Chapter 13
Logistics Modeling and Forecasting with Regression

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ABSTRACT

In this chapter, the method of multiple regression is introduced for describing the functional relationship among several variables, as well as for predicting the values of a variable from the values of a group of variables. The tools for model fitting, model validation, and prediction are presented, while emphasis is given on understanding the types of data that can be analyzed via regression. More specifically, the method of least squares is discussed. Regression analysis is proposed due to its simplicity and wide applicability. Modeling outsourcing or demand forecasting can both be achieved by regression analysis, providing useful information for logistics service providers or 3PL companies. Hauling freight data collected from a logistics company based in Ohio were utilized to demonstrate the applicability of regression analysis and its usefulness for logistics service providers, 3PL companies, and transportation companies. Finally, limitations, solutions, and alternative strategies are discussed.

INTRODUCTION

Regression analysis is a statistical method used to describe the relationship among various variables as well as to predict a response variable. Regression is a statistical tool with applications in many areas. More specifically, it is one of the widely used tools in the business world due to its applicability and simplicity. Regression analysis can be used with cross-sectional data, that is data gathered from the same period of time, and time-series data, that is data observed at several points in time. Here, we will focus on introducing regression when used with cross-sectional data. Time-series data are treated differently since they use past data of the time series to predict future ones.

Regression analysis for cross-sectional data is used when we want to understand whether and how a variable, called the *dependent variable* or *response*, changes as a function of one or more

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variables, known as *explanatory* variables or *predictors*, as well as, when we want to make predictions or both. Regression analysis allows the investigator to infer causal relationships, associations or generalizations to larger populations.

There are several classifications of regression analysis depending upon the number of available dependent and/or independent variables, the nature of data and the form of the relationship between dependent and independent variables. Univariate regression requires only one quantitative response, whereas multivariate regression two or more responses. Simple regression refers to the case of one explanatory variable, whereas multiple regression refers to the case of two or more explanatory variables. Logistic regression is used when the response is qualitative. Linear regression requires that parameters enter the equation linearly, whereas in nonlinear regression parameters are nonlinear or the relationship between response and some of the predictors is nonlinear.

In this chapter, we will focus on linear regression with one quantitative response and one or more explanatory variables. Our objectives are: to understand the types of data that can be analyzed via regression, to present the estimation of equations that describe the relationship among variables and inferential tools associated with regression, to understand the interpretation of estimated parameters and model, and to finally assess the estimated model.

Modeling outsourcing and demand forecasting are only some of the common goals for various types of companies that provide useful information for logistics activities such as purchasing, inventory management and transportation. Regression is be used to build a mathematical formula to associate for instance demand with several factors. More specifically, customers demand may depend on product price, advertising costs, promotions and seasonality. There are several demand forecasting methods available, out of which are qualitative and other quantitative based on whether information about historical data is available. Here we will discuss one of the quantitative methods that is commonly used, that is a causal method known as *multiple regression* analysis. In what follows, we will introduce the steps for regression analysis and we will present a case study that focuses on studying relationship among hauler profit, the prices of the fuel, the cost of the freight and the distance travelled for various freight transports. This application may be of great interest for all players in the supply chain (suppliers, manufacturers and carriers).

BACKGROUND

Outsourcing logistics activities is very common practice nowadays adopted by various businesses. Outsourcing is an agreement between a business and a provider such that the provider is responsible for managing and controlling various activities for the business. Third-party-logistics (3PL) is a special form of outsourcing logistical activities such as transportation, warehousing, inventory control, distribution, information systems related, audit payments. The main reasons for outsourcing are: cost reduction for the outsourcer, demand forecasting, service improvement, risk sharing and management of unbalanced freight networks, strategic planning, improved efficiency of distribution (Taylor, 2008). Today, outsourcing of logistic activities to 3PL is the core of competitive advantage and cost savings of a company. Modeling outsourcing and forecasting demand are common goals for various types of companies that provide useful information for several logistics activities such as purchasing, inventory management and transportation.

A simple linear regression model was utilized in Wilding and Juriado (2004), to show that the overall satisfaction of a company with its 3PL providers is positively related with the level of outsourcing logistics services in the European consumer goods industry. Fite J.T. et al (2002), forecasted freight demand using a variety of