

$$\ln(Q_{it}^{import})=a_0+a_1 ln(JGDP_t)+a_2 ln\left(\frac{JPNyen_t}{USD_t}\right)+a_3 ln\left(PJ_{it}^{k}\right)+a_3 ln\left(PW_{it}^{k}\right)$$
$$+a_{5m}\sum_m DCOM_m+e_t \tag{13}$$

$$\ln(AR_{it}^{import})=b_0+b_1 ln\left(Q_{it}^{import}\right)+b_2 ln\left(RefP_t^{\frac{air}{sea}}\right)+b_{3\tau}\sum_\tau DVAL_\tau$$
$$+b_{4m}\sum_m DCOM_m+u_t \tag{14}$$

(2) System of export function

$$\ln(Q_{it}^{export})=\alpha_0+\alpha_1 ln(JGDP_t)+\alpha_2 ln\left(\frac{JPNyen_t}{USD_t}\right)+\alpha_3 ln\left(PJ_{it}^{i}\right)+\alpha_{4m}\sum_m DCOM_m+\varepsilon_t \tag{15}$$

$$\ln(AR_{it}^{export})=\beta_0+\beta_1 ln\left(Q_{it}^{export}\right)+\beta_2 ln\left(RefP_t^{\frac{air}{sea}}\right)+\beta_{3\tau}\sum_\tau DVAL_\tau$$

$$+\beta_{4m} \sum_m DCOM_m + \mu_t \quad (16)$$

where $DVAL_\tau$ is the dummy variable that denotes the product lifecycles. $DVAL_0$ takes 1 when the valuation of commodities was at its peak, $DVAL_{-1}$ takes 1 for one-year before the valuation of commodities was peak, $DVAL_1$ takes 1 for one-year after, etc. We have five $DVAL_\tau$ variables, and subscript τ starts with -2 and ends with 2. $DCOM_m$ is the commodity-specific fixed effect dummy variable, and "m" denotes the type of commodity such as pharmaceuticals, semi-conductors, etc.

4. The data

We collected the data from Japan's custom classification statistics maintained by the Ministry of the Treasury. Retail price indices, standardized by the average of samples, were obtained from World Economic Outlook Databases (IMF). The dataset of exports is the unbalanced panel data of 14 commodities for a 24-year period. The number of sample observations should thus be 336, but the data of chemical powder for the years 1988–89, 1992–93 and 2011 and those of nonferrous junk materials for 1988, 1994, and 1995–96 are unavailable, so the number of whole sample observations is 327. The commodities used here were the ones classified by five-digit category in the custom classification. The dataset of imports is also the unbalanced panel data of 18 commodities for 24 years. The total sample observation should be 432, but the 1998 data of the pulp and paper industry are missing. The number of sample observation is thus 431. Table 3 is the descriptive statistics of continuous variables.

Table 3. Descriptive statistics of continuous variables

Variables	Average	S.D.	Minimum	Maximum	Median
Import air ratio	0.374	0.299	0.008	0.991	0.301
Export air ratio	0.377	0.348	0.007	0.999	0.226
Import cargo volume (000t)	59191.1	152700.5	3.1	834928.8	1173.4
Export cargo volume (000t)	51623.6	121044.3	0.1	651568.2	535.1
Import reference price (air/sea, Yen)	118.5	450.7	0.8	5641	9.6
Export reference price (air/sea, Yen)	364.2	1833.0	0.001	19431.8	15.0
Net GDP (Billion yen)	47	3.6	38.2	52.4	47.5
Nikkei price index (Yen)	16937.1	6545.2	9426.7	34579.8	16394.3
Exchange rate (Yen against USD)	114.2	15.7	79.8	144.8	113.9
Total population (000)	126280.1	1628	122745	128057	126926
Import price index (Yen)	96.5	14	79.6	133	93.8
Export price index (Yen)	101.4	23.5	37	137.5	103.7

S.D.: standard deviation.

5. Empirical results

Firstly we estimated simultaneous equations (13) and (14) by generalized two-stage least squares (G2SLS) detecting that there exists heteroscedasticity.[2] The result is shown in Table 4.

Table 4. Estimated results for cargo import and air ratio functions

	Variables	Coefficients	t-ratio	t-test
Cargo import function				
Log of	Japan's GDP	2.028	4.095	***
	Yen/USD	−0.057	−0.426	
	Import Price Index (nominal)	−0.236	−1.341	
	Nikkei stock prices	0.315	4.257	***
Dummy variables of	Fat of animal origin	−1.937	−35.983	***
	Pharmacy	3.590	46.376	***
	Essential/cosmetic oils	−1.776	−14.816	***
	Chemical powder	−4.695	−165.680	***
	Leather/Leather goods	2.645	41.701	***
	Strings for clothes	5.412	152.430	***
	Cotton clothes	6.073	86.147	***
	Wool clothes	2.862	68.212	***
	Silk clothes	2.524	32.307	***
	Synthetic fibers	3.521	99.555	***
	Precious/semi-precious stones	−0.258	−5.207	***
	Motors/engines	−2.509	−19.145	***
	Pulp/paper products	−5.258	−69.281	***
	Cars/car parts	−4.157	−60.806	***
	Airplane/airplane parts	−5.729	−139.700	***
	Ship/ship parts	−2.092	−17.938	***
	Constant	−4.608	−1.901	*
Import air ratio function				
Log of	Cargo valuation ratio (air/sea)	0.217	6.683	***
	Import cargo volume	−0.436	−13.185	***
	Japan's GDP	1.369	5.626	***
Dummy variables of	Two year before the peak	0.042	0.475	
	One year before the peak	0.072	0.937	
	Peak year of commodity's valuation	0.045	0.679	
	One year after the peak	−0.120	−1.894	*
	Two years after the peak	−0.179	−2.528	**
	Fat of animal origin	−0.770	−9.933	***
	Pharmacy	3.985	16.007	***

[2] We carried out the heteroscedasticity test for both export and import cases. The Breusch and Pagan chi-square value of import function, export function, import air ratio function and export air ratio function are 191.90(22),145.37(16),427.39 (22), and 159.20(16), respectively. The degrees of freedom are in parentheses, and all the null hypotheses of homoscedasticity were rejected at 1% level.

	Essential/cosmetic oils	0.796	7.157	***
	Powder	−1.267	−10.871	***
	Leather/Leather goods	3.197	12.751	***
	Strings for clothes	1.790	5.175	***
	Cotton clothes	3.535	10.149	***
	Wool clothes	3.763	12.224	***
	Silk clothes	3.230	11.622	***
	Synthetic fibers	2.347	8.364	***
	Precious/semi-precious stones	1.965	27.295	***
	Nonferrous metals	1.160	14.043	***
	Motors/engines	1.033	14.953	***
	Automobiles /car parts	−0.471	−3.965	***
	Ship/ship parts	−1.138	−6.341	***
	Post Lehman Brothers shock	−0.169	−3.840	***
	Constant	−6.404	−6.689	***
G2SLS estimation, R-Square of import function=0.991, R-Square of import air ratio function=0.920, n=431. The benchmark of the fixed effect dummy variable is meat. t-test results:*** is significant at 1%, ** at 5%, and * at 10% level.				

The import function shows the correct sign, although the exchange rate and the export price index are not significant. The air ratio function also shows comprehensive results. It tells that in the case of imports, Japanese industries tend to use seaborne transport. The parameter of cargo-valuation ratio shows a positive sign as is fixed in Eq. (8). We have five dummy variables of commodity valuation, and the first three are not statistically significant. This result means that high valued commodities are not necessarily transported by air in the case of imports. In addition, the fourth and the fifth dummy variables (that is, one year after the peak and two years after the peak) indicate that as the commodities become matured or standardized, they are transported by sea.

Our next interest is in the case of exports. Table 5 indicates the estimated results of cargo export function and export air ratio function.

Table 5. Estimated results of export and air ratio functions

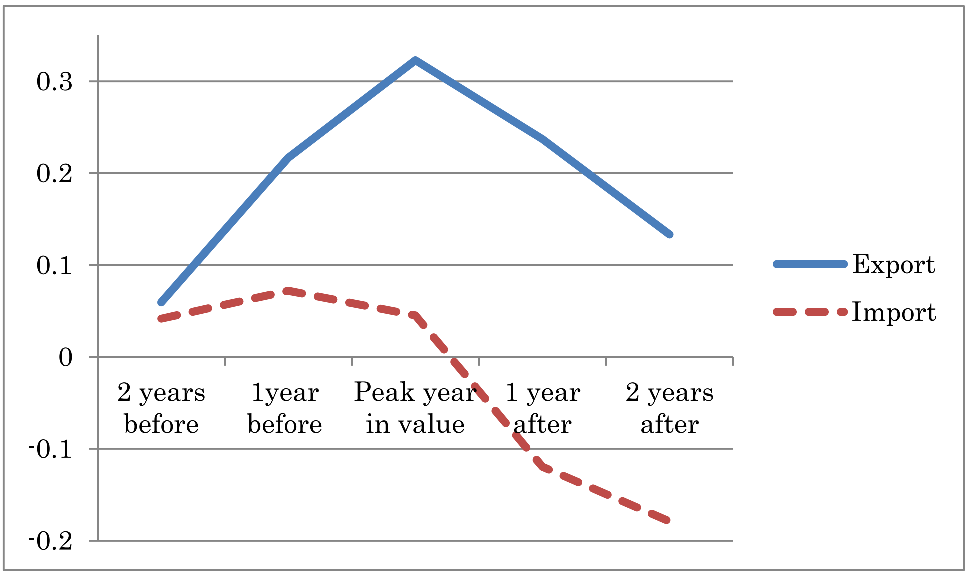
Cargo export function				
	Variables	**Coeff.**	**t-ratio**	**t-test**
Log of	Export price index (deflated by average of RPI)	−1.558	−5.040	***
	Japanese yen/USD	0.504	2.523	**
	Japan’s GDP	2.405	4.422	***
Dummy variables of	Raw fish	4.346	19.868	***
	Meat	5.680	16.896	***

	Pharmacy	10.091	29.897	***
	Chemical Powder	−0.420	−1.291	
	Strings for clothes	4.781	13.903	***
	Pearl	10.696	32.361	***
	Nonferrous metals	6.272	18.644	***
	Motors/Engines	6.272	18.644	***
	Pulp/Paper products	2.422	7.081	***
	Audio Apparatus	10.228	30.035	***
	Loud speakers, microphone	12.353	34.184	***
	Semi-conductors	11.669	33.593	***
	Gold	3.970	11.343	***
	Constant	−15.456	−3.521	***
Export air ratio function				
Log of	Export cargo volume	0.918	7.370	***
	Cargo valuation ratio (air/sea)	0.109	4.332	***
Dummy variables of	Two years before the peak	0.141	0.830	
	One year before the peak	0.255	2.209	**
	Peak year of commodity's valuation	0.350	2.442	**
	One year after the peak	0.242	2.528	**
	Two years after the peak	0.959	0.723	
	Raw fish	−4.129	−7.672	***
	Meat	−5.724	−9.566	***
	Pharmacy	−6.904	−6.019	***
	Strings for clothes	−4.411	−8.425	***
	Pearl	−7.239	−5.998	***
	Nonferrous metals	−4.787	−7.031	***
	Motors/engines	−4.787	−7.031	***
	Pulp/paper products	−1.996	−7.991	***
	Audio Apparatus	−7.248	−5.948	***
	Loud speakers, microphone	−9.673	−6.372	***
	Semi-conductors	−7.910	−5.556	***
	Gold	−0.760	−1.732	*
	Constant	−9.161	−8.978	***
G2StLS estimation, R-Square of export function =0.985, R-Square of export air ratio function =0.739, n=327. The benchmark of fixed effect dummy variable is junk/scrap of metallic/mineral. T-test results:*** is significant at 1%, ** at 5%, and * at 10% level.				

The positive sign of Japanese yen/US dollar means that as the Japanese yen is weaker against the US dollar, the export increases. Contrary to the case of imports, Japanese shippers tend to export by air. Also contrary to the parameters of the dummy variables of imported cargo valuations, the shippers choose air transportation one year before the peak of their cargo values, the peak year, and followed by one year after the peak. Therefore, commodities at their peak or adjacent to peak valuations in their product lifecycle tend to be transported by air.

Figure 5 shows the changes in the coefficients of valuation dummy variables for both import and export cases. It is apparent that the lifecycle of export cargoes changes on a single-year basis, and it appears that the lifecycle of export cargo from the births of commodities to the maturities continues beyond five years. The import cargoes (dotted line) have relatively short lifecycles, and even in the time of highest validation, they are not always transported by air. If we regard these import cargoes as matured and/or standardized commodities, it is natural to think that they already experienced or did not have a high-valuation phase. The more these commodities lost their value, the more they were transported by sea. In addition, it is inferred from the idea of product lifecycle that these matured commodities may not be traded since they may not stand even the price of the seaborne mode's low fares, and then their production is ceased.

Fig. 5. Lifecycle of cargo valuation and choice of air/seaborne transportation.



The vertical axis shows the coefficients of the series of cargo valuation variables.

6. Conclusion

The empirical contribution of this paper is that we demonstrated that the more cargoes were imported to Japan, the less they were transported by air, whereas the opposite result was obtained in the case of exports. In addition, the outstanding feature of this paper is that we showed the relationship between the idea of product lifecycle and air ratios. We approximated the idea of product lifecycle to the overtime-increase and decrease in cargoes' valuations. We found that the product lifecycle of cargo outgoing from Japan exactly matched the upward and downward move of the air ratio (the bold line in Fig. 5). On the other hand, the product lifecycle of incoming cargos were not in line with the changes in air ratio. As we mentioned above, since incoming cargos have been transported by sea, we can regard them as matured and/or standardized commodities, as we can see in Table 4. If so, these commodities have no peak valuation. Therefore, their product lifecycle changes were not synchronized with the changes in air ratio, and the more matured these commodities were, the more they are transported by sea (dotted line in Fig. 5).

From the national economic perspective, it is implied that the high-tech industries would choose air transportation; these industries are better located adjacent to international (cargo) hub-airports. In addition, since shippers choose air or seaborne service depending on the phase of the product lifecycle of their commodities, it would be better for airports and seaports to collaborate in order to facilitate shippers' choices and minimize shippers' transaction costs when they export or import.

Our analysis might be useful for the cases of other island countries such as Australia, New Zealand, Taiwan, the Philippines, etc. Of course, our study has the following limitation: we did not perform an origin/destination-specific analysis. Although the sample number will decrease if we do so, the estimated results may change between countries and economy blocks. Therefore, our results might be understood as "on average" analyses between Japan and other countries. We will continue our study to address this limitation.

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