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Green and Sustainable Forecasting for Future Container Throughput for Malaysian Ports: An Improved Generic Multivariate Approach

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ABSTRACT

Many research has studied diversely on mathematical models to forecast more accurately the future throughput using multivariate factors, which are assumably affecting the fluctuation. However, given each distinct and unique ports features, factors may differ and could be left out with many unconsidered factors , which may be strongly correlated with the change in throughput volume for individual port. This paper proposes a two-part framework, first to correlated all consolidated factors influencing each three major throughput types of imported container, exported container and containers for transshipment. Second to cointegrate the strongest variables for each container type by VECM, then to forecast the future throughput. Results yield similar error occurrence for both conventional and green and sustainable forecasting, while showing sustainable forecasting superior by being able to capture individual throughput trend. Case study on Kuching Port Authority and Pelabuhan Tanjung Pelepas concludes that no terminal has the same fix set of variables to provide reliable forecast in a associative forecasting model.

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INTRODUCTION

Undeniably, Seaborne transport will continue to flourish as the choiced mode of logistic, seeing decline in other mode of transport such as road-based, rail-based, but slight increase in air-based transport (Hilmola, 2011)

Even in the economic growth of transportation uncertainty, it remains a challenge to analyze situation in meaningful mean that can be explain plainly in number, conveying a degree of information that paints a clearer picture of what is happening. Container shipping volumes also are affected by economic turmoil through the 1997 and 2009 crisis, which saw the sharp decline in freight rate (Henrik, 2010). Nevertheless, minor fluctuations does occur throughout the years' session of production and deliver through international borders.

Ultimately, economist and even researchers are seeking to pin point the factors affecting the volume throughput fluctuation characteristics as to provide accordingly storage and operation capacity, in order not to over supply nor run on short services, further more the demand to be green and sustainable becomes a point of competition (Jasmine, 2011). Both putting business at risk of reputation and losses.

When making trade forecasts, a wide-broad picture approach is required, essentially to provide fore-knowledge to make investment decisions for either the expansion of the terminal or change in port policies. Therefore, sustainable forecasting for the purpose of equipment procurement must cover the time necessary(planning time horizon) to implement possible changes. The forecast should be timely. Usually, a certain amount of time is needed to respond to the information projected in a forecast. For example, capacity cannot be expanded overnight, nor can inventory levels be changed immediately. Hence, the forecasting horizon, usually up from two years to about 5 years (2-3 years to be considered long-term)

Above all, the forecast should be accurate, and the degree of accuracy should be stated. This will enable users to plan for possible errors and uncertainty upon the basis of comparing alternative forecasts. For sustainable design of terminal expansion and operation (Joan & Armin, 2011), it is made mentioned of the necessity to account for a probable further growth in port throughput volume that would result in capacity demands and even increase in environmental impact. Since the entire terminal design comprising quay length, storage capacity, handling system, equipment numbers, control system, etc, it substantiates a robust and reliable

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forecast of future throughput. Accurate forecasting discounting unnecessary throughput avails much to minimize requirements and aide the design of sustainable logistic design (Young *et al*., 2012).

This paper aims to establish a sustainable forecasting framework through integrating various prominent methodologies of forecasting. The next section, illustrates the need and progress of green and sustainable forecasting in the academic advancement in its proper timeframe. In the following section, methodology exemplifies the model framework, algorithms, variables of influence for container throughput forecasting and the detailed methodology of analysis. Not forfeiting two case studies on Kuching Port Authority and Pelabuhan Tanjung Pelepas to validate the model, with discussions on the difference in forecasting in last section. A converging conclusion will be delineated on the uncertainty and the robustness of the model.

Need for green and sustainable forecasting:

Past methodology ignored possibility of external, yet to be identified factors, that may be correlated strongly to TEU throughput growth. Too many researchers hold a one sided approach of projecting forecasting from singular aspect or even by just a univariate approach(Peng *et al*., 2009). For example of economical influences and port performances such as foreign trade, construction investment, port investment, GDP, household income, freight rate, currency, seasonal arrival of ships, indexd average container handled, terminal storage capacity, etc (Li & Xu, 2011; Syafi, 2005; Amoako, 2002; Gosasang, 2011; Shabayek, 2001; Liu *et al*., 2011).

Of late, researchers realized the unique dynamism of ports and embarks on correlating influencing factors from 'outside the box'. Daiz *et al*. (2011) proposes an improved model solely on empty container repositioning; Cho & Yang (2011) foregone all port selection criteria that commonly attributes to the change in throughput volume and interjects that port-level determinants should include 'information and communication technology (ICT) capacity' by penetration count on telephones, computer and internet; 'innovation' by royalty payment, receipts and patent application; 'institutional influence' by regulation and cognitive institution. Liu & Park (2011) also broke down forecasting influence into categories of port facilities, geographical position, economy level, port service, government attitude.

Through reading the review on passed literature, we observe that almost all studies forecast throughput as lump-sum against selected variables, regardless of its type of inbound or outbound. Next, by analyzing ports by economical aspect only proves the model as not generic and aren’t applicable to all kinds of port. Non-generic model can only serve for short-term forecasting, not in terms of the period of forecasting but the framework was not design to meet future changes that may affect TEU throughput into certain specific port in any country.

Green and sustainable forecasting methodology:

This section explains the proposed framework for green and sustainable forecasting, the flow of methodology is as depicted in figure 1. Green and sustainable demands the complete element of environmental, social and economical, hence relevant variables in those regard are solicited. As green and sustainable approach dictates the present future's direction, including environmental variable will set as indicator to be observed as would improvement in environment bring increase to container throughput. (Darbra, 2009; Dekker, 2010)

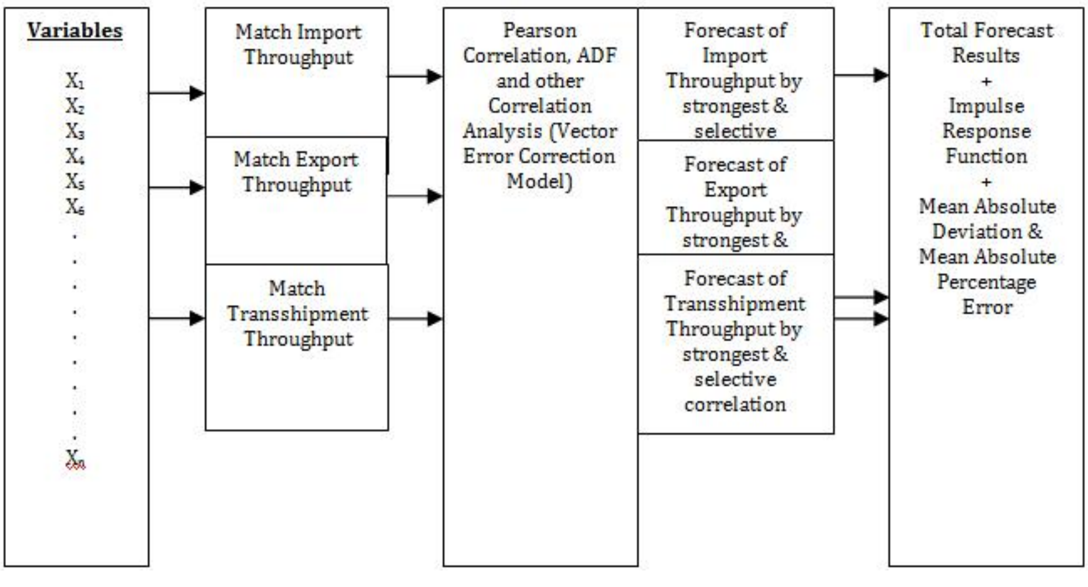

Fig. 1: Framework flow illustrating the methodology for green and sustainable forecasting.

The framework starts by injecting critical analyzed variables by literature review into the Pearson correlatation model for closely-match associated variables to individual throughput sets. Then, unit root test and cointegration test are done to ensure the fitness of data sets for forecasting. On top of that, impulse response function (IRF) will check against the stability of the vector autoregressive model with a one standard deviation shock test. After which, 20 period forecasting will be performed for all individual throughput sets, then, they will be summed up for comparison against the conventional model and the actual TEU throughput. A standard error deviation calculation for forecasting results will give am extra analysis of the robustness of the green and sustainable forecasting model.

Pearson correlation:

Suitability for strong correlation, statistical significance has to be taken into account and it can be expressed as below:

$$r = \frac{n(\sum x_n x_m) - (\sum x_n)(\sum x_m)}{\sqrt{[n\sum {x_n}^2 - (\sum x_n)^2][n\sum {x_m}^2 - (\sum x_m)^2]}} \quad (1)$$

Where, r = deviation score, x_n = dependent variables influencing container throughput, x_m = independent variables influencing container throughput.

ADF –Unit Root Test:

Before estimating cointegration space and determination of cointegration rank, it is important to test the order of integration of each variable or to check the existence of unit roots by the following (Dickey & Fuller, 1979):

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{l} \Delta Y_{t-1} + \varepsilon_t \quad (2)$$

Where, $\beta 1$, $\beta 1$, αi are parameters, εt is pure white noise error term; t is the time or trend variable; l is the number of lagged difference

Johansen Cointegration Test:

The fundamental idea of cointegration is that although two series or more are non-stationary, or integrated, such that first difference are required to obtain stationarity, a liner combination of these series can be stationary (Johansen & Julius, 1994). This linear combination is known as cointegrating vector or cointegrating relationship.

$$trace\ (z|k) = -T \sum_{i=r+1}^{k} \ln(1 - \lambda_i) \quad (3)$$

$$\lambda_{max} = -T \ln(1 - \lambda_{r+1}) \quad (4)$$

Where z is cointegration relationship; k is the number of variables; T is number of observations and λ_i is the i-th eigenvalue. The Johansen technique proceeds by transforming a vector autoregressive model in levels into an equivalent differenced form, including lagged differences and an implied set of cointegrating vectors as the right hand explanatory variables. The differenced form is then estimated by using maximum likelihood methods. The implied vector cointegrating vectors are extracted using reduced rank regression technique. By Johansen approach, VECM can be estimated in which error correction term is included in each equation. Likelihood ratio test statistics can be derived from Johansen procedure, namely, the trace test statistics (Engle& Granger, 1987).

Vector Error Correction Model:

A vector autoregressive (VAR) model is a multivariate time series model whose general mathematical form with K-dimensional is given by the following formulation:

$$Y_t = \pi_1 Y_{t-1} + \ ... + \pi_k Y_{t-k} + \Phi D_t + \ \varepsilon_t + \quad (5)$$

Where, Πi Are K xK coefficient matrix, k is the order of VAR, ε_t is residual error term. The deterministic term Dt can contain a constant, that we consider fixed and non-stochastic. The Granger representation theorem states, under the hypothesis of cointegration, the VAR can be written as vector error correction (VEC) model as following formulation:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i\, \Delta Y_{t-i} + \Pi Y_{t-1} + \Phi\, D_t + \ \varepsilon_t + \quad (6)$$

For model use in this study, K is the number of variables correlated, Yt = (TEU, GDP, population, ICT, CPI, MPH, BDI, Harpex, patent application, CO2 generation, etc)

Impulse Response Function:

The impulse response function (IRF) trace out the moving average representation of the system and describes how the variable responds over time to a single surprise increase in itself or in any other variables (Potter, 2000).

The variance decomposition tells us how much of the average squared forecast error variance of one variable at the k-th step ahead is associated with surprise movements in each variable of the model.

$$A_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + u_t \quad (7)$$

$$\Phi_n(\varphi_{ik,n}) = \sum_{j=1}^{n} \Phi_{n-j} A_j \quad (6)$$

Where, n = 1, 2,… $\Phi_0 = I_k$, $A_j = 0$ for j>p and $\varphi_{ik,n}$ (the ik-th element of Φ_n) represents the response of variable y_i to a shock in variable k, n periods ago. Since covariance matrix of a VAR, $\sum_u$, is positive definite, it is essential to transform the innovation of the system into a contemporaneously uncorrelated form.

Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE):

The mean deviation is the first measure of dispersion. It is the average of absolute differences between each value in a set of value, and the average of all the values of that sets.

The mean deviation is calculated either from mean or median, but only median is preferred because when the signs are ignored, the sum of deviation of the sets taken from median is minimum. The formula to calculate Mean deviation are as stated below:

$$MAD = \frac{\sum|x_n - \bar{X}_n|}{N} \quad (7)$$

Mean Absolute Percent Error (MAPE) is the most common measure of forecast error. MAPE functions best when there are no extremes to the data. MAPE is the average absolute percent error for each time period or forecast minus actuals divided by actual (Duru & Yoshida, 2009):

$$MAPE = \frac{1}{N}\sum_{n=1}^{N}\frac{|X_n - \bar{X}_n|}{A_k} \quad (8)$$

Results:

Port Performance Variables Chosen:

As the dependent variable, container throughput volume will be divided into three groups of TEU-import, TEU-export and TEU-transshipment. Data sets are collected from the ministry of transport, Malaysia. A six year history spread across 24 quarters are tabled and another 20 forecasted quarters are projected. For port capacity, closely related as port performance indicator, move per hour (MPH) of container handling unit gets higher when more throughput comes through. However, it does waver when extra units are added, the movement is shared lowering the MPH.

As for other port indicator, Baltic Dry Index is a shipping and trade index created by the London-Based Baltic Exchange that measures fluctuation in cost for all raw materials transport. Price levels for given route (Capesize, Supramax and Panamax) and time to delivery. A rise in BDI reflects positive economic growth, thus spurring increase in TEU throughput. Other similar indictor created especially for container eight classes of ships rates by Harper Peterson & Co in 2004.

Environmental Independent Variables Chosen:

The environmental variable sets could be accounted by sources of emission which can mainly by electricity usage, generated by combustion of coal, gas and other natural resources. Furthermore, to tie all loose ends of environment emission, a gross account of the nations carbon footprint, considering car fuel consumption.

Table 1: Table of Variable Categories according Variable Type.

Port Performance Variable		Environmental Variables		Social Variables		Economical Variables	
Three TEU Sets	√	Electricity Usage (industry)	X_5	Population	X_8	GDP	X_{11}
Container Handling Time (MPH)	X_1	Nation Carbon Generation	X_6	ICT Penetration	X_9	DIA/FDI	$X_{12,13}$
Incoming Vessels	X_2	Green Projects (government funding)	X_7	Patent Application	X_{10}	CPI	X_{14}
BDI	X_3					Imp-Exp Trade	$X_{15,16}$
Harpex	X_4						

Malaysia government has set up a green technology financing scheme, approving RM 1.932 Billion since 2008. Green Projects may be reflective of progress of improving the environmental that boost economical activities as a domino effect. Having that said, more projects

Social Independent Variables Chosen:

In maritime industry, development of information and communication technologies (ICT) is crucial in handling extremely complex systems with highly dynamic interactions between participants and logistics control, etc. (Cho *et al*., 2011) argues that the relationship of ICT can be theoretically explain by resource-based view, can be regarded as internet penetration or even fix-line penetration (per 1000 people). Essentially, an increase in ICT capability could lead to an increase in container throughput; so goes to the domestic population growth that would create a supposed increase in throughput.

Medda and Carbonaro (2007) states that sea and land transport system growth is attributed to innovation taken place, which contribute the growth in the maritime industry. Innovation can be taken as the simple average of the scores of total royalty and patent applications approved.

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Economical Independent Variables:

Gross Domestic Product, a primary indicator to gauge the health of a country's economy represented in the total dollar (Ringgit Malaysia) value of all goods and services produced over a period of time (usually announced in yearly manner, yet available in quarterly form by data collection). This income approach measured can mean positive growth for any sector in the country

Apart from GDP, other economical indicators are all injected into the model to test as to which correlates fit to the TEU sets. All common indicators included are national domestic investment (DIA), foreign direct investment (FDI), consumer price index (CPI) as equal to inflation rate, Import and export trade volume.

Pearson Correlation Test:

Table 2: R value of Pearson Correlation for Xn (where n = 1,2,…,12)

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16
TEU Export	.549**	***.494****	-.308	-.273	.951**	.795**	.333	.820**	.817**	.211	.779**	.355	.402	.839**	***.831*****	***.927*****
	.005	.014	.144	.197	.000	.000	.112	.000	.000	.323	.000	.088	.052	.000	.000	.000
TEU Import	.163	.113	-.145	-.246	***.533*****	.207	.211	***.438****	***.454****	-.042	.457*	.171	.080	***.483****	.385	.433*
	.447	.599	.499	.247	.007	.331	.322	.032	.026	.846	.025	.425	.709	.017	.063	.035
TEU Trans.	***.754*****	.295	***-.541*****	-.350	.916**	***.903*****	.393	.928**	.923**	.100	***.893*****	.286	***.567*****	.923**	.759**	.898**
	.000	.162	.006	.093	.000	.000	.058	.000	.000	.643	.000	.176	.004	.000	.000	.000

** $p < 0.05$ significant
* $p < 0.1$ significant

The correlation displays the correlated variables matching each TEU sets, it's apparent that each variable has difference influence on TEU throughput (dependent variable). The choice of decision matching variable to TEU sets is subjected to the basis of high R correlation and ….and that each TEU sets should have at least two integrated variables.

Below are the selections of variable for Teu-Import, Teu-Export, Teu-Transshipment, both Kuching Port Authority(KPA) and Pelabuhan Tanjung Pelepas(PTP):

Table 3: Variable Selection for Kuching Port Authority.

	Teu Import (KPA-TI)	Teu - Export (KPA-TE)	Teu - Transshipment (KPA-TT)
1	Electricity Use	Vessel	MPH
2	Population	Export Trade	BDI
3	ICT Penetration	Import Trade	CO2 Emission
4	Consumer Price Index		GDP at constant 2005
5			Foreign Direct Investment

Table 4: Variable Selection for Pelabuhan Tanjung Pelepas.

	Teu Import (PTP-TI)	Teu - Export (PTP-TE)	Teu - Transshipment (PTP-TT)
1	MPH	CO2 Emission	BDI
2	Vessel	Population	GDP at constant 2005
3	Electricity Use	ICT Penetration	
4	Foreign Direct Investment	Consumer Price Index	
5	Import Trade	Export Trade	

Some interesting points to note from the correlation result is that some variables are not correlated to, such as Harpex index, cases of green projects, patent application, domestic investment abroad. As much as Harpex is based on the global container flow, while Baltic Dry Index is projected by all bulk cargo shipments from all canals, Harpex Index is not correlated in this series. This proves the findings for suggested variables may or may not be applicable to all ports.

ADF –Unit Root Test:

All variables for the full sample for the full period of 6 years, divided into 4 quarters, are stationary at first differenced, since the null of unit root is rejected at first difference. Though some are differently stationary by probability all are accepted at first differenced.

Table 5: Unit root test by Augmented Dickey-Fuller (ADF)

Series	Level	First difference	Second Difference	Integrated Order
(X_1) TEU import (Kuching)	-3.07203	-4.59378**	-	I(1)
	-0.1403	-0.0096		
(X_2) TEU Export (Kuching)	-4.39805*	-4.26386*	-8.39424**	I(1)
	-0.0109	-0.0158	0	
(X_3) TEU Transshipment (Kuching)	-0.80889	-5.64572**	-	I(1)
	-0.9484	-0.0009		
(X_4) M.P.H. (Kuching)	-2.1734	-5.25012**	-	I(1)
	-0.481	-0.0018		

….	….	….	….	….
….	….	….	….	….
….	….	….	….	….
(X_{21}) TEU Export (PTP)	-3.56582	-4.53824*	-6.50623**	I(1)
	-0.0557	-0.0115	-0.0002	
(X_{22}) TEU Transshipment (PTP)	-2.28024	-6.07834**	-	I(1)
	-0.4224	-0.0004		

** p < 0.05 significant
* p < 0.1 significant

Johansen Co-Integration Test & Vector Error Correction Model:

Maximum eigenvalues and trace statistics are computed by Johansen procedure in table 5 and 6. Table 7 shows the regression results on the Johansen procedure, a series was generated for a sample period to estimate how well the series match with the actual data. The estimation is used in the same manner to project the 20 period forward TEU throughput.

Table 6: Unrestricted Cointegration Rank Test (Trace) for TEU-KPA-Import Cluster

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.972130	184.8302	95.75366	0.0000
At most 1 *	0.912753	106.0659	69.81889	0.0000
At most 2 *	0.804318	52.40755	47.85613	0.0176
At most 3	0.430303	16.51974	29.79707	0.6752
At most 4	0.168372	4.141421	15.49471	0.8918
At most 5	0.003868	0.085271	3.841466	0.7703
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				

Any transformation done to the data is then again reverted back to the original value (level).

Table 7: Cointegration Test by Johansen Procedure for TEU-KPA-Import Cluster.

		No of Variables	No of Co-integrating Equations		Note
			Trace Test	Max-Eigen value test	
Kuching	KPA-TI	6	*3*	3	Ok
	KPA-TE	6	*4*	4	Good
	KPA-TT	3	*2*	2	Good
PTP	PTP-TI	5	*1*	1	Weak
	PTP-TE	4	*2*	2	Ok
	PTP-TT	6	*4*	4	Good
Where, TI = Teu Import, TE= Teu Export, TT = Teu Transshipment					

Table 8: Coefficient matrix of vector error correction model.

Error Correction:	d(teuimport)	d(mph)	d(vessel)	d(electricity)	d(imtrade)	d(fdimil)
d(teuimport(-1))	-0.045983	-0.000134	-0.000263	-0.100917	0.201705	0.026124
	(0.26470)	(0.00027)	(0.00108)	(0.06819)	(0.77415)	(0.24542)
	[-0.17371]	[-0.49516]	[-0.24478]	[-1.47993]	[0.26055]	[0.10644]
d(mph(-1))	-302.1489	0.029577	1.800127	35.55162	1039.517	4.809994
	(251.393)	(0.25701)	(1.02204)	(64.7615)	(735.217)	(233.080)
	[-1.20190]	[0.11508]	[1.76131]	[0.54896]	[1.41389]	[0.02064]
d(vessel(-1))	9.439168	0.088499	0.277669	11.23535	98.15048	36.18087
	(62.3914)	(0.06378)	(0.25365)	(16.0727)	(182.468)	(57.8465)
	[0.15129]	[1.38747]	[1.09468]	[0.69903]	[0.53790]	[0.62546]
d(electricity(-1))	-5.426500	-0.001068	-0.037678	-0.337768	-4.871991	-2.089468
	(2.73180)	(0.00279)	(0.01111)	(0.70374)	(7.98935)	(2.53280)
	[-1.98642]	[-0.38227]	[-3.39248]	[-0.47996]	[-0.60981]	[-0.82496]
d(imtrade(-1))	0.316166	-0.000130	0.003016	0.035442	0.505369	0.021945
	(0.12549)	(0.00013)	(0.00051)	(0.03233)	(0.36702)	(0.11635)
	[2.51936]	[-1.01192]	[5.91055]	[1.09631]	[1.37696]	[0.18861]
d(fdimil(-1))	-1.216750	-0.000474	-0.008155	-0.100952	-0.421306	-0.087982
	(0.66595)	(0.00068)	(0.00271)	(0.17156)	(1.94762)	(0.61744)
	[-1.82709]	[-0.69553]	[-3.01192]	[-0.58845]	[-0.21632]	[-0.14250]
c	580.8857	0.691033	0.697859	120.3469	1109.850	56.15258
	(742.117)	(0.75869)	(3.01709)	(191.177)	(2170.38)	(688.057)
	[0.78274]	[0.91083]	[0.23130]	[0.62950]	[0.51136]	[0.08161]
Where, observations are error estimates, ( ) are estimates standard error; [ ] are t-statistics for estimates						

Impulse Response Function:

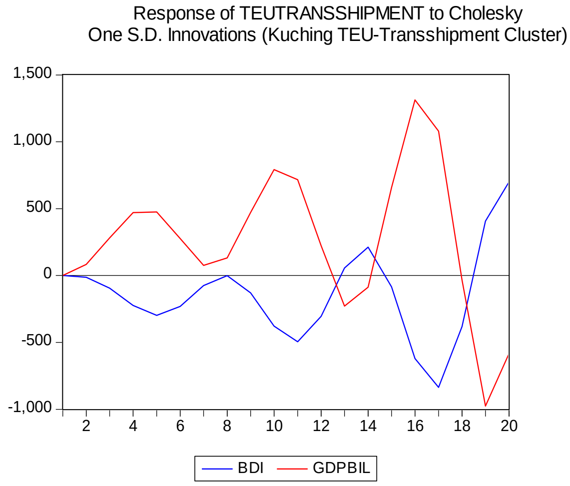

Fig. 2: IRF for KPA TEU-import.

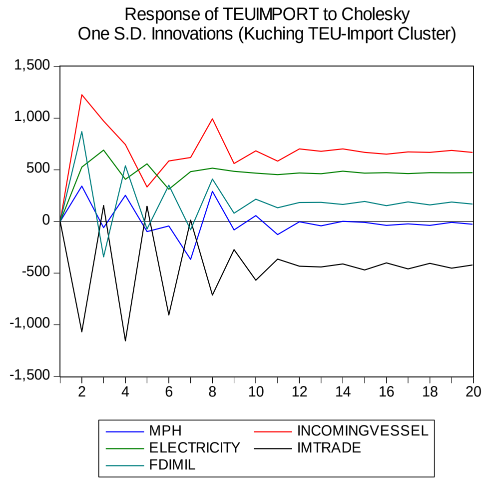

Fig. 3: IRF for KPA TEU-transshipment.

Results of all cointegrated variables, as assigned to TEU sets, are responding in a died-off scenario (stabilized). All impulse of a one deviation shock from all variables on the independent TEU sets works out to converge around the 0 region and flat out as depicted in figure 2. Understandably, when a shock of incoming vessel, MPH, electricity used, FDI and import trade provides a positive response, it shows an steady increase in variables contributes a steady increase on the TEU sets.

Throughput Forecast:

After combining the sets of throughput that made up the total throughput, the results shows a different forecast trend, even for both ports (KPA and PTP). As compared to the actual Teu throughput, KPA's forecast by green and sustainable approach is lower than the forecast by conventional approach; PTP's conventional forecast has least error and closely correlated (MAD and MAPE in figure 9 displays the list of deviation between all forecasts), however the forecast by green and sustainable approach fluctuates unstably after projected 12 periods.

The fluctuation in the green and sustainable approach for KPA forecast, as able as it was able to capture the trend of fluctuation at the end of actual throughput, has IRF that indicates instability in KPA transshipment (shown in figure 3). There are observation to justify the model's integrity is probably due to the following causes:
1) KPA's transshipment experience a steep decrease the last three period.
2) Transshipment has a short and fluctuating history as just a beginning seaport.
3) Transshipment has variables (Baltic Dry Index, GDP) that may not be exactly correlated at the moment

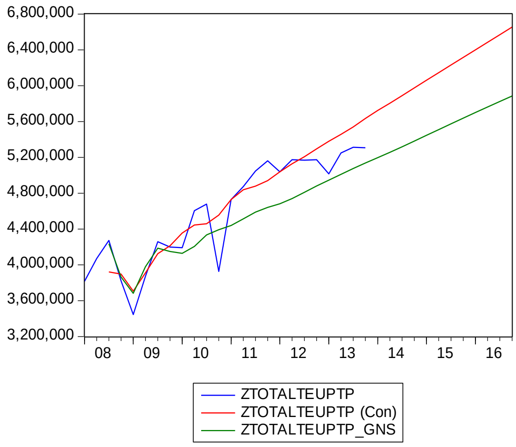

Fig. 5: IRF for KPA TEU-transshipment.

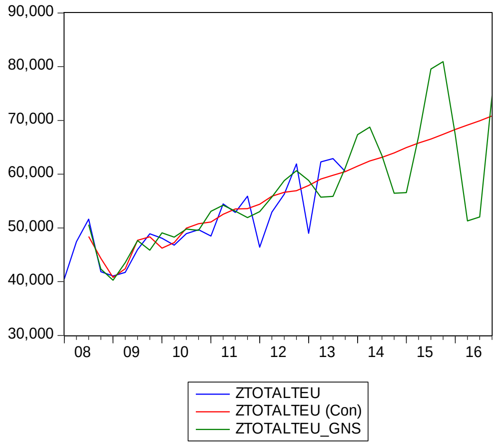

Fig. 4: IRF for KPA TEU-import.

Table 9: Statistics of MAD and MAPE

	Actual.KPA	Con.KPA	GnS.KPA	Actual.PTP	Con.PTP	GnS.PTP
N Valid	22	22	22	22	22	22
Std. Error of Mean	1403.208	1205.239	1228.209	121200.62	125886.51	86465.22
Std. Deviation	6581.627	5653.075	5760.813	568481.329	590460.061	405557.846
Variance	43317818.82	31957258.05	33186968.31	3.232E+11	3.486E+11	1.644E+11
MAD	N/A	2383.317	2668.368	N/A	172797.2	254579.7
MAPE	N/A	4.665%	5.141%	N/A	3.83%	5.37%

MAD And MAPE:

The most common gauge for compatibility for forecasting comes down to the deviation of available

Conclusion:

From all the findings, we may draw the conclusion (1) that proves different ports possess different correlating variables that may change following port growth, e.g. from hubport to transshipment hub or economical development. In all cases, total throughput should be divided and separated, forecasted by each individual sets. (2) From the trend capturing and sensitivity to data progression, green and sustainable forecasting proves a better forecasting on basis of ability to capture little changes in each individual TEU sets, despite the extra error (little significance of 1-3% deviation from actual trend). (3) For a generic green and sustainable forecasting, variables are inexhaustible for individual ports dynamic change and therefore should be always on the look for more compatible variable for forecasting every now and then.

Being able to forecast better in this green and sustainable forecasting, more environmental monitoring with statistical access data would increase reliability and robustness of the model. However, all these could be materialized, subjected to technological breakthrough as each field matures. For further research coverage, call for more comprehensive green and sustainable approach can be implemented by hybrid forecasting – a fusion of statistical and judgmental forecasting as enhancement.

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