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A non-structural approach to assess competitive conditions in container liner shipping market: 2009–2014

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Abstract: This paper aims to assess the demand elasticities and competitive conditions in container liner shipping (henceforth: CLS) market. Using a dynamic model, the regression results reveal that the degree of competition measured by Panzar-Rosse (P-R) H statistic varies from 0.37 to 0.97 for the period of 2009 to 2014. It implies that CLS market can be described as displaying monopolistic competitive behaviour. The conclusion is consistent with previous studies conducted for earlier periods; moreover, the increasing trend of P-R H statistic value implies increasing degree of competition in the industry. The findings contribute to the understanding of theoretical explanation of competitive condition in latest CLS market. Unlike other studies, this paper establishes a dynamic model that makes it possible to measure both short-run and long-run effects.

Keywords: container liner shipping; CLS; shipping market; demand elasticities; competitive conditions; monopolistic; competitive; competition degree; non-structural; Panzar-Rosse h-statistic; dynamic model; shipping; transport; logistics; short-run effects; long-run effects.

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1 Introduction

Since the ideal-X was modified to be the first container ship in 1956, container liner shipping (CLS) has developed rapidly in the ensuing 60 years. Endured both golden times and periodical recessions over long history, the industry has been experiencing dramatic shuffling especially in past few years. Formation of large alliances¹ makes slot sharing easier in and across alliances, average number of operators and slot charterers per service has increased significantly. It is of relevant parties' great interest to understand the competitive conditions in CLS market.

Hirata and Murakami (2015) study CLS market empirically and suggest that CLS is contestable during 2009 to 2011. However, the degree of competition is not discussed in their research. This paper aims to assess the competitive condition basis on their research finding.

Methods to assess competitive conditions are often divided into two main streams: structural and non-structural approaches (Bikker, 2004). Structural methods are based on the structure-conduct-performance paradigm of Mason (1939) and Bain (1951), which predicts that more concentrated markets are more collusive. In structural models, competition is proxied by measures of concentration, such as the Herfindahl-Hirschman index (HHI).

Non-structural methods are derived from profit maximising equilibrium conditions. One of the well-known non-structural approaches is P-R H statistic developed by Panzar and Rosse (Rosse and Panzar, 1977; Panzar and Rosse, 1987). P-R H statistic is estimated as the sum of the elasticities of the reduced form equilibrium revenue with respect to input prices. P-R H statistic has been primarily applied in banking industry to assess competitive conduct, often in specifications of controlling for firm scale or using a price equation (for example, Shaffer, 1982, 1983; Neave and Nathan, 1991; Yildirim and Philippatos, 2007; Bikker et al., 2012).

This paper applies to the implications of P-R H statistic to assess the degree of competition in CLS market. The key objectives are to

- 1 estimate the short-run and long-run elasticities
- 2 assess the degree of competition in CLS market
- 3 provide regulation party and policy makers with theoretical evidence of market structure in CLS industry.

The rest of the paper is organised to achieve specific objectives as follows. Section 2 reviews the literature on competitive conditions in CLS market. Section 3 discusses the applied research methodology, which is devoted largely to the alternative way of obtaining P-R H statistic. Section 4 discusses statistical methodology to obtain short-run and long-run demand elasticities. Section 5 describes the data, Section 6 presents the estimate results and Section 7 contains a summary.

2 Literature

Studies taking structural approach observe different competition structures in different CLS routes overtime. Some scholars, (e.g., Bailey, 1981; Baumol, 1982; Davies, 1986) suggest that CLS market is contestable: a carrier can enter or leave rapidly any market

with minimal sunk cost and potential competitors have the same cost function as incumbent. In other words, entry and exist barrier to the market is close to free, which matches the conditions of contestable market. Miyashita (2002) and Sys (2009) test the impact of HHI and suggest that CLS market is contestable in some routes but oligopolistic in some others in 1990s and 2000s. Hirata and Murakami (2015) suggest higher HHI does not lead to more collusion and CLS market is highly contestable during 2009 to 2014.

Corresponding with the results from structural based research, studies taking non-structural approach also suggest CLS market is competitive. Endo (2005) estimates P-R H statistic for top three Japanese line companies (NYK Line, MOL, K-Line) during 1986 to 2002. The author defines a logarithm linear model derived from inductive revenue function with capital costs, labour costs, operation costs and deflated GNP as independent variables. The P-R H statistic obtained is 0.54, indicating that the top three Japanese container companies were unable to act as cartel, but rather operated in monopolistic competitive condition during the period for consideration.

Sys et al. (2011) investigate the competitive conditions in CLS industry for the period 1999 to 2008 for a sample of 18 container liner companies. The authors find the P-R H statistic during the ten years varies from 0.68 to 0.87, which suggests that CLS industry operates in a monopolistic competitive environment.

Study taking non-structural approach for 2009-onward period is not present. This paper aims to fill the gap by extending the research period to 2009 onwards. In addition, unlike the literature reviewed that apply static model, this study establishes a dynamic model that allows measurement to both short-run and long-run effects.

3 Methodology

P-R H statistic is based on the estimation of the reduced form revenue equation of the market participants $R(z, y, w)$, with z denoting exogenous variables shifting the firm's revenue function, y denoting exogenous variables shifting the firm's cost function and w representing factor prices. The reduced form equation is derived from marginal revenue, cost functions and the zero profit constraint in equilibrium. The gist of this approach is to estimate the elasticities of total revenues of the individual firm with respect to the firm's input prices. P-R H statistic is defined as,

$$H = wR_w / R = R_q^2 / \prod_{qq} R \quad (1)$$

where \prod is the profit function, R is the revenue function, w is a vector of input prices, q is the output quantity and subscripts denote partial derivatives.

The H-statistic ranges from minus infinity to unity. If firms' pricing policies are consistent with the model of monopoly or a perfect colluding oligopoly, H is negative. In long-run equilibrium, the market structure is characterised by monopolistic competition if H is positive but less than unity; and by perfect competition if the H-statistic equals unity. Table 1 summarises the properties of P-R H statistic.

As input prices in CLS sector are rarely publicised, it is difficult to estimate P-R H statistic through input prices. An alternative way of obtaining P-R H statistic is to use

demand elasticity. Let e denotes the firm's demand elasticity, Shaffer (1982, 1983) demonstrates.

$$H = e + 1 \quad (2)$$

The steps to derive the equitation are summarised in Appendix.

Next, extend the approach to market level. A firm's demand elasticity can be interpreted as the ratio of its percentage change in output (q) to its percentage change in price (p).

$$e = \% \Delta q / \% \Delta p \quad (3)$$

Denotes the elasticity of demand across the entire market or industry as E

$$e = \% \Delta Q / \% \Delta P \quad (4)$$

where Q and P denotes the aggregate output and price of all firms in the market, respectively.

CLS market is competitive, (e.g., Sys et al., 2011; Hirata and Murakami, 2015; Hirata, 2017). Formation of large alliances makes slot sharing easier in and across alliances (Hirata and Murakami, 2015). All carriers respond to changing cost and demand conditions by altering their output quantities. This is possible because carrier can easily purchase slots from other carriers in alliance or charter laid-up vessels to increase capacity supply, withdraw a number of sailings to reduce supply. This implies $\% \Delta q = \% \Delta Q$ and $e = E$. Thus, given the market demand elasticity defined, H statistic of the industry can be expressed as,

$$H = E + 1 \quad (5)$$

Table 1 Properties of the H statistic

<i>H statistic</i>	<i>Competitive environment test</i>
$H < 0$	Monopoly disequilibrium Oligopoly disequilibrium
$H = 0$	Monopoly equilibrium Perfect colluding oligopoly
$0 < H < 1$	Monopolistic competition Perfect competition with constant average cost curve
$H = 1$	Perfect competition Natural monopoly in a perfectly contestable market Sales maximising firms subject to breakeven constraints

Source: Author compiled from Rosse and Panzar (1977), Shaffer (1982, 1983), Nathan and Neave (1989), Neave and Nathan (1991) and Bikker et al. (2012)

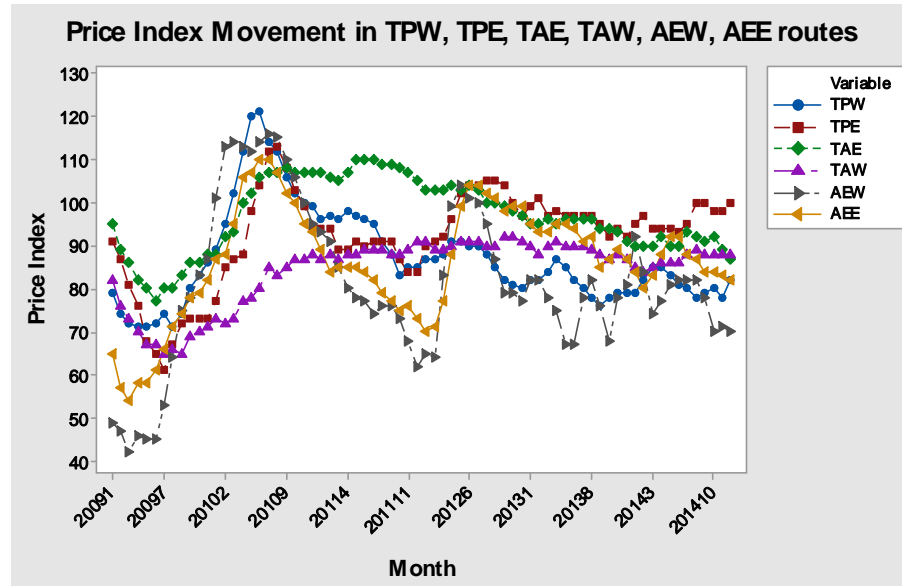
4 Demand elasticities

Container shipping routes can be divided into three main groups (UNESCAP, 2007):

- 1 East-west trades, which circle the globe in the Northern Hemisphere linking the major industrial centres of North America, Western Europe and Asia.
- 2 North-south trades articulating around major production and consumption centres of Europe, Asia and North America and linking these centres with developing countries in the Southern Hemisphere.
- 3 Intraregional trades operating in shorter hauls.

This paper discusses the routes in the east-west trades, which are of the largest market size in the three groups. Demand elasticities are different in the six east-west routes (markets), namely Trans-Pacific Eastbound (TPE), Trans-Pacific westbound (TPW), Asia-Europe eastbound (AEE), Asia-Europe westbound (AEW), Trans-Atlantic eastbound (TAE) and Trans-Atlantic westbound (TAW). Figure 1 and Figure 2 demonstrate price (freight rate) and demand quarterly movement in the six East-West container liner routes during 2009 to 2014. The plots intuitively indicate different moving patterns of price and demand in the six east-west routes over time.

Figure 1 Monthly freight index movement (2009–2014) (see online version for colours)



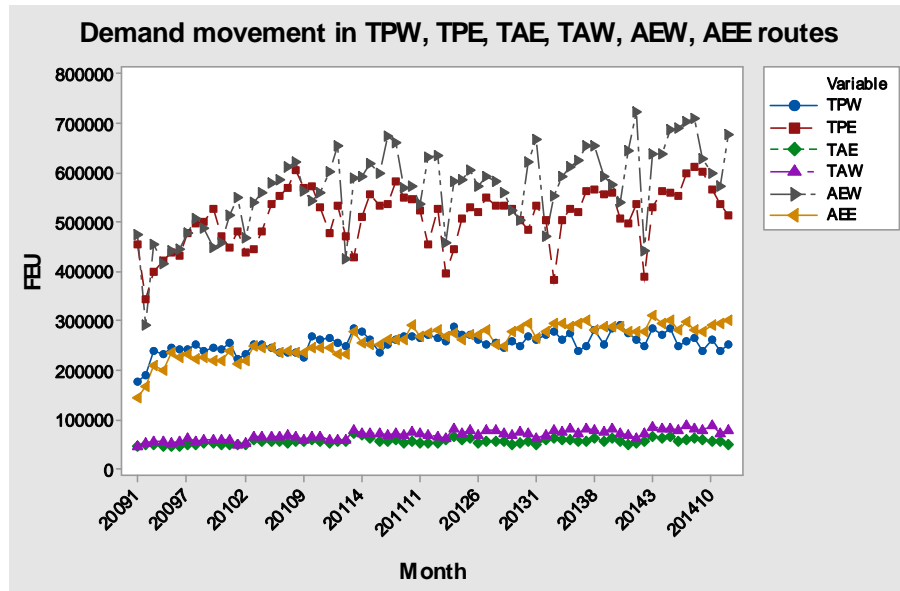
Source: Author compiled basis on CTS data

A dynamic model is necessary to assess the demand elasticities in the six routes. A static specification will not be sufficient, since it does not take into account the fact that behavioural change in response to changes in price may take time to come about. For example, movement towards equilibrium maybe delayed due to imperfections in

alternative transport markets and stickiness in changes to loyalty contract.² Thus, elasticity estimates from a static model only account for adjustments in the current time and may actually produce short or intermediate-run estimates only.

Dynamic models assessing short and long-run demand elasticities usually set up to vary lag specification nested, (e.g., Maddala et al., 1997 for energy industry; Graham et al., 2009 for metro). Auto-regressive distributed lag (ADL) is the major workhorse in dynamic single-equation regressions. Shen et al. (2013) take ADL approach to estimate both short-run dynamics and long-run equilibriums of top five container ports. The approach provides a solution to assess port competition and forecast container demand.

Figure 2 Monthly demand movement (2009–2014) (see online version for colours)



Source: Author compiled basis on CTS data

Without deploying too many complexities, this paper develops a simple ADL model to measure the short and long-run responses in demand to a change in price. Since in CLS market, adjustment of supply and costs agents cannot realise their desired holdings immediately, a partial adjustment is applied to factor the delay of responses.

First, define a basic double log model

$$\log D_t^* = b_0 + b_1 \log P_t + b_2 \log Y_t + v_t \quad (6)$$

where D_t^* is desired demand in FEU at time t , P_t is real price. Y_t is GDP per capita and v_t is an error term.

Since desired demand (D_t^*) is not observable, we cannot estimate the demand model directly. Denoting observed demand as D_t , the following equation holds,

$$\log D_t - \log D_{t-1} = \delta (\log D_t^* - \log D_{t-1}) \quad (\delta \leq 1) \quad (7)$$

where δ is the partial adjustment coefficient.

The partial adjustment hypotheses are,

$\delta = 1$ means observed changes are equal to desired changes in container capacity demand, or full adjustment.

$\delta < 1$ means agents are only able to fulfil changes they desired partially.

Replace D_t^* and solve for D_t to get

$$\log D_t = \delta b_0 + \delta b_1 \log P_t + \delta b_2 \log Y_t + (1 - \delta) \log D_{t-1} + \delta v_t \quad (8)$$

This can be written as

$$\log D_t = \alpha + \beta \log P_t + \theta \log Y_t + \gamma \log D_{t-1} + \mu_t \quad (9)$$

where $\alpha \equiv b_0/\delta$, $\beta \equiv b_1/\delta$, $\theta \equiv b_2/\delta$, $\gamma \equiv 1 - \delta$ and $\mu_t \equiv v_t/\delta$.

Increase P today in one unit will change D in β , which is the short-run effect.

- in period $t + 1$, D will continue to change, since past demand has an effect: $\gamma\beta$
- in period $t + 2$, another effect will be observed: $\gamma\gamma\beta = \gamma^2\beta$
- ...

Addition of all of these effects, or *the long-run effect* is then,

$$\beta + \beta\gamma + \beta\gamma^2 + \beta\gamma^3 + \dots = \beta / (1 - \gamma) \quad (10)$$

The model used for estimation in this paper is as such defined as:

$$\log D_{it} = \alpha + \beta \log P_{it} + \theta \log Y_{it} + \gamma \log D_{i,t-1} + \varepsilon_{it} \quad (11)$$

where $i = 1, \dots, 6$ (route subscript) and $t = 1, \dots, 6$ (year subscript). β is the short-run price elasticity of demand and the long run elasticity equals to $\beta/(1 - \gamma)$.

Seven models are estimated in this way to estimate the short-run and long-run elasticities in the six east-west routes and east-west market overall.

5 Data and variables

Table 2 outlines data sources and variable descriptions, followed by detailed explanation of the variables in subsections. The descriptive statistics of the regression variables are outlined in Table 3.

Table 2 Variables and data sources

Variable	Description	Source
Dependent variable		
D	Demand, actual carried volumes in FEU	CTS, PIERS
Independent variable		
P	Liner freight rate indices	CTS
Y	GDP per capita based on purchasing power parity (PPP) paper.	The World Bank

Table 3 Descriptive statistics of variables

<i>Name</i>	<i>Mean</i>	<i>St. dev</i>	<i>Minimum</i>	<i>Maximum</i>
D	371,750	371,750	48,018	1,405,900
P	88.34	11.13	60.00	109.00
Y	13,582.00	969.55	12,107.00	14,923.00

5.1 Demand (*D*)

Demand is the actual volumes of containers carried. For Trans-Pacific and Trans-Atlantic routes the data is sourced from port import/export reporting service (PIERS, 2015). PIERS gather raw data of waterborne cargo vessels that enter and exit ports in the USA, sourced by US Customs and Border Protection. The raw data is subsequently verified and synthesised with supplementary data sourced from the United Nations, US Census and direct international country sources. PIERS data is in forty-foot equivalent unit (FEU).

Demand data for Asia Europe routes is sourced from container trades statistics (CTS, 2015). CTS database is derived from data supplied by many of the world's major container shipping lines. CTS original data is in twenty-foot equivalent unit (TEU) and converted to FEU in this research, aligning to the unit of PIERS report. One TEU equals to 0.5 FEU.

5.2 Price (*P*)

CTS aggregated price index (API) is used as proxy of price. CTS APIs are weighted average of the sea freight rates including all surcharges and ancillary charges except inland haulage charges. It has 2008 price index value as 100.

5.3 GDP per capita (*Y*)

GDP per capita based on PPP is sourced from the World Bank Database (2015). It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current international dollars based on the 2011 International Comparison Program (ICP) round.

This research uses world GDP per capita basis on two considerations: First, in container shipping, the majority of global cargos are transhipped in a few regional hub ports, e.g., Singapore in Asia; Rotterdam in Europe; and Long Beach in North America. The volume breakdowns at country level are not available. Lack of reliable statistics on numbers of trading partner countries in each market, as well as share of each trading partner country, applying country GDP per capita in the model would cause measurement problems and statistical bias. Second is due consideration for the existence of cross trade logistics where logistic flow does not match capital flow. Unless the statistics on the same is available, using country level GDP per capita may bias the result.

For these two reasons, it is more appropriate to apply a world GDP per capita in the estimation to generalise the results and eliminate statistical bias to the extent possible.

6 Results and discussions

With the purpose of investigating competitive condition in each route (market), the estimate results are regressed per route without taking advantage of panel data.

The short-run demand elasticities demonstrate notable trend towards significance in TPW, TPE and TAW routes, a slight slide towards significance in TAE, AEW, AEE and east-west market overall (Table 4). Due to low degree of freedom, the implication has limitations. However, it clearly indicates the demand elasticities differ in the six routes.

Since lag variable of demand (D) is applied, Durbin h-test is applied to test autocorrelation between current D and lagged D. For a test of the null hypothesis of no autocorrelation against the two-sided alternative of auto-correlated errors, at a 5% level, the decision rule is if $-1.96 < h < 1.96$ the null hypothesis cannot be rejected. By applying the decision rule it can be seen that autocorrelation for the six routes cannot be rejected at 5% level of significance. At 10% significant level, the critical value is 1.645, in which circumstance autocorrelation in three routes TPE, TAW and AEW can be rejected. Taking a note that these three routes are the top three routes in terms of numbers of containers transported, the model is considered to be relevant.

Table 4 Regression results (dependent variable: $\log D_t$)

Variable	East-west routes						
	TPW	TPE	TAE	TAW	AEW	AEE	ALL
$\log P_t (\beta)$	-0.626* (0.093)	-0.137* (0.012)	-0.213 ^a (0.049)	-0.151* (0.017)	-0.572 ^a (0.122)	-0.034 ^a (0.010)	-0.263 ^a (0.080)
$\log Y_t (\theta)$	-0.373 ^a (0.078)	0.345 ^a (0.087)	0.791 ^a (0.234)	0.482 ^a (0.127)	2.645 ^a (0.601)	-0.098 (0.271)	0.665 ^a (0.149)
$\log D_{t-1} (\gamma)$	-0.226 (0.128)	-0.364* (0.054)	-0.059 (0.106)	0.505* (0.062)	-1.044 ^a (0.260)	0.728 ^a (0.127)	-0.339 ^a (0.123)
Constant (α)	21.643* (2.347)	15.269** (0.301)	4.998 ^a (1.077)	1.656 ^a (0.497)	4.405 (2.033)	4.521 ^a (1.062)	13.716* (1.308)
Durbin h-statistic	-0.904	-1.847	-1.383	-1.859	-1.715	-1.389	-1.143
R-squared adj.	0.899	0.435	0.125	0.992	0.285	0.966	0.712
Observations	6	6	6	6	6	6	6

Notes: ***, **, *, ^adenotes significance at the 1%, 5%, 10%, 20% level against two-sided alternative. The estimated coefficients without a *or ^aare not statistically significant at a level lower than 20%. Standard errors in parenthesis.

Many behaviours are potentially more responsive to long-run changes in economic conditions or government policies than transitory fluctuations in conditions. In that case, the lagged values of conditions control for the duration of the change and the presence of lagged effects reflects differential response to short and long-run variation in conditions. The general purpose of using the lagged dependent variables is a ‘partial adjustment’ for any mean reverting behaviour. The general theory behind the partial adjustment is that the over demand will soon be fulfilled by additional supply or vice versa, therefore supply and demand are mean reverting in long term. The positive lagged D indicates drift, where the price movement today continues the following day. The negative lagged D indicates a reversion towards an equilibrium value. Any price movement today

partially reverts the following day. In this paper, the coefficient of lagged D is negative in AEW, TAE, TPE and TPW routes, indicating price movement in the four routes has revert impact to the price in future dates.

Containerisation has transformed ocean shipping in a relatively standardised process. Product differentiation exists nonetheless as a result of route densities, cargo and customer types, schedule time sensitivity and degree of digitisation among other factors. Existence of product differentiation decides that CLS market is not of perfect competition.

The degree of competition measured by P-R H statistic varies from 0.37 to 0.97 (Table 5), suggesting that CLS market demonstrates monopolistic competition during the period. The result is consistent with previous studies for different period of time (Endo, 2005; Sys et al., 2011). Comparing with conclusions from previous research, an increasing trend of P-R H statistic is observed, which may imply the increasing degree of competition in CLS industry.

Table 5 Demand elasticities and P-R H statistic in east-west routes

	E_{SR}	E_{LR}	H_{SR}	H_{LR}
TPW	-0.63	-0.51	0.37	0.49
TPE	-0.14	-0.10	0.86	0.90
TAE	-0.21	-0.20	0.79	0.90
TAW	-0.15	-0.31	0.85	0.69
AEW	-0.57	-0.28	0.43	0.72
AEE	-0.03	-0.12	0.97	0.88
East-west trades overall	-0.28	-0.21	0.72	0.79

Note: E_{SR} and E_{LR} denote short-run and long-run demand elasticity; H_{SR} and H_{LR} denotes short-run and long-run P-R H statistic.

7 Conclusions

This paper estimates the short-run and long-run demand elasticities in the six east-west routes during 2009 to 2014. The contribution is twofold. First, it researches competition condition for a period that is not previously studied. Second, unlike literature reviewed using a static model, this research establishes a dynamic model that allows measurement to both short-run and long-run effects.

This paper also finds that freight rate movement demonstrates revert impact to freight rates in future dates in the four head-haul routes, i.e., AEW, TAE, TPE and TPW routes. The effect is most significant in AEW. The freight movement in these four routes may revert in the following year, i.e., 2015. The fact that freight rates picked up slightly in 2015 matches the estimate results in this paper.

Two limitations of this research should be kept in mind. First, GDP the low degree of freedom is acknowledged. Second, due to data unavailability (CTS price indices have only been measured as of 2008), the study in this paper covers only six years period from 2009 to 2014, which is considered as relevantly short to evaluate demand elasticities. A cross section panel data could have largely increased the sample size. However, it is more meaningful to regress per individual group (route), since market in each route

demonstrates different levels of competition in reality. Needless to say that given infinite time and resources, large samples are always preferred over small samples. I leave it as one of the research topics for future when more data samples become available.

Overall, the conclusion in this paper offers insights to regulatory bodies, since degree of competition is important information for policy-making. The conclusion also offers great reference to carriers, since market structure determines carrier's behaviour in the market.

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References

- Bailey, E.E. (1981) 'Contestability and the design of regulatory and antitrust policy', *The American Economic Review*, Vol. 71, No. 2, pp. 178–183.
- Bain, J.S. (1951) 'Relation of profit rate to industry concentration: American manufacturing 1936–1940', *The Quarterly Journal of Economics*, Vol. 65, No. 3, pp.293–324 DOI: 10.2307/1882581.
- Baumol, W.J. (1982) 'Contestable markets: an uprising in the theory of industry structure', *American Economic Review*, Vol. 72, No. 1, pp.1–15.
- Bikker, J.A. (2004) *Competition and Efficiency in a Unified European Banking Market*, Elgar, Edward Publishing, Cheltenham.
- Bikker, J.A., Shaffer, S. and Spierdijk, L. (2012) 'Assessing competition with the Panzar-Rosse model: the role of scale, costs and equilibrium', *Review of Economics and Statistics*, Vol. 94, No. 4, pp.1025–1044, DOI: 10.1162/rest_a_00210.
- Container Trades Statistics (CTS) (2015) [online] <https://www.containerstatistics.com/> (accessed 4 July 2015).
- Davies, J.E. (1986) 'Competition, contestability and the liner shipping industry', *Journal of Transport Economics and Policy*, Vol. 20, No. 3, pp.299–312.
- Endo, N. (2005) 'Analysis of competitive nature of liner shipping industry', *Journal of Transport Policy Studies Review*, in Japanese, Vol. 8, No. 3, pp.42–48.
- Graham, D.J., Crotte, A. and Anderson, R.J. (2009) 'A dynamic panel analysis of urban metro demand', *Transportation Research Part E: Logistics and Transportation Review*, Vol. 45, No. 5, pp.787–794, DOI: 10.1016/j.tre.2009.01.001.
- Hirata, E. (2017) 'Contestability of container liner shipping market in alliance era', *Asian Journal of Shipping and Logistics*, Vol. 33, No. 1, pp.27–32, DOI: 10.1016/j.ajsl.2017.03.004.
- Hirata, E. and Murakami, H. (2015) 'Liner shipping market contestability in alliance era', *Journal of Logistics and Shipping Economics*, Vol. 49, No. 1, pp.42–50.
- Maddala, G.S., Trost, R.P., Li, H. and Joutz, F. (1997) 'Estimation of short-run and long-run elasticities of energy demand from panel data using shrinkage estimators', *Journal of Business and Economic Statistics*, Vol. 15, No. 1, p.90, DOI: 10.2307/1392078.
- Mason, E. (1939) 'Price and production policies of large-scale enterprise', *American Economic Review*, Vol. 29, No. 1, pp.61–74.
- Miyashita, K. (2002) *Nihon Butsuryugyō no Global Kyōsō*, in Japanese, Chikura shōbō, Tokyo.

- Nathan, A. and Neave, E.H. (1989) 'Competition and contestability in Canada's financial system: empirical results', *Canadian Journal of Economics*, Vol. 22, No. 3, pp.576–594.
- Neave, E.H. and Nathan, A. (1991) 'Reply to Perrakis', *The Canadian Journal of Economics*, Vol. 24, No. 3, p.733, DOI: 10.2307/135596.
- Panzar, J.C. and Rosse, J.N. (1987) 'Testing for 'monopoly' equilibrium', *The Journal of Industrial Economics*, Vol. 35, No. 4, p.443, DOI: 10.2307/2098582.
- Rosse, J. N. and Panzar, J. C. (1977) *Chamberlin vs. Robinson: an Empirical Test for Monopoly Rents*, Bell Laboratories Economic Discussion Paper, No. 90.
- Shaffer, S. (1982) 'A non-structural test for competition in financial markets', *Economics Letters*, Vol. 10, No. 1, pp.167–171.
- Shaffer, S. (1983) 'Non-structural measures of competition', *Economics Letters*, Vol. 12, Nos. 3–4, pp.349–353, DOI: 10.1016/0165-1765(83)90061-7.
- Shen, C.W, Lee, H.C. and Chou, C.C. (2013) 'Measuring dynamic competitiveness among container ports: an autoregressive distributed lag approach', *International Journal of Shipping and Transport Logistics*, Vol. 5, No. 6, p.637, DOI: 10.1504/ijstl.2013.056855.
- Sys, C. (2009) 'Is the container liner shipping industry an oligopoly?', *Transport Policy*, Vol. 16, No. 5, pp.259–270, DOI: 10.1016/j.tranpol.2009.08.003.
- Sys, C., Meersman, H. and Van De Voorde, E. (2011) 'A non-structural test for competition in the container liner shipping industry', *Maritime Policy and Management*, Vol. 38, No. 3, pp.219–234, DOI: 10.1080/03088839.2011.572708.
- The Port Import/Export Reporting Service (PIERS) (2015) [online] <https://www.ihs.com/products/piers.html> (accessed 4 July 2015).
- United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2007) *Study on Regional Shipping and Port Development: Container Traffic Forecast 2007 Update* [online] <http://www.unescap.org/resources/study-regional-shipping-and-port-development-container-traffic-forecast-2007-update> (accessed 4 July 2015).
- World Bank Database (2015) [online] <http://data.worldbank.org> (accessed 4 July 2015)
- Yildirim, S.H. and Philippatos, G.C. (2007) 'Efficiency of banks: recent evidence from the transition economies of Europe, 1993–2000', *The European Journal of Finance*, Vol. 13, No. 2, pp.123–143, DOI: 10.1080/13518470600763687.

Notes

- 1 Namely 2M Alliance (Maersk Line and MSC), the Ocean Alliance (Cosco shipping, CMA CGM, Evergreen Marine, OOCL) and Japanese-three (NYK, Mitsui Osaka, K Line).
- 2 Royalty contract is a contract with an ocean common carrier or agreement providing for
 - a a shipper to obtain lower rates by committing all or a fixed portion of its cargo to that carrier or agreement
 - b a deferred rebate arrangement.

Appendix

Schaffer (1982)'s approach to derive P-R statistic H.

First, define P-R H statistic as

$$H = wR_w / R = R_q^2 / \prod_{qq} R \quad (A1)$$

where \prod is the profit function, R is the revenue function, w is a vector of input prices, q is the output quantity and subscripts denote partial derivatives.

For the case of single-output, profit-maximising firm in the absence of a zero-profit condition, the firm's profit function is,

$$\prod(q, w) = R(q(w)) - C(q, w) \quad (A2)$$

where R is the firm's revenue function equal to output price times output quantity while quantity itself is a function of input prices, C is the firm's cost function, q is the firm's output quantity and w is a vector of input prices. Profit maximising first order condition requires

$$\prod_q = R_q - C_q = 0 \quad (A3)$$

By definition the firm's elasticity of demand is $e = (p/q) (\partial q / \partial p)$ and $R = pq$, as such

$$R_q = p + q \left(\frac{\partial p}{\partial q} \right) = p \left(\frac{e+1}{e} \right) \quad (A4)$$

Substitute (4) into (2), we get

$$\prod_q p \left(\frac{e+1}{e} \right) - C_q = 0 \quad (A5)$$

Take second order condition, we get

$$\prod_{qq} = -\frac{p}{e^2} \frac{\partial p}{\partial q} + \left(\frac{e+1}{e} \right) \frac{\partial p}{\partial q} - C_{qq} \quad (A6)$$

For locally constant demand elasticity ($\partial e / \partial p = 0$) and the firm's cost curve is locally linear ($C_{qq} = 0$), then the expression reduces to

$$\prod_{qq} = \left(\frac{e+1}{e} \right) \frac{\partial p}{\partial q} = \frac{p}{q} \frac{e+1}{e^2} \quad (A7)$$

Substituting (4) and (7) into (1), we get

$$H = R_q^2 / \prod_{qq} R = p^2 \left(\frac{e+1}{e} \right)^2 / R \frac{p}{q} \frac{e+1}{e^2} = \frac{pq}{R} (e+1) \quad (A8)$$

Since $R = pq$, the expression reduces to

$$H = e+1 \quad (A9)$$

Next, extend to market level. A firm's demand elasticity can be interpreted as the ratio of its percentage change in output to its percentage change in price,

$$e = \% \Delta q / \% \Delta p \quad (\text{A10})$$

Likewise the elasticity of demand across the entire market or industry is

$$e = \% \Delta Q / \% \Delta P \quad (\text{A11})$$

where Q denotes the aggregate output of all firms in the market.

Thus, given the market demand elasticity defined, H statistic of the industry can be expressed as $H = E + 1$.