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Characterization of Freight Trip from Textile Powerloom Units – A Case Study of Surat, India

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Abstract

Surat, a city located in western part of India is known for its textile industries. The city produces 40% of the total man-made fabric production in the country. There are close to 700,000 weaving machines producing approximately 30 million meters of raw fabric every day. Almost 650,000 of these weaving machines are powerlooms or shuttled looms. Powerlooms are widely used because they are cheaper, needs lesser space and offers variety of weaving options. A large variety of raw fabric is produced based on its utility which is sent for its further processing works to the processing units. A textile market area located on the ring road is a hub for trading of various textile goods. A large number of goods movement trips occur from various powerloom units to the market and other processing units in the city. With 25000 weaving units located in different parts of the urban area, 320 processing units and 140 wholesale trading market complexes, the internal or intra-city textile goods movement becomes very complex. In this study freight trip generation characteristics of powerloom industry is studied here and a model is developed to forecast the number of freight trips from various powerloom units clusters so as to estimate the overall flow of freight vehicles at the network level.

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Keywords: Urban freight, goods movement, logistic sprawl, congestion, freight trip generation

1. Introduction

Urban freight transportation is entirely different from passenger transport and its impact on transportation system and environment is significant. Freight movement has gradually become top on the priority list for all major transport researchers and stakeholders across the world due to its unpredictable characteristic at city level. Though very good research studies have been carried out in various area of freight movement like urban, regional and

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international freight movement in the technologically advanced nations like the U.S., U.K., Germany, Netherland, Sweden and Japan etc., but it is still in a dormant stage in most of the developing economies of the world. India is considered as one of the fastest growing major economies in the world and it is expected to have atleast 10 megacities by 2030. With high growth in industrialization and expanding city boundaries the movement of goods in the cities is becoming more and more complex. Cities in India, like most of the developing nations, have a highly heterogeneous traffic conditions. Lane discipline and traffic sense is found to be in a dismal state in most of the Indian cities. In such a scenario the goods vehicle, whichever category are permitted in a given urban space, often result in overall speed reduction and acts as a hindrance to the other private and public modes. The current situation is bound to get worsened with increasing urbanization and cities getting denser.

Textiles manufacturing is the second largest industry after agriculture offering large scale employment to both skilled and unskilled workforce, with more than 35 million people in the country directly engaged in it. In India many cities like Surat, Kanpur, Ahmadabad, Mumbai, Banaras, Mysore, Kolkata, Coimbatore and Madurai etc. are the hub of the textile manufacturing. Cities in India, like most of the developing nations, have a highly heterogeneous traffic conditions. Lane discipline and traffic sense is found to be in a dismal state in most of the Indian cities. In such a scenario the goods vehicle, whichever category are permitted in a given urban space, often result in overall speed reduction and acts as a hindrance to the other private and public modes. The current situation is bound to get worsened with increasing urbanization and cities getting denser. The urban freight movement resulting out of the textile industry disturbs the city traffic operation and also has great impacts on the congestion and pollution levels. In this study a survey of powerloom industry primarily contributing to the weaving of raw fabric for the entire textile industry in carried out. Data regarding the freight generation and freight trips generation from individual PU as well as the entire clusters of PUs located in different parts of the city is collected by personal interview and discussion with the industry experts. Location and boundaries of various.

Nomenclature

FTG	Freight trip generation
FG	Freight generation
PU	Powerloom unit
RRM	Ring road market

2. Literature Review

The studies for achieving a harmonious freight flows started in the early 80’s in Europe and the US. Different stratification strategies were attempted by Brogan (1980) for improving trip generation models, wherein it was identified that land use was the most effective stratification technique for improving significance of the model. Bartlett and Newton (1982) studied FTG for a group of firms; these groups were classified according to freight trip generation intensity of each type. Using regression models based on independent variables like total employment and site area. Model results matched very well with actual vehicle-trip counts. Haulage firms, waste disposal firms, concrete distribution businesses and fuel supply agencies were the most intensive generators, while manufacturers and printers were the least intensive. It was also observed that the freight generation rate varies significantly within the same industry sector. Middleton et. al. (1986) collected data related with trip generation rates, trip length and vehicle type. He analyzed trip generation characteristics for special land use truck traffic in Texas; their study included an assessment of each special land use class in terms of freight trips.

The Federal Highway Agency Guidebook on State Travel Forecasting (FHWA 1999) uses travel diaries and shipper behavior(data of land use and trip data) to estimate truck trips; and then distributed using a form of gravity models that are calibrated with trip length frequency distributions obtained from trip diaries. Another trip-based model, the Quick Response Freight Manual by Cambridge Systematics Inc. (1996) applied trip generation rates using economic activity data for the traffic analysis zone, calculates the number of commercial vehicle trips at the zonal level, commercial vehicle volumes at external stations, and commercial trips between zones. The model uses mode shares for each trip and then loads the O-D matrix to the network after the trips have been estimated; for the purpose of calibration the estimated vehicle kilometer traveled (VKT) were compared with control VKT. The study showed that applying a much aggregated model (e.g., the one suggested by the Quick Response Freight Manual) to a study area using extremely disaggregated Travel Analysis Zones (TAZs) results in no noticeable loss in model accuracy. Marker and Goulis (1998) implemented this model in a truck flow survey study that investigated the effects on traffic assignment when using different degrees of geographic resolution.

For a broad range of land use types the ITE Trip Generation Manual, 8th Edition (Institute of Transportation Engineers 2008) contains a comprehensive compilation of estimated FTG rates. Although the ITE Manual focused on all vehicle types, some of the results can be applied directly to FTG, e.g., truck terminals. The ITE Trip Generation Hand-book, 2nd Edition, give guidelines on how these rates (for all vehicle types) may be used for a given trip generation study. The most noticeable ones are related to the need to: use consistent definitions of trucks and truck trips; consider the age of the existing FTG data; avoid land use classes which are too broadly defined; and think carefully about the selection of independent variables. Iding et al. (2002) estimated linear regression models (truck trip generation) at industrial sites The sample included 1,529 firms within the Netherlands with more than 5 employees, parameters (slope and intercept) were obtained for two different classification types (18 sectors and 5 types of heavy industry site) and two independent variables (area and employment). The results indicate that independent variable is better depends on the industry sector and on the direction of freight (in- or outbound). It was found that the logistics and transport services sector have the highest average level of outbound trips produced.

Other vehicle trip models estimate FTG rates for productions and attractions using cross classification-Bastida and Holguín-Veras (2009) compared the use of cross classification and OLS for FTG modeling. Taking into consideration the authors estimated disaggregated freight trip delivery rates, company attribute. The authors identified the groups of company attributes that best explain FTG by Using cross classification analysis. When using linear regression models, the authors identified commodity type, industry segment, and employment are strong predictors for FG**.** Tadi and Balbach (1994) estimated trip generation rates based on vehicle type stratification for non-residential land uses in Fontana, California; traffic counts were used on their estimations. Kawamura et al. (2005) took into consideration the supply chain decisions made by individual businesses in the estimation of FTG. Among other findings, the authors concluded that store floor space and the number of employees are poor indicators of truck trips at retail stores. At the city level, different freight models were developed in Europe that include some form of trip generation modeling (Taniguchi and Thompson (2002) and Patier and Routhier (2008). Models are generally linear and based on zonal aggregates or survey data. Examples are Russo and Comi (2002) for Italy, and Routhier et al. (2002) for France.

FTG models of various kinds have been developed for special facilities such as ports (Guha and Walton 1993; Wegmann et al. 1995; Holguín-Veras et al. 2002). Al-Deek et al. (2000) and Al-Deek (2001) used regression analysis and neural networks respectively to develop trip generation models. Wagner (2010) carried out an analysis of trip generation around the port of Hamburg, Germany. Regional warehouse trip production rates were published by DeVries and Dermisi (2008) for the Chicago metro area, and by Orsini et al. (2009) for France.

Other methodologies that have been implemented for production and attraction include: time series models, Input-Output, and related models. Time series data have been used to develop models that range from growth factor models to auto-regressive moving average models (Garrido 2000). Sorratini (2000) estimated truck flows for the state of Wisconsin, using data from the 1993 CFS and IO coefficients. The authors derived production and attraction rates in tons for heavy truck mode for 28 economic sectors; the annual tons for the county level were converted to daily truck trips using aver-age tons-per-vehicle load factors. The trips were then assigned to the network and the results were compared to real counts. It was found that the production and attraction values were underestimated since not all truck trips were included.

3. Study area profile

Surat, located on the western part of India in the state of Gujarat, is one of the fastest growing major city in the country and is ranked as 9th biggest city in the country from population and economy point of view. Surat is popularly known as "The silk city" or "The synthetic capital of India". Surat city has area of 326.515 Sq. Km with population of 44, 66,826 (as per Census 2011). City has density of 13,680 persons / Sq. Km. Decadal population growth of the city is 55.29% (2001-11). The city has seven administrative zones, 29 election wards and 101 census wards.

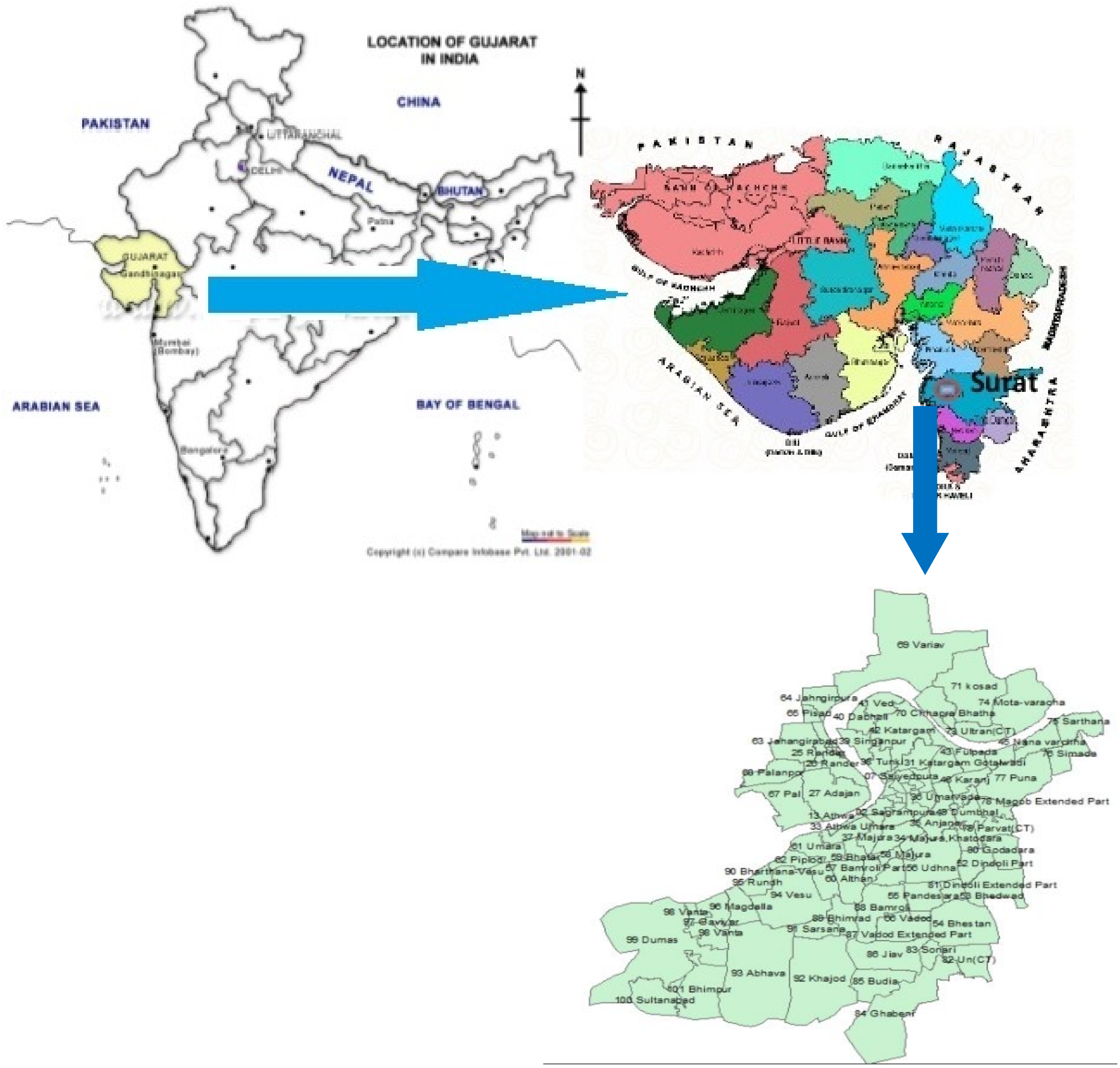


Fig. 1. Study area location

Source: Maps of India and Surat Municipal Corporation website

The major industries in Surat are Textiles, Diamond polishing, Engineering, Chemicals, etc. A report by Industrial Entrepreneur Memoranda (IEMs) (2006-07) on Surat district has shown that Textiles has the highest employment generation potential. Majority of population migrating to Surat for employment is involved in textile industry. Surat accounts for 40% of total nation's man-made fabric production and 28% of man-made fibre production. It also accounts for 18% of total nation's man-made fibre export. As per the report of Vibrant Gujarat (2017) the textile industry of Surat produces 30 million meters of raw fabric and 25 million meters of processed fabric daily. The textile industry in the city has developed organically with different segments of production units located in different part of the city. The main segments of the industry, that are weaving unit, processing and dyeing unit and value addition are located in different parts of the city in the form of industrial clusters.

To understand the scale of operations and have basic understanding about the textile industry of the city secondary data regarding the numbers and location of the various units was obtained from Office of Textile Commissioner, Ministry of Textile, Regional Office. Various other associations and societies working in collaboration with the textile industry were approached and meetings with their officials were arranged to understand and device an effective and efficient methodology for obtaining primary data from the various units. This associations included Man-Made Textiles Research Association (MANTRA); Ved Road Art Silk Small Scale Co-operative Federation; Pandesara Weavers Co-operative Society; The Federation of Gujarat Weavers' Association (FOGWA); The Surat Art Silk Cloth Manufacturers Association (SASCMA); Federation of Indian Art Silk Weaving Industry (FIASWI), Southern Gujarat Chamber of Commerce and Industry (SGCCI) and District Industries Center (DIC), Ministry of Micro, Small and Medium Enterprises.

4. Data collection and analysis

As per the data registered with Office of Textile Commissioner for the year 2011-12 there are about 650,000 plain power loom machines, 513 processing units, 140 textile markets and 8 textile parks in Surat. There are more than 60,000 traders associated with the industry here. Recently value addition units like embroidery and laces have picked up well and it is estimated that there are more than 125,000 of these machines currently installed in the city. Exact numbers of the machines or units is not available as the industry is highly segmented and small scale operation makes it impossible to have exact data. Also the industry is not having any controlled manufacturing policy and hence the data obtained are only close estimates from the concerned authorities. From the several meetings conducted it was learnt that the manufacturing pattern and the associated freight flow pattern is as given in figure 2.

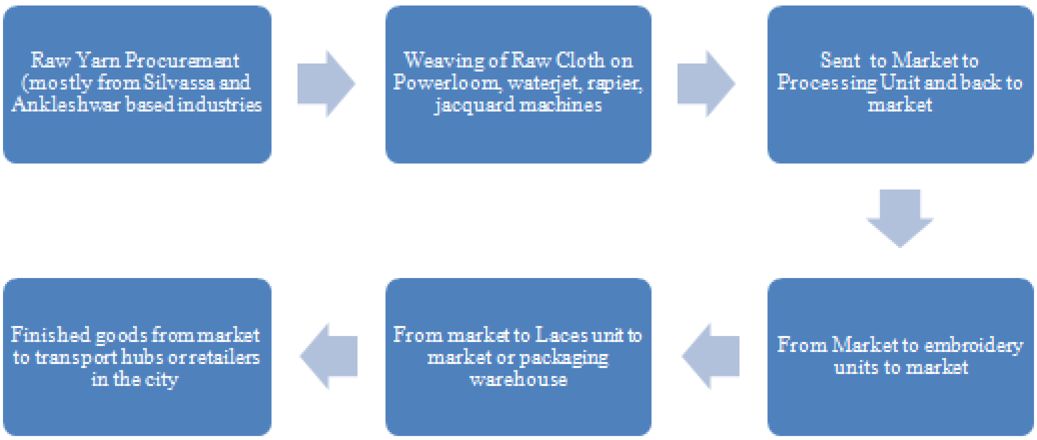
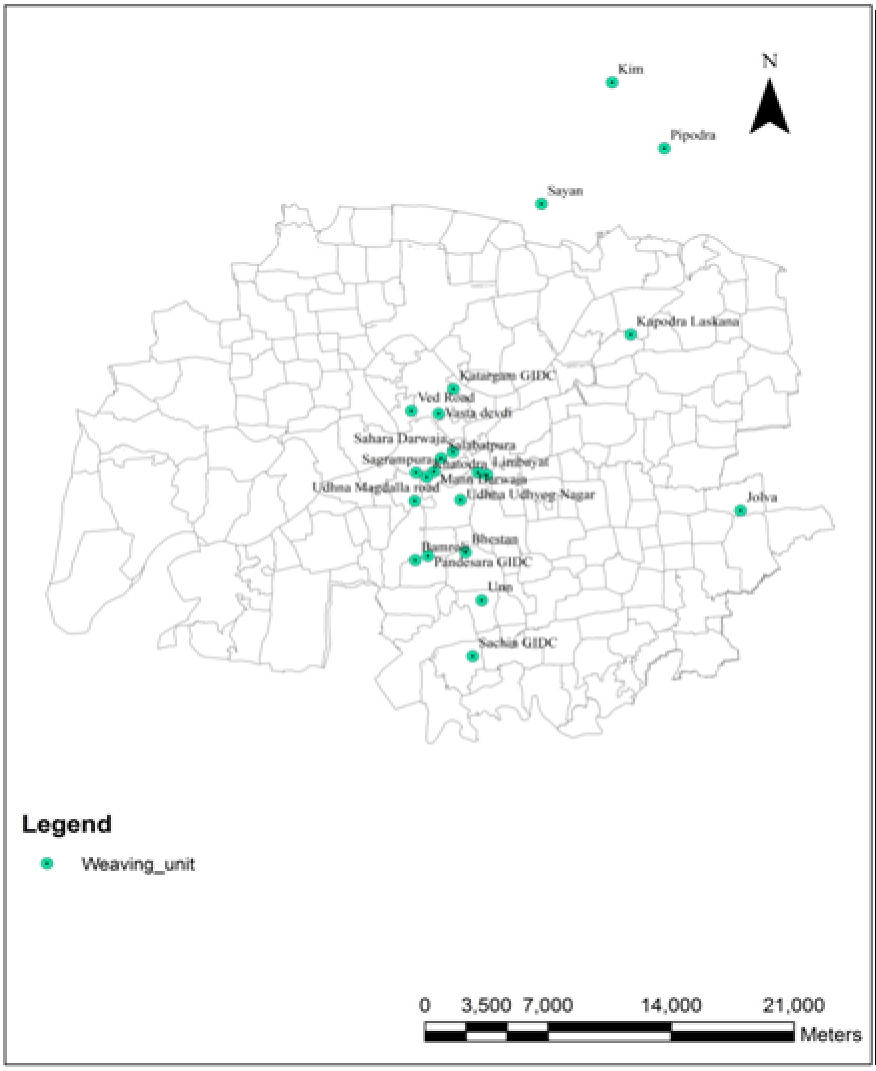


Fig. 2. Flow of freight in textile industry of Surat

From the above flow diagram it can be observed that there occurs a minimum of five trips for movement of goods before the final product reaches the transportation hub. Now as these different units of production/ value addition being located in various parts or zones of the city, there occurs a lot of intra-city movement of goods. Due to segregated nature of the industry each phase of production is being handled separately at different locations by different people. Trading of semi-finished goods occur at every stage of production, and due to the complex nature of supply chain processes traders prefers to take physical delivery of the goods in most of the cases. Traders as well as producers default in many cases leading to dispute among them, which is also one of the reasons for taking physical delivery of goods. RRM is very important location for trading of all sorts of textile goods. There are 140 wholesale trading market are located on RRM area with approximately 50,000 trading shops.

Powerloom machines consist more than 95% of all the weaving machines installed in the city. Newer technology like water-jet, air-jet, rapier, dobby and jacquard are having better output and efficiency, but they are less used to their space requirement and high initial costs. Majority of the newer technology machines are installed in the industrial clusters located in the outskirts of the city as land is easily available and prices are reasonable as compared to older or quite established industrial clusters located in various parts of the city. As per the proposed development plan 2035 by Surat Urban Development Authority powerloom industrial clusters are located at the twenty locations given in figure 3.



Powerloom unit industrial clusters in Surat	Distance from ring road market (trading hub) in km
Udhna Magdalla Road	6.2
Sachin	12.8
Pandesara	7.5
Bamroli	10.3
Unn	10.6
Udhna udyog Nagar	3.8
Bhestan	8.5
Vasta Devdi	4.9
Kapodra Laskana	11.9
Limbayat	4.3
Parvat Patia	3.2
Ved Road	5.2
Katargam GIDC	5.9
Salabatpura	1.4
Sagrampura	2.2
Khatodra	2.1
Sayan	18.5
Kim	33.4
Pipodra	26.9
Jolva	18.7
Average Dist. (Km)	*9.9*

Fig. 3. Location of PU cluster in Surat region

As majority of the freight trips generated from PUs are directed to the central market hub located on ring road, distance of each of the PU cluster from ring road market area is also given in figure 3. Various clusters are located in different corners with some as close as 1.4 km (Salabatpura) from the RRM area while some are as far as 33.4 km (Kim). Average distance from the market location is 9.9 km. Hence a single trip from a powerloom cluster to and fro causes a movement of approximately 20 km.

A survey questionnaire was used to obtain information regarding several aspects of their production and supply chain network were asked. The questionnaire aimed to get data regarding the following factor influencing freight generation or FTG from the establishment.

- Quantity of Cargo Produced per month in meters (grey cloth)
- Number of outward delivery trips per month
- Numbers and type of weaving machines at the establishment
- Total floor area and space for storage/warehouse
- Total number of employees (including workers and other staff)

As owners were reluctant for sharing of data; some part of data was not obtained required for establishing relation for trip generation while some data points were found outlying the other data points. Such samples were considered as outliers and relation was formed for plain power loom machines. From 122 samples, 42 samples were used for trip generation model.

Individual relationship of number of freight trips generated with respect to the quantity of goods produced per establishment, area of the establishment, number of weaving machines and number of workers were found using simple linear regression, It was found that the number of freight trips generated had a positive relationship with each of this factor.

4.1. Relationship between Freight Trips Generated and Quantity produced

Linear Regression equation is given as:

$$T = 0.3685 + 0.1001 * Q \quad (1)$$

Where,
T = Trips generated per month (in number)
Q = Quantity of cloth produced per month in 1000 m

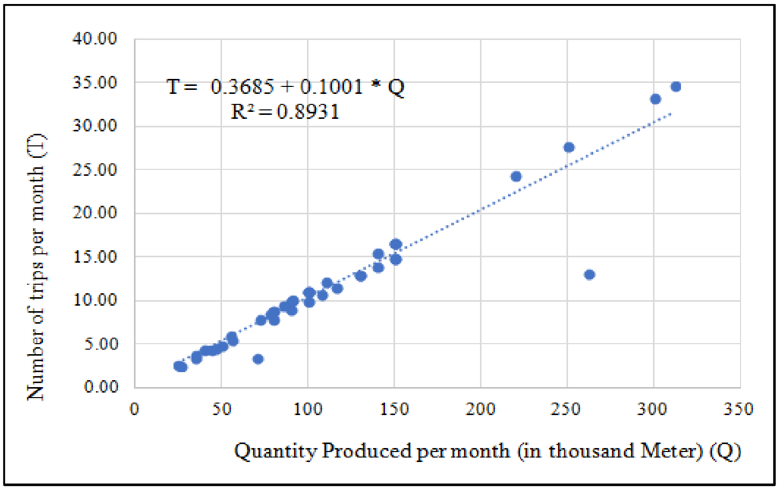


Fig. 4. Linear relation graph for Trips Generated and Quantity produced in 1000m

Figure 3. shows relation between trips generated and quantity produced in 1000m. Two points lie away from the trendline, the main reason for outlier points is due to the possibility of having higher quantity of production but vehicle used for carrying goods is of lower carrying capacity.

4.2. Relationship between Freight Trips Generated and Floor Area of the Establishment

Linear Regression equation is given as:

$$T = 0.8899 + 0.011 * A \quad (2)$$

Where,
T= Trips generated per month (in number),
A = Total floor area at the unit (in sq. mt.)

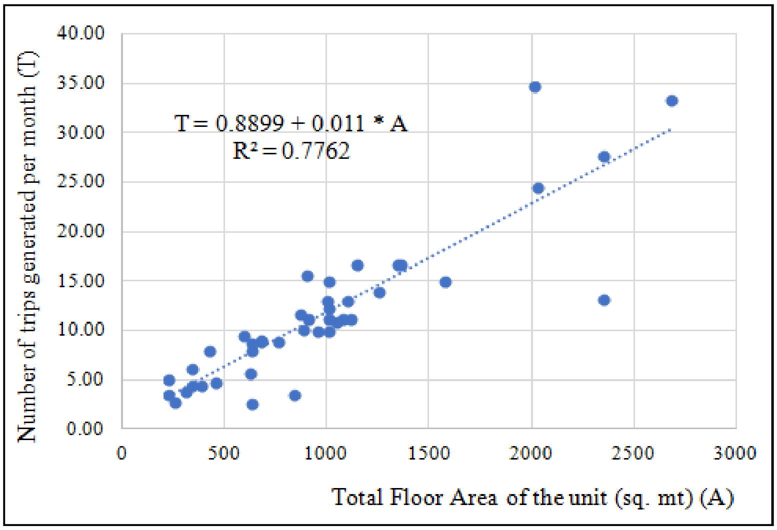


Fig. 5. Linear relation graph for Trips Generated and Total floor area (sq. mt.) at the unit

From discussion with owners of weaving units it was understood that power loom machines are mostly placed on ground and first floors. In rare cases they are placed on upper floors; on upper floors other activities of manufacturing (TFO or worping etc.) are carried out or use for storage purpose or used as office or even used by embroidery units. Owners were not able to provide the specific area details (i.e. area under manufacturing of grey cloth), which is the main reason for variation.

4.3. Relationship between Freight Trips Generated and Number of Machines

Linear Regression equation is given as:

$$T = 1.5918 + 0.1351 * N_{pm} \quad (3)$$

Where,
T= Trips generated per month (in number),
N_{pm} = Number of power loom machines at the unit (in number)

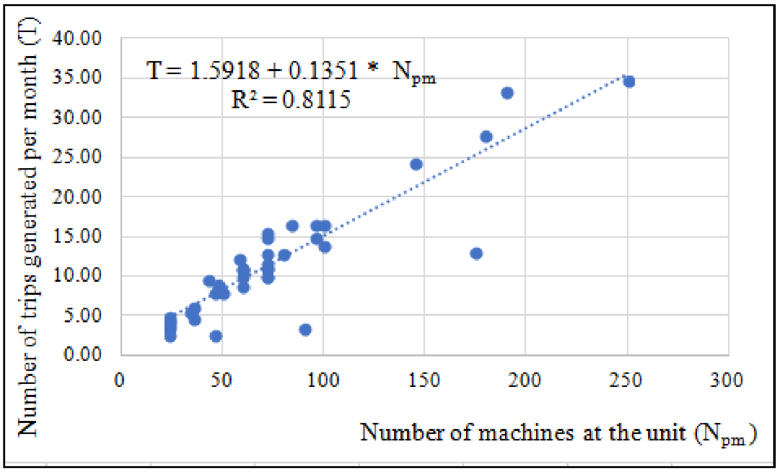


Fig. 6. Linear relation graph for Trips generated and Number of machines at the unit

As shown in fig. 5. points are away from trendline, the reason for this is this work hours of the unit and type of vehicle used for transportation of goods. For same number of machines there is variation in number of trips generated. Working hours of the unit and type of vehicle play an important role in this context.

4.4. Relationship between Freight Trips Generated and Number of Employees

Linear Regression equation is given as:

$$T = 1.136 + 0.6346 * Ne \quad (4)$$

Where,
T= Trips generated per month (in number),
Ne = Total Number of employees (in number)

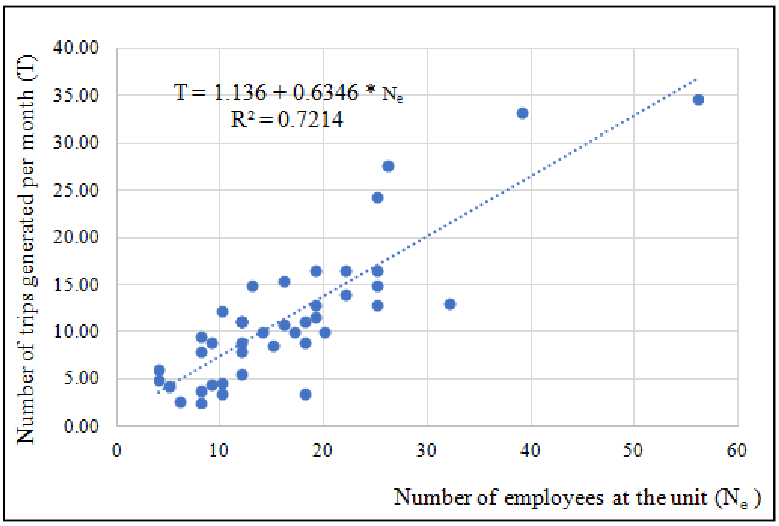


Fig. 7. Linear relation graph for Trips generated and Number of machines at the unit

Survey showed that there are different categories of worker working in weaving unit. The different workers are power loom unit worker, TFO worker, winding worker, etc. It was understood that one worker can handle 12 power loom machines for one shift. Number of workers depend on number of machines at the unit and work hours of the unit which being the reason for point lying away from trend-line as shown in figure 6.

Multi-linear Regression model was prepared for estimation of trips generated per month and quantity produced per month based on number of power loom machines, area of the unit and number of employees. Number of trips generated is dependent variable in the multi-linear regression model. Total number of power loom machines at the unit, total floor area of the unit and total number of employees employed at the unit in all shifts are the independent variables in model.

Multi-linear Regression model for trip generation per month is given as:

Trips generated per month = (0.0652* Number of power loom machines at the unit) + (5)
(0.0044*Total Floor Area of the unit (sq. mt.) +
(0.1120* Total number of employees) +
0.6438

5. Results

As per the data collected there are 650 thousand power loom machines, 25,000 weaving units and the average area of one unit from survey is obtained as 970 sq. mt. number of employees are considered as per thumb rule that one worker can handle 12 machines for one shift of 12 hours. From this data magnitude of trips generated per month due to weaving unit can be estimated.

Trips generated per month = (0.0652*620000) + (0.0044*970*25000) + (0.1120*103334) + 0.6438

Trips generated per month = 158698.052

Trips generated per day = 5289.935

As per the model approximately *5300 trips per day* will be generated due to power loom unit.

The Ring Road Textile market, the central hub for trading of semi-finished textile goods is functional from 10 a.m. to 8 p.m. for six days a week from Monday to Saturday. Not considering the lunch break hours, for an average work hours of 7 to 8 hours in a day then there will be approximately 800-1050 trips per hour (varying based on the type of LCV used), as per the estimation from the model developed.

6. Conclusion

Considering the ring road market location as the central hub for trading of raw fabric produced in this PUs. The average trip length for the 20 clusters located in the city turns out to be 9.9 km. The above mentioned trips are considering only the trips generated from the PUs. As shown in the supply chain flow chart earlier in the study there are 5 different stages of production. Hence it is quite possible that the total number of freight trips from raw fibre to finished fabric would be considerably higher. However that can be considered as further continuation of study so as to establish a complete model for FTG from entire textile industry of the city. In India with more than 10 major textile hubs like Surat coming up in the near future this study would be useful for infrastructure planning so as to attain a sustainable growth in this industry.

Multiple freight trips generated as a result of complex production chain in textile industry of Surat with segments decentralised and located in different parts of the city, mixed traffic flow, loading/ unloading of goods on ring road, slow moving vehicles carrying textile goods, high pedestrian movement, overloaded vehicle carrying textile goods and on-street parking of commercial vehicle carrying textile goods results in traffic congestion and pollution in the city. It is recommended to plan for integrated textile hubs to overcome this problem before it acts as a bottleneck for city's growth. Integrated Textile Park with weaving unit, processing unit, value addition units and trading markets at the same place is a long term and probably sustainable solution for reduction of multiple textile freight trip in the city. Combination of all segments of textile industry will result in reduction of overall trip length and will lead to reduction in carbon footprint. This textile hub needs be located at a moderate from the city and in such a way that even if city sprawl takes place the hub won‘t be a part of city traffic. In order to avoid the present condition where city sprawl resulted in inclusion of textile industry within the city limit. If the integrated textile hub located nearer to National highway, it will also cut off entry of medium and heavy commercial vehicles carrying textile goods into the city. Also the location should be selected in such a way that it remains convenient for the work force driving this industry to conveniently travel from home to work.

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