Trip generation modeling from Kandla port region of Gujarat

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Abstract: *Number of trips plays an important role in planning of an infrastructure. One of the classifications of trips is as commercial and non-commercial trips. Commercial trips differs in many aspects like number of trips, trip length, origin and destination characteristics, travel time, goods characteristics and so on. Truck trips from infrastructure like a port may have a common origin or destination. There are 12 major ports in India. Kandla port is one of the major port in western part of India. The present paper focuses on trip generation modeling from Kandla port, Gujarat, India. A roadside questionnaire survey was adopted for data collection. Model is developed in MS Excel. A multilinear regression model is developed. Single Origin Multiple Destination (SOMD) truck trip generation model reveals that Average distance, GSDP and total tonnage were found more significant.*

Keywords: **Truck trip, modeling, port, trip generation, survey.**

1. Introduction

Widely used transportation modes are air, water, and land. Each of them has its inherent characteristics. Historically, several cities have grown around the sea throughout the world. In the current situation, it is very necessary to determine the number of trips to plan the road network effectively. The trading activity around ports is significant for a long time and even today. It has been observed from the economic data that the activity at several ports has grown continuously. Port traffic is increasing year by year. Freight transport is the process of transporting commodities and goods. Freight trips contribute to the economy and hence it has a direct impact on the development of a country's economic growth. It has an impact on regional level traffic also. The demand for road networks from ports is a major issue in port planning. Much of the work done in the field of modelling is on modelling personalized transport. In recent years, interest in modelling freight activity at ports has increased throughout the world.

Trade through import and export of commodities has a significant impact on the economics around them. The movement of goods to and from ports can be through trucks and railways but is dependent on several characteristics such as Gross State Domestic Product (GSDP) of the state, freight demand, land use characteristics, socio-economic factors, and location. It requires expansion or improvement of ports in terms of the network of road and rail infrastructure as the demand for goods grows in that surrounding states. Travel demand is the primary input for transportation planning and analysis. Each port is different depending on its size, the type of commodities, and the volume of commodities, and may also include a seasonal variation of demand.

The next section deals with the review of literature for the study.

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2. Literature Review

Ashtakala. B. and A. S. Narsimha Murthy (1988) applied the Gravity model for modelling commodity transportation for Alberta. The survey data were grouped into specific commodity categories, and a set of O-D tables have been developed. These O-D tables were the basis for the development of gravity models. The study comprised of a set of gravity models, one for each commodity category, was developed to represent the commodity flows on a province-wide basis. The gravity model for each commodity category is calibrated by an optimization technique, which uses a power function and regression analysis. Models were acceptable as by statistical measures and commodity haul frequency diagrams.[1]

For the port of Miami, the truck trip generation model for container and trailer operation was developed by Al-Deek et al. (2000). The major factors identified were particular weekday of operation and amount & direction of cargo vessel. For predicting freight trip generation models, regression analysis and back-propagation neural (BPN) models were employed. Out of two techniques, the BPN model was found to be more accurate. [2]

Holguin Veras and Thorson (2000) examined trip length distributions (TLD) based on tonnage and freight demand for Guatemala. The data was collected through a questionnaire survey. The study revealed that major TLDs were affected by freight generators. The shape of TLD was governed by the type of movement being considered. [3]

Hongxia GUO (2008) carried out the reform and pilot study of the survey methodology for road freight transport. Two methods were adopted for data collection. The on-site questionnaire survey was adopted for goods and vehicles and the commercial vehicle typical enterprise survey was adopted for non-commercial vehicle study. [4]

Serag and Al-Tony (2010) in their study modelled international freight transport through lands and seaports of Arab countries from 1997 to 2001. The data collection parameters like delivery time, shipping time, transport time, custom process time were included and statistically tested. [5]

Hsing-Chung Chu (2011) has formulated some models of truck-trip generation for hauling containers at a major international seaport. The model adopted was the internal-external truck-trip forecast model. Factors considered were based on monthly data like natural disasters, economic growth attributes, and regional and freight activity attributes. The final forecasting model was determined by comparing the prediction accuracy of a multiple regression model, time-series models, and a neural network model.[6]

Aronietis et.al (2011) made a comparative study on Port hinterland connections of Polish and Belgian. It was found that both port centers have an important road hinterland connection that faces competition from other alternative modes of freight transport. [7]

Allen, Browne, and Cherrett(2012) did the investigation on relationships between road freight transport, facility location, logistics management, and urban form. Their findings suggest that several geographical, spatial, and land use factors have important influences on freight activity in urban areas. Commercial and industrial land use patterns affect the types and quantities of goods produced, consumed, and hence the total quantity of freight transport handled. This also influences the distances over which goods are moved and by what specific mode. The length of haul on journeys to and from urban areas studied was found to be greatest for those areas with a major seaport and/or which were geographically remote. This affects the road freight transport intensity of goods transport journeys. [8]

A study was conducted by Lorenzo Masiero and David A. Hensher(2012) to identify the parameters related to freight transport modelling. Within a freight transport context, the origin-destination distance and the weight of the shipment play an important role in the decision of the most preferred transport service and in the way logistics managers evaluate the transport service's attributes. In particular, the attributes commonly used to describe a freight transport service in a stated choice framework are cost, time, punctuality, and risk of damages, respectively. [9]

Freight mode choice was modelled by Moschovou and Giannopoulos (2012) for Greece. The Linear regression equations were developed to show the relationship between various attributes. Disaggregate logit analysis was also performed. Variables like reliability time, ease of access, shipment value, the capability of handling large size load were selected for model development. [10]

Jusus et. al. (2012) estimated Daily Vehicle Flows for Urban Freight Deliveries and discussed the type of data used. The data is composed primarily of the available commercial statistics, which do not include data such as the firm size, the number of employees, or the floor area of the premises, things used by other authors to build their generation models. The authors carried out several small low-cost surveys, but without collecting any supply-chain, routing, or behavioural information. [11]

G. Ramadurai et. al. (2014) in his case study of Urban Freight Trip Generation of Chennai city has taken sources of data from Websites like Yellow Pages, Sulekha, Just Dial, Chennai Corporation, Sales Tax Department, and Economic Census. [12]

Demand forecasting models developed by Patil and Sahu (2015) for Mumbai port were developed based on inbound and outbound demand forecasting. Additive regressive and time series techniques were used in the model. The significant parameters were found to be economic indicators, Gross Domestic Product (GDP), and Crude Oil Production (CRLP) in regression analysis. [12]

Siddartha,. M. , Bhushan,. M, and C.S.R.K. Prasad (2018) in their study on Modelling Freight Generation and Distribution for Nationwide Interstate Freight Movement developed freight generation and distribution models using secondary sources of data from planning commission of India. Ordinary least square regression models were formed. It was found that Net State Domestic Product (NSDP), Area, Agricultural Area, Secondary sector workers, Petroleum and Electricity Consumption of the Traffic Analysis Zones were the influencing factors for the freight generation.[13]

3. Methodology

The major objective of the study is to develop a truck trip generation model for highway networks connecting to the port. The model can be used to understand the freight traffic and to determine the significant parameters for truck trip generation for Kandla port.

- The minor objectives of this study are:

1. To find the present O-D scenario of truck trips.
2. To determine the effect of import/export commodities on truck trip generation.
3. To study the effect of parameters generating truck trips from the port.

Scope:

- Carry out traffic surveys for the inward and outward (entering to and leaving study area) trips connecting to the Kandla port.
- Development of a truck trip generation model to estimate future trips which can be helpful to administrators for policy framework.

Entire study is represented in the form of a flow chart as under:

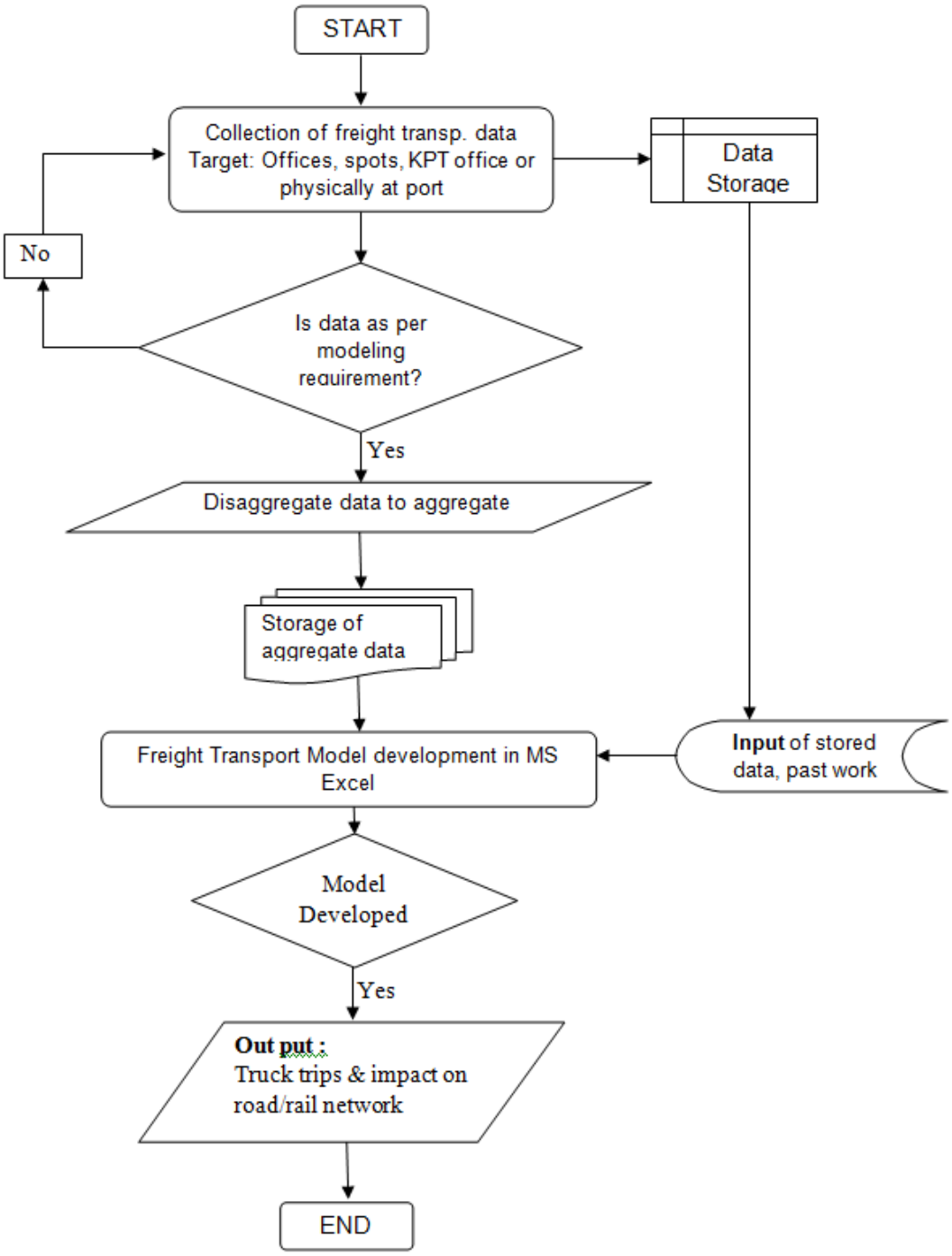

Figure 1 : Flow chart of methodology

4. Data Collection and Data analysis

A roadside intercept survey at Samakhiyali RTO check post was carried out for the data collection. The data based on characteristics of the mode which include travel time and distance has an important effect. Hence, the parameters related to it are:

- Type of vehicle
- Vehicle registration number (for identity)
- Origin of trip
- Destination of trip
- Overall journey time

- Distance (derived from origin and destination)
- Based on characteristics of the goods including shipment type is considered for goods related variables.
- Type of commodity carried
- Quantity of commodity carried (Gross weight/Tonnage)
- Package characteristics

All above variables were considered for data collection.

Moreover, the data was collected in two different seasons i.e. before monsoon and after monsoon. Total 1055 truck drivers were interviewed. Data was collected in two groups i.e. Trips towards the study area (considered as inbound trips) and trips leaving study area (considered as outbound trips). There are 895 observations for outbound trips and 160 observations for inbound trips. Only outbound trips were considered for trip generation modelling.

Figure 2 : Actual photograph of data collection work at Samakhiyali post

Following are the observations of the data analysis:

1. Seasonal variation in trips is less affected by the commodity demand.
2. The percentage share of trips in the loose state is the highest.
3. Majority of the vehicles are of Multi Axle Vehicle (MAV)
4. Most of the trips are from Rajasthan, Punjab, Maharashtra, Haryana, Gujarat, and Delhi which matches the hinterland of Kandla port.
5. The percentage share of trips by coal, oil, and steel (and its allied) products is higher for all outbound trips regardless of the season.
6. For the survey duration, rice trips are observed in more percentage indicates a demand for rice for export.
7. Majority of trips are in distance range of 1000 km to 1500 km.
8. The majority of the trips are attracted from a distance of 1000-1300 km range because the hinterland of the port is extended up to Haryana in North India and

Tamilnadu in South India. The highest share, about 20% of trips in the distance range of 1100-1200 km for both inbound and outbound trips.

5. Model calibration and validation

Having different categories of heavy vehicles like 3 Axle, 4 Axle and Multi Axle it is practically not true to consider average weight carried in each trip. Hence, a weighted arithmetic mean is worked out from following equation:

$$W = ((n1 \times w1)+(n2 \times w2)+(n3 \times w3)) / (n1+n2+n3) \quad (1)$$

Where, n1, n2, and n3 are number of 3 axle, 4 axle, and Multi-axle trucks respectively, and w1,w2, and w3 are average tonnage of respective category.
From above equation, weighted tonnage W comes out to be 26.62 tons.
Weighted tonnage is used to estimate the total number of trips generated from Kandla port in the respective year.

Equation for Export cargo,

$Y = 0.753X + 5.559$, $R^2 = 0.938$ (Linear) (2)

$Y = 6.367e0.069X$, $R^2 = 0.933$ (Exponential) (3)

Equation for Import cargo,

$Y = 0.661X + 2.072$, $R^2 = 0.886$ (Linear) (4)

$Y = 3.082e0.097X$, $R^2 = 0.914$ (Exponential) (5)

Where, Y=No. of trips (in Lakhs)
X= Cargo handled in Million Metric Tonne in *i* th year.
Above equations are formed based on the time series data available for import and export cargo from Kandla port traffic office.

From Kandla port, Survey data reveals that freight demand is independent of the distance, travel time, packaging characteristics, and total freight tonnage but depends on economic parameters like GDP, GSDP, area, and population. After several trials, a regression model is generated to build the relationship between the number of trips generated and independent variables like average distance (in 100 Kilometers), percentage GSDP of destination state, Gross area of the state (in 10000 Km^2), and Population in Millions. The model which depicts the best value of R^2 is as under.

$$Y = 8.652 - 0.491\ X_1 + 0.076\ X_2 - 0.028\ X_3 + 0.009\ X_4 + 3.57\ X_5 \quad (6)$$

Where,
Y = No. of truck trips
X_1 = Average distance in 100 Kilometers
X_2 = GSDP of attracting state
X_3 = Area in 10000 km^2
X_4 = Population in Millions
X_5 = Total tonnage
The above equation indicates a strong relationship between a dependent and independent variable with a strong value of $R^2 = 0.998$ and can be considered as the true representation of the study.
Following are the observations from the model.
1. Combining states of hinterland indicates a good value of R^2 but has a very high additive constant.

2. Considering all parameters as discussed in Equation 6 for all destination states indicates true representation. The number of trips depends on the area of destination. In above equation 6, a negative value indicates the aggregate area is considered. Hence further it can be refined considering only agricultural and production areas which generate freight transport.
3. A separate commodity-wise model can help to understand the effect of demand in the hinterland.

6. Summary and conclusions

There are significant data gaps in the road transport sector that need to be addressed. In the case of India, the data in respect of vehicles is available in terms of the number of registered vehicles. At present, no mechanism provides regular data on freight movement in terms of tonne-kilometres and passenger movement in terms of passenger kilometer by the private sector bus operators and other motorized means in the road transport sector. This is a major gap in the country for freight transport. The current trend in the field of freight modelling is to develop models based on economic data. The present research is aimed to analyze the truck trips by commodity type, its demand, total tonnage handled by Kandla port, and demand-supply effect.

The survey carried out reveals that the number of truck trips for the commodity is independent to the distance. Journey time data from survey data is highly biased from driver to driver. Freight models are difficult to calibrate and validate. A nationwide systematic data collection program like developing countries (NCFRP in the United States) is necessary for India. Though research in freight transport is scarce in India, an attempt is made in the present study to enlighten the need for such programs which can prove to be an aid to policymakers.

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