Analysing the Determinants of Logistics Service Provider Efficiency in Urban Distribution

Analysing the Determinants of Logistics Service Provider Efficiency in Urban Distribution

Anna Corinna Cagliano*, Alberto De Marco*, Muhammad Salman Mustafa*, Giovanni Zenezini*

** Department of Management and Production Engineering, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy*

(anna.cagliano@polito.it, alberto.demarco@polito.it, muhammad.mustafa@polito.it, giovanni.zenezini@polito.it)

Abstract:

Traffic congestion, lack of parking spaces, and high levels of pollution in urban areas, together with an increased awareness of freight transportation impacts, stress the importance of City Logistics (CL) as a comprehensive approach aimed at mitigating the negative effects of distribution activities without penalizing social, cultural, and economic development. CL faces a relevant degree of complexity, which causes uncertainty about planning and managing urban logistics activities. Several models have been developed to optimize CL focusing on distribution warehouses, freight flows, the routing task, vehicle loading, the size and type of vehicles that can enter urban areas, and possible congestion charges. However, a successful implementation of such models requires a proper level of internal efficiency of the stakeholders involved. Among them, logistics service providers (LSPs) play a crucial role because they are expected to offer high quality services in urban areas. The paper proposes an empirical analysis on the operational factors determining the level of efficiency of a LSP, which is here assessed through productivity. Data about an Italian LSP involved in urban freight distribution are analyzed and a regression analysis is completed. Two managerial levers are found to affect the level of productivity: the organization of the distribution network, and the vehicle loading strategy. The first lever implies a more efficient location of warehouses, an extension of the area covered by each driver and a more effective routing structure. Furthermore, vehicles should not be excessively loaded, especially with big parcels, in order to ensure flexibility. This study represents an attempt to develop a comprehensive panel of operational variables affecting the efficiency of the urban distribution system of LSPs. The enhancement of LSP efficiency contributes to achieve a better quality of life in urban areas as well as the associated economic and environmental benefits.

Keywords: City Logistics; Logistics Service Providers; Efficiency; Regression Analysis

1. Introduction

Rapid urbanisation and urban population growth have generated an increasing freight transportation demand in cities. These phenomena cause environmental and mobility problems mainly associated with air pollution and traffic congestion (Benjelloun and Crainic, 2008). Thus, in recent years, researches and institutional authorities have focused their efforts on City Logistics (CL) issues. CL vision suggests a more integrated logistics system, where shippers, carriers, and movements are coordinated, and the freight of different customers and carriers is consolidated into the same "green" vehicles. In order to reduce the negative impacts of urban freight distribution, CL studies aim at identifying alternative and collaborative network designs, such as the introduction of City Distribution Centres and hub-satellite systems, developing new environmental-friendly vehicles (e.g. hybrid vehicles), and optimizing vehicle routings in terms of travel times, CO_2 emissions, and travelled kilometres.
Within CL, Logistics Service Providers (LSPs) play a key role. Their activity mainly consists in carrying out freight distribution to customers (Ehmke and Mattfeld, 2012), and they are expected to offer high quality and reasonably priced delivery services. Urban areas present several peculiarities that can affect their performance like traffic congestion and restricted traffic areas, which add route limitations and sources of uncertainty.
Furthermore, the development of e-commerce in the B2C market has also contributed to transform freight distribution in urban areas. Changes of the downstream supply chain concern several aspects, such as shipment size, number of delivery stops, delivery frequency and time windows, number of vehicles required, and vehicle size (Rotem-Mindali and Weltevreden, 2013). Most of the deliveries nowadays are single order ones with small-sized packages, representing a significant challenge to LSPs (Lim and Shiode, 2011). In fact, LSPs offer deliveries of goods to several customers' homes or offices in one trip, and each vehicle serves up to 200 customers per day, which means that each vehicle has to reach around 200 locations in one day.
As a consequence, LSPs aim at enhancing their efficiency and consequently improving their productivity. Therefore, understanding which factors influence the number of stops per tour would improve the productivity of LSPs.
The research challenge of this paper is to give a first insight of this issue, based on an empirical analysis of real LSP data. In particular, the paper aims at identifying a set

of operational variables that are likely to influence the productivity of LSPs, measured as the number of successful stops daily made by a driver to pick up or deliver parcels. Several indicators of LSP service are selected and their relationships with the number of stops are investigated through the analysis of data collected from an Italian company.

The paper is structured as follows. First, a literature review of relevant CL studies is proposed. Then, the methodology is described and the empirical analysis is presented. Finally, the results are discussed, and implications and conclusions are drawn.

2. Literature Review

Several literature contributions have recently studied and described urban freight distribution. Most of the studies propose general distribution models compliant with the CL vision. These papers suggest alternative network designs andinvestigate their advantages in terms of costs and greenhouse gases emissions. They include the implementation of City Distribution Centres and a network of satellite platforms close to the city centre (McKinnon et al., 2012; Perboli et al., 2011), modal shifts, and Intelligent Transportation Systems(ITS) (Giannopoulos, 2009). All these papers are based on cooperative freight transportation systems.

Other papers deal with the planning of City Logistics Service Providers' (CLSP) activities with two main purposes. The first one is to support CLSPs in performing a reliable and efficient service, while reducing costs. In particular, the reliability of the service is related to the number of timely deliveries. Thus, several new models consider congestion and travel time variations in urban areas, in order to avoid congested links and to respect delivery time windows (Ehmke et al., 2012; Jiang and Mahmassani, 2013). The second purpose focuses on the environmental sustainability of urban freight deliveries. In particular, several studies investigate new solutions that allow minimizing the amount of CO_2 emissions (Jabali et al., 2012; Rossi et al., 2013).

The above-mentioned literature highlights the common trends of considering LSPs as passive actors of the system, i.e., they apply the distribution models proposed by other stakeholders (public authorities, manufacturers or other supply chain echelons). On the contrary, LSPs are organizations which adapt the delivery system rules to their business model in order to maximize their productivity and hence profit. Such issue leads to the research question of this paper: how the productivity of a LSP is linked to its operational delivery service. In fact, papers generally focus on the cost reduction as almost unique way to increase CLPSs' profit, disregarding the revenue component.

Moreover, very few papers perform an efficiency analysis of LSPs. Min and Joo (2006) develop a set of financial benchmarks to identify best practices, implementing a Data Envelopment Analysis (DEA) for measuring the operational efficiency of various third party logistics providers. The operational efficiency is assessed through input/output ratios. The input parameters selected by the authors are: account receivables, salaries and wages of employees, operating expenses other than salaries and wages, and property and equipment. On the output side, they measure the overall performance by only considering the operating income. Thus, the authors take into account general parameters, which are not strictly related to the daily activities. Wanke (2013) implements three-stage DEA models and Stochastic Frontier Analysis (SFA) to investigate the efficiency of the largest trucking companies in Brazil. The considered inputs are the number of branches, the employees, the fleet size, and the fuel consumption. The outputs are total cargo transported (expressed by tons per year) and distance travelled (measured by the kilometres per year). This paper also proposes an analysis of LSP performance on a yearly basis. Another example is provided by Chandraprakaikul and Suebpongsakorn (2012)who benchmark the performance of 55 logistics companies applying DEA and Malmquist Productivity Index (MPI). The inputs include the net value of lands, the buildings and the equipment, the shareholder fund, the operating cost, the cost of sales and/or cost of service, and the current liabilities. Profits and revenues are considered as outputs.

In conclusion, at the best of our knowledge, there is a lack of papers discussing the operational factors that influence the productivity of a vehicle tour. For such a reason, in this paper an empirical analysis is carried out on the operational factors determining the level of productivity of a LSP, with particular reference to those organisations operating in urban contexts.

3. Methodology

The research is conducted through the following steps. First, based on the literature analysis we identify a set of operational variables that are likely to influence the number of stops for a vehicle delivering goods in urban areas. Then an exploratory data analysis is completed and finally, after assuming that the number of stops is the response variable, a linear regression analysis is performed to understand the relationships between the management of the pickup and delivery service and the productivity of a CLSP.

4. Empirical Analysis

This paper studies different performance indicators affecting the productivity of a CLSP committed to freight transport, storage, and delivery of documents, parcels and items throughout the world. In particular we study the productivity defined as the number of successful stops made by a driver that collects and deliveries items each day (Lin et al., 2010). The LSP logistics operations run as follows. Customers place order and a van fleet leaves the local depot in the afternoon to pick up the customers' items at their locations and return them to the trip-originating local storage. Here all the items are loaded on trucks and sent to a consolidation centre wherein they are sorted by destination, re-loaded on trucks, and shipped to the assigned final local depots . There, items are received early in the morning, re-sorted and re-loaded on vans to reach the end customer locations. In this operational model the number of stops that a driver performs appears to be crucial for the business of the company.

To describe operations, several variables have been considered. There are a lot of metrics that can describe the activities of a LSP. Krauth et al. (2005) propose a list of 130 elements classified by the perspectives of different stakeholders. Among those, relevance is assumed by the kilometres per day, the labour utilization, the number of deliveries, and the delivery performance. Lin et al. (2010) suggest to take into account the vehicles' capacity and Gunasekaran et al. (2001) highlight the importance of the number of faultless deliveries. The company under study monitors a lot of elements related to its business, and several of these, which are supposed to influence the level of productivity, have been included in the model. In particular:

- DELIVERY HOUR (1): it represents the time when the first delivery of the day occurs, that is to say the effective time when the pick-up and delivery operations start. This variable in our analysis is measured as the number of minutes elapsed from 6am. In particular, we expect that if the driver leaves the depot too late, less time is left to complete pickup and delivery duties, since the operating window is shorter, as well as the effective hours available to complete the distribution service.
- STEM TIME (2): it indicates the difference expressed in minutes between the time of the first delivery and the time when the driver exits the warehouse. It is expected that a high STEM TIME negatively influences the productivity because a driver spends a longer time to carry out the first delivery and, consequently, there is a shorter operating window, resulting in a lower number of stops.
- WORK TIME (3): this is the driver's daily work duration, measured in minutes. The longer the WORK TIME, the higher the opportunity to increase the number of stops. The upper limit is eight hours per day..
- MASS (4): it is the weight, expressed in kilograms, of parcels and items loaded on a vehicle. Intuitively, it is expected that the greater this value, the lower the productivity of the driver because the number of parcels that can be actually loaded is smaller. In fact, most heavy parcels are also bulky and less comfortably manageable.
- MASS SATURATION (5): it shows the relation between the weight and the load capacity of the vehicle. This variable is recorded because it is useful for the company to understand if the vehicles are saturated or not. The productivity is negatively affected by this variable.
- VOLUME (6): it indicates the volume, measured in cubic meters, of items loaded on a vehicle. The smaller the VOLUME, the lower the productivity because the number of parcels that can be loaded decreases.
- KM TOT (7): it represents the total number of kilometres travelled by a driver in a day. The longer the distance travelled, the greater the number of stops because the driver has more opportunities to serve more customers.
- KM EFFICIENCY (8): it is the ratio between the KM TOT and the optimal distance travelled, which is the optimal number of kilometres computed by the IT system of the company based on the stops sequence of the driver. This indicator is important because it allows understanding how the drivers perform their job. If KM EFFICIENCY is greater than 1, the driver makes more kilometres than optimal and in turn productivity should increase.
- FAILED DELIVERY STOPS (9): this variable expresses the number of failed stops for the delivery activity. Obviously, the higher its value, the lower the productivity.
- TOTAL SERVICES (10): they are the daily number of pickups and deliveries performed by the driver. Similarly, in this case it is expected that the greater the number of services assigned to a driver, the higher his productivity.
- SERVICE LEVEL (11): it is calculated as the ratio between the number of successful deliveries and the assigned ones. Hence, the closer this value to one, the higher the productivity of the driver because he has completed all the assigned deliveries.
- DELIVERY STOPS / PICKUP STOPS (12): it shows the ratio between the number of stops made for deliveries and pickups. Since the pickup activities are usually more time-consuming than the delivery ones, we expect that the fewer the pickup stops, the more the delivery stops and the higher the ratio, and therefore the higher the productivity.
- DEPOT AREA (13): this is defined as the net storage surface of the local depot measured in square meters. It is expected that the larger the depot size, the larger the associated served urban distribution area and, consequently, the larger the potential customer base (B2B or B2C).
- PARCELS/M^2 (14): it is the number of parcels managed by the depot divided by the depot area. So the greater the number of parcels managed in the depot, the greater the number of stops because the urban distribution area is probably more productive and exploitable.

4.1 Data Analysis

Data have been collected for one week (namely week 15 of 2013) for all the Italian depots of the company at issue. The period under study appears to be suitable for the analysis, because it is not influenced by special events such as bank holidays, or adverse weather conditions.

Table 1 summarizes the independent variables that are supposed to have an influence on the level of productivity of the CLSP. The columns report respectively the mean, the standard deviation, the quartiles, and both minimum and maximum value for each variable.

Table 1 Summary of the dataset

VARIABLE	MEAN	ST DEV	Q1	Q2	Q3	Q4	MIN	MAX
(1)	598,55	75,09	556,00	589,00	628,00	1.230,00	421,00	1.230,00
(2)	21,13	16,55	9,00	16,00	29,00	89,00	0,00	89,00
(3)	502,32	74,02	456,00	501,00	549,00	985,00	128,00	985,00
(4)	589,29	366,84	373,16	516,04	702,67	9.268,73	0,35	9.268,73
(5)	0,50	0,35	0,30	0,42	0,60	9,27	0,00	9,27
(6)	5,58	94,63	2,52	3,49	4,83	9.508,59	0,01	9.508,59
(7)	138,77	81,51	79,81	121,41	175,60	932,09	4,82	932,09
(8)	1,62	0,44	1,31	1,53	1,84	4,89	0,00	4,89
(9)	1,80	1,90	0,00	1,00	3,00	18,00	0,00	18,00
(10)	78,34	24,83	63,00	78,00	93,00	275,00	3,00	275,00
(11)	0,97	0,03	0,96	0,98	1,00	1,00	0,62	1,00
(12)	5,36	5,55	2,56	3,80	6,00	67,00	0,06	67,00
(13)	4.134	3.095	1.725	3.264	5.191	11.937	640	11.937
(14)	1,17	0,39	0,85	1,11	1,40	3,27	0,34	3,27

To explore the relationship of the productivity performance, the analysis focuses on understanding which ones of the indicators listed above are relevant factors of the number of stops. This goal is reached through a regression analysis that aims at testing if the independent variables considered are significant factors and whether they have positive or negative impact on the response variable. First, the normality test on the response variable has been performed, and then all the independent factors have been normalized, in order to get a better comprehension of the results after the analysis. In order to have predictors linearly independent from one and others the multicollinearity check has been performed (Tabanick and Fidell, 2001).

In order to evaluate the level of multicollinearity among independent variables, the Variance Inflation Factor (VIF) is used. It iscalculated as follows:

$$VIF_i = \frac{1}{1-R_i^2}$$

Where

R_i^2 = multiple coefficient of determination in a regression analysis of the predictor i on all the other independent variables.

Some researchers use a VIF of 5 and others use a VIF of 10 as a critical threshold, which correspond, respectively, to R_i^2 values of 0.80 and 0.90.

Table 2 Multicollinearity

Predictor	VIF
DELIVERY HOUR(min)	1.004
STEM TIME(min)	1.442
TW(min)	1.067
MASS(Kg)	**14.447**
MASS SATURATION	**13.158**
VOLUME (m3)	2.768
KM_TOT	1.567
KM EFFICIENCY	1..242
FAILED DELIVERY STOPS	**6.746**
TOT SERVICES	1.657
SERVICE LEVEL	**6.700**
DELIVERY STOPS / PICKUP STOPS	1.2.03
DEPOT AREA(M2)	1.283
PARCELS/M2	1.129

Table 2 shows that multicollineary exists in the model because several variables presents very high values for the VIF. Therefore multicollinearity is avoided by removing those variables with VIF higher than 5 from the model.

Table 3 Results of the regression analysis

Predictor	Coef	P-value	VIF
Constant	0.103805	0.000	
DELIVERY HOUR(min)	0.001828	0.694	1.002
STEM TIME(min)	-0.038280	**0.000**	1.432
TW(min)	-0.412448	**0.000**	1.060
MASS SATURATION	- 0.162310	**0.000**	2.465
VOLUME (m3)	0.170600	0.645	2.557
KM_TOT	0.054634	**0.000**	1.540
KM EFFICIENCY	0.010473	0.065	1.231
TOT SERVICES	0.887020	**0.000**	1.233
STOP DELIVERIES/STOP PICKUP	-0.031381	**0.001**	1.176
DEPOT AREA(M^2)	0.016759	**0.002**	1.248
PARCELS/M^2	0.002047	0.689	1.129

Table 3 shows the results of the regression analysis performed with Minitab software tools. The columns report the estimate of the regression coefficient, the p-value, and the values of VIF. The level of significance is associated with the p-value. The smaller the p-value, the lower the probability that rejecting the null hypothesis is wrong. In the regression analysis the null hypothesis states that the coefficient equals zero. If the p-value is lower than a critical value - α - , which usually equals 5%, the null hypothesis is rejected and therefore there is an effect of the independent factor on the dependent variable. The outputs of the regression show that the STEM TIME, the WORK TIME, the MASS saturation, the KM TOT, the TOT SERVICES, the DELIVERY STOPS / PICKUP STOPS, and the DEPOT AREA are significant factors of the level of productivity of the CLSP.

5. Discussion of Results

The results of the regression analysis originate some considerations on the relationships between the productivity of a CLSP and both operational and non-operational variables. Two variables have not confirmed the expected behaviour. In particular the STEAM TIME presents a positive influence on productivity. This is probably due to the fact that a driver knows he has to travel a long distance to perform the first delivery and he will organize his activities in order to complete deliveries and pickups in a short time, so his productivity can in turn increase. Relating to the ratio between the stops for deliveries and the stops for pickups, the model shows a negative relationship with the total number of stops and this could be explained by the fact that drivers are paid based on the number of successful deliveries they perform. Therefore, a driver is likely to spend much time of its workday to successfully deliver a parcel and try to avoid failures, especially for B2C services, and this negatively affects productivity. The negative impact of WORK TIME shows that if the driver has a short time to complete his services he will likely speed up activities so that the productivity will increase. Similarly, huge MASS SATURATION of the vehicle reduces the potential number of stops, because the number of parcels that the driver could effectively load is lower. This is especially true in the case of B2B deliveries where the volume and the weight of each single parcel are usually high. For this reason a company should always pay attention to the vehicle loading strategy in order to enhance its productivity. Then, about KM TOT, outcomes have confirmed that the driver is productive if he travels more kilometres and this is due to the fact that there is a higher opportunity to meet more customers. Coherently, both the total services completed by a driver and the area of the warehouse positively influence productivity

Seven out of eleven variables reveal a significant impact on the number of stops. Such result shows the level of complexity of the system under analysis.

Based on this study two main managerial levers can be identified for the improvement of the CL system. The first one is associated with the design of the network and encompasses the STEM TIME, the WORK TIME, the kilometres covered by a driver, the number of services that are completed, and the trade-off between the number of pickups and the number of deliveries. In particular, a more efficient location of the depots, an extension of the area covered by each driver, and a more efficient routing structure can significantly improve the level of productivity. The second lever refers to the vehicle loading strategy and to the dimension of the depot. In fact, vehicles should not be excessively loaded, especially with bulky parcels, so that the business can be performed more efficiently.

6. Implications

This model highlights some theoretical and practical implications associated with the design of the distribution system of a LSP. Efficient distribution systems are becoming more and more relevant considering that transportation costs can account for up to 20% of the total cost of a product. In this context, strategic fleet decisions involve considerable capital investment. Vehicles are generally long-lived assets: there is an intrinsic uncertainty about the demand they will serve over their lifetime and about the conditions under which they will operate. These conditions make the risk associated with such decisions very high. Thus, it is of paramount importance to design the vehicle fleet in a proper way in order to effectively exploit the associated investments.

From a theoretical point of view, this study represents a first attempt to develop a comprehensive panel that includes many operational aspects in order to manage the distribution system of CLSPs more efficiently, by measuring the main elements that affect their productivity. This is a crucial aspect that leads to another important practical feature related to the structure of the urban environment and to its design. In urban areas, logistics companies should develop proper strategies able to fit with the environment in terms of number of customers and kilometres travelled. The benefits associated with the enhancement of productivity are not only economics but also environmental. Nowadays, the level of pollution and the climate change have become significant drivers towards more efficient transportation. An improved level of productivity for a CLSP, in terms of the number of stops for pickup and delivery activities, reflects on a decreased number of vehicles in the LSP's fleet. In fact, optimised routings, together with a proper location of depots and a better loading strategy, can significantly increase the number of stops for a single vehicle. Thus, a smaller number of vehicles properly loaded that cover more efficiently a specific urban area leads to a lower level of CO_2 emissions in the atmosphere. Therefore an efficient CL system appears to be an important element in achieving better quality of life in urban areas in terms of air quality and traffic congestion. Unfortunately, city transportation systems are characterized by a high level of complexity and it is difficult to identify precise elements that can improve them. In fact, there are many drivers that participate to the running process of these systems and for this reason policy makers are not always able to implement efficient actions. Therefore, there is a strong need for easy tools to support standards, procedures, solutions, and good practices. In this context the proposed model has identified several areas of action wherein it is possible to operate in order to improve the productivity of a CLSP's vehicle fleet with positive effects on the environment and in terms of savings.

7. Conclusion

In this paper an analysis of the productivity of a CLSP, here measured as the number of stops made by a driver to collect or to delivery parcels, has been carried out. In particular the objective was the identification of the main aspects- having significant influence on productivity, which is one of the main aspect of the CL issue. As a matter of fact, CL has been recently risen up as a crucial element for the improvement of the quality of life in terms of traffic congestion and air pollution but also a potential source of significant savings for LSP operating in urban areas. To this end, a real case study of a logistics company operating in Italy has been analysed. Several variables have been selected and a regression analysis has been carried out in order to highlight the main leverages that impact productivity. Results show that many of the variables taken into account significantly influence the level of productivity meaning that the issue under study is very complex to be analysed. However two different levers have been identified for the enhancement of the efficiency of a distribution system. In particular, the structure of the routing system and the vehicle loading strategy play a crucial role in determining the level of productivity, and in turn they can improve both the economic and the environmental efficiency of the system. Future research will be addressed towards analysing different business environments and other geographical areas. In this way it will be possible to figure out the main aspects associated to each market under study and to perform comparisons between the Italian context and other countries.

References

Benjelloun, A., and Crainic, T.G. (2008). Trends, challenges and perspectives in City Logistics. **Proceeding of Transportation and land use interaction**, Tralsu 2008, Bucarest, Romania.

Chandraprakaikul, W., and Suebpongsakorn, A. (2012, September). Evaluation of logistics companies using data envelopment analysis. In **Logistics and Industrial Informatics (LINDI)**, 4th IEEE International Symposium on, 81-86. IEEE.

Ehmke, J. F., and Mattfeld, D. C. (2012). Vehicle routing for attended home delivery in city logistics. Procedia-Social and Behavioral Sciences, 39, 622-632.

Ehmke, J. F., Meisel, S., and Mattfeld, D. C. (2012). Floating car based travel times for city logistics. **Transportation research part C: emerging technologies**, 21(1), 338-352.

Giannopoulos, G. A. (2009). Towards a European ITS for freight transport and logistics: results of current EU funded research and prospects for the future. **European Transport Research Review**, 1(4), 147-161.

Gunasekaran, A., Patel, C., and Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. **International journal of operations and production Management**, 21(1/2), 71-87.

Jabali, O., Woensel, T., and de Kok, A. G. (2012). Analysis of Travel Times and CO2 Emissions in Time-Dependent Vehicle Routing. **Production and Operations Management**, 21(6), 1060-1074.

Jiang, L. and Mahmassani, H. S. (2013). City Logistics: Freight Management with Time-Dependent Travel Times and Application to Large-Scale Networks. **Transportation Research Board 92nd Annual Meeting**.

Krauth, E., Moonen, H., Popova, V., and Schut, M. (2005, June). Performance indicators in logistics service provision and warehouse management–a literature review and framework. In **Euroma International Conference** (pp. 19-22).

Lim, H., and Shiode, N. (2011). The impact of online shopping demand on physical distribution networks: a simulation approach. **International Journal of Physical Distribution and Logistics Management**, 41(8), 732-749.

Lin, E. T., Lan, L. W., and Hsu, C. S. (2010). Assessing the on-road route efficiency for an air-express courier. **Journal of Advanced Transportation**, 44(4), 256-266.

McKinnon, A., Browne, M., and Whiteing, A. (2012). **Green Logistics: Improving the environmental sustainability of logistics.** Kogan Page Publishers.

Min, H., and Joo, S. J. (2006). Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis**. Supply Chain Management: An International Journal**, 11(3), 259-265.

Perboli, G., Tadei, R., and Vigo, D. (2011). The two-echelon capacitated vehicle routing problem: models and math-based heuristics. **Transportation Science**, 45(3), 364-380.

Rossi, S., Colicchia, C., Cozzolino, A.,and Christopher, M. (2013). The logistics service providers in eco-efficiency innovation: an empirical study. **Supply Chain Management: An International Journal**, 18(6), 583-603.

Rotem-Mindali, O., and Weltevreden, J. W. (2013). Transport effects of e-commerce: what can be learned after years of research?. **Transportation**, 40(5), 867-885.

Tabachnick, B. G., and Fidell, L. S. (2001). **Using multivariate statistics**. Pearson Publishing.

Wanke, P. F. (2013). Evaluating efficiency in the Brazilian trucking industry. **Associação Brasileira de Engenharia de Produção**. doi:10.1590/S0103-65132012005000088.