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Developing B2C freight trip generation model from Courier Express Parcel establishments: A case study of two Indian cities

Momi Deb [1*], Rajrishi Deka[1], Subhadip Biswas[1], Suprava Jena[1]

[1]*PhD Scholar, Civil Engineering Département, NIT Silchar*
[1]*M. Tech, Civil Engineering Département, NIT Silchar*
[1]*Assistant Professor, Civil Engineering Département, NIT Silchar*
[1]*Assistant Professor, Civil Engineering Département, NIT Silchar*

Abstract

A panoptic study of transportation planning requires an investigation of both passenger and freight transportation for the holistic growth of the concerned infrastructure. The increase in online purchases in the last few years has surcharged the courier, express and parcel (CEP) sector and the inclusion of freight trips generated by such establishments is essential while exploring urban freight transport scenarios. This paper essentially explores the different parameters which impact B2C freight trip generation and employs the ordinary least square (OLS) regression approach to model the same. A combined dataset of 104 CEP establishments from two cities in Northeast India, Guwahati and Silchar, was collected using an establishment-based freight survey (EBFS). Modelling inferences showed that delivery executives (DE), gross floor area (GFA) of the establishment, and category of clients (COC) were significant variables in forecasting B2C freight trip generation. The statistical results also showed a positive correlation between the predictors and the B2C freight trips. The estimation of the B2C freight trip model showed that CEP establishments are large freight traffic generators which will provide insight to the urban planners for policy making and r emedial measures.

Keywords: B2C freight trip generation, Urban freight, Courier express and parcel, Establishment based freight survey, Ordinary least square regression.

1. Introduction

Freight generation (FG) is a significant parameter for assessing the economic progress of any country since, with the increase in the former, the latter also rises. Freight Generation (FG) refers to the production and consumption of actual cargo, while Freight Trip Generation (FTG) refers to the freight traffic required to transport the FG (Holguín-Veras et al., 2011). According to a report from Statista (Sun, 2023), the logistics market of India is estimated to rise from 250 billion dollars in 2021 to 380 billion dollars in 2025. Whilst there is considerable research in passenger transportation and its allied topics worldwide, relatively little attention has been paid

* Corresponding author: Momi Deb (momidebsrv18@gmail.com)

to freight transportation, resulting in inadequate transportation planning in this sector. Unlike passenger transportation where passengers are sole decision makers, freight transportation has different entities like producers, distributors, shippers, carriers, retailers and consumers who contribute to the decision making of any purchase/ sale/ transport/order of cargo. This makes the nature and range of the freight dataset humongous. Developed nations have been contributing to the urban freight studies by dissecting different supply chain characteristics using various modelling techniques (Alho & de Abreu e Silva, 2015; Bastida & Holguín-Veras, 2009; Comi and Nuzzolo, 2016). However, in developing nations, there is a scarcity of ample data from establishments which the owners are unwilling to share owing to the competition in the market. In addition, the absence of a database regarding establishments and freight movements by central organisation, particularly in India, makes it arduous for researchers to enhance the urban freight literature. India, a budding economy, is going to witness an expansion in its infrastructure in this decade, thus all types of transportation including the freight movement scenario in each sector (manufacturing, services etc.) need to be explored. In India, a few studies from Kerala, Trichy and Jaipur gave insights into FG and FTG scenarios at the microscopic level (Pani et al. 2018; Sahu and Pani, 2020; Venkadavarahan & Marisamynathan, 2021). However, with the advent of e-commerce sites as an option for consumers, the freight movement study has become more complex and diverse. The increase in internet and smartphone penetration accelerated by the 'Digital India' programme by the government is expected to increase the number of online shoppers to 220 million by 2025 (IBEF, 2023). Indian e-commerce is forecasted to grow from 4% of the total food and grocery, apparel, and consumer electronics retail trade in 2020 to 8% by 2025 (Mordorintelligence.com, 2023). The drastic rise of e-commerce, higher internet penetration into the masses, and the latest technological innovations in the CEP (courier, express and parcel) sector have been the driving force for its growth rate of 10.5% between 2018-2028 in the market (Mordorintelligence.com, 2023). The COVID-19 pandemic also accelerated online purchasing, positively impacting the CEP industry's growth and increasing its market share. This indicates a noteworthy rise in the freight trip movement in urban areas in the form of B2C freight trips, transported by delivery executives to the B2C units. Therefore, the CEP sector, with its gigantic exponential growth, requires adequate transportation planning and parallel development of infrastructure so that it does not conflict with passenger transport on a complicated road network. The policy makers will have to restructure the policies in order to avoid traffic congestion on the roads, which will be a likely situation if not done in a structured manner. This study, thus intends to investigate the B2C freight trip generation from the CEP sector.

This paper consists of five sections, of which the present one is the Introduction. A Literature Review is in the next section which briefly discusses the past research, the gap in the literature and the objectives. The third section includes Methodology depicting the study areas, data collection and modelling approach. The fourth section i.e., Results and Discussion presents the descriptive analysis, modelling results and comparison of the existing studies. This is followed by Conclusion in the last section describing the policy implications, limitations and the future scope of this study.

2. Literature Review

An extensive survey of the literature was undertaken to comprehend the nitty-gritty of the freight(trip) generation. The keywords chosen for the literature search were 'freight generation', 'online shopping', 'e-commerce freight', 'city logistics', 'Establishment Based Freight Survey (EBFS)', and 'household freight'. The present review includes the articles published within the period of 2000-2023.

The papers which were reviewed predominately deal with freight flows in urban areas (Russo and Comi, 2020). In one of the studies, Comi explained commodity flows in urban areas with

a modelling framework linking purchasing, restocking and delivering of goods. Apart from that, the areas considered in the past studies include Belgium (Beckers et al. 2022), Brazil (Oliveira et al.,2017), Italy (Comi and Nuzzolo, 2016), Netherlands (Iding et al., 2002), Portugal (Alho & de Abreu e Silva, 2015; Alho & de Abreu e Silva, 2017), Sweden (Sanchez-Diaz et al., 2013; Sánchez-Díaz, 2017) and USA (Bastida & Holguín-Veras, 2009; Holguín-Veras et al. 2011; Jaller et al., 2015).FG/FTG studies are in their infancy both in India and other developing nations, although an increase in research for examining the FG and FTG has been witnessed in India in the last few years. Freight tour activities, crop production and attraction, freight production and attraction from establishments were analysed and modelled in those studies (Balla et al., 2023; Dhulipala & Patil, 2020; Pani and Sahu, 2018; Pani and Sahu, 2020; Venkadavarahan & Marisamynathan, 2021; Venkadavarahan et al., 2020; Venkadavarahan & Marisamynathan, 2022). Few studies investigated B2C freight in Belgium, Rome and the USA (Beckers et al., 2022; Comi and Nuzzolo, 2016; Rodrigue, 2022). A detailed survey describing the home deliveries of parcels in an apartment in New Jersey for 4 years was done to study its temporal patterns (Rodrigue, 2022). Following a concise overview of the study areas covered in the mentioned research, the subsequent review will delve into the adopted explanatory variables and modeling approaches.

2.1 Explanatory variables

The explanatory variables utilised in past studies to forecast FG/FTG include employment and gross floor area (Alho & de Abreu e Silva, 2015; Bastida and Holguín-Veras, 2009; Dhulipala & Patil, 2020; Sahu and Pani, 2020; Venkadavarahan and Marisamynathan, 2022). The transferability of FG/FTG models across different industry categories is questionable as this category itself plays an essential role in determining the FG/FTG (Alho & Silva, 2014; Alho & de Abreu e Silva, 2017; Iding et al. 2002; Venkadavarahan & Marisamynathan, 2022). Apart from that, several explanatory variables like, business age (Pani et al., 2018), location (Alho & Silva, 2014; Oliveira et al., 2017), number of suppliers (Venkadavarahan and Marisamynathan, 2022), seating capacity(Patil et al., 2021), vehicle ownership (Patil et al., 2021; Venkadavarahan and Marisamynathan, 2022), population, gross cropped area (GCA), gross irrigated area (GIA) (Dhulipala and Patil, 2020), income and education (Beckers et al., 2022) were considered in several FG/FTG models. In this regard, while employment turned out to be a strong regressor for freight production (FP) models, the freight attraction (FA) was largely governed by the gross floor area (Pani and Sahu, 2018; Sahu and Pani, 2020). However, in US context, the industry category and type of commodity were found to be strong regressors for modelling FG (Bastida and Holguín-Veras, 2009) amongst the other regressors such as employment and gross floor area. For modelling FTG from restaurants in India, employment, seating capacity and vehicle ownership turned out to be significant parameters (Patil et al., 2021). FTG modelling for restaurants and pubs in Brazil had area and employment as significant parameters (Oliveira et al., 2017). In a study conducted in Belgium, amongst all predictors (gender, age, family size, type of goods) chosen for modelling online shopping frequency and delivery locations, income and education were found to be the significant parameters (Beckers et al., 2022). The past research witnessed the importance of employement and area in modelling FG/FTG. A few studies on agriculture and restaurants have specific characteristic predictors like GCA and GIA, seating capacity and vehicle ownership. All of these abovementioned explanatory variables considered in the previous studies are systematically reported in Table 1.

Table 1: Different explanatory variables and modelling approaches used in previous studies

Authors and Year	Modelling approach	Response variable	Study area	Significant explanatory variables			
				Infrastructural variables		Other variables	
				Gross Floor Area/Seating Capacity	Vehicle ownership	Employees	Industry category
Iding et al. (2002)	Linear regression	FTG from all establishments except CEP		Industry category, employment and gross floor area		✓	
Bastida and Holguín-Veras (2009)	(OLS) linear regression and MCA	FG from establishments	USA	✓		✓	✓
Holguín-Veras et al. (2011)	(OLS) linear regression and MCA	FTG from different industry sectors except CEP	USA			✓	✓
Alho & de Abreu e Silva (2014)	OLS linear regression	FTG from establishments	Portugal			✓	✓
Jaller et al. (2015)	Binary logit model and discrete continuous modelling approach	FTG from establishments	USA	✓		✓	
Sánchez-Díaz (2017)	Ordered logit modelling, binary logit regression, linear regression	FG and FTG from retailers, food services, health care, public sector offices and education	Swed-en	✓		✓	✓
Oliveira et al. (2017)	Linear regression	FTG from pubs and restaurants	Brazil	✓		✓	
Pani et al. (2018)	OLS linear regression	FG from establishments	India	✓		✓	
Venkadavarahan & Marisamynathan (2021)	MCA	FTG from establishments	India	✓		✓	
Patil et al. (2021)	FTG models using Poisson regression & linear regression	FTG from restaurants and pubs	India	✓	✓	✓	
Balla et al. (2023)	MCA and Support Vector Regression, OLS, Weighted Least Square, Robust Regression, Seemingly Unrelated Regression	FG from establishments except CEP sector	India	✓		✓	

2.2 Modelling approaches for FG/FTG

Various modelling approaches were adopted to develop FTG prediction models (Iding et al.,2002; Holguín-Veras et al., 2011; Oliveira et al., 2017). Bastida and Holguín-Veras modelled FG by collecting data from establishments in Brooklyn and Manhattan and compared the results of ordinary least square (OLS) linear regression and multiple classification analysis (MCA) (Bastida and Holguín-Veras, 2009. Holguín-Veras, 2011). This comparison revealed that OLS performs with better accuracy to predict the FG for the following industries: transportation, communication, and utilities, motor freight transportation and warehousing and wholesale trade. Sánchez-Díaz used the establishment based data from Gothenburg, Sweden. The author employed binary logit and linear regression for FTG and freight volume attraction (FVA) modelling and ordered logit modelling for freight weight attraction (FWA). The establishments considered are retailers, food services, health care, public sector offices and education (Sánchez-Díaz, 2017). For distinguishing intermediaries (the establishments having both trip attraction and production), Jaller et al. utilised a binary logit model and discrete continuous modelling approach for forecasting FTG. The authors had data of 248 establishments in Manhattan. They concluded the need to identify the intermediaries, which if not done, would lead to over estimation of freight traffic by the existing models (Jaller et al., 2015). Alho and de Abreu e Silva employed OLS to forecast weekly deliveries per establishments (Alho & de Abreu e Silva, 2015; Alho & Silva, 2014) and later compared the outcomes obtained by generalized linear (GZLM), ordinal logit (ORD), partition method (PM) and MCA (Alho & de Abreu e Silva, 2017). The authors used the percentage of correct prediction, root mean square error (RMSE), absolute error average etc. to compare the performance of the models. The PM model showed the best performance followed by ORD. Ordinal logit and multinomial logistic regression were used for exploring household freight due to online shopping (Beckers et al., 2022). Swamy and Baindur in 2014 attempted to map the pattern and intensity of the freight flow in the transportation network of Ahmedabad(Swamy & Baindur, 2014). Dhulipala and Patil used multiple linear regression (MLR) and generalized additive modelling(GAM) to forecast crop production from eight states in India. GAM addressed non-linear interaction of predictor variables i.e., population, employment, gross cropped area and gross irrigated area on crop production. The spatial variables (longitude and latitude) were also considered in GAM models by the authors (Dhulipala and Patil, 2020). OLS was extensively used by Pani et al. to predict freight generation in thirteen industrial sectors in seven cities of Kerala. The effects of cities on models were also examined using analysis of covariance (ANCOVA) (Pani et al.,2018). Balla et el. found non-parametric (MCA and Support Vector Regression) models better for FG predictions than parametric ones (OLS, Weighted Least Square, Robust Regression, Seemingly Unrelated Regression). RMSE and MAPE values were used as performance parameters for comparison purposes (Balla et al., 2023). Venkadavarahan and Marisamynathan developed FTG models using MCA & studied the temporal pattern of daily freight trips from/to establishments of Trichy. Data was taken from 647 establishments using establishment based freight survey. The freight trip rate table showed employment was positively correlated with weekly freight trips (Venkadavarahan & Marisamynathan, 2021). The FTG model was later enhanced by considering the establishment classification process using Kernel Support Vector Machine and Artificial Neural Network (ANN) (Venkadavarahan & Marisamynathan, 2022). Venkadavarahan et al. formulated freight tour models using exponential regression, ANN, SVM and k-nearest neighbour(k-NN) modelling (Venkadavarahan et al., 2020). Poisson regression outperformed linear regression while formulating FTG models from 150 restaurants in Mumbai and Delhi, India(Patil et al. 2021).

The above discussion indicates that a variety of modelling approaches were employed in the previous studies to model FG/FTG for different industries. These approaches are also systematically provided in Table 1. Further, the section also shows the robustness of the types of commodities and industry sectors involved in FG/FTG modelling. To a great extent, researchers had clubbed all those different commodities for FG/FTG estimation from urban establishments considering employment and area as the strong predictor (Pani et al., 2018). Few researchers have taken industry classification as the predictor but the CEP establishments were ignored in all the previous studies (Jaller et al., 2015). Unlike passenger transportation, the diversity in the commodities and concerned stakeholders makes it debatable to predict FG & FTG in a simple manner. One way to avoid these complications is to split the industry sectors based on the dealt commodities. Likewise, as per Sanchez-Diaz et al., each industry sector should be separately examined for freight studies (Sanchez-Diaz et al., 2013). This recommendation was further supported by several other researchers also. (Oliveira et al., 2017;Patil et al., 2021).

In Table 1, as may be seen, the response variable considered in the previous studies did not include the CEP establishment. Few researchers analysed the characteristics and the shopping behaviour of consumers for forecasting freight trips from e-commerce (Rodrigue, 2022; Beckers et al., 2022). CEP establishments, being smaller in number as the B2C freight generating nodes than the end consumers, are assumed to be more practical for forecasting B2C freight trips from the CEP sector. But, none of the FG/FTG studies have reckoned the CEP sector in the industry classification. Thus, the establishments dealing with CEP were omitted in the freight trip generation studies both in developing and developed nations. Therefore, the scope of this study encompasses the trips generated from the CEP establishment to the receivers' or consumer's address, which are termed as B2C freight trips.

To fill this identified gap of the exclusion of CEP establishments in the FTG studies, this study primarily aims: i) to develop a complete data collection and modelling framework for the B2C freight trip generation from CEP establishments to the existing literature ii) to identify input parameters which influence the B2C freight trip generation and iii) to develop B2C freight trip generation models for CEP establishments in Guwahati and Silchar, India.

3. Methodology

A vivid description of the adopted methodology is shown below in Fig 1. After selecting the study areas (Silchar & Guwahati), data collection was conducted through Establishment-based Freight survey. *B2CFTG* model was developed after analysing the collected data. The study culminates with concluding remarks regarding policy implications and future scope

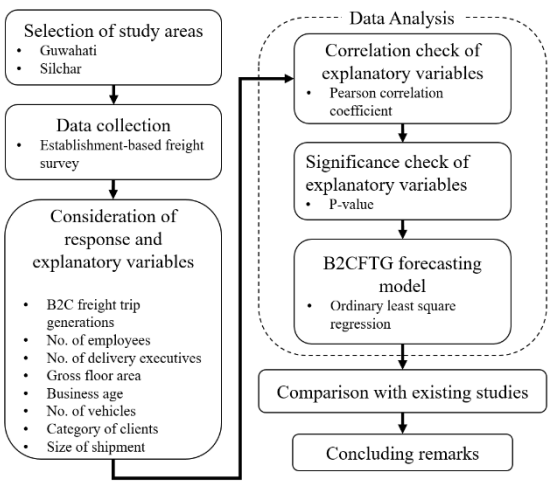


Figure 1: Methodological flowchart

3.1 Study areas

Guwahati, being the capital of Assam, a north-eastern state of India, is the highest populated city of the state and is considered as the gateway to the Northeast region. According to the census 2011, Guwahati is forcasted to be the dwelling of 1.25 million people in the year 2023 and is a tier II city. Silchar, a town in the southern part of Assam, succeeds the capital city in terms of population, area and GDP. The population of Silchar was 172,830 in 2011 and is forecasted to be 0.314 million by 2023 with respect to the past growth rate. The CEP establishments which deliver the shipments to the consumers dwelling in these two study areas are considered for collecting data. The courier services present in Guwahati and Silchar include top market players like DTDC, Delhivery, E-com Express, E-kart Logistics, Ship rocket, Blue Dart, Xpress bees, Shadow fax, etc. There are numerous smaller players catering the needs of city dwellers like Trackon, Shree Maruti Courier Services, Shree Tirupati Courier Services, Excel Courier & Cargo, Aramex, Fly king Courier Service etc. These stores deal with P2P (person to person) and B2C (Business to Consumer) shipments. B2C shipments refer to the ones which are sold and purchased at e-commerce sites and social media platforms. These include e-commerce giants like Flipkart, Amazon, Myntra, Ajio etc. and budding startups dealing with medicines, grocery, apparel, home decor and consumer electronics.

3.2 Data Collection.

An Establishment based Freight Survey (EBFS) is appropriate for collecting information about vehicle trip generation and total goods flows to/from establishments (Allen et al., 2012). The elaborated literature review made the foundation of the EBFS questionnaire form for this study (Patil et al., 2021; Sánchez-Díaz, 2017) along with a few additional questions relevant to the CEP sector. Two surveyors, fluent in local languages and well versed in transportation engineering were assigned to conduct the EBFS through face-to-face interviews. Unlike the previous studies that calculated the sample size through the Raosoft sample size calculator with a 95% confidence interval and 5% margin error (Pani et al. 2018; Venkadavarahan and Marisamynathan, 2021), this study covered all the available CEP establishments in the urban areas of the chosen cities. Instead of letting the respondents of the establishment fill up the form, one of the surveyors interrogated colloquially and the other one filled up the responses. This technique has been used extensively by researchers and proven to yield a better response rate (Venkadavarahan & Marisamynathan, 2022) than the self-completion approach (where the survey forms are left to be filled by the respondents of establishments)(Allen et al., 2012). Data collection was carried out on weekdays from Dec,2022-Jan,2023 on weekdays. Weekends were reserved for interviewing those establishments whose respondents were unable to spare time on weekdays. After the pilot survey and observing its response rate, the EBFS form was rephrased and finalised. It comprised of total 21 questions and the survey from a particular establishment was completed in 10 minutes.

The selected dependent variable was the daily B2C freight trip generated (*B2CFTG*) from a CEP establishment which refers to the trip made by the delivery executive to the receiver for fulfilling the delivery of shipment. The past studies considered four significant explanatory variables while developing the FG/FTG models. The present study considers all of these variables except the industry category since the research is exclusively focused on CEP establishment and investigating the effect of industry category is irrelevant. However, two new explanatory variables are introduced and considered in the present study viz. category of client and buisness age which are expected to have significant influences on the *B2CFTG*. The no. of

employees (*EMP*) represents the employees involved in the desk work and operations in the establishment. The no. of delivery executives (*DE*) were the ones who make the trips to deliver the B2C freight or shipments. For B2C freight trips, this variable is expected to have a significant influence on B2C freight trip generation. Gross floor area (*GFA*) is the total area of the establishment available for employees, consumers, and goods. The business age (*BA*) depicts the number of years since the inception of the establishment. The category of clients (*COC*) served refers to the producers or senders of the shipments and is bifurcated into B2C (business to consumer) and P2P (person to person). The size of the shipment (*SOS*) is categorised based on shipment weight: small(0-3kg), medium(4-6kg), and large (>6 kg). No. of vehicles(*NOV*) represents the count of vehicles owned by the CEP establishments.

3.3 Modelling approach

The selection of the modelling approach is governed by the type of dependent variable and the assumptions related to the data distribution. In the present case, the dependent variable is continuous in nature and both of the dependent and independent variables can be assumed to be normally distributed. In this context, the ordinary least square (OLS) regression approach is preferable as it is simple and based on fundamental mathematics. This approach is also popular in this domain as it was used repeatedly in the previous studies (Jaller et al., 2015, Sánchez-Díaz, 2017, Alho & de Abreu e Silva, 2015). The IBM SPSS 27 software was used for this purpose. The functional form of the model is represented in Eqn. 1:

$$B2CFTG = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \varepsilon \quad (1)$$

Where *B2CFTG* = B2C freight trip generation, β_0 = intercept, x_i = explanatory parameters like *EMP, DB, GFA, BA, COC,* β_i = coefficient of the explanatory parameters x_i, ε = error term which includes all the factors that cannot be forecasted precisely.

4. Results and Discussion

4.1 Preliminary analysis

Prior to modelling, the descriptive analysis of the collected data is discussed in this section. The required data were collected from 104 CEP establishments (70 in Guwahati and 34 in Silchar). 83 datapoints i.e. 80% of the total 104 datapoints were used for developing the model and the rest 20% were used for the model validation. Fig 2. depicts the distribution of no. of daily B2C freight trips generated from CEP establishments. The number of daily B2C freight trips delivered ranges between 0 and 4400. B2C freight trips are from those establishments which deal only with sending shipments to consumers. The average number of B2C freight trips produced by CEP establishments is 406.98. 59.7% of the establishments produced less than 200 B2C freight trips whereas 8% of the sample had more than 1200 B2C freight trips daily. Regarding the explanatory variables, the average number of delivery executives employed in CEP establishments is 5.95 (approximately, 6). The lowest and the highest no. of delivery executives employed is 0 and 51 respectively. Fig 3a. shows that a significant percentage (79%) of delivery executives employed by CEP establishments ranges between 0-5. Similarly, Fig 3b. describes around 70% of the establishments had 2-5 employees and 8.5% had more than 10 employees. Fig 3c&d show the pictorial distribution of establishments based on gross floor area and category of clients served. It was observed that 78% of the establishments had a gross floor area less than 500 sqft. It indicates that the CEP establishment does not require a larger space since there is no need of storing the couriers. Only 9.7% of the

establishments had 501-1000 sqft, 7% had more than 2000 sqft and 3.6% had 1001-2000 sqft of gross floor area available for employees, consumers, and couriers. Moreover, 59.7 % of the establishments deliver P2P shipments whereas only 6.1% deliver exclusively B2C shipments. However, the rest 34.15 % of the outlets deliver both P2P and B2C shipments. Besides, 26% and 71% of the outlets are less than 5 and 15 years old as shown in Fig 3e. This is due to the recent rise in e-commerce platforms for Indian consumers and the ease of internet access in the last decade. Fig 3f. shows that 31% of the establishments do not own any vehicle. These establishments rely on third-party logistics. On the other hand, 39% of the establishments owned 1-5 vehicles and only 3% owned more than 5 vehicles.

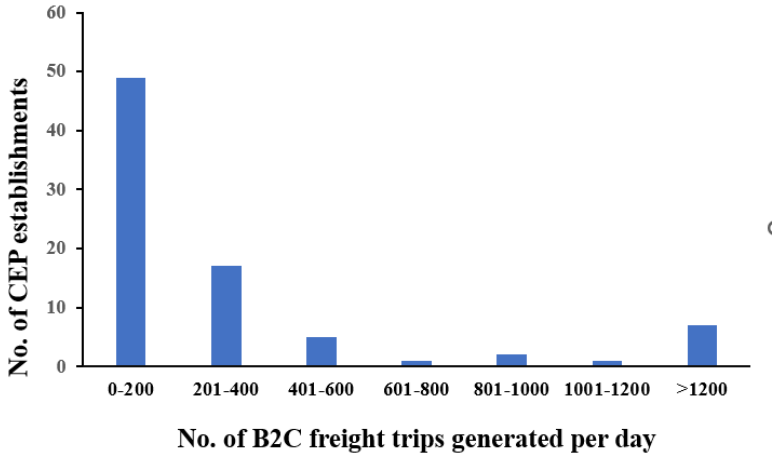
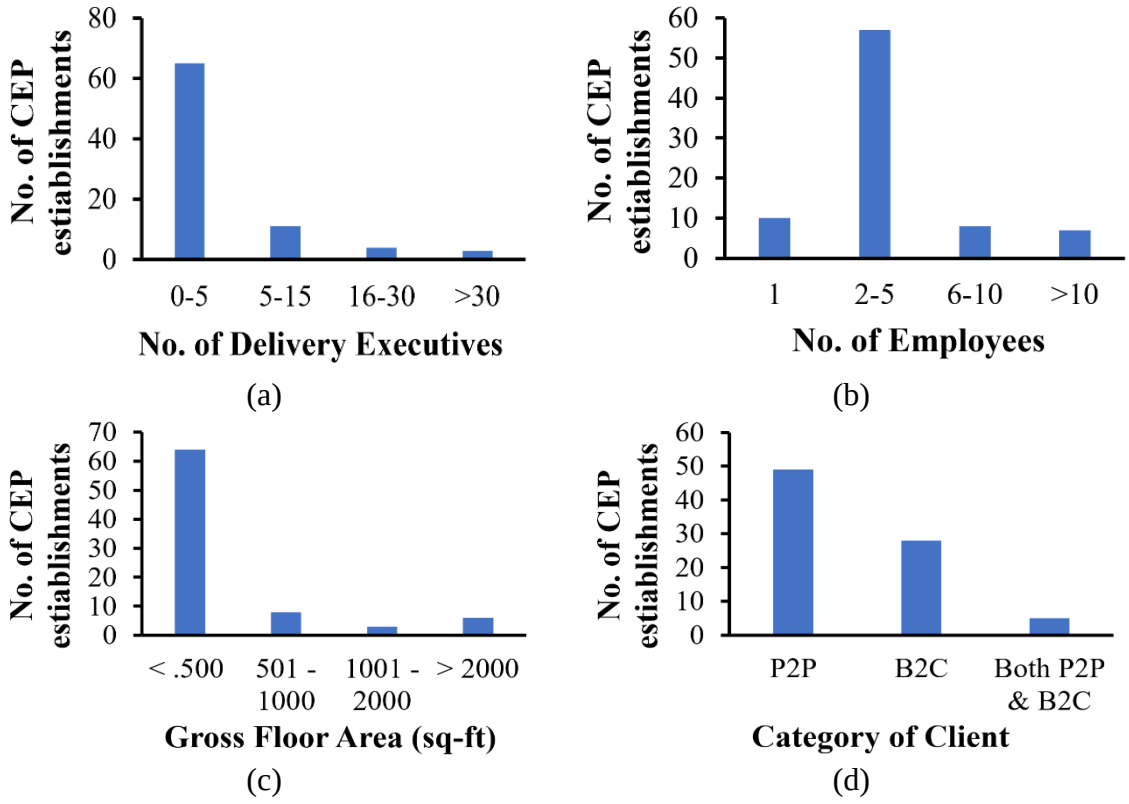


Fig 2: Distribution of the number of daily B2C freight trips from CEP Establishments



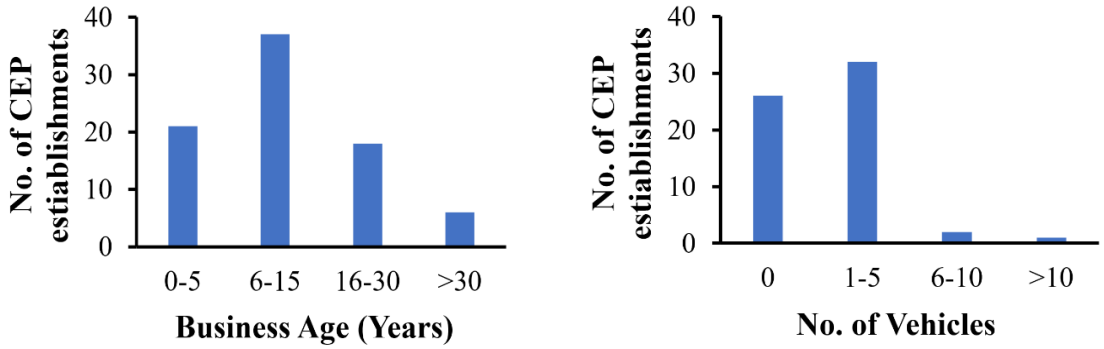


Figure 3: Distribution of CEP establishment as per various explanatory variables; a) No. of delivery executives, b) No. of employees, c) Gross floor area, d) Category of client, e) Business age, and f) No. of vehicles

To understand the relationship between dependent and independent variables, the Pearson correlation test was conducted in SPSS software with a significance level of 0.05. The p-values and the signs describe the nature of the correlation between two variables. No significant linear relationship exists between two variables if the p-value is more than 0.05. Table 2 depicts the results of the Pearson correlation test. The variables which significantly influence B2C freight trip generations based on the p-value, were identified. No. of employees, no. of delivery executives, gross floor area, size of shipments and category of clients are found to be correlated with *B2CFTG*. The B2C freight trips increase with the decrease in size of shipments and no. of vehicles as both of the parameters have negative correlation i.e., -0.314 and -0.327 whereas the rest are positively correlated. No. of delivery executives and gross floor area have similar and highest correlation of 0.69, followed by no. of employees (0.47) and category of clients (0.26). Since delivery executives fulfil the delivery of the shipments, thus the dependence of *B2CFTG* is greater on delivery executives than the employees. The category of clients shows that the impact of B2C shipment delivery is significant.

Table 2: Correlation between dependent and independent variables

Variable	**Pearson Correlation**	**p-value**
B2CFTG	1	
No. of employees	0.47	<0.001
No. of delivery executives	0.69	<0.001
Gross floor area	0.69	<0.001
Business age	-0.08	0.470
Size of shipments	-0.31	0.004
No. of vehicles	-0.33	0.001
Category of clients	0.26	0.020

*Significant at the 0.05 level

4.2 B2C freight trip generation model

The observed data of B2C freight trip generation along with explanatory variables were taken to the model development and a multiple linear regression model was developed using the OLS approach. The results obtained in the regression analysis are given in Table 3. The

significant variables at 95% confidence level are only presented in the Table and considered for further analysis. The result showed a satisfactory goodness-of-fit denoted by a R^2 of 0.85. Also, VIF values of explanatory variables were less than 10 denoting the insignificant multicollinearity issues. Delivery executives (*DE*) is found to be a stronger explanatory variable than no. of employees (*EMP*). No. of employees was stronger explanatory variables which explained FG/FTG models in previous studies (Dhulipala and Patil, 2020; Holguín-Veras et al., 2011; Jaller et al., 2015; Oliveira et al., 2017; Sahu And Pani, 2020). No. of employees (*EMP*) is an insignificant parameter in CEP establishments because of their negligible involvement in making B2C freight trips and more contribution to desk operations at the establishments. Whereas, *DE* are the carriers of the B2C freight fulfilling the delivery of the shipments to its respective destination i.e., the receivers/consumers, hence the significance. Encompassing all the establishments in a single FTG model will underestimate the freight traffic as it is evident that trip generation from the CEP sector to consumers' units is huge as compared to establishments from other commercial sectors. This *B2CFTG* which can not be explained by the number of employees alone and a distinguished predictor is required. The number of B2C freight trips from an establishment increases by 44.6 times with the increase of a single delivery executive.The t-stat of *DE* shows its highest impact on the response variable which is *B2CFTG*. *GFA* shows that the bigger the area of CEP establishment, the larger generation of B2C freight trips will take place, owing to the accommodative capacity of such establishments for the shipments. Nevertheless, *GFA* for CEP sectors is a strong predictor like other industry segments (Bastida and Holguín-Veras, 2009; Pani et al. 2018; Sahu and Pani, 2020). Another significant parameter is found to be *COC* which shows that those establishments dealing with only P2P shipments will have 86 B2C freight trips, B2C shipments will have 172 B2C freight trips and both B2C and P2P shipments will have 258 more B2C freight trips. The influence of e-commerce/online purchases on B2C freight trip generation is apparent from the parameter *COC*. It shows the estabilshments dealing with just P2P shipments generate considerably lesser B2C freight trips than the rest.

Table 3: Results of OLS

Variables	**Coefficient**	**t-stat**	**Sig.**	**VIF**
Intercept	-230.316	-1.408	0.045	
No. of Delivery Executives (*DE*)	44.624	8.837	<0.001	2.050
Gross floor area (*GFA*)	323.048	7.667	<0.001	1.425
Category of clients (*COC*)	86.422	2.407	0.019	1.218
R^2	0.847			

4.3 Model validation and comparison with the existing studies

In order to check the predictability of the developed model, it was further validated based on 20% of the observed data which was kept aside in the training phase. Hence, the observed data of the explanatory variables were taken as inputs in the proposed model and therefore *B2CFTG* was predicted for each set of data. These *B2CFTG* predicted by the model were compared with the observed data and plotted against each other in Fig 4.

As may be seen in the figure, the observed and the predicted data have a good agreement denoted by a Mean Absolute Error (MAE) of 172 trips/day. This indicates a satisfactory accuracy of the proposed model in predicting *B2CFTG* based on an unknown dataset. The formula to estimate MAE is given in Eqn 2.

$$\text{MAE}= \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i| \quad (2)$$

Where, P_i = predicted data and O_i= observed data, n =total datapoints.

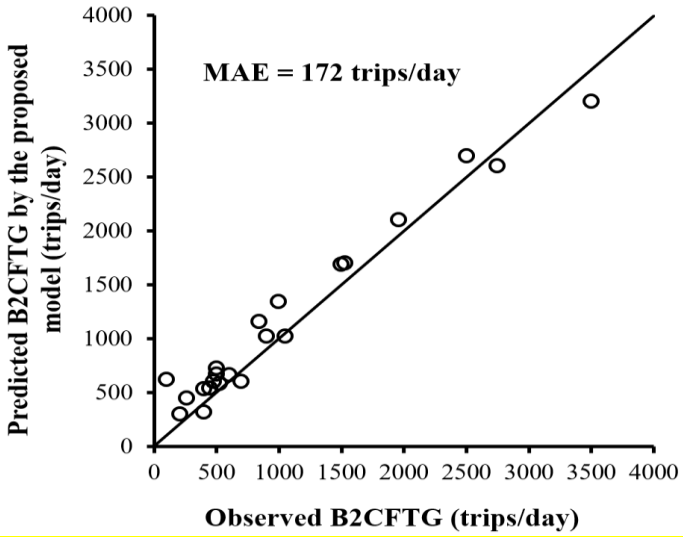


Figure 4: Scatter plot exhibiting the comparison between the observed B2CFTG data and the same predicted by the developed model

Further, the performance of other existing models vz. Holguín-Veras et al. (2011) and Alho & de Abreu e Silva (2014) were also evaluated based on the same 20% of the observed data. Therefore, similar validation was conducted and the error obtained for each model was subsequently reported in Table 4. MAE was estimated as 1026 and 1023 trips/day, respectively for the models forwarded by Holguín-Veras et al. (2011) and Alho & de Abreu e Silva (2014). Hence, it is evident that the proposed model in this study outperforms the existing ones in predicting *B2CFTG*. It might be attributable to the fact that the existing models were developed by considering various industry categories while CEP establishment was not included. On the other hand, the proposed model is exclusively contextual to CEP establishment and hence, performs effectively. This comparison of performances further highlights the need of developing an industry-specific FTG model in order to achieve high predictability.

Table 4. Errors (in terms of MAE) yielded by different models in predicting FTG

Model proposed by	MAE
Proposed model	172 trips/day
Alho & de Abreu e Silva (2014)	1022 trips/ day
Holguín-Veras et al. (2011	1026 trips/day

5. Conclusion

The segregation of urban freight based on different manufacturing and service sectors is crucial to understand the influences of different input parameters on FTG and for subsequent policy making. Examining the CEP sector is essential owing to its distinct characteristics of making a substantial number of trips from the establishments to the location of the receiver on a daily basis. A sample of 104 data from Guwahati and Silchar of Northeast India were the stimuli to comprehend the relation between the explanatory variables and the daily B2C freight trip generation. Delivery executives, gross floor area and category of clients were found to impact the dependent variable significantly more than the rest. The model developed in this study has yielded a satisfactory accuracy in terms of MAE while predicting the B2C freight

trips. A validation test also ensured that the proposed model has outperformed the existing FTG models.

The developed B2CFTG model has significant policy implications in the form of planning a sustainable B2C freight transportation infrastructure. Policymakers, entrepreneurs and concerned stakeholders can utilise the insights from this study to enhance the delivery efficiency of B2C shipments, reduce congestion by finding optimal and sustainable solutions and optimise the B2C freight routes. Additionally, the results of this study shall assist in designing policies that promote resilient and sustainable B2C freight transportation.

The study area of this paper is limited to two cities in India which can be extended in future by considering different tiers of cities. While this study is one of the first to address the B2C freight trips generated from CEP establishments, there is a need to collect a large dataset from metro cities as well for analysing the differences in patterns of B2C freight trip generations of various cities. Another limitation of this study is the exclusion of the government post officies of India which also transports couriers and parcels across the country. The inclusion of these post offices can be covered in future for analysing the CEP trip generation. This study provides insight into a different set of FTG i.e., B2C freight trips which have significant numbers for consideration while making policies for the freight sector.

Notations:

BA: Business age
B2C: Business-to-consumer
B2CFTG: Business-to-consumer freight trip generation
CEP: Courier, express and Parcel
COC: Category of client
DE: No. of Delivery Executives
EMP: No. of employees
FG: Freight generation
FTG: Freight trip generation
GFA: Gross floor area
MAE= Mean absolute error
OLS: Ordinary least square
NOV: No. of vehicles
P2P: Person to person
SOS: Size of Shipment

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Appendix

Establishment-based Freight Survey

1) What is the name of the CEP establishment ?

Ans :

2) What is the location of the establishment ?

Ans :

3) Is the establishment a hub ?

Ans :

4) If yes, then how many other establishments does it serve or connect with ?

Ans :

5) How many total B2C freight trips are generated from the establishment daily ?

Ans :

6) How many employees are working in the establishment (except delivery executives) ?

Ans :

7) How many delivery executives are working in the establishment ?

Ans :

8) What is the gross floor area of the establishment ?

☐<500 sqft.
☐501-1000 sqft.
☐1001-2000 sqft.
☐>2000 sqft.

9) Does the establishment have any warehouse ?

Ans :

10) If yes, what is the gross floor area of the warehouse ?

Ans :

11) Does the establishment hire 3rd party logistics ?

Ans :

12) What are the number of vehicles owned by the establishment ?

Ans :

13) What are the type vehicles owned by the establishment ?

Ans :

14) What are the type of vehicles used by the delivery executives for B2C freight trips ?

Ans :

15) How many of the delivery executives uses e-vehicles for delivering B2C freight ?

Ans :

16) What is the size of shipment ?

☐Small (0-3kg)
☐ Medium (4-6 kg)
☐ Big (> 6kg)
☐ All of the above

17) Which category of clients are being served ?

☐ P2P
☐ B2C
☐ Both P2P & B2C

18) What are the timings of delivering the B2C freight ?

Ans :

19) How much radius is covered by the establishment for deliveries ?