

# An Exploration in to the Causal Relationship between Performance Inputs and Traffic of Major Ports in India: A Panel Data Analysis

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Received December 30, 2013; Revised March 18, 2014; Accepted March 20, 2014

**Abstract** The present research work started with a very simple question: Is there a long run relationship and causality between port performance inputs and port traffic of major ports in India? The study is try to evaluate the long run relationship and causality between port performance inputs and port traffic with the sophisticated panel data models such as unit root, cointegration, error correction model, granger causality, impulse response function and variance decomposition tests of 12 major ports in India over the period of 1993 to 2012. Based on the analysis it is found that there exists long run relationship and causality between port performance inputs and port traffic. The study concluded that the evidence of long run relationship between performance inputs and total traffic, and causality of pre-berthing waiting time and operating expenses unidirectional with port traffic indicate that the major factors influencing port traffic. Over all the results imply that port performance variables that are having the co-integrating relationship with port traffic should be given priority for increasing the port traffic of major ports in India.

**Keywords:** port performance, port traffic, panel data analysis, panel cointegration, panel error correction model, panel granger, impulse response function, variance decomposition

**Cite This Article:** T. Rajasekar, Malabika Deo, and Rong Ke, "An Exploration in to the Causal Relationship between Performance Inputs and Traffic of Major Ports in India: A Panel Data Analysis." *International Journal of Econometrics and Financial Management*, vol. 2, no. 2 (2014): 72-81. doi: 10.12691/ijefm-2-2-3.

## 1. Introduction

Recent time is witnessing increased awareness on the ports, their infrastructure and performance which are regarded as the contributors to the trade performance of a country. Performance of ports has been linked with growth and efficiency of transportation of overseas trade. This awareness has been eagerly activated since the implementation of liberalization from 1991. It is understood that poor port performance reflects negatively on the country's economic development. Thus the performance, cause and effect of such performance need to be studied in sequential manner for evaluating the port efficiency. It is obvious that the performance of ports can differ from region to region. Based on the earlier studies it is understood that Singapore, Hong Kong are rated as most efficient ports in the Asian region. Whereas the inefficient ports are found to be in Ethiopia, Nigeria and Malawi in the Africa region, the ports of Colombia, Venezuela and Ecuador in South America region (Wu, J., & Lin, C, 2008, & Wu, et al., 2009). It seems to suggest that geographical location play a determinant role of ports efficiency. Apart from location, some ports are seen to have become inefficient because of lack of combined services, out-of-date work practices or the out modes

services. All these can adversely effect on port efficiency, thereby have telling effect on the country's economic growth in the borderless world. Because of increasing inefficiency many countries have been forced to deregulate the port operating system in and around world (Estache, A., & Carbajo, J. 1997, and Bollard, A., & Picford, M. 1998). Most of the countries have begun to deregulate their port activities and centralized decision making system in order to increase productive efficiency of the ports in addition to liberalizing their respective economies. On the above ground many governments, around the world, have started to reformulate their ports administration by controlling, managing and regulating with the principle of minimal direct intervention, and increased private participation. According to Thomas and Monie (2000), the efficiency of ports and terminals must measure the performance of the economy and its foreign trade. The measurement of ports or terminal efficiency is of particular importance, because they are vital to the economy of a country and to the success and welfare of its industries and citizens respectively. Many a previous studies have proved that container handling activities like number of berths, berth length, equipment's available and cost of handling etc. are the important factors for the port performance in terms of total traffic. Based on this perspective the present study tries to investigate the causal relationship between performance and traffic among major

ports in India. The variables that were considered influencing port performance were based on the location of the port, equipment's available in the port, cost for both cargo handling and service (Veldman & Vrookmen 2007, Zohil & Prijon 1999, Tongzon 1995). Some of the earlier research works tried to measure the relationship between transport costs, infrastructural development and port efficiency (Clark et al. 2004, Sanchez et al. 2003). On the basis of above observation it is understood that no study tried to find the causal relationship between performance and traffic in panel approach, of major ports in India. Since our data structure is both cross section i.e. 12 major ports and time series i.e. over the period of time 1993-2012, it was thought appropriate to include the panel models for the study. In this direction the present study has made an effort towards investigating cause and effect relationship of input & output of major ports in India over the period of 1993 – 2012.

There was dearth of studies both in India or global level, on finding determinants or causes of port performance applying panel data methodology. However panel data determinants analysis were found to have been applied in some sectors like determinants of economic growth (Twinmukye, E 2006 and Dewan, E & Hussein, S 2001) performance of economic growth (Akbar et al 2011) determinants of farm land price (Duvivier, R et al 2005) cross – border tax information sharing (Lighthart, J 2008) small and medium enterprise performance (Matheev, M and Anastasov, Y 2010). Though Wanke, P et al 2010, attempted to study the factors determining port performance through panel data methodology, the analysis was based on efficient and inefficient ports. Hence the present study tried to evaluate the causes of port performance measured in terms of port traffic in major ports of India.

The main purpose of the study is to investigate the causal relationship between the performance input and traffic of major ports in India over the period of 1993 to 2012. To find out the relationship and causality, this study considered necessary panel data models for analysis. The organization of the research paper is as follows. Section 2 deals with data and methodology. Section 3 shows the econometric models and results of cause and relationship between performance and traffic of major ports in India. Finally concluding remarks have been presented briefly in section 4.

## 2. Data & Methodology

The facilities of the ports can be taken from port infrastructure and these facilities can help to increase the port traffic. The performance input variables were formulated through composite variables inside the ports like pre-berthing waiting time (PBWT), Percentage of idle time at berth to time at working berth (IDLE), operating expenses (OPEXP) berth length (BLENTH), number of employees (NOE) and cargo equipment's (CAREQUIP) for 12 major ports over a period of 20 years starting from 1993 to 2012. The necessary data were directly collected from administration of the respective ports and some of the data's were collected through Centre for monitoring Indian Economy (CMIE) data bases.

To determine the causal relationship between performance and traffic the important econometric tools

like unit root test, cointegration test, error correction model, granger causality test, impulse response function and variance decomposition methods have been used. Since our data structure flows in panel i.e. both cross section and time series, the present study follows panel data models in above said econometric tools to judge the nature and the relationship of performance inputs and traffic of major ports in India.

Basically any econometric analysis follows sequentially several steps, before employing the final model. It is presupposed to measure the basic assumptions, i.e. testing the unit root process to understand the order of getting stationarity i.e. level I (0) or first difference I (1). If the data is not getting stationary in level, it must be differenced enough to achieve stationarity whether at first difference or second difference. Once the unit root process is completed then it can move to measure the relationship whether the series is cointegrated in long run or short run. For checking the relationship we have to use panel cointegration test. Since we know the cointegration test is especially for long term and we used error correction model for measuring the short run relationship between the variables. After finding out the long and short term relationship, the study used granger causality test for examine the cause and effect between performance and traffic. Impulse response function and variance decomposition methods are used to find out effect of the shocks given to the residuals on the total traffic in the future periods through graphical as well as tabular presentation.

## 3. Empirical Analysis and Results

### 3.1. Panel Unit Root Test

Unit root tests is an integral part of time series analysis, as mostly the economic time series data are non-stationary and without bringing data to stationarity, application of any regression model may result in to spurious or misleading results. For panel data the test of unit root was developed in the beginning of 2000. There after several models have been developed for testing the unit root in panel data. The test of panel unit root used for checking the non-stationarity in economic series is done by differencing and detrending the data series. Basically the panel unit root tests are follows same version of standard dynamic models, such as;

$$y_{it} = \rho y_{it-1} + \delta_0 + \delta_1 t + n_i + v_t + \varepsilon_{it} \quad (1)$$

From the model testing the coefficient of  $\rho$  is equal to one. Subscript denotes  $i = (1, 2, \dots, N)$  distinguishes the  $N$  individuals included in the panel. Before applying the unit root test it is necessary to check the data type. Since our data is balanced panel i.e. equal number of observation in both time series and cross section, we must use appropriate test of unit root which will support the balanced panels. Hence the present study adopts the unit root test models advocated by LLC (2002), Breitung (2000), IPS (2003) and Hadri (2000) for balanced panel. The test of LLC (2002) and Breitung (2000) measures unit specific time trends in addition to common. Whereas IPS (2003) is based on averages of the individual unit root test statistics. The models like LLC (2002), Breitung (2000)

and IPS (2003) are based on augmented dickey fuller (ADF) principles i.e. the null hypothesis of a unit root is the presence of unit root process or non stationarity and

the alternative is no unit root process or stationary. But the hypothesis are interchanged by Hadri (2000) which adapts KPSS tests to panel for the null of stationary process.

Table 1. Panel Unit Root Results

A. Level	LLC	Breitung	IPS	F- ADF	Hadri
TOTRAFFIC	-0.780	1.695	-0.210	28.608	5.762 ***
PBWT	1.945	-0.281	2.083	12.320	5.211 ***
IDLE	-0.197	-0.488	-0.400	24.758	5.298 ***
CAREQUIP	0.982 **	0.094	0.093	21.398	3.058 ***
BLENTH	0.577	-1.052	1.639	12.183	5.583 ***
NOE	-0.353	-0.925	1.757	53.352 ***	5.975 ***
OPEXP	0.611	0.150	1.067	0.217	4.258 ***
First differences	LLC	Breitung	IPS	F-ADF	Hadri
<b>B. TOTRAFFIC</b>	-6.399 ***	-2.403 **	-3.615 ***	76.958 ***	1.164
PBWT	-9.504 ***	-1.592 **	-2.182 ***	115.69 ***	1.024
IDLE	-8.546 ***	-2.142 **	-4.325 ***	102.26 ***	1.763
CAREQUIP	-10.306 ***	-1.348 *	-4.610 ***	142.32 ***	0.177
BLENTH	-6.824 ***	-5.917 ***	-4.130 ***	97.19 ***	0.438
NOE	-4.104 ***	-3.717	-4.720	65.72 ***	-1.700
OPEXP	-4.689 ***	-3.584 ***	-1.512 *	47.90 ***	0.168

LLC = Levin, Lin, Chu (2002), Breitung (2000), IPS = Im, Pesaran, Shin (2003), based on ADF and PP, these test statistics are asymptotically distributed as standard normal with a left hand rejection area. The null hypothesis of non stationarity. Hadri (2000) unit root statistics are asymptotically distributed as standard normal with a right hand side rejection area. The null hypothesis of stationarity process. The selection of lag is based on modified Akaike information criterion. Newly – West selection using Bartlett kernel. Fisher tests are asymptotic chi-square distribution.\*- significance at 10% level, \*\*- significance at 5% level, \*\*\*- significance at 1% level.

In econometric analysis the preliminary step is to check the integration properties of the variables which are chosen for the study. Table 1 presents the results of panel unit root test for LLC, Breitung, IPS and Hadri of major ports in India. Panel unit root models were employed with fixed effects and individual time trends in the data generating process. From the table it is evident that all the variables accepted the unit root hypothesis of unit root process or non stationarity at levels. But these variables are getting stationary at first difference at different confidence level except CAREQUIP which is getting stationary in level under test LLC. From the results of panel unit root it can be concluded that the series are non-stationary and integrated at order one i.e. I (1). Once the data integrated in the first order, panel cointegration test can be applied to investigate the long run relationship, if exists, between the variables.

### 3.2. Panel Cointegration Test

The panel cointegration test examines the existence of long term relationship between performance inputs and traffic of major ports in India. In this section we apply the homogeneous as well as heterogeneous panel Cointegration tests like Kao (1999), Pedroni (1999) for the null hypothesis of no cointegration in homogeneous panels and Fisher (1998) type combine Johansson for the null hypothesis of no cointegration in heterogeneous panels.

#### 3.2.1. Kao Cointegration Test

The residual based panel cointegration suggested by Kao (1999) homogeneous panel cointegration tests is employed in this study. The tests assume homogeneous slope coefficient across individuals. The present study tries to find out the causal relationship between performance inputs and traffic of major ports in India Kao

(1999) tests is applied with null of no cointegration. This test is based on the residuals  $\hat{\epsilon}_{it}$  of the OLS panel estimation by applying two types of panel cointegration tests i.e. Dickey – Fuller (DF) and Augmented Dickey – Fuller (ADF).

$$\hat{\epsilon}_{it} = \rho \hat{\epsilon}_{it-1} + v_{it}$$

$$\hat{\epsilon}_{it} = \rho \hat{\epsilon}_{it-1} + \sum_{j=1}^p \varphi_j \Delta \hat{\epsilon}_{it-j} + v_{itp}$$

The null hypothesis of no cointegration can be written as  $H_0 : \rho = 1$  is tested against the alternative hypothesis of stationary residuals i.e.  $H_a : \rho < 1$ .

#### 3.2.2. Pedroni Cointegration Test

The test of Pedroni (2000) cointegration adopts measures the heterogeneous panels, in which heterogeneous slope coefficient, fixed effects and individual specific deterministic trends are permitted. This panel cointegration allows to test the null hypothesis of no cointegration and the residuals based on the panel analogue of Engle and Granger (1987) statistics to test the distributions.

The Pedroni (2000) panel cointegration regression is as follows

$$S_{it} = \alpha_i + \delta_i t + \beta_{1i} X_{1it} + \dots + \beta_{mi} X_{mit} + \epsilon_{it}$$

$$t = 1 \dots T, i = 1 \dots N.$$

Pedroni (1999) developed seven Cointegration statistics, out of seven first four statistics are based on within dimensions and rest are based on between statistics. The first of the sample panel Cointegration is a type of non-parametric variance ratio statistics. The second is a panel version non-parameteric analogues to the familiar PP-rho

stat. The third statistics is also non-parametric, analogues to the PP – statistics. The fourth statistics is simple panel Cointegration statistics which corresponds to ADF statistics. The rest of the three statistics are based on a group mean approach, the first one is analogous to the PP-rho statistics and rest two are analogous to the PP and ADF statistics respectively.

**3.2.3. Fisher Combined Johansson Test**

Johansen (1998) proposed two different approaches, one of them is the likelihood ratio trace statistics and the other one is maximum eigenvalue statistics, to determine the presence of Cointegration vectors in non stationary time series. The trace statistics and maximum eigenvalue statistics are derived by fitting the equation below.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$$

Here T is the sample size, n is total number of variables  $\hat{\lambda}_i$  is the i th largest canonical correlation between residuals from the three dimensional processes. For the

trace test the null hypothesis of at the most r Cointegration vector against the alternative hypothesis of full rank  $r = n$  Cointegration vector, the null and alternative hypothesis of maximum eigenvalue statistics is to check the r coingrating vectors against the alternative hypothesis of r+1 cointegrating vectors.

The results of Kao (1998) homogeneous panel cointegration tests are given in the Table 2. Where the hypothesis tested that null of no cointegration between port performance inputs and port traffic. The results show that for port performance inputs and port traffic the null hypothesis of no cointegration can be rejected based on Kao (1998) test and it can be interpreted that port performance inputs and port traffic having long run relationship in overall test statistics. From the above result it is noted that individually the variables like berth length, number of employees and operating expenses having strong relationship with port traffic while rest of the variables do not have the long run relationship. The panel Cointegration tests point out the existence of a long run relationship between port performance inputs and port traffic as far as overall port performance variables are concerned.

**Table 2. Kao Residual Homogeneous Co-integration Test**

Variable	t – stat	Prob	R – variance	HAC - variance
PBWT	0.135	0.446	0.015	0.029
IDLE	-0.964	0.164	0.015	0.026
CAREQUIP	-0.128	0.448	0.015	0.027
BLENTH	-2.057 **	0.019	0.014	0.024
NOE	-1.401 *	0.085	0.015	0.025
OPEXP	-2.727 ***	0.003	0.012	0.018
Overall	-2.373 ***	0.008	0.009	0.009

Models contain total traffic of major ports in India and an alternative indicator of preberthing waiting time, idle time, cargo equipment’s, berth length, number of employees, operating expenses. Statistics are asymptotically distributed as normal. The Kao Residual Co-integration test are described in details in Kao (1999). Homogeneous assumptions: individual intercept and no individual trend, Lag selection based on Akaike information criterion, Newly – West automatic bandwidth selection with Bartlett Kernel. \*- significance at 10% level, \*\*- significance at 5% level, \*\*\*- significance at 1% level.

The results of the Pedroni (1999) panel cointegration tests are given in the Table 3. The results show that for port performance inputs taken and port traffic, the null hypothesis of no cointegration can be rejected in the panel variance long run test, panel – ADF test and group – ADF tests. However it was not rejected in other tests like panel – rho stat, panel – pp stat, group – rho and group – pp stats. As the port performance input variables are found in the relationship with port traffic we can conclude that the

evidence indicates that there is existence of long run relationship between the variables. The panel Cointegration tests point at the existence of a long run relationship between port performance inputs and port traffic as far as all the port performance variables are concerned. Pedroni (1999) results rejected the null hypothesis of no cointegration in the important tests like panel-variance test, panel-ADF and group – ADF.

**Table 3. Pedroni (1999) Heterogeneous Panel Co-integration Tests for Bivariate Models**

Variable	P-V stat	P – rho	P – PP	P – ADF	G – rho	G – PP	G – ADF
PBWT	10.676 ***	0.981	0.648	-2.109 **	1.964	0.670	-2.501 ***
IDLE	8.963 ***	1.229	0.404	-2.503 ***	1.748	-0.028	-2.091 **
CAREQUIP	8.491 ***	1.692	1.542	-1.871 **	2.246	0.616	-2.327 **
BLENTH	7.245 ***	1.159	0.701	-1.136	2.036	0.689	-1.370 *
NOE	10.189 ***	1.020	0.840	-3.302 ***	1.664	0.420	-3.830 ***
OPEXP	2.363 ***	1.686	1.757	-1.235	2.029	1.215	-2.734 ***

Models contain total traffic of major ports in India and an alternative indicator of pre-berthing waiting time, idle time, output per ship per day, operating surplus per ton, cargo equipment’s, berth length, number of employees, rate of return on turn over, operating expenses. Statistics are asymptotically distributed as normal. The Pedroni statistics are described in detail in Pedroni (1999). Heterogeneity assumptions: individual intercept and individual trend, Lag selection based on Akaike information criterion, Newly – West bandwidth selection with Bartlett Kernel. \*- significance at 10% level, \*\*- significance at 5% level, \*\*\*- significance at 1% level.

The results of Fisher Johansen combined test results are presented in the Table 4. From the table it is observed that both trace and max eigen value results show there is a long run relationship between port performance inputs and port traffic. The result under none statistics indicates that, all the variables are found to have cointegrating relationship between the variables except Preberthing waiting time (PBWT) which was found to have no cointegrating relationship at max-eigen value. When we

tested the same variables into Atmost 1 most of the variables were found to have cointegrating relationship between the variables except number of employees (NOE) and operating expenses (OPEXP) which were found no cointegrating relationship in both trace and max-eigen value statistics. Overall Fisher Johansen Cointegration test results proved that there is existence of long run relationship between port performance inputs and port traffic.

Table 4. Johansen Fisher Panel Co-integration Test for Bivariate Models

Variable	None		At most 1	
	Fisher trace stat	Fisher Stat – Max – eigen value	Fisher trace stat	Fisher Stat – Max – eigen value
PBWT	37.13 **	31.99	36.52 **	36.52 **
IDLE	53.99 ***	47.32 ***	39.78 **	39.78 **
CAREQUIP	46.71 ***	38.09 **	43.56 ***	43.56 ***
BLENTH	53.58 ***	47.56 ***	37.52 **	37.52 **
NOE	41.50 **	40.84 **	25.91	25.91
OPEXP	36.99 **	34.51 **	30.00	30.00

Models contain total traffic of major ports in India and an alternative indicator of preberthing waiting time, idle time, output per ship per day, operating surplus per ton, cargo equipment's, berth length, number of employees, rate of return on turn over, operating expenses. Statistics are asymptotically distributed as normal. The Johansen Fisher panel co-integration test is described in details in Johansen Fisher test (1998). Homogeneous assumptions: Linear deterministic trend, Lag selection interval was 1, 1. \*- significance at 10% level, \*\*- significance at 5% level. \*\*\*- significance at 1% level.

### 3.3. Panel Vector Error Correction Model (VECM)

After being able to find the existence of long run relationship through cointegration tests to know the nature of the relation error correction model has been employed. This model is applied to find out the short run relationship, if any, between performance inputs and traffic of major ports in India. This test measures the multivariate cointegration framework with N individuals with time trend dimension T and the set of first difference variables. The heterogeneous vector cointegration model takes the following form;

$$\Delta Y_{it} = \Pi_i Y_{i,j-1} + \sum \Gamma_{ik} \Delta Y_{i,j-k} + \varepsilon_{it}$$

$$i = 1, \dots, N$$

Where Y is a  $p \times 1$  vector of variables and the long run matrix  $\Pi$  is of order  $p \times p$ . This equation is estimated for each individual N, using the maximum likelihood method, and the trace statistic is calculated. The null hypothesis tested here is that all N individuals have the same number of cointegrating vectors (r) among the p variables. In other words  $H_0: \text{rank}(\Pi) = r_i < r$ , against the alternative hypothesis,  $H_1: \text{rank}(\Pi) = p$  for all  $I = 1 \dots N$ .

Table 5. Panel Vector Error Correction Model

Variables	Lag	Co-eff	SE	Prob	Lag	Co-eff	SE	Prob
TOTRAFFIC	1	-0.083 **	0.079	0.014	2	-0.073	0.082	0.375
PBWT	1	-0.041 *	0.024	0.093	2	-0.032	0.022	0.156
IDLE	1	0.098 *	0.057	0.088	2	0.029	0.056	0.603
CAREQUIP	1	0.029	0.019	0.134	2	0.005	0.019	0.768
BLENTH	1	-0.054	0.092	0.556	2	-0.026	0.094	0.781
NOE	1	-0.020	0.125	0.871	2	0.060	0.124	0.628
OPEXP	1	-0.005	0.070	0.941	2	-0.072	0.068	0.288
Cons		0.067 ***	0.014	0.000				
U <sub>t</sub> (Error term)		-0.083 ***	0.027	0.003				
Wald F – stat		0.863		0.536				

Models contain total traffic of major ports in India and an alternative indicator of preberthing waiting time, idle time, output per ship per day, operating surplus per ton, cargo equipments, berth length, number of employees, rate of return on turn over, operating expenses. Statistics are asymptotically distributed as normal. Lag selection interval was 1 and 2. Ut – Error Correction Term. Wald F-stat calculated through coefficient of Wald co-efficient restriction test. \*- significance at 10% level, \*\*- significance at 5% level, \*\*\*- significance at 1% level.

From the test results of vector error correction model (VECM) presented in the Table 5 we can identify the short run dynamics between the variables as well as the long run relationship. From VECM result the variable having negative sign and significant coefficient will be treated of

having a long run relationship also apart from short run relationship, the variable showing negative but not significant will be understood to have short run dynamic relationship only. To confirm the short run relationship between the variables Wald F-stat is required. Over all the

model relationship can be predicted by  $U_t$  (error term) which if negative and significant then it will be confirmed that there exists a long run relationship. From the results it can be observed that the variables like pre-berthing waiting time, idle time have a long run relationship. The lag selection is automatically done on the basis of best model selection. From the results it is also observed that the error correction term shows negative and significant value, Hence it can be said that long run relationship exists between the variables. Further as Wald statistics was found to be insignificant, it was inferred that there is no short run relationship between the variables in the present model.

### 3.4. Panel Granger Causality Test

After investigating the short and long run relationship the enquiry proceeds to find out the causality between the variables test to identify the cause and effect. The present study used panel granger causality test based on Granger's (1969) concept. Granger causality tests measures the causal relationship with bivariate data sets and these relationships can be expressed as unidirectional or bidirectional. The panel Granger causality tests takes the following form;

$$Z_{it} = \sum_{j=1}^p \Gamma_{ijt} Z_{i,t-j} + \mu_{it} + \varepsilon_{it}, i = 1, \dots, N \ \& \ t = 1, \dots, T$$

With  $Z_{it}$  K-dimensional. For the bivariate models  $K=2$  with  $Z_{it} = [\text{Port Performance}_{it} \ \text{Port Traffic}_{it}]$  with "L" indicating natural logarithms. The vector  $\mu_{it}$  contains individual specific i.e. major ports in India and period fixed effects;  $\mu_{it} = \alpha_t + \beta_i$ , accounting for both common

shocks and general growth difference between ports. Accordingly, we allow for at most period effects. The disturbances  $\varepsilon_{it}$  are assumed to be independently distributed across individuals and time, with means 0 and variances  $\alpha^2_i$ , permitting individual heteroscedasticity.

The parameter matrices,  $\Gamma_{ijt}$ , potentially vary with  $I, j$  and  $t$ . As all coefficients cannot differ, we allow for temporal heterogeneity in causal links that are assumed homogeneous across individuals, and the converse case of individual specific causal links that are invariant over time. A specific element of  $\Gamma_{ijt}$  is denoted by  $\gamma_{ab,ijt}$ , which are of interest in granger noncausality using Wald statistic, whereas we test  $H_0 : \gamma_{21,ijt} = 0 \ \forall i, j, t$  to determine whether port performance inputs are granger noncausal for port traffic.

Table 6, presents the bivariate causality outcomes of port performance inputs and port traffic of major ports in India. The results were obtained in three different lags for the better results of causality between the variables. The results indicate that pre-berthing waiting time (PBWT) granger cause of total traffic in all the three lags, whereas operating expenses (OPEXP) found to be cause of total traffic in the first two lag. Only two variables are mainly found to be the cause of total traffic rest of the variables independently performed and they did not show any causal effect with total traffic. Only two variables were found to have unidirectional causal relationship instead of bidirectional they are PBWT and OPEXP causing total traffic thus they may be considered as the influential factors causing better or otherwise performance of the ports in India.

Table 6. Panel Granger Causality

Null Hypothesis	Lag	F – Stat	Lag	F- Stat	Lag	F - Stat
PBWT does not Granger cause of TOTRAFFIC	1	5.034 **	2	3.023 **	3	1.516 *
TOTRAFFIC dos not Granger cause of PBWT	1	0.892	2	2.216	3	0.847
IDLE dos not Granger cause of TOTRAFFIC	1	0.358	2	1.693	3	0.967
TOTRAFFIC dos not Granger cause of IDLE	1	0.002	2	0.995	3	1.041
NOE does not Granger cause of TOTRAFFIC	1	0.580	2	0.280	3	0.176
TOTRAFFIC dos not Granger cause of NOE	1	0.019	2	0.166	3	0.481
CAREQUIP does not Granger cause of TOTRAFFIC	1	0.602	2	1.345	3	0.990
TOTRAFFIC dos not Granger cause of CAREQUIP	1	0.384	2	0.480	3	0.462
BLENTH does not Granger cause of TOTRAFFIC	1	1.434	2	0.364	3	0.269
TOTRAFFIC dos not Granger cause of BLENTH	1	0.022	2	0.971	3	1.221
OPEXP does not Granger cause of TOTRAFFIC	1	3.468 *	2	2.573 **	3	0.986
TOTRAFFIC dos not Granger cause of OPEXP	1	0.005	2	1.552	3	1.511

Models contain total traffic of major ports in India and an alternative indicator of preberthing waiting time, idle time, output per ship per day, operating surplus per ton, cargo equipment's, berth length, number of employees, rate of return on turn over, operating expenses. Statistics are asymptotically distributed as normal. The test of Panel Granger causality test lags of 1, 2and 3.\*- significance at 10% level, \*\*- significance at 5% level, \*\*\*- significance at 1% level.

### 3.5. Impulse Response Function

Causality tests may not tell us the complete story about the interactions between the variables and its systems. In the applied research work, it is important to understand the response of one variable to an impulse with another variables when shocks given to the residuals. Impulse

response function finds out the reaction on other variables for future period when one positive standard deviation shock given to the residuals. Through this test we can identify exactly the positive and negative relationship in relation with future periods. This kind of impulse response analysis is called multiplier analysis or impulse response function.

Table 7. Impulse Response Function Test

Period	TOT	PW	ILE	CREU	BLE	NOE	OEXP
1	0.092982	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.029387	0.010941	0.012013	0.013920	0.022098	0.002897	0.005732
3	-0.017685	-0.012527	0.080099	0.069927	0.044220	0.099322	0.010756
4	-0.039863	-0.046195	0.040618	0.132616	0.155365	0.185268	0.057761
5	-0.042666	-0.096261	0.158986	0.034867	-0.083193	0.286597	-0.184482
6	-0.004908	-0.041538	0.087368	0.088721	0.169110	-0.137741	0.310904
7	-0.159708	-0.245146	0.393766	-0.094363	-0.746432	0.809164	-1.039685
8	0.179851	0.228891	-0.990335	0.699238	2.111515	-1.366527	2.844694
9	-0.635832	-0.878968	2.416767	-1.586838	-5.481697	4.738560	-7.251441
10	1.694467	2.606705	-6.531644	4.035833	14.48190	-12.61203	20.48676

Cholesky Ordering: TOT PW ILE CREU BLE NOE OEXP

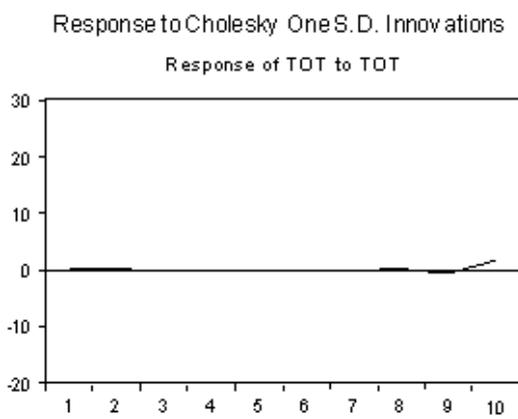


Figure 1. Impulse Response to Cholesky One S.D. Innovations

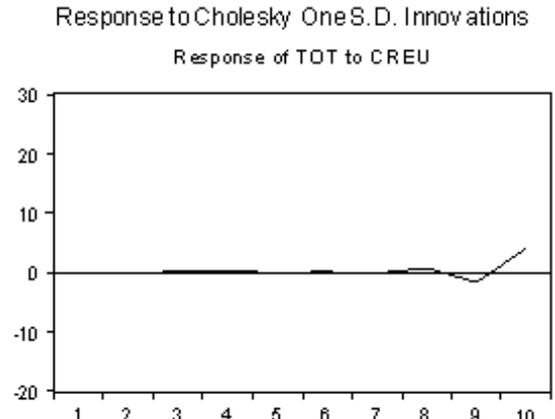


Figure 4. Impulse Response to Cholesky One S.D. Innovations

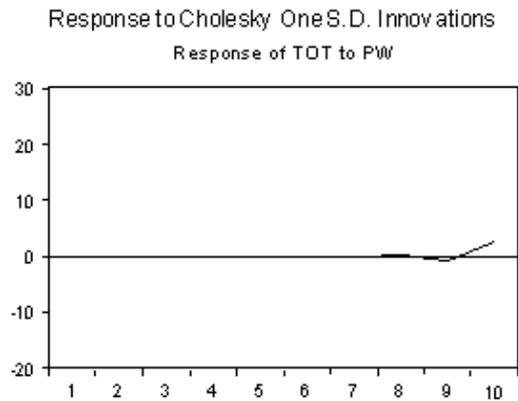


Figure 2. Impulse Response to Cholesky One S.D. Innovations

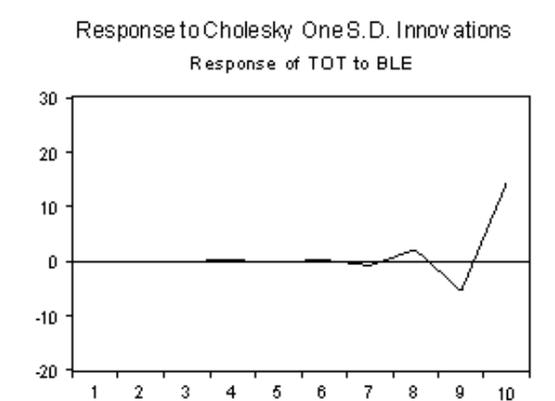


Figure 5. Impulse Response to Cholesky One S.D. Innovations

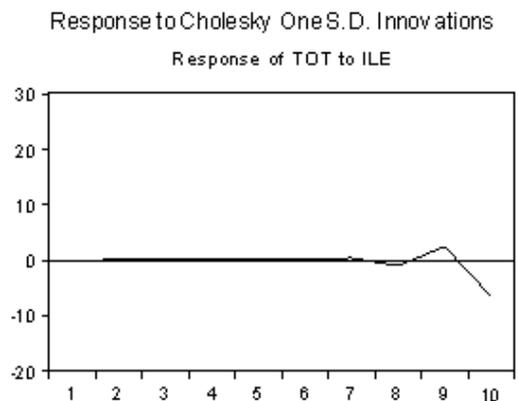


Figure 3. Impulse Response to Cholesky One S.D. Innovations

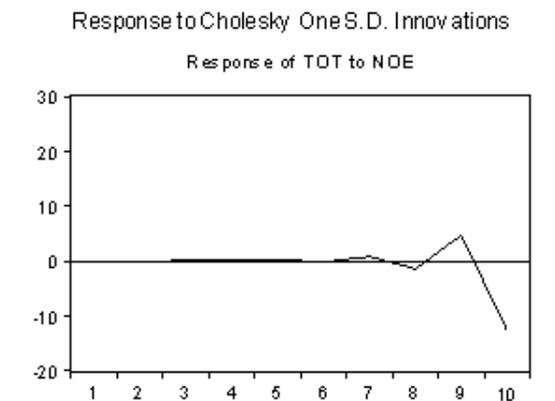


Figure 6. Impulse Response to Cholesky One S.D. Innovations

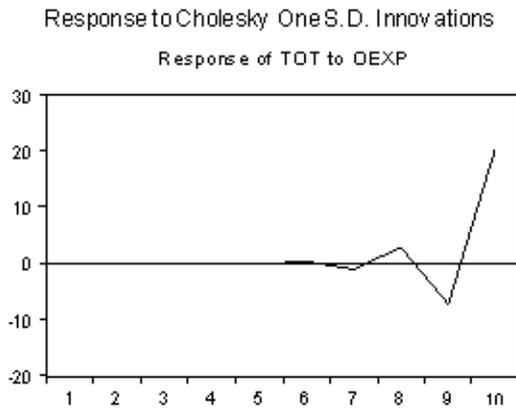


Figure 7. Impulse Response to Cholesky One S.D. Innovations

From the results of impulse response function one standard deviation of positive shocks given to the residuals and it can be find out what will be the reaction of other variables in the future periods. The results of impulse response function of one positive standard deviation (s.d.) to the total traffic and the reaction is noted on the total traffic in fluctuating fashion with positive and

negative signs the ten future periods. The same way when one s.d. positive shock was given to pre-berthing time it reacted to the total traffic negatively in 6 out of 10 years. But when one s.d. positive shock was given to idle time and cargo equipments it was positively reacting to the total traffic in 8 out of 10 years thus the reflection was positive. For the variables like berth length, number of employees and operating expenses when one positive s.d. shock was given to the above variables and it reflected positively to the total traffic in 7 out of future ten periods. For a clear understanding the same has been presented graphically as under in Figure 1 - Figure 7.

### 3.6. Variance Decomposition

Variance decomposition analysis indicates the amount of information each variable contributes to the other variables in the autoregression. This analysis also determines how much forecast error variance can be explained by the exogenous shocks to other variables. This can be explained by percentage changes in one variables and percentage of change in variance to the other variables.

Table 8. Variance Decomposition Test

Period	S.E.	TOT	PW	ILE	CREU	BLE	NOE	OEXP
1	0.092	100.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.102	90.593	1.140	1.374	1.846	4.652	0.079	0.313
3	0.184	28.712	0.808	19.177	14.860	7.143	28.862	0.434
4	0.344	9.591	2.026	6.901	19.052	22.344	37.151	2.929
5	0.528	4.731	4.175	11.975	8.541	11.980	45.178	13.416
6	0.664	3.004	3.038	9.321	7.199	14.077	32.940	30.417
7	1.727	1.299	2.463	6.575	1.362	20.755	26.815	40.727
8	4.353	0.375	0.664	6.208	2.793	26.786	14.071	49.099
9	11.557	0.355	0.672	5.253	2.281	26.296	18.806	46.333
10	31.475	0.337	0.776	5.014	1.951	24.715	18.591	48.612

Cholesky Ordering: TOT PW ILE CREU BLE NOE OEXP

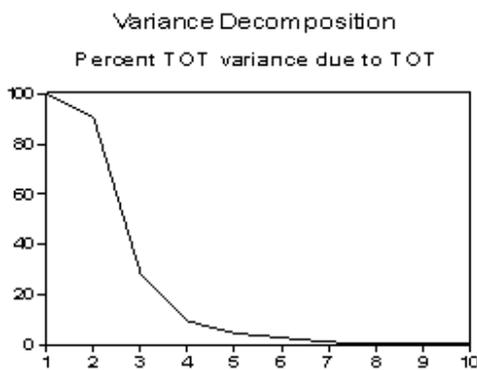


Figure 8. Variance Decomposition Tests

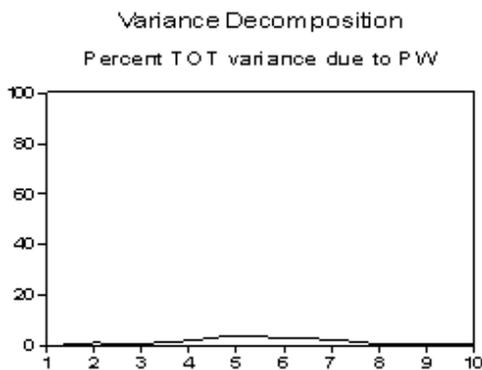


Figure 9. Variance Decomposition Tests

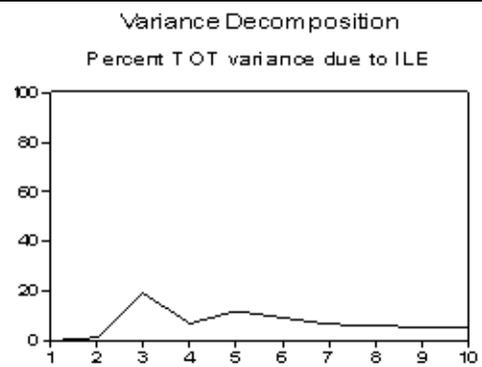


Figure 10. Variance Decomposition Tests

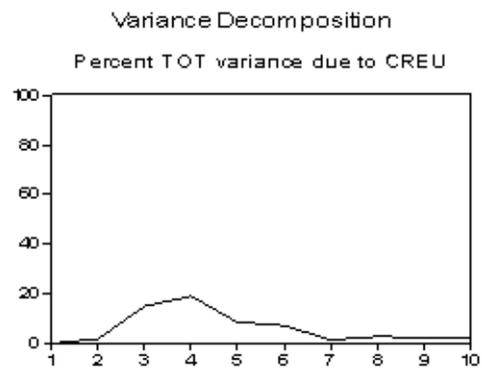


Figure 11. Variance Decomposition Tests

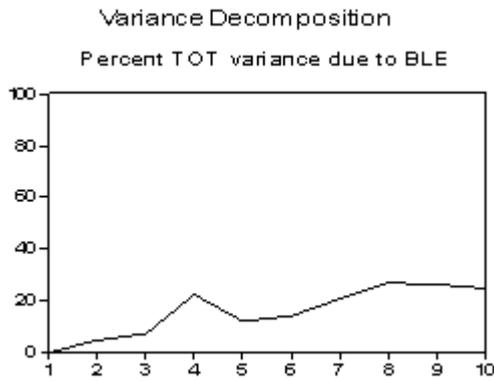


Figure 12. Variance Decomposition Tests

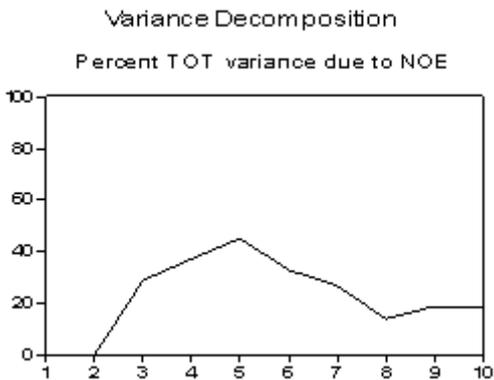


Figure 13. Variance Decomposition Tests

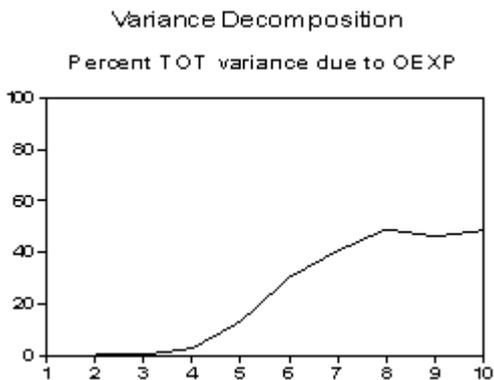


Figure 14. Variance Decomposition Tests

From the results of variance decomposition analysis it can be identify that percentage of changes in variance due to other variables. The results of variance decomposition table shows that percentage changes in variance of future ten years with performance inputs of pre-berthing time, idle time, cargo equipments, berth length, number of employees and operating expenses. From the table it can be observed that percentages of changes in total traffic with performance inputs are positive in future ten years. The variables like berth length, number of employees and operating expenses variances react positively with high percentage changes in future periods. Whereas other variables like pre-berthing time, idle time and cargo equipments are variances change positively with least percentage changes in future periods. For a clear understanding the percentage changes in variance with performance inputs in future period is presented through graphical presentation in Figure 8 – Figure 14.

## 4. Concluding Remarks

We started with a very simple question: is there a long run relationship and causality between port performance inputs and port traffic of major ports in India. The present study is try to evaluate the long run relationship and causality between port performance inputs and port traffic with sophisticated panel data models such as panel unit root, panel cointegration, panel error correction model, panel granger causality, impulse response function and variance decomposition tests of 12 major ports in India over the period of 1993 to 2012. Individual modeling suggested that there exists long run relationship and causality between port performance inputs and port traffic during the study period. The conclusion drawn from the evidence of long run relationship between performance inputs and total traffic, and causality of pre-berthing waiting time and operating expenses unidirectional with port traffic indicate that the major factors influencing port traffic. Based on the impulse response function test the variables like cargo equipments, berth length and operating expenses are positively responding when shocks given to the residuals. Variance decomposition tests implies that percentage changes in total traffic is due to the variables like berth length, number of employees and operating expenses is positive with high frequency in the future periods. Over all the results imply that port performance variables that are having the cointegrating relationship with port traffic should be given priority for increasing the port traffic of major ports in India.

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