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The Cargo Throughput Response to Factor Cost Differentials – An Analysis for the Port of Hong Kong

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Abstract

Previous studies on port cargo throughput have been simplified. The regression models are based mainly on the autoregressive time series, in which the port throughput is regressed against the lagged value from the preceding time period. Most factors are assumed exogenous to port throughput. This approach is based on the premise that ports are oligopoly markets and many factors (e.g. port charges) are not available for inclusion in research. The main objective of this study is to include the costs of using the port in the regression model so as to reflect real commercial decision. Due to port costs generally not being available, the real estate prices and other factors are chosen as proxy variables to indicate indirectly the costs and benefits of using the port under study.

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Keywords

Hong Kong; Port; Cargo transportation; Terminal handling charges; Real estate price; Error correction model

1. Introduction

Since the opening of China's economy to the outside world in 1978, Hong Kong has become the gateway to China and the leading international port for southern China and the region. Taking advantage of lower operating costs, ample supply of cheap land and a hardworking labor force, much of Hong Kong's own original manufacturing has moved to Guangdong Province. To keep those factories running, raw materials and semi-finished products have to be imported and the finished products exported. The obvious choice is through the port of Hong Kong, which is well known for its superb deep-water harbor, high efficiency, reliability and hassle-free customs procedures. Hong Kong and Guangdong have since benefited tremendously from this symbiotic relationship and Hong Kong has boomed as China's economy expands. That is particularly so since China joined the WTO. The port of Hong Kong is also a major logistics hub in the global supply chain and is served by more than 80 international shipping lines to over 500 destinations worldwide. There are few international ports like Hong Kong, where another international port serve the same hinterland and the direct port competition is inevitable. Without a monopoly controlling the freight market, the port of Hong Kong provides a competitive operating environment for cargo transportation.

All signs point to strong growth in China’s freight transport sector. Particularly with the openness of the market to foreign companies and, more goods heading for the US and Europe and more raw materials such as corn and oil flowing in, its overall prospect looks promising. In contrast, Hong Kong's seaborne freight has been facing serious threats from the newly built ports around the Pearl River Delta (PRD). They are sharing and also competing for the growing cargo- handling market. Recent figures reveal that the Shenzhen ports handled 9.5 million TEUs (Twenty Feet Equivalent Units) in the first half of 2007, 13.7% up on Jan-June 2006. Over the same period, Hong Kong enjoyed only a 2.5% increase, to 11.6 million TEUs.

Hong Kong port still has its ways to survive. The port of Hong Kong was the world's busiest container port between 1992 and 2004. Being one of the most prosperous cities in the world, Hong Kong is highly competitive in an economic sense. Its port has an edge not only because of its highly productive labor, but also because of its high value added services, sophisticated facilities, flexibility and efficiency in port operations (e.g. Yip 2008). What could possibly make Hong Kong lose out to its competitors?

Hong Kong's monopoly in South China's containerized trade came to an end in the 1990s, when Shenzhen port began operating a direct connection to international shipping. Containers can move through various ports to the hinterland. Clearly, for ports to attain and attract more cargo throughput, they need to deliver their services economically.

That is to say, it is likely that cost factors have undermined the competitiveness of Hong Kong port. More precisely, it loses out to rival ports such as Shenzhen because of its weak comparative advantages which are not entirely authentic. In other words, its throughput volume, a measure of success, hinges on its costs, direct or indirect, relative to its neighboring competitors in the port business.

At issue in this study are two important cost differential factors: land and terminal (handling) costs. First, we hypothesize that the land price differential between Hong Kong and Shenzhen plays a key role in determining the cargo throughput volumes of their ports. In addition, Shenzhen offers a lower labor cost than Hong Kong's--- to ship a container (TEU or FEU) through Hong Kong is some USD300 more expensive than to do so through Shenzhen (EDLB 2004; THB 2008). Second, we hypothesize that the terminal cost differential has an impact on the port throughput between the ports in the two cities. It is expected that any change in the two differential factors would shift the balance in port throughput volume between the two competitors. This study will postulate the future role of the port in Hong Kong in the cross-border context of Hong Kong and Shenzhen.

A consultancy project "*Hong Kong Port Masterplan 2020*" was conducted for the Hong Kong Port Development Council, HKSAR government. The study was carried out by a consultancy team, in which the regression analysis approach was used in forecasting port cargo throughput based on existing trends, and consequently identified a preferred scenario to guide port planning. In addition, interviews with key stakeholders were adopted with professional judgments and qualitative adjustments to the forecasts. Though the project contributed a very careful analysis of strategy for the Hong Kong port, it excluded the land price factor which we believe is very important in determining port expansion and container terminal charges. We are not aware of any literature on the dynamic interdependence of the port market and real estate market from a macroeconomic perspective. The objective of this study is thus to include the costs of using the port into the regression model so as to reflect real commercial decisions. The study examines whether indirect costs (e.g. real estate price), particularly in terms of price differentials, are critical to the volume of port throughput. The results are expected to provide valuable insights into the current status of port throughput modeling. The paper is organized in the following sequence: 2. literature review; 3. research framework and data description; 4. results and discussion; and lastly 5. conclusion and future research.

2. Literature Review

Prior research has documented that port cargo throughput is most directly related to trade activities and macroeconomic indicators. Seabrooke, Hui, Lam and Wong (2003) used a regression model of cargo throughput, trade value and GDP to account for the cargo throughput of Hong Kong. Their regression model was further used to evaluate the regional role of Hong Kong port through a combined assessment of Pearl River Delta. Lam, Ng, Seabrooke & Hui (2004) applied neural network models to forecast 10 years of 37 types of freight movements, which were used to forecast the port cargo throughput in Hong Kong. They further used Monte Carlo simulation to assess the reliability of the forecasts, which were proved to be more reliable than those which used regression analysis. Hui, Seabrook & Wong (2004) analyzed Hong Kong port cargo throughput by estimating a cointegrated error correction model, which addressed the non-stationary issue and the reliability difficulty of PMB (Port and Maritime Board)'s simple regression model. Their results also showed an important and constant impart on Hong Kong cargo growth from its regional competitor, Shenzhen. Kawakami & Doi (2004) analyzed the case of Japan regarding the causal relationship between port capital and economic factors such as GDP and private capital through Vector Error Correction Model (VECM), concluding that economic factors had a substantial effect on port capital in Japan.

The modern analysis of logistical markets has been advanced by the revolution of time series analysis techniques. In particular, modeling the behavior of demand for logistical services, trying to explain the rail throughput (e.g. Babcock, Lu & Norton, 1999) and seaborne throughput (e.g. Veenstra & Haralambides, 2001; Babcock & Lu, 2002), and port throughput (Hui, Seabrook & Wong, 2004). These previous studies confirmed that logistical system throughput and port cargo throughput are directly related to trading activities and macroeconomic indicators, regardless of the cause of the positive correlation between trading value and cargo throughput. It is understood that macroeconomic indicators reflect regional economic activities and that trading is one of these major economic activities. Thus and in turn trading value indicates potential demand for port activities, including port cargo throughput. However, the relationship between port activities and underlying financial costs has not been considered.

Meanwhile, port cargo analyses have been carried out on the basis of mutual substitutability among ports. Fung (2002) applied the Vector Error Correction Model (VECM) to forecast Hong Kong container throughput between the Hong Kong and Singapore ports. Yap and Lam (2006) analyzed the competition dynamics among 10 ports in East Asia, by using Cointegration Test and Error Correction Model, concluding that inter-port competition in this region would intensify in the future as mainland China gradually became the center of gravity of cargo volume.

The cost of transportation is an important factor in the economics of international trade. Since ports contribute to the final cost of goods that flow through them, it is important that port costs be considered when forecasting. Port costs are a key factor for cargo owners selecting a port for trading through. Fung, Cheng and Qiu (2003) studied the impact of Terminal Handling Charges (THC) on overall shipping charges by empirical analysis, such as the Wald Test. Their results showed that the separation of ocean freight charges and THC's, lead to an increase to the overall shipping charges, and that THC's would have a negative effect on the container throughput. However, their model only considered one single port (i.e. Hong Kong) without taking competing ports (e.g. Shenzhen) into account. Thus, their conclusion is not generalized to a typical port market. As cargoes can be transported through any one of competing ports, the degree of cost difference among the ports could influence the port cargo throughput. Unsurprisingly, THC's are considerably higher in Hong Kong than in Shenzhen. Thus, our model will include financial indicators presented in a differential format.

Secondly the demand for container transportation is derived from the demand for international trade in containerized goods. For transporting containers from/to South China, Hong Kong port and Shenzhen port are the dominant hub ports. Some shippers may decide to use Shenzhen terminals for lower THC, but cargoes may spend a longer time in port. Others may use Hong Kong terminals in order to shorten the cargo's time in port, although the THC is higher. However, the total port costs include direct charges (e.g. THC) and indirect charges. The level of total port costs, including THC, may be indicated by the cost of living, i.e. real estate prices.

When tracking real estate markets, property values have been of common interest for a long time because of its importance in matters relating to the land capital. Residential property is valued for what surrounds it (neighborhood, parks and infrastructure) (Alonso, 1964). Cervero and Landis (1993) analyzed the relationship between office property value and the distance to stations. They found that offices located at or near stations, are of higher value than properties farther away. However, while the real estate market works at the regional level, the property rates actually reflect the demand for the land and the cost of economic activity at the location. In other words, real estate rates importantly determine and form a part of port charges. The main assumption of this model is that the port and real estate attain a certain static equilibrium because of the proxy variable real estate rates indicating the costs of using the port indirectly. Thus it is further assumed that the real estate market is related to the port throughput.

We are aware of the fact that, apart from economic variables, port characteristics, like port security (e.g. Pinto and Talley, 2006; Lee, Song and Wang, 2008) and port safety (De and Ghosh, 2003; Yip, 2008a; Yip 2008b), have influences on port performance. It was found that a port's security and safety services can have a negative as well as positive impact on its throughput performance and there exits an optimal allocation of security and safety level against throughput. However, we do not include these port features in our models. Instead, our models are used for their simplicity without a loss of generality. Our models can be easily extended by taking other determinants like security level and safety level into account.

We attempt to analyze port cargo throughput by rigorously quantifying the market dynamics between the port throughput and unobserved port costs and other related factors. This will allow us to develop better planning across two different regulatory systems (port and real estate). While this study will complement the traditional economic thoughts on the port market and real estate market, the results may provide new insights into these two discrete markets.

3. Research Framework and Data Description

Considering the information in one market is useful to another market, this study builds a new forecast model, including the costs of using the port, to analyze Hong Kong cargo throughput while taking account of the relation between port throughput and real estate price. The analysis is conducted using the Error Correction Model (ECM) approach. An ECM is a special type of differenced model that includes an "error correction" term to predict short-run adjustments of the dependent variable. Suppose a set of variables is linked by the following long-run equilibrium relationship:

$$y_t = \alpha + \sum_{i=1}^{n} \beta_i x_{i,t} + e_t \qquad (1)$$

The corresponding ECM takes the following form:

$$\Delta y_t = \alpha' + \beta_0 \Delta y_{t-p} + \sum_{i=1}^{n} \beta_i' \Delta x_{i,t-q} - \lambda e_{t-1} + u_t \qquad (2)$$

Where $\Delta y_t = y_t - y_{t-1}$ and $\Delta x_t = x_t - x_{t-1}$. The Engle-Granger (1987) two-stage procedure is adopted to estimate an ECM for determining the port throughput. An ECM describes short-run adjustments and considers changes in marginal values rather than levels of the variables. It includes a disequilibrium error term, which is the extent of deviation from the long-run relationship, as one of the regressors. The values of the error term in the short-run model are obtained from the long run model with the disequilibrium error term e_t. Once the coefficients of long-run relationship are estimated and the error term values obtained, the second stage calls for estimating the short-run model.

The rationale behind the error term e_t is that in the real world, any economic system is rarely precisely in equilibrium. In disequilibrium, the value of error correction term e_t is intrinsically growing over time, implying that the relationship departs increasingly away from the presumed "equilibrium" and a long-run stable relationship unlikely exists. On the other hand, if the error term is stationary and fluctuates around the equilibrium, the long-run relationship is evidenced statistically. Nevertheless, if a long-run relationship exists, the ECM allows the disequilibrium trend to correct itself in time (hence error correction), resulting in a path that oscillates about the long-run equilibrium. The error correction term therefore incorporates an adjustment process into the model, so that the dependent value is always being pushed back toward "equilibrium" whenever it was out of equilibrium in the previous period. Given this tendency of self-correction, the extent of disequilibrium error is therefore useful information in estimating the short-run movement of variables. Once the long-run relationship is estimated, the error term e_t is obtained by comparing predicted and observed values of the dependent variable (i.e. Hong Kong cargo throughput). The second stage of the Engle–Granger procedure is the construction of a short-run model that includes e_t as one of the regressors. After having set up the long-run and short-run equations and shown that the model is cointegrated and passes diagnostic tests, we then proceed to estimating model coefficients.

By reducing the system to its critical determinants, we consider the quarterly Hong Kong cargo throughput (*HKCARGO*) as being the dependent variable with six explanatory factors assumed in the model: i. Price differential between real estate of Hong Kong and Shenzhen (*HPDIF*); ii. Terminal handling cost differential between Hong Kong and Shenzhen ports (*THCDIF*); iii. Hong Kong GDP (*HKGDP*); iv. Total external trade value of imports and exports (*HKTRADE*); v. Number of shipping berths (*BERTH*); vi. Shenzhen's cargo throughput (*SZCARGO*). The latest available data of Hong Kong freight movements and explanatory factors (from 1994 to 2006) are used and the summarized statistics of the variables are presented in **Table 1**.

Table 1 Descriptive Statistics of the Variables (1994-2006)

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
HKCARGO (Thousand tons on quarterly basis)	46214	44369	61755	34144	7651	0.48	2.05
HPDIF (HKD)	31464	26357	63167	16651	11882	1.03	3.30
THCDIF (USD)	1026	1125	1314	802	164	-0.15	1.76
HKGDP (HKD million)	1265193	1295807	1474329	935221	125736	-1.02	3.47
HKTRADE (HKD million)	841567	785456	1380688	497921	200760	1.04	3.41
BERTH	19	18	24	18	2.5	1.15	2.44
SZCARGO (Thousand tons on quarterly basis)	19082	14229	48361	7073	12633	0.83	2.32

Note: Hong Kong cargo statistics are obtained from the Shipping and Cargo Section of Census and Statistics Department in Hong Kong. Trade value data is provided by the International Monetary Fund. Shenzhen cargo statistics are obtained from the Shenzhen Information and Statistics Bureau.

The historical data of the Hong Kong cargo throughput was obtained from the Monthly Digest of Statistics, published by the Census and Statistics Department of the Hong Kong Special Administrative Region (HKSAR) Government. The Census and Statistics Department of the HKSAR government compiles seaborne and river cargo statistics based on samples of consignments on cargo manifests and publishes the compiled data of historical shipping. The THC data was collected from Hong Kong Shippers' Council.

Quarterly historical housing prices and economic data (1994-2006) of the explanatory factors were obtained from the Annual Digests of Statistics, published by the Census and Statistics Department of the Hong Kong Special Administrative Region (HKSAR) Government. In this study, a national uniform data source that permits quality control is needed to study housing prices in Shenzhen. The composite housing price index of Shenzhen (SZHPI) used in this paper is obtained from the Statistical Yearbooks of Shenzhen Real Estate, while the Shenzhen Statistics Bureau is responsible for releasing the data regularly and controlling variations in quality with prices adjusted. SZHPI is a form of Laspeyres Index with a base point of 100 in Shenzhen in January, 2001, and is calculated on the basis of market investigations into the selling prices of dwellings in the second class market. SZHPI therefore represents the sales market of all kinds of private dwellings, in other words, the SZHPI are fundamentally transaction-based indices reporting market price trends, whether or not they are smooth.

| Insert Figure 1 |

Figure 1 shows that the cargo throughputs of Hong Kong and Shenzhen possess growing trends across the sample period while the growing trend of Shenzhen is apparently more steady and steeper than that of Hong Kong. The trend of Hong Kong cargo throughput is more fluctuating and the growth rate generally lags behind than that of Shenzhen. In **Figure 2**, it is observed that the cargo throughput and housing price differentials move quite in line over the sample period. Some practitioners may claim that the increasing competitiveness of Shenzhen port is acting to stimulate the city's prosperity, resulting in a surge in real estate prices. However, **Figure 2** clearly presents a lead-lag relationship between the cargo throughput and property prices differentials. The Hong Kong's real estate prices peaked in 1997 and gave the greatest price differential, following an ascent of cargo throughput differential in later years. Afterwards, Hong Kong's property market was ruined by the painful Asian Financial crisis, resulting in a significant depreciation of property value and dwindling price differential. Since then, the cargo throughput differential has been reducing accordingly. Our hypothesis is that, as the real estate price may reflect the unobservable indirect costs of using a port, the real estate market, in reality, is influencing the port business invisibly and nonlinearly. To uncover the nonlinear characteristics of property price on the port's throughput, a square term will be introduced to capture the nonlinear effect and will be explained in later sections.

| Insert Figure 2 |

The terminal handling cost differences are rarely included in econometric models, because those real costs data are not published in the market and are difficult to collect. Thus, we include published direct port costs (e.g. terminal handling charges) and indirect costs (e.g. real estate prices, labor costs) as explanatory factors in our regression model.

Demand for port services is derived from demand for both imports and exports. Hence the value of regional trade is clearly an important determinant for the volume of cargo throughput. As there is more than one port in a given region, cargo share at each port would be determined by their relative competitiveness, bounded by each port's handling capacity. An implicit assumption of the regression model is that the relationship between regional trade value and cargo throughput will be stable over time. Historical records show that this has indeed been the case but the relationship can potentially be disrupted by external events not captured by the current model.

Hong Kong port is known for high volume of cargo movements and associated port congestion. There are currently nine terminals operated by five different operators from the private sector. The port of Hong Kong in Kwai Chung-Tsing Yi basin consists of 24 berths and 8,530 metres deep water frontage, accounting for 275 hectares of land. Hong Kong Port Development Board (PDB) acknowledged that the adoption of a "trigger point mechanism" policy led to a time lag between available cargo handling capacity and actual demand (TD 1999), since under the trigger point mechanism, new terminals will not be built until forecast throughput reaches forecast capacity. Given that port capacity is often a binding constraint on throughput volume, the number of shipping berths is included as a regressor so that the amount of throughput increase due to the construction of additional berths can be estimated.

Port competition plays a critical role in determining cargo throughputs, especially between Hong Kong and Shenzhen in recent years. Speculations over the future of Hong Kong port inevitably stems from the review of competition with Shenzhen. These two ports are within 50 km of each other and they are competing for virtually the same cargo base. Shenzhen's western port area, namely Chiwan and Shekou, lies in the Pearl River Estuary while the eastern port area, Yantian possesses a wide and deep-water natural harbor. The geographical position of Shenzhen port provides good connections with other cities or counties along the Pearl River Delta.

With a competitive edge over Hong Kong in terms of price and location, Shenzhen has been expanding dramatically in recent years. Hong Kong PMB (2001) predicted that Shenzhen would surpass Hong Kong in terms of market share by year 2020. Shenzhen's cargo throughput is included in the model so that its impact on Hong Kong's port traffic can be fully understood.

4. Results and Discussion

Following the above line of discussion, the linear model is proposed for consideration:

$$\ln HKCARGO_t = a + b_1 \ln HPDIF_t + b_2 \ln THCDIF_t + b_3 \ln HKGDP_t + b_4 \ln HKTRADE_t + b_5 \ln BERTH_t + b_6 \ln SZCARGO_t + e_t \quad (3)$$

To ensure that the model to be tested is correctly specified, Ramsey's (1969) regression error specification test (RESET) is conducted to test for mis-specification. RESET is a general test for mis-specification that may manifest itself in terms of missing variables and/or incorrect functional form.

Table 2 Results of RESET Test for the Linear Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$FITTED^2$	-2.21E-05	4.60E-06	-4.810	0.000

where $FITTED^2 = (ln\, H\hat{K}CARGO_t)^2$. Because $FITTED^2$ is statistically significant at the 5% significance level, as shown in **Table 2**, the misspecification of the linear model Eq. (3) is accepted. Therefore, an alternative model is extended to include the second order term $(\ln HKDIF_t)^2$ as an additional explanatory variable in the previous model Eq. (3) and considered as follows:

$$
\begin{aligned}
ln\, HKCARGO_t &= a + b_1\, ln\, HPDIF_t + b_2 (ln\, HPDIF_t)^2 + b_3\, ln THCDIF_t \\
&+ b_4\, ln\, HKGDP_t + b_5\, ln\, HKTRADE_t + b_6\, ln\, BERTH_t + b_7\, ln\, SZCARGO_t + e_t
\end{aligned}
\tag{4}
$$

Table 3 Result of RESET Test for the Extended Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$FITTED^2$	-0.462	0.420	-1.100	0.278

Following the same RESET procedure, this extended model is tested for mis-specification. The test results reported in **Table 3** show that $FITTED^2 = (ln\, H\hat{K}CARGO_t)^2$ is insignificant at the 5% significance level, suggesting that the specification of extended model Eq. (4) is acceptable. It should be noticed that a nonlinear term of $(\ln HPDIF_t)^2$ is presented in the model. The addition of a square term may help explain the indirect interaction between real estate price and cargo throughput. Consequently the model is generalized by including the nonlinear term such that the model will deliberate crucial properties of real estate price on port throughput across time.

To avoid using a spurious regression, the cointegration test is applied to test for the two conditions: (I) whether the variables are in the same order of integration and, (II) whether the disturbance or error term is integrated of order zero. As all time series variables are non-stationary at the level values while stationary on first differencing, condition (I) is satisfied.

With regard to the condition (II), the stationary property of the error term e_t of Eq. (4) is tested. If the disequilibrium error grows over time, it implies that the relationship departs increasingly away from the presumed equilibrium. On the other hand, if the error term is stationary, the long-run equilibrium is supported with evidence.

Table 4 Augmented Dickey-Fuller Test for Order of Integration of e_t (Extended Model)

Null Hypothesis: e_t has a unit root
Exogenous: None
Lag Length: 2 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.698	0.000
Test critical values:	1% level	-2.613	
	5% level	-1.948	
	10% level	-1.613	

*MacKinnon (1996) one-sided p-values.

Results of **Table 4** suggest that the disequilibrium does not grow over time. Thus both conditions (I) and (II) are satisfied, and the variables in Eq. (4) are cointegrated in the presence of stable equilibrium relationship. The long-run equilibrium relationship satisfies the diagnostic tests and, the long-run model Eq. (4) is correctly specified.

Once the coefficients of the long-run model are estimated, the values of error term e_t can be obtained by comparing predicted and observed values of $\ln HKCARGO_t$. The second stage of the Engle-Granger procedure is the construction of a short-run model that includes the residual series e_t of Eq. (4) as one of the regressors. The short-run model, Eq. (5) is a differenced variant of the long-run model, with the addition of the lagged error term e_{t-1}.

$$\Delta \ln HKCARGO_t = a + b_1 \Delta \ln HPDIF_t + b_2 \Delta (\ln HPDIF_t)^2 + b_3 \Delta \ln FEUDIF_t + b_4 \Delta \ln HKGDP_t + b_5 \Delta \ln HKTRADE_t + b_6 \Delta \ln BERTH_t + b_7 \Delta \ln SZCARGO + \lambda e_{t-1} + \mu_t \quad (5)$$

The results of **Table 5** clearly reveal that all variables, excluding the terminal handling charge differential and the number of berths, are statistically significant at the 5% significance level with desirable coefficient signs on the theoretical ground. The positive sign of $\ln SZCARGO_t$ shows the co-movement in port throughput and there is little evidence that increases in Shenzhen port's throughput reduce Hong Kong's. Indeed, the increase of both port throughputs reflects the growth of the common hinterland. The $\ln SZCARGO_t$ coefficient of 0.142 tells us that a 10 per cent increase in Shenzhen port throughput results in a 1.42 per cent increase in Hong Kong port throughput. The coefficient sign of the first order of the real estate price differential is negative, and this implies that a displacement effect exists or the larger the real estate price differential between Hong Kong and Shenzhen is, the lower the Hong Kong's cargo throughput will be. However, in the presence of a second order term of positive sign, the displacement effect will diminish when the value of $\ln HPDIF$ becomes large. In other words, when the price differential increases, the nonlinear effect will then dominate over the linear effect. The displacement effect implicitly assumes the impossibility of port expansion because of relatively high land price, i.e. substantial operating cost. The container terminal operators and even urban planners would suggest moving the port business to an area with a lower production cost, from a financial standpoint. Our model captures this interesting phenomenon showing that the high land price of Hong Kong relative to Shenzhen prohibits the growth of port cargo throughput of Hong Kong as well as diminishing the competitiveness of Hong Kong's port.

Table 5 Regression results for long-run model

Dependent Variable: ln$HKCARGO_t$
Method: Least Squares
Sample: 1994Q1 to 2006Q4
Included observations: 52

Variable	Full Model	Reduced Model
Constant	15.087 (2.742) **	15.235 (3.452) **
ln$HPDIF_t$	-2.302 (-2.299) *	-2.264 (-2.768) **
(ln$HPDIF_t$)^2	0.112 (2.328) *	0.111 (2.830) **
ln$THCDIF_t$	-0.010 (0.240)	-
ln$HKGDP_t$	0.180 (2.236) *	0.148 (2.468) *
ln$HKTRADE_t$	0.242 (4.306) **	0.249 (4.674) **
ln$BERTH_t$	0.071 (0.599)	-
ln$SZCARGO_t$	0.142 (3.524) **	0.162 (6.478) **
R-squared	0.964	0.963
Adjusted R-squared	0.958	0.959
Durbin-Watson stat	1.845	1.789
Prob(F-statistic)	0.000	0.000

Note: t-statistics in parentheses
* and ** represent significance levels of 5% and 1% respectively

Table 6 Regression results for short-run model

Dependent Variable: $\Delta lnHKCARGO_t$
Method: Least Squares
Sample (adjusted): 1994Q2 to 2006Q4
Included observations: 51 after adjustments

Variable	Full Model	Reduced Model
Constant	0.001 (0.118)	0.003 (0.650)
$\Delta lnHPDIF_t$	-0.605 (-0.454)	-
$\Delta(lnHPDIF_t)^2$	0.029 (0.448)	-
$\Delta lnTHCDIF_t$	-0.089 (-2.280) *	-0.091 (-2.514) *
$\Delta lnHKGDP_t$	0.025 (0.182)	-
$\Delta lnHKTRADE_t$	0.339 (7.260) **	0.352 (8.294) **
$\Delta lnBERTH_t$	0.454 (3.032) *	0.466 (3.276) **
$\Delta lnSZCARGO_t$	0.054 (0.604)	-
e_{t-1}	-1.077 (-7.446) **	-1.076 (-8.200) **
R-squared	0.742	0.738
Adjusted R-squared	0.693	0.715
Durbin-Watson stat	1.854	1.854
Prob(F-statistic)	0.000	0.000

Note: t-statistics in parentheses
* and ** represent significance levels of 5% and 1% respectively

In order to test the possible over-specification, the models are tested after excluding insignificant factors. By comparing the full model (column 1) and reduced model (column 2), we found that both overall significance of regression tests and individual variables are similar. There is evidence that the model forms are robust.

Compared to the long-run model, the short-run model (**Table 6**) shows that only the terminal handling cost differential, total external trade, number of berths and the lagged error correction term e_{t-1} are significant at the 5% significance level. The results are reasonable since for the short-run period, the most important factors for the cargo throughput should be the cost of transport (i.e. THCDIF), capacity of port (i.e. BERTH) and volume of shipping goods with other explanatory factors playing an insignificant role in the short-run. Particular attention should be paid to the lagged error correction term e_{t-1}, which is the characteristic of the error correction model.

This factor is significant, implying that a certain proportion of deviation run relationship in the current period will be corrected in the next period. This is evidence of the presence of an equilibrium relationship over the long-run. The coefficient of the error correction term is an estimate of the speed of adjustment back to the long-run equilibrium. The negative coefficient (i.e. -1.077) on the lagged error-correction term e_{t-1} implies that in case a deviation between the actual and long-run equilibrium level exists, there is always an adjustment back to the long-run equilibrium in subsequent periods to eliminate this discrepancy. On the other hand, both long-run and short-run models exhibit satisfactory adjusted R^2, of 0.958 and 0.693 respectively, implying that the nearly 96% and 69% of the variations in Hong Kong's cargo throughput can be explained by the explanatory variables. Durbin-Watson statistics reveal that both models have very low possibility of serial correlation.

Our findings agree with the observations associated with the recent financial tsunami. It is known that the recent financial tsunami was caused by the subprime mortgage crisis and has shown a direct impact on the housing price. Based on our model, the port throughput decreases if the housing price drops. In Hong Kong, the housing price index deceased from August 2008 to February 2009 about 13% (RVD 2009) and the port throughput 32% (THB 2009). This recent financial tsunami originated from the housing market has impacted on the logistics industry. The real case illustrates the findings of our model.

5. Conclusion and Future Research

This study provides valuable insights into the current status of port throughput modeling in the literature. Port cargo forecasting currently puts most of its emphasis on autoregressive time series. Our study provides statistically significant evidence that indirect costs (e.g. real estate prices) are critical to the volume of port throughput. From a policy perspective, the findings have identified essential factors that can contribute to the sustainability of a port.

The model specified demonstrates a high explanatory ability. The results demonstrate that the macroeconomic environment (e.g. real estate price and trade activities) account for the port throughput in the long run, whereas the cost of transport (i.e. terminal handling cost differential) and port capacity (i.e. number of berths) are significant in the short run. It is unsurprising to find out that real estate prices are one of the main indicators/factors for port throughputs. This is because the container port market is situated at a fixed location meaning that operational costs are reflected indirectly by the real estate price. The major factor acting against an increase of port throughput is the high cost of operation. Meanwhile the terminal handling cost differential and port facility are significant in the short-run but not in the long-run. The results suggest that offering a competitive handling charge against that of Shenzhen port cannot facilitate the increase in the cargo throughput volume of Hong Kong's port in the long-term. In addition, policy strategies should not be limited simply to port pricing or facility development if port throughput is the objective. Instead, the macro trade environment should be enhanced to promote port throughput.

Further research is needed to test the port throughput model across the world and to explore the impact of various port market environments. The port cargo flows can be divided into import, export and transshipment and these 3 activities may be affected differently against the same situation. Further research on the 3 separated models will be helpful to enhance individual port activities. This study should be extended to consider the general adoption of non-shipping markets in port cargo analysis and how such adoption affects port throughput. In particular, the nonlinear term of real estate price is necessary to specify the forecast model, which may reveal a general non-linear relationship between discrete markets. This is important because any future framework of port cargo analysis should result in enhanced port throughput, consequently boosting profitability and sustainability.

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Figure 1 Housing price differential versus cargo throughputs of Hong Kong and Shenzhen

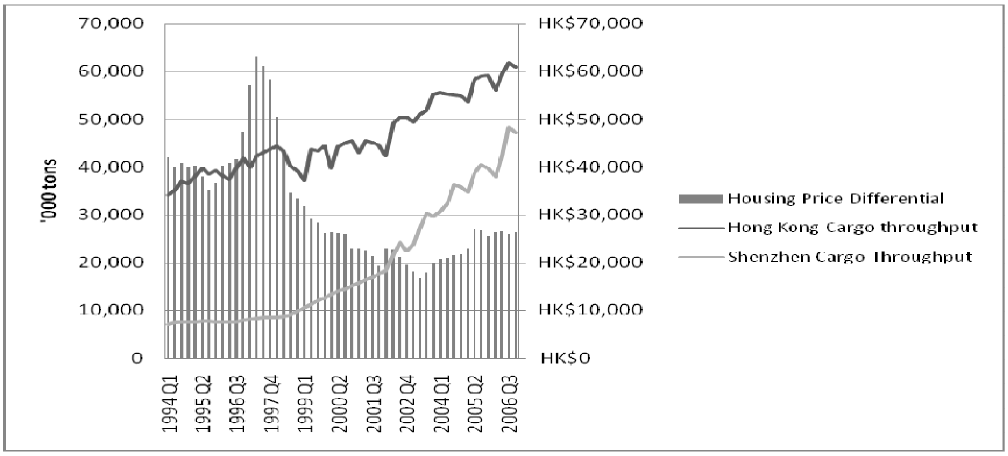

Figure 2 Cargo throughput differential versus housing price differential