Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 54(8) (2022) 621-624
DOI: 10.22060/ceej.2022.20385.7409

Forecasting Generation of Freight Groups with Regression Models for Traffic Analysis Zones in Iran

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ABSTRACT: In this research, for the first time, linear regression models are developed for Iran's inland freight production & attraction classified by commodity types which provide an insight into long-term transportation planning. The dependent variables of these models are the total road and railway freight shipped to/from 418 counties across the country. In these models, general population and employment variables are implemented together with the binary variable of significant industrial and borderland counties to explain variations in the response variable. Validation of models involved considering a causal relationship between independent and response variables and measuring the statistical significance of regressors. The R-square statistic of the calibrated models stands between 0.85 and 0.98 which is appropriate considering the limited variables employed. To predict independent variables over the study horizon, the age profile of the base year is developed in a 25-year timeline starting from 2016, using time-varying birth rates and constant mortality and migration rates. Then assuming four unemployment scenarios, employment in each county is projected using the last predicted populations. According to the models' estimation, the total freight produced/attracted is expected to reach 545/551 million tons in 2021 and 668/660 million tons in 2041 with a 12.5 percent unemployment rate. Furthermore, with the unemployment rate rising to 25 percent, the total produced/attracted freight is expected to fall 8.6/2.2 percent in 2021 and 9.4/2.4 percent in 2041. The results indicate the inadequacy of employment as the only explanatory variable of the production models while the population appropriately explains the bulk of the freight demand variations.

Review History:

Received: Aug. 08, 2021
Revised: Dec. 14, 2021
Accepted: Jan. 27, 2022
Available Online: Feb. 03, 2022

Keywords:

Freight Transport
Freight Production and attraction Models
Regression Model
Logistics
Population Prediction

1- Introduction

Freight transport is one of the key drivers of supply chains and accounts for nearly 50 percent of logistics costs [1]. Forecasting freight demand has numerous applications in transportation planning including traffic management, traffic impact assessment, economic appraisal of infrastructure investments and estimating demand for parking facilities and freight terminals. In view of the significant role of freight shipment in industrial development and foreign trade, this paper is aimed at developing Iran's predictive freight generation models classified by commodity type in traffic analysis zones for the first time. Ultimately, these models provide a tool for decision-makers to assess infrastructure development scenarios, the trend of workforce and population evolutions and manage existing shipping facilities.

These regression models are calibrated with the use of national freight distribution data across 418 counties in 2015. The response variable of this model is the summation of road and railway-shipped goods in each of 10 pre-specified commodity groups. Subsequently, explanatory variables are projected in a 20-year horizon until 2041 which yields the estimated freight production and attraction.

2- Methodology

In previous studies, Input-output and least squares methods have widely been used to predict freight trip production. In this research, However, Considering the size, accuracy and level of aggregation of available data, only linear regression models can be calibrated.

Examining previous studies on freight trip production models in U.S. indicated high frequency of employment as the main explanatory variable in the models. In a sense, employment represents the magnitude of economic activities inside a traffic zone, however, to varying degrees in different industries. Thus the selection of commodity categories is a critical issue. The general approach in modeling applications is to use commodities that correspond closely to industry/ employment categories which are forecast at the zonal level in socioeconomic models.

In similar fashion, the employment variable is implemented

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Table 1. Effect of binary variables on R-square of models

Commodity Type	Production model		Attraction model	
	Without	With	Without	With
	binary variables			
food	0.399	0.870	0.864	0.869
metals	0.229	0.862	0.753	0.88
ores	0.001	0.970	0.021	0.975
Household items	0.790	0.874	0.896	0.896
machinery	0.786	0.912	0.728	0.944
chemicals	0.346	0.896	0.277	0.938
wood and paper	0.511	0.850	0.898	0.937
apparel	0.265	0.867	0.738	0.868
wastes	0.867	0.982	0.894	0.894
building material	0.928	0.960	0.757	0.851

in this study to explain variations of freight production across analysis zones. Nevertheless, With respect to the complexity involved in the prediction of employment in various industry sectors, general county employment data have been used in freight production models.

As for freight attraction, the population can estimate the volume of shipped cargo to ultimate consumers in a traffic zone. In addition, distinguishing between the purchasing power of urban and rural consumers further add to the estimates accuracy. The closer an industry is to the final consumers in a supply chain, the accuracy of estimates is expected to be higher.

Furthermore, in order to identify the effect of counties with remarkable industrial and transportation infrastructure on freight generation, binary variables are taken into account. These variables which are used in the multiplicative form together with the employment variable, are also expected to enhance the models goodness of fit.

Validation of the models, involved measuring the goodness of fit, statistical significance of variables, the insignificance of models constant, checking the sign of coefficients, parsimony of models, causal relationship between regressors and regressand and analysis of residuals.

With freight generation models calibrated for the status quo, independent population and employment are required to be projected in 5-year horizons. This process involves developing the population age pyramid of the base year using the time series data of birth rate, mortality and migration. Assuming four scenarios for unemployment rate in future, employment estimates are then obtained.

Table 2. Total predicted freight production

Year	Unemployment rate			
	5%	10%	12.5%	25%
2016	-	-	518.2	-
2021	573.4	554.6	545.3	498.4
2026	605.6	585.3	575.2	524.5
2031	639.2	617.3	606.4	551.7
2036	672.5	649.0	637.2	578.5
2041	705.3	680.2	667.7	605.2

3- Results and Discussion

Results of calibrated models indicate high level of statistical significance for both employment and population coefficients. Table 1 shows the effect of implementing binary variables on models goodness of fit. In the case of production models eliminating binary variables results in significantly lower R-square values which implies the inadequacy of the employment variable as the sole regressor. In contrast, the population variable is capable of estimating the bulk of variations in attracted goods regardless of binary variables.

freight production and attraction using the calibrated regression models. According to these estimations, total produced/attracted freight is expected to reach 545/551 million tons in 2021 and 668/660 million tons in 2041 with 12.5 percent unemployment rate. Furthermore, with the unemployment rate rising to 25 percent, the total produced/attracted freight is expected to fall 8.6/2.2 percent in 2021 and 9.4/2.4 percent in 2041.

Table 3. Total predicted freight attracted

Year	Unemployment rate			
	5%	10%	12.5%	25%
2016	-	-	518.2	-
2021	558.4	553.6	551.1	538.9
2026	590.3	585.1	582.4	569.3
2031	620.0	614.3	611.5	597.4
2036	646.3	640.3	637.3	622.3
2041	669.4	663.1	659.9	644.0

4- Conclusions

Considering significant role of freight transportation in foreign trade and economic growth, this study develops Iran's inland freight generation models for the first time. These linear regression models are classified by commodity type and are developed on the scale of 418 traffic analysis zones.

Reviewing the literature on the subject suggests a high frequency of employment as the main regressor of freight trip production models. By the same token, this study uses employment and population as the main regressors.

The Results suggest that the employment variable is inadequate in explaining the bulk of freight variations and requires the use of auxiliary variables. This issue can be attributed to the lack of variables that account for the nature of freight production which in turn is influenced by the geography of inland and foreign trade and the complexities of freight demand. To compensate for the lack of explanatory variables, counties with seaport, road, or railway infrastructure of national significance have been added to the models. Thus it is expected that including Such macroeconomic factors as foreign trade volume and GDP in future studies substantially enhances the accuracy of existing models.

References

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HOW TO CITE THIS ARTICLE

H. R. Najafi, Kh. Khavarian, L. Hosein Rashidi, M. Arbabi, A. Samimi, Forecasting Generation of Freight Groups with Regression Models for Traffic Analysis Zones in Iran, Amirkabir J. Civil Eng., 54(8) (2022) 621-624.

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