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Impact of Ports on National Economy: Methodological Issues

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ABSTRACT

Economic and social benefits of the economy due to port activities and associated logistics are assessed by methods like input-output (I/O) model, autoregressive distributed lag (ARDL) model, structural equation model (SEM), gravity Model, value addition, etc. However, considering limitations of each such method, and lack of access to relevant data at regional and national levels showing impacts of Ports only, the paper attempts to find impact of port performances on national economy by correlations and regression analysis with emphasis on major ports of India. Parametric tests covering narrow subclass of possible cases have limitations to detect stationarity in time series data. Multiplier analysis assuming constant marginal propensity to consume (MPC) and no resource limitations may involve subjectivity to estimate direct, indirect and induced benefits. Economic impacts of ports by gross value addition are port specific and cannot be generalized. Multiple linear regression equations can better be fitted to the data to find empirical relationship of GDP with the chosen independent variables relating to performances of ports, logistics service providers and other service providers. Qualities of such regression equation need to be tested for linearity of error scores with zero mean and constant variance; significance of multiple correlation (R^2) and relative importance of the selected independent variables. Proposed methods of $r_{xy} = 1$ and $R^2 = {C'}^T {R_{XX}}^{-1} C' = 1$ may avoid the bad leverage points and correlation issues. It is recommended to go for robust multiple regression equation avoiding problems of bad leverage points and correlation issues.

1. Introduction.

Maritime transport is at the core of international trade and needs among others, well-functioning ports (Marleny, 2020). Every hour of port-time saved by ships translates into savings of capital costs for carriers and inventory holding outlays for shippers and also in port infrastructure expenditure (Sebastian, 2019). Ports are essentially value propositions to their regions and countries by contributing to economic and social benefits and act as channels of integration into the global economic system. Ports as important nodes of the logistics chain facilitate integration of logistics supply chain (LSC) and their operations have direct effect on economic development of the country (Tovar et al. 2007). Improved logistics performance (LP) with higher reliability, lesser damage, timeliness of delivery, etc. is achieved with better quality of port infrastructure (QPI). Improved QPI and the resultant LP help to reduces freight costs (Lakshmanan,2011) which increase the local and global accessibility of the country and opportunities to expand markets. An additional ship-day in transit results in reduction of trade volume by 1% and increases freight rate (Djankov et al. 2006; Wilmsmeier and Hoffmann, 2008). Efficient ports with regular shipping services are key to reducing costs of trade, transport and logistics, supporting global trade and also determinant of foreign direct investment (FDI) into a country (Panayides et al., 2015). In India, significant volumes of FDIs are concentrated in and around ports.

Port performance can influence countries' trade competitiveness. Port inefficiency is reflected by longer container dwell-time, interruptions in vessel traffic clearance, protracted documentation handling, lesser handling of container per crane-hour (Kahyarara, 2020). Reduced port costs imply reduction

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of international trade costs through FOB (free on board) prices for exports and CIF (cost, insurance, and freight) price for imports and benefit the exporters and importers. Increase in port efficiency from 25-th to the 75-th percentile reduces shipping costs by 12% (Clark et al., 2004). Improvement in port efficiency leads to increase of export volume (Puertas et al. 2014). Niselow (2018) observed that 25% improvement in port efficiency increased growth by 2%, demonstrating the close relationship between port effectiveness and trade competitiveness (Booth 2018).

GDP of a country is highly correlated with its trade (UNCTAD 2015) and ports stimulate economic growth of countries (Chang, et al., 2014). Impacts of port performance on trade have been investigated (Humphreys et al. 2019; PWC 2019; UNCTAD 2020).

Economic and social benefits of the economy due to ports are assessed by methods like input-output (I/O) model, ARDL (autoregressive distributed lag) model, structural equation model (SEM), Gravity Model, Value addition, etc. However, considering methodological limitations of each such method, and lack of access to relevant data at regional and national levels showing exclusive impacts of Ports, the paper attempts to find impact of port performances on national economy by correlations and regressions with emphasis on the major ports of India.

2. Impact on economy.

Extent of benefits from ports to economy varies. Estimation of the economic impacts of ports focuses on the effectiveness of transport infrastructure as a catalyst for direct, indirect and induced benefits including generation of employment, wages, revenues, etc. Methodologies used to estimate the impacts vary in sophistication. Commonly observed economic benefits of ports for regional employment are:

- Port throughput is positively related to employment in port regions (Ferrari 2011), though the influence on employment is weak (elasticity < 0.05).
- Each direct port employment is commonly associated with about three to four indirect jobs, although such figures vary widely. However,empirical evidence about job multiplier figures are limited.
- Employment impacts are different for different commodities. Container and break bulk traffic usually have twice the employment impact of dry and liquid bulk traffic.
- Employment effects of port activities may extend beyond the regional or even national level. For example, Shipping lines generate employment at local level via their liner shipping agencies in the ports of call. But, jobs related to ship management, container fleet management, investment, commercial strategies, etc. are usually concentrated at global or regional headquarters. Similarly, global container terminal operators like PSA, Hutchison Ports, DP World, APM, etc. generate jobs at local port level but centralized activities, like equipment purchases / replacements, etc. are in global or regional headquarters. Terminal operators may purchase terminal equipment from local or foreign suppliers. Flow-on employment effects may be larger than the flow-on effects to the local / regional economy. The economic benefits of port activities are more related to the dynamics of the supply chains they support. Direct economic benefits can be readily assessed, while indirect and induced effects are complex to capture. Average turnover of ports may not imply higher traffic volume handled by them (Economic Survey, 2020-21). Deployment of large container ships with reduced number of port-calls results in lowering the total costs of cargo handling in the ports and total time required for port operations (Kowalczyk, 2012).

Measures of economic benefits are direct, indirect and induced multipliers from input-output (I/O) models (Toh et al. 1995), regression analysis with Gross National Income (GNI) (Berköz ,1999) or Gross Domestic Product (GDP) as the dependent variable and port efficiency factors as independent variables (Humphreys et al. 2019; UNCTAD 2020). As per GDP through expenditure approach, incomes of ports are expenditures of the port users. Thus, both income and expenditure of ports contribute to country's GDP.

Direct benefits from ports involve revenues generated from the port activities and various charges levied on ships and cargo like charges for pilotage, berthing and towing, cargo handling, ship repairing at Dry Docks, supply of water and bunkers, etc. Additional revenues are also generated from terminal concessions, port land/estate leased, etc.

Indirect benefits from ports involve Customs Duty (tax imposed on imports and exports of goods), revenue earned by dry ports (ICDs/CFSs), Shipping agents, Freight-forwarders, Stevedores, agencies to whom berths and other port facilities leased out, trucking companies, railways, IWT operators, profits earned by firms that import or export goods using the port and enjoying cost savings that arise from reduced operating costs, lower shipping costs due to improved (reduced) turnaround time of ships visiting the ports and reduced dwelling time for cargo at the ports. In addition, savings in ship operating costs due to economies of scale from larger ships requiring deeper drafts and additional facilities, and savings in insurance costs due to port improvements and savings in interest costs related to inventory due to better supply chain management practices, also contribute to indirect benefits.

Induced benefits to the economy include benefits that filter through to the suppliers of input factors, like income to direct and indirect employments in ports and port-related activities like supplying goods and services to the ports. Multiplier effect of such incomes results into re-spending, generating further employment and income. The process continues. However, such benefits are not as straightforward as cost-saving benefits. Additional economic catalytic impacts ("spillovers" benefits to other industries) may also result from the wider role of the ports, like functioning of variety of industries like fishing, dredging and those reliant on the import/export of raw materials, sea-based watersports, maritime museum, etc.

3. Ports and shipping in India.

India with a coastline of over 7.517 km and 12 major ports (under the control of Govt. of India) and around 200 notified minor and intermediate ports enjoys robust demand. Cargo handled by Ports of India during 2022-23 was 1445 million tonnes with 55.02% share of major ports. India's rank in Ease of Doing Business (EoDB) index improved from 146 in 2018 to 68 in 2020. Similarly, in terms of Logistics Performance Index (LPI), India ranked 38th in 2023 *vis-à-vis* 54^{th} rank in 2014 (Economic Survey 2020-21). India ranked 22nd in 2023 from 44th rank in 2014 in the Global Ranking in the International Shipments category. Sea transport sector of India received FDI amounting to USD 4.2 billion over the last 9 years.

Cargo handling capacity of Indian ports has increased to 2600 Million Tonnes Per Annum (MTPA) from 1,400 MTPA in 2014. Physical performances of major ports also registered improving trends. For example, average turnaround time (TAT) improved to 61.75 hours in FY 2021 against 126.96 hours in FY2011 and 96 hours in FY2015. Similarly, average output per ship-berth-day increased to 16,433 tonnes in FY20 from 12,458 tonnes in FY15. For the Shipping sub-sector, Gross tonnage of shipping stood at the level of 12.75 million tonnes (June 2020) with 1453 ships (November, 2020) against 11.60 million tonnes and 1316 ships in 2016-17.

Maritime India Vision 2030 with an envisaged investment of INR 3, 00,000 - 3, 50,000 Crores has identified 150+ initiatives across various maritime sectors like ports, shipping and waterways. This vision roadmap is estimated to help unlock INR 20,000+ Crores worth of potential annual revenue for Indian Ports and create an additional 20, 00,000+ jobs (direct and non-direct) in the Indian maritime sector.

4. Methodology.

Different methods have been used for assessing port efficiency and port performance (Ducruet et al. 2014). Total cargo throughput is a common measure of functioning of ports and their capability to entice business (Lei and Bachmann 2020; United States Department of Transportation 2021).

Toh et al (1995) used *Input-Output analysis* to estimate income, output and employment multipliers of activities of Port of Singapore. I-O analysis is used to quantify the linkages and transactions between different sectors of the economy by a set of tables. Quantification of inputs and outputs for a given year are entered in an input-output matrix/table to analyze overall change in activity level that results from an initial change in activity, across various sectors of an economy. *Multiplier analysis* effectively adds all the successive rounds of re-spending, assuming that major factors such as input prices are unchanged and that there are no resource limitations. The I-O technique estimate multipliers for a variety of impact measures, like output, employment, and income. Multipliers can also be estimated for major components, like cargo types. As per the model, impact of final demand $\mathbf{F}$ on outputs of n-industries is given by $\boldsymbol{X} = (\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{F}$ where $\boldsymbol{X}_{n\times 1}$ is the vector of total outputs of n-industries; $\boldsymbol{A}_{n\times n}$ is the matrix of Technical coefficient. The matrix $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ represents the output multiplier matrix, also known as Leontief inverse matrix. Similarly, the vector of total income effects $\boldsymbol{Y}$ is obtained as $\boldsymbol{Y}= \widehat{\boldsymbol{Y}}(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{F}$ where $\widehat{\boldsymbol{Y}}$ the diagonal matrix of income coefficient is and y_i is the direct value added by the i-th industry**.** In a similar fashion, the vector of total income effects $\mathbf{L}$ can be found considering the diagonal matrix of employment coefficient. I –O analysis may follow a top-down approach building upon comprehensive sector-wise data or a bottom-up approach where overall impacts are computed based on firm-level data (balance sheets or annual accounts of individual firms), or primary data collected via surveys. Multipliers based on I-O analysis make certain assumptions, violation of which may not give accurate impact estimates (Siegfried et al. 2007).

More sophisticated techniques to assess economic impact of ports are *integrated modeling* technique, combination of I-O analysis and econometric techniques; *computable general equilibrium* (CGE) modeling, etc. Data requirements of both sophisticated techniques are very high, implying high costs of performing such analysis.

Another approach is to consider value addition by ports and related industries. Seaports with substantial economic investments can be viewed as economic catalysts for the nation as they provide enough value to justify such investments as factor of added value and growth. A port may consider Economic value added (EVA) to find value generated by the port from the funds invested, or Market value added (MVA) or Cash value added (CVA) reflecting its contribution to national economy. EVA is computed as $EVA = NOPAT - (CE * WACC)$ where T : Net Operating Profit after Taxes; CE : Capital Employed and $WACC$: Weighted Av. of Cost of Capital.

MVA is computed as market value including equity and debt minus total capital invested. CVA is taken as Gross cash flow - Economic depreciation – (cost of capital $*$ gross investment).For a particular year, values of EVA, MVA and CVA are different for a port. Better is to consider Gross value-added (GVA) by ports computed as GDP plus selling price of a product/service (SP) minus cost to produce the product/ service (CP), reflect contribution of the ports to national economy in a given year. Thus, GVA is essentially financial value addition assessing economic significance of ports. Report of the Working Group set up by the Ministry of Shipping, Road Transport & Highways (2010)considered major port-wise value addition as contributions to GDP. Merk et al. (2011) found that value addition (both direct and indirect) by the port cluster of Le Havre / Rouen, represented over 21% of regional GDP in 2007, and the port cluster of Antwerp generated around 3% of national GDP.

Munim and Schramm (2018) considered the following latent constructs and indicators for structural equation model (SEM) to examine the impact of port quality on trade:

1. Quality of port infrastructure (QPI): Measured by Likert questionnaire consisting of items covering perceptions of stakeholders on port facilities, where "1" represented extremely underdeveloped port infrastructure and "7" represents efficient by international standards (http://data.worldbank.org/indicator/IQ.WEF.PORT.XQ).

2. Logistics performance (LP): Measured by asking operators on the ground (global freight forwarders and express carriers) to provide feedback on the logistics "friendliness" of the countries in which they operate in terms of Tracking of consignments, Competence and quality of logistics services, Ease of arranging competitively priced shipments, Efficiency of customs clearance process, Frequency of receipt of shipments by consignees within scheduled or expected time, Quality of trade and transport-related infrastructure (http://lpi.worldbank.org/).
3. Seaborne trade (ST): Container port traffic (Thousand - TEUs); Liner shipping connectivity index (LSC index) based on five maritime transport components (number of ships handled, their container-carrying capacity, maximum vessel size, number of services, and number of companies that deploy container ships in a country's ports. (http://data.worldbank.org/indicator/IS.SHP.GCNW.XQ)
4. National economy (NE): GDP per capita (Purchasing power parity) (Int. $)

The study showed that port quality is vital for trade performance and port quality improves trade and economic growth.

Many economic time series exhibit non-stationarity trending behavior in the mean e.g. exchange rates, real GDP, etc. The ARDL model was used for investigation of (i) stationary, (ii) cointegration and panel ARDL estimation (Menegaki, 2019). To corroborate the findings obtained from the ARDL models, Fixed Effects and Random Effects models were also used. However, panel unit root tests can lead to spurious conclusions if they fail to take account of significant degrees of cross-section dependence (Pesaran, 2007). A shock witnessed in one of the panel unit can greatly affect the other units. This is known as cross-section dependence in econometrics (Benhür & Özyeşil, 2019). Cross-sectional dependence can also be caused by other factors like common shocks and model misspecification (Chudik and Pesaran 2013). If cross-sectional dependence is ignored, the regression results can be biased and unreliable (Phillips and Sul, 2003). The problems may be avoided by performing cross-dependence tests like the Breusch-Pagan LM, and the Pesaran CD tests followed by unit root tests like Levin, Lin and Chu test, Pesaran and Shin test, Fisher-type tests, etc. (Bai and Ng 2004; Phillips and Sul, 2003). If the unit root shows that the variables are of different order of integration, the next step is to go for Cointegration test. Pedroni (2004) introduced seven test statistics to test the null hypothesis of no cointegration in non-stationary panels. The seven test statistics allow heterogeneity in the panel, both in the short-run dynamics as well as in the long-run slope and intercept coefficients (Neal 2014).

Olayungbo and Quadri (2020), proposed Pooled Mean Group (PMG) estimator for pooling and averaging the coefficients over the cross-sectional units. This accommodates a combination of stationary and non-stationary variables, and is applicable for small sample size. An advantage of the PMG is that the underlying ARDL structure dispenses with the importance of the unit root pre-testing of the variables in question (Fayissa and Nsiah, 2012). Pesaran et al. (1999) proposed an estimation approach in which the long-run coefficients on the explanatory variables remain unchanged across units. However, the Mean Group (MG) estimator derives the long-run parameters from ARDL models for individual countries by estimating country-wise separate regressions and calculating the coefficients as unweight means of the estimated coefficients for the individual countries (Fauzel et al. 2019). Detecting stationarity in time series data, parametric tests have limitations as they cover only a narrow sub-class of possible cases encountered in real data.

Gravity Model approach is used to measure different effects on trade flows. Chang et al. (2014) used a gravity model to study the ex-post effect of trade agreements using worldwide trade data for 2007, 2010 and 2015. The study showed that port performance had a positive effect on trade and logistics performance. To investigate the effect of economic mass and distance on trade flows between countries, Tinbergen (1962) and Pöyhönen (1963) used the gravity model considering GDP as a proxy for economic proportions, and the distance between the countries as a space measure.

$$T_{ij} = C * \frac{Y_i.Y_j}{D_{ij}} \quad (1)$$

where T_{ij} denotes the trade between country *i* and *j*; Y_i and Y_j are the mass coefficients, say GDP and D_{ij} is the distance between capitals of *i-th* and *j-th* countries. The Equation, converted into log-linear form is:

$$lnT_{ij} = C + \alpha\ lnY_i + \beta lnY_j - \theta lnD_{ij} + \delta Z + \mu_{ij} \quad (2)$$

where C is the regression constant; δZ represents any hidden factors that could affect export performance and μ_{ij} is the error term.

To investigate relationship between performance of ports and trade, Mlambo, (2021) used the model: $TR = f(INF, PP, GDP, EXCH, D)$ and found statistically significant positive relationship between port performance and trade, where TR: trade, INF: inflation, PP: port performance, EXCH: exchange rate and *D>0* is a dummy variable reflecting unevenness of performance of the ports located in a country. Positive value of *D* is in line with the idea of increasing transportation cost with increase in distance.

5. Methodological Issues.

5.1. Multiplier Analysis.

Data on direct, indirect and induced benefits pertaining to the Ports only may not be available at national level and estimation of benefits from the port sector, per se may involve assumptions. Multiplier analysis assumes that input prices are unchanged and there are no resource limitations and may involve subjectivity to estimate direct, indirect and induced benefits. For example, to incorporate changes in induced income, Toh et al (1995) treated consumption as an endogenous variable and the matrix $\boldsymbol{A_{n\times n}}$ was extended to $\boldsymbol{A_{(n+1)\times(n+1)}}$ by adding additional column showing consumption coefficients and additional raw showing income or value added coefficients.

Multiplier = $\frac{1}{1-MPC}$ has limitations: (i) constant marginal propensity to consume (MPC). Values of MPC are different during depression and boom and may be different at different phases of business cycles, levels of income, etc. Linear consumption function with constant MPC may not be supported empirically. (ii) A time-lag exists from the receipt of income and the consumption expenditure, increase of which may reduce the value of the multiplier. This time-lag is not considered in Keynes analysis. (iii) Increased expenditure on the consumption (induced consumption) may also induce further investment, which in turn will raise the levels of income, output and employment. The output, income and employment will expend as a result of multiplier, as long as there are unemployed resources in the economy and full employment level is not reached.

5.2. Gravity models.

Application of gravity model requires prior testing zero mean, fixed variance of the error term μ_{ij} in (2) where $\mu'_{ij}s$ are uncorrelated with each explanatory variable. In addition, application requires appropriate choice of the model to estimate (specification). Basic gravity model assumes that bigger countries trade more, and distant countries trade less, i.e. from (2), $\frac{\partial \log T_{ij}}{\partial \log D_{ik}}$ = 0 $\Longrightarrow$ reduction of trade costs on one bilateral route does not affect trade on other routes, which is against standard economic theory. In addition, consideration of equal decreases in trade costs across all routes, including domestic trade in basic gravity model does not fit the case of fall in the price of POL which reduces transport costs to all countries including domestic trade (Shepherd et al. 2019). Current trend is to use number of theoretically grounded gravity models, with provision of inclusion of policy variables to facilitate estimation of consistent and unbiased parameters and also an appropriate platform for conducting counterfactual simulations.

5.3. Value addition.

Evaluation of *GVA= GDP+SP – TP* is complex in the context of integration of services produced by ports and value-added logistics services (VALS). In addition, there are many indirect impacts on the whole ecosystem of economic activities. With growth of international trade, the indirect impacts of ports on national economies became even more important. Pena Zarzuelo (2021) analyzed relationship between the size of the port and its GVA to investigate the economic impact of Spanish Ports but warned that the conclusions are applicable only to the environments with similar characteristics.

5.4. Likert scales.

Likert scales are used to assess perceptions/preferences of stakeholders on port performance. Major issues are:

- Ordinal discrete Likert scores or Rating scales are not additive as they are not equidistant (Wakita et al. 2012)
- Assign equal importance to the items despite showing different values of correlations with total score and different factor loadings.
- Non-satisfaction of the equidistance assumption implies non-admissibility of operations like averaging. The analysis need to be limited to frequencies under item-response category combinations.
- Mean, SD, skew, kurtosis of scales may be distorted by considering "Zero" as an anchor value of Likert items Frequent zero responses to an item result in lowering the covariance and correlation with that item.
- Anchor values of Likert items may be -3, -2, -1, 0, 1, 2, and 3. Better could be to assign numbers 1 – 7 to the levels, keeping the nature of generated data invariant when the anchor values are replaced by a linear transformation of such numbers.
- Does not consider patterns of getting a particular score. Different responses to different items can generate the same Likert scores for more than one respondents. Thus, the scale fails to discriminate the respondents getting same Likert score.
- Distribution of item scores and test scores are different and often found to be skewed
- Mean and SD of Likert scales with *K*- number of levels (*K*-=3, 4, 5, 6, 7 .... and so on*)* increase as *K* increases (Finn, 1972). Different values of *K* distorts shape of score distribution and influence item/test parameters like Reliability, validity, and discriminating power, more by number of levels than the underlying variable (Prestan and Colman, 2004)

5.5. Correlation and regression.

Major issues of regression analysis are (i) selection of dependent variable (as measure of development of economy) (ii) selection of independent variables and (iii) test of linearity. Berkoz, (1999) considered GNI, UNCTAD (2020) correlated GDP and maritime trade.

Significant positive correlation between regional economy and value added activity at Chinese ports was observed by Deng et al. (2013) which could be due to the fact that the authors included total volume of imports and exports in the value-added activity construct, which is actually part of the seaborne trade.

Linear regression equations are often fitted when correlation between dependent and independent variable is moderate or high. However, high correlation may not imply linearity. Chakrabartty, (2023) gave examples of high correlation between *X* and *f(X)*, but *f(X)* is a non-liner function of *X*. Linearity may be tested by fitting a regression line Y= $\alpha + \beta X + \epsilon$ and testing normality of ϵ-scores and low value of SD of error of prediction by $S_{\epsilon} = \sqrt{\frac{1}{n}\sum (Y_i - \hat{Y}_i)^2} = S_Y \sqrt{1 - r^2}$ indicating acceptance of linearity. Anderson-Darling test could be used for normality. If the data fail to pass normality test, Rosseel (2012) suggested Satorra-Bentler rescaling method.

Widely used regressions of GDP of a country at *t*-th year $GDP_t = \alpha + \sum_{i=1}^{n} \beta_i X_i$ may causes problems in interpretation of results and give rise to paradoxical findings. For example, as per the univariate regression of Y on the predictorX_1, the regression coefficient β_{YX_1} was significant but consideration of additional $X_i s$ in the multiple regression model may show non-significance of $\beta_{YX_1}$and a significant β-coefficient in multiple regression may not be significant in the univariate regression (Feng et al. 2016). These are primarily due to different values of r_{Y,X_i} and non-satisfaction of the assumptions of the univariate and multiple regression models. Other problem areas include presence of outliers which can affect correlation and mislead the nature of the association among the variables considered. In addition, departure from bivariate normality may distort associations Wilcox (2022).

If X_i is an outlier among the bivariate points $(X_1, Y_1), (X_2, Y_2), \ldots, (X_n, Y_n)$, the point (X_i, Y_i) is a leverage point. Let the linear regression equation fitted with the data points be $Y = \alpha + \beta X$ and $r_i = Y_i - \alpha - \beta X_i$ is the residual for the i-th observation. If r_i is an outlier among the set of residuals $\{r_1, r_2, \ldots\ldots.., r_n\}$ and the corresponding (X_i, Y_i) is a leverage point, then the point (X_i, Y_i) is a bad leverage point which can negatively impact Pearson's correlation, Kendall's τ and Spearman's ρ and indicate poor fit of the linear model. If (X_i, Y_i) is a leverage point but the corresponding r_i is not an outlier, the point (X_i, Y_i) is a good leverage point and is taken as consistent with the regression equation$Y = \alpha + \beta X$.

Number of methods are there for detecting bad leverage points like regression line using the least median of squares (LMS) estimator (Rousseeuw and van Zomeren, 1990), Estimator proposed by Theil(1950) computed the slope (β) as median of the$S'_{ij}s$ where $S_{ij} = \frac{Y_i - Y_j}{X_i - X_j}$ for each $i < j$ and the intercept $\alpha = M_Y - \beta M_X$, where M_Y is the median of $\{Y_1, Y_2, \ldots\ldots.., Y_n\}$ and M_X is the median of $\{X_1, X_2, \ldots\ldots.., X_n\}$. Wilcox (2023) proposed computation of slope and intercept removing the bad leverage points.

For given data on X and Y with sample size n, possible solutions to the above problems could be use of non-linear transformation $y = \boldsymbol{G}.\, \|x\|\, \|y\|.x$ to get $r_{xy} = 1$ where x and y are deviation scores, $\boldsymbol{G}_{n \times n}$ is the generalized inverse (G-inverse) of the matrix $\mathbf{A} = x.x^T$ and y denotes the transformed scores (Chakrabartty, 2023). The concept of perfect correlation may be extended to multiple correlation coefficient $R^2 = C'^T R_{XX}{}^{-1} C'$ where the original vector $\boldsymbol{C} = (r_{x_1 y}, r_{x_2 y}, \ldots r_{x_n y})^T$ of raw data is replaced by $\boldsymbol{C}' = (r_{x_1 \hat{y}}, r_{x_2 \hat{y}}, \ldots, r_{x_m \hat{y}})^T$ ensuring$C'^T R_{XX}{}^{-1} C' = 1$.

6. Discussion.

Evaluation of economic benefits due to activities related to ports and their effects on the economy use various methods like input-output (I/O) model, ARDL model, SEM model, Gravity Model, Value addition, etc. including evaluation of perceptions of stakeholders on port performance using Likert/ratting scales.

For example, parametric tests covering narrow sub-class of possible cases have limitations to detect stationarity in time series data. Multiplier analysis assuming constant marginal propensity to consume (MPC) and no resource limitations may involve subjectivity to estimate direct, indirect and induced benefits. Moreover, output, income and employment will expend as a result of multiplier, as long as there are unemployed resources in the economy. Economic impacts of ports by GVA are port specific and cannot be generalized.

Multiple linear regression equations can better be fitted to the data to find empirical relationship of GDP_t with set of chosen independent variables relating to performances of ports, logistics service providers and other service providers. Qualities of such regression equation need to be tested for linearity of error scores with zero mean and constant variance; significance of multiple correlation (R^2) and relative importance of the selected independent variables. Proposed methods of $r_{xy} = 1$ and $R^2 = C'^T R_{XX}{}^{-1} C' = 1$ may avoid the bad leverage points and correlation issues.

Conclusions.

Based on Methodological limitations of sophisticated approaches and different values of MPC across time, rural – urban doweling, etc. to reflect multiplier effect, it is recommended to go for robust multiple regression equation avoiding problems of bad leverage points and correlation issues. Future empirical investigations with real life data on such regression analysis are suggested.

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