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Abstract

This paper identifies the most important factors that influence the productivity of the urban fleet of a Logistics Service Provider (LSP). Through a regression analysis on a dataset from distribution warehouses of a single LSP, three main levers are shown to have significant impacts on productivity, namely the network design, the vehicle loading strategy, and the business environment wherein the operations are carried out. This paper contributes to bridge the gap about the lack of works addressing the efficiency of LSPs operating in urban areas, by performing a detailed empirical analysis instead of taking an aggregated company perspective.

Keywords – City Logistics, Logistics Service Provider, Efficiency, Regression Analysis, Italy

1. Introduction

The mounting urban population together with larger mass production, increased turnover of goods and new distribution models have been some of the major causes to the remarkable growth of freight flows in urban areas (Browne and Gomez, 2011; De Marco et al., 2016).

However, the structure of many cities is not designed for an intensive use by freight vehicles (Muñuzuri et al., 2012). Traffic infrastructure is used to its maximum capacity in a way that accessibility constraints and logistics problems result in trip delays, poor vehicle utilisation, low service reliability, inefficient vehicle routings, and high delivery costs. Distribution vehicles cause traffic congestion, infrastructure deterioration, and environmental problems, like noise and air pollution, with an obvious influence on the quality and safety of urban life (Taniguchi and Tamagawa, 2005; Kuse et al., 2010; Anand et al., 2012; Neirotti et al., 2014). In addition, the dynamic characteristics of urban traffic congestion, the difficulty of finding parking spaces, limited delivery time allowed for pedestrian areas, or time-access restrictions to urban areas in general imposed by local regulations induce a high level of uncertainty that affects planning, management and performance of urban freight distribution (Kuhn and Sternbeck, 2013). Another crucial aspect is related to the development of the e-commerce that has made the distribution of parcels in urban areas more and more challenging (Hamzaoui and Ben-Ayed, 2011).

In this context, City Logistics (CL) has emerged as a comprehensive approach to make the last mile logistics service more organized and to mitigate the negative impacts of freight distribution without penalising social, cultural and economic activities in urban settings (Witlox, 2007; Gevaers et al., 2010).

In the last decades, a rich body of literature has been developed on such topic. With this regard, efficiency can be considered as a major driver for design and implementation of an effective CL system. Efficient urban logistics activities aim to increase the performance of urban distribution systems and of their stakeholders, such as improving the logistic service level for clients and consumers, maximizing revenue or reducing cost of service trips performed by freight carriers. In particular, Logistics Service Providers (LSPs) are one of the most relevant group of freight carriers in urban areas, as they roughly account for 30% of the urban freight distribution (Ducret and Delaitre, 2013). LSPs play an important role in seeking the promised goals of CL efficiency because they have direct interest in ensuring cost-effective urban distribution trips and, in turn, reasonable prices while managing customer-oriented services, short delivery times, high schedule reliability, and delivery flexibility (Tamagawa et al., 2010; Russo and Comi, 2011; Anand et al., 2012; Ehmke and Mattfeld., 2012; Ehmke et al., 2012b; Ballantyne and Lindholm, 2013).

All these aspects have been progressively taken into account in the last two decades, with the view of improving the effectiveness and the efficiency of the provided services (Ross et al., 2010). In this context, LSPs can positively influence the efficiency of CL systems by increasing the productivity of their vehicle fleets through the reduction of the traveling distance or the number of vehicles to be used (Yu and Qi, 2014), and associated transport service trips (Lin et al., 2010).

Scholars have tackled the issue of LSPs' efficiency by addressing the impact of external factors. From a commercial standpoint, logistics innovation and customer orientation affect supply chain effectiveness and the level of service (Harding, 1998; Panayides and So, 2005, Ellinger et al., 2008). The effect of mitigating policies on the number of delivery trips and other operational variables makes up for another consolidated research stream (e.g. road pricing (Holguín-Veras et al., 2006) or access time windows (Muñuzuri et al., 2013).

However, the literature has typically focused on the efficiency of LSPs' operations at a company level (Hamdan and Rogers, 2008; Wanke and Correa, 2012) and few studies are related to vehicle fleet productivity in urban areas. Moreover, little evidence is available on the extent to which internal operational aspects impact on the productivity of urban logistics.

With the purpose of filling this research gap, the present study identifies some main factors affecting the productivity of a LSP's urban delivery fleet and analyzes the way these factors contribute to increasing the efficiency of a city LSP and, in turn, of urban last-mile distribution systems. In fact, the understanding of the main drivers of fleet productivity (e.g.: such as distance travelled, number of vehicles, etc.) can help improving the fleet management service with resulting benefits in enhanced service level, cost savings, expanded business, and reduced environmental impact at the city level.

In the next sections, pertinent literature is firstly reviewed. Then, based on analysis of previous works, the notion of productivity of a vehicle fleet is defined. After that, several operational and context variables, that are supposed to have an influence on the fleet productivity, are identified. Finally, a linear regression analysis is presented and results are discussed as an attempt to draw potential implications, not only for researchers, but also for logistics managers and practitioners.

2. Literature Review

An extensive literature is available in various areas of CL studies. CL literature has focused over the years on defining the different stakeholders whose decisions and scope of activities are relevant for the success of CL measures, and consequently on organisational and technological frameworks for planning and managing CL systems by involving wide ranges of stakeholders (Crainic et al., 2004; Benjelloun and Crainic, 2009; Kuse et al., 2010; Ballantyne and Lindhom., 2013).

City Logistics scholars and practitioners tend to mix the concepts of LSPs and freight carriers, and in their studies usually combine all type of freight carriers, (e.g. LSPs, local transportation companies) into one group of stakeholders such as the Carrier group.

From a freight carrier perspective, a major stream of research available in CL literature consists of various type of optimization problems. This stream of research coaches on the knowledge area of operations and focuses on mathematical models for determining the optimal storage location in both one-tier and two-tier distribution schemes (Crainic et al., 2004; Boccia et al., 2010) by addressing vehicle routing and fleet scheduling problems, including optimal, dynamic, and time-dependent routing algorithms (Taniguchi and Shimamoto, 2004; Ehmke and Mattfeld, 2012; Ehmke et al., 2012a). Methodological approaches typically adopt contextual factors as input variables, such as, for example, the total demand of a city and the location of end users. In particular, higher income families are more likely to use internet and purchase goods online, as to induce more deliveries to specific areas and, possibly, putting a strain on LSPs' urban operations efficiency (Eurostat, 2015).

A second line of research focuses on the response of private actors to the introduction of urban freight transport measures. These studies analyse the behaviour of freight carriers exploiting quantitative simulation (Taniguchi and Tamagawa, 2005; Russo and Comi, 2011), which make use of optimization algorithms to compute the effect of urban freight transport measures on the carriers' operations.

CL studies generally refer to efficiency as one of the major concerns for sustainable urban freight transportation systems and normally consider transport efficiency in terms of trips, kilometres travelled, operations time, and generalized travel cost (Leonardi et al., 2014, Russo and Comi, 2011). However, efficiency is not thoroughly investigated in CL literature in terms of the contextual and operational variables that might support prediction tasks.

The literature about LSPs is mainly devoted to investigating the definition of third-party logistics, the reasons for outsourcing logistics operations, the scope of the activities performed, and types of organisations (Wanke and Correa, 2012), while there is scarce contribution focusing on their efficiency. In fact, the majority of papers about LSPs' efficiency are focused on comparing a group of firms based on data envelopment analysis. While the approaches are quite similar, the available literature on LSPs' efficiency can be divided into works that either consider economic and financial inputs and outputs to perform the analyses or studies looking at operational quantities. Examples of economic inputs include net fixed assets, cost of sales, account receivables, administrative expenses, wages, and other operating expenses while outputs include revenue and operating income (Min and Joo, 2003; Min and Joo, 2006; Min and Joo, 2009; Chandraprakaikul and Suebpongsakorn, 2012). In logistics, the efficiency is usually measured through the total logistics costs, and it is quantified together with the logistics effectiveness that is associated with the ability of the company to offer quick services (Gallmann and Belvedere, 2011). Efficiency evaluations based on operational variables consider fleet size, number of employees, labour hours, fuel consumption, footage and number of warehouses as the input of the models, while total tons of transported freight, distance travelled per year, number of accidents involving fatalities, total number of clients, and space utilisation are the output variables (Hamdan and Rogers, 2008; Wanke and Correa, 2012; Wanke, 2013). In distribution network and supply chain planning literature, the size, location and density of customers are significant variables for organizing efficient freight transportation (Jayaraman, 1998; Cachon, 2014). Integrated production-inventory-distribution-routing problems instead seek to reach optimal solution that minimize inventory and transportation costs, and take into account the number of items, the delivery time, the shipment size and the vehicle routing as the most important variables (Federgruen and Tzur, 1999; Bard and Nananukul, 2009). Vehicle routing is associated with travel times, idle times, and loading/unloading time (Desaulniers et al., 1998). Efficiency can also be achieved by starting the delivery tour later to avoid peak traffic, hence moving forward the first delivery, and the distance between the depot and the first delivery (Freight Best Practice, 2006).

The above mentioned literature is summarized in table 1. This table classifies literature according the main topic that has been studied, the scope and level of analysis. In particular, research works can investigate Operational aspects, such as labour hours, warehouse space, expenses; Economic aspects, including economic variables such as operative cost and revenues, and might also cover Contextual aspects, which are not dependent on the company and include aspects such as demand quantity and location or the purchasing cost of vehicles. The second axis of the taxonomy discerns the literature based on its level of analysis. In fact, the papers highlighted investigate the problem of efficiency either at the enterprise level (e.g. revenues, income, total assets productivity) or at the detailed level of logistics operations (e.g. number of vehicles, number of trips, fuel productivity).

Table 1 Literature taxonomy

TOPIC	**SCOPE OF ANALYSIS**			**LEVEL OF ANALYSIS**		**REFERENCES**
	Operational aspects	***Economic aspects***	***Contextual aspects***	***Enterprise level***	***Operations level***	
Mathematical modelling for evaluating City Logistics policies, via investigating freight flows and determining optimal storage location	X	X	X		X	Crainic et al., 2004; Boccia et al., 2010; Russo and Comi, 2011
Vehicle routing and fleet scheduling problems, including optimal, dynamic, and time-dependent routing algorithms	X		X		X	Taniguchi and Shimamoto, 2004; Taniguchi and Tamagawa, 2005; Ehmke et al., 2012a; Ehmke and Mattfeld, 2012
Studies looking at operational quantities at company level, to evaluate efficiency by benchmarking different LSPs		X		X		Min and Joo, 2003, 2006 and 2009; Hamdan and Rogers, 2008; Wanke and Correa, 2012; Chandraprakaikul and Suebpongsakorn, 2012
Impact of Managerial practices on performance management, service level and productivity	X	X		X		Stainer, 1997; Kuhlang et al., 2011; Gallman and Belvedere, 2011

Most available works measure the efficiency of the transportation service at a company level and a more granular perspective is often neglected. In summary, current literature on LSPs' efficiency is mostly focused on estimating the global efficiency of a company and benchmarking to its competitors, with particular attention to the economic and financial performance. In addition, there is a substantial lack of works specifically addressing urban LSPs.

Therefore, high is the need to analyse the operational levers that can enhance the efficiency of city LSPs. In particular, the productivity of the transportation service is used to measure the efficiency of a LSP's operations. As a matter of fact, the efficiency can be related to the extent to which customer requirements are met, and productivity is associated to the resources required to achieve a given level of customer satisfaction (Lai et al., 2004). In other words, the productivity of a LSP is a measure of service efficiency and fulfilment of customer's requirements.

In general, the productivity measures the quantity of output produced per unit of input. There are a variety of techniques that have been developed to construct measures for productivity, often relying on the calculation of simple ratios (Graham, 2008). When it comes to logistics and distribution processes, several authors have provided specific definitions of productivity. Fawcett and Cooper (1998) measure productivity as the number of orders that are delivered per vehicle, while Kuhlang et al. (2011) consider the logistics productivity as the distance travelled by vehicles in order to calculate the transportation time and cost. Time is a key input to logistics processes because all operations are time constrained and a prompt service is of paramount importance to ensure the service efficiency. Thus, Stainer (1997) conceives productivity in the logistics arena as a measurement of resources including the time element. Liao and Kao (2014) suggest that the productivity of a LSP should be expressed as the number of pick-up and delivery services that each vehicle makes in a given time window, for instance during one day. According to Kuhlang et al. (2011), the productivity in logistics encompasses transportation distances and duration. Since each of these aspects is associated with a vehicle's stop, the productivity of a LSP can also be measured as the number of pick-up and delivery services of a vehicle in a given time frame (Lin et al., 2010; Liao and Kao, 2014). This is the definition of productivity retained in this paper as it is directly related to the use of vehicles and, therefore, it is expected to be significant for the assessment of the output produced by a vehicle fleet dedicated to urban distribution.

3. Research Methodology

As an attempt to fill the research gap, this research identifies the main factors affecting the productivity of the last-mile distribution routing model and vehicle fleet management system of an LSP that runs the urban distribution business throughout Italy. The case LSP under investigation claims for its anonymity in this publication.

A regression analysis is performed to describe its fleet productivity and to identify the associated significant determinant factors. This statistical method has been selected since it proves it suitability for estimating how different variables can affect a dependent variable. In particular, it can be used to determine how the response variable changes when one or more predictors change (Ghinea et al., 2016). As mentioned above, in this paper the fleet productivity is referred to as the distribution productivity defined as the number of stops made by drivers while providing their daily pickup and delivery service. The main goal is to find the key levers that can help to optimise the LSP's fleet in terms of routing, distance travelled, and number of vehicles in urban areas. A more rational management of the distribution fleet is likely to improve the efficiency of the LSP's operations with positive impact on the urban freight transportation system.

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 of a vehicle while executing the service trips within an urban area. Furthermore, in several context variables are taken into account in order to consider the business environment (Hesse, 2002). Then, an exploratory data analysis is carried out on a dataset collected from 94 urban distribution warehouses and their associated city distribution fleets. The data were gathered from an international LSP that has been operating in the Italian market for almost 30 years. The company under study has 2,700 employees in Italy and 56,000 all over the world. It performs 155,000 out of 1 million of daily deliveries in Italy. The choice of selecting Italy in the study originates from the region where the authors usually conduct their research. In fact, they are engaged into a primary research program in logistics at a national level in Italy. This is also an opportunity to provide an interesting and peculiar case to verify and justify CL problems that may incur in systems characterized by small city centres, narrow streets, and high problems of pollution and congestion that can significantly benefit from the enhancement of urban logistics activities. Finally, after assuming that the number of times vehicles stop to successfully execute the pickup and delivery service is the response variable, a linear regression analysis is performed to understand the relationships between the organisation of the pickup and delivery service, the external business environment, and the productivity of the LSP's distribution service. The analysis has been conducted using the Minitab software tool in the light of its user- friendliness and since it is adopted by 4 thousand colleges and universities worldwide. It is also important to notice that 90% of the Fortune companies use this software for analysing data (Minitab, 2016). It is important here to specify that the number of successful stops during the daily service is a significant measure of the fleet productivity: in fact, in an urban context of disaggregated and fragmented market demand for pickup and delivery services, more stops are likely to generate more services and, in turn, higher income for the LSP.

4. Empirical Analysis

This paper is a contribution to understanding the factors affecting the productivity of a case LSP committed to freight transport, handling, storage, and delivery of documents, parcels, and items in urban areas. In particular, it provides for an analysis of the daily last-mile distribution fleet productivity.

The case-study LSP's operations run as follows. Customers place their orders and a vehicle fleet leaves the local urban warehouses in the afternoon to pick up the customers' items at their locations and return them to the trip-originating warehouses. Each vehicle is driven by one single driver, who also executes the pick-up and delivery service trips on her own within a predetermined urban area. At the local warehouse all items are loaded into a van and addressed to one of the company's consolidation centres wherein the items are sorted by target town, re-loaded into a van and shipped to the assigned final destination local warehouse. At this point, items are received early in the morning, re-sorted, and then re-loaded to reach the end customer urban location. In this model, the number of stops that a driver performs during the daily transportation duty appears to be crucial for the business of the company.

To measure the performance of the activities involved in a LSP's operations, several variables are often considered. For example, Krauth et al. (2005) propose a list of 130 elements classified by the perspectives of different stakeholders. Among others, the daily distance travelled, the labour utilization, the number of pickups and deliveries appear as relevant factors. Also, 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.

Specifically, the case company monitors several operational variables related to its business. Based on an analysis of literature and discussion with the case company's managers, those that are likely to influence the level of productivity have been included into the present model, as per Table 2. CL is a complex system encompassing different aspects characterized by many connections of various nature among them (Koç et al., 2016). Thus, in order to develop a model that takes into account all those variables that might potentially influence the LSP productivity in urban areas, seventeen independent variables have been used. The choice of quite a large number of variables was possible also because the large number of observations in the available sample (Section 4.1). Moreover, in order to prove the validity and reliability of the selected variables, the definition of each of them is supported by references to literature contributions in the fields of freight transportation, LSPs, and urban logistics addressing the associated quantities. Also, the expected impacts on the response variables are formulated according to interviews with managers from the case company as well as the outcomes of the literature review.

Table 2. Operational variable definition

VARIABLE	DEFINITION	LITERATURE REFERENCES	EXPECTED IMPACT ON RESPONSE VARIABLE
FIRST DELIVERY TIME	The time when the first service (pick-up or delivery) of the day occurs, measured as the number of minutes elapsed from 6am	Figliozzi, 2007	The later drivers leave the warehouse the shorter the time available to complete services. The number of stops tends to be small
REACH TIME	The time between when the first service is performed and when the driver exits the warehouse	Ehmke et al., 2012b; Wasner and Zäpfel, 2004	If drivers spend a long time to reach the location of the first service the available operating window will be short, resulting in a small number of stops
WORK TIME	The driver’s daily work duration. Upper limit: eight hours	Hamdan and Rogers, 2008	The longer the WORK TIME, the higher the opportunity to increase the number of stops
WEIGHT	The weight of parcels and items loaded on a vehicle	Ehmke et al., 2016	The greater the weight, the lower the productivity of the driver because the number of parcels that can be actually loaded is smaller. Most heavy parcels are also bulky and less comfortably manageable
WEIGHT SATURATION	The relation between the weight and the load capacity of the vehicle	Glock and Kim, 2015	The influence of such variable on the productivity is difficult to predict because it depends on the specific weight of the items. Thus, in a vehicle few large items, that may be either light or heavy, may be loaded and the productivity is low. At the same time, the vehicle may contain many small items, that again may be either light or heavy, and in this case the productivity becomes higher.
VOLUME	The volume of items loaded on a vehicle	Männel and Bortfeldt, 2016	The smaller the volume, the lower the productivity because the number of parcels that are loaded tends to be small
DISTANCE TRAVELLED	The total number of kilometres actually travelled by a driver in a day	Figliozzi, 2010; Hamdan and Rogers, 2008; Wanke, 2013; Wanke and Correa, 2012	The longer the distance travelled, the greater the number of stops because the driver has more opportunities to serve more customers
ROUTING EFFICIENCY	The ratio between DISTANCE TRAVELLED and the optimal distance computed by the IT system of the company based on the stops	Russo and Comi, 2011; Villarreal et al., 2016	If ROUTING EFFICIENCY is greater than one, the driver makes more kilometres than optimal and, in turn, productivity should potentially increase

	sequence of the driver		
FAILED STOPS	The number of failed stops for pick-up or delivery activities	Edwards et al., 2010; Visser et al., 2014	Based on the definition of productivity considered in this work, the higher the value of such variable, the lower the productivity
TOTAL SERVICES	The daily number of pickups and deliveries assigned to a driver	Männel and Bortfeldt, 2016	The greater the number of services associated with a driver, the greater the number of stops, the higher her productivity
SERVICE LEVEL	The ratio between the number of successful services and the assigned ones	Domingues et al., 2015; Kayakutlu and Buyukozkan, 2011	The closer this value to one, the higher the productivity of the driver because she has completed most of the assigned services, so has performed successfully most of the planned stops.
STOP RATIO	The ratio between the number of stops made for the delivery and pick-up services	-	Pick-up tasks are usually more time-consuming than the delivery ones. The fewer the pick-up stops, the longer the time available to perform deliveries, and the more the delivery stops, the higher the stop ratio with subsequent positive effects on a higher productivity
DEPOT SIZE	The net storage surface of the local depot	Russo and Comi, 2011	The larger the depot size, the higher the associated business volume. This potentially implies a larger urban distribution area served by the depot and, consequently, a larger potential customer base. The more the customers, the greater the number of stops and, therefore, the higher the productivity
ITEMS' DENSITY	The number of items managed by the depot divided by the depot size	-	The greater the number of items managed in the depot, the greater the number of stops because the urban distribution area is likely more productive and exploitable. Also, it is expected that the served urban area has more customers

In addition, other variables can be taken into account to understand how the context and business environment are likely to influence the fleet productivity. This choice is based on the idea that the productivity of a LSP does not only depend on the operational variables associated with the way the company carries on its business, but also on the business context per se. Such context variables' data have been collected from the Italian National Institute of Statistics (ISTAT, 2011). The considered context variables are given in Table 3. The expected relationships with the response variables have been defined as for operational variables.

Table 3. Context variable definition

VARIABLE	DEFINITION	EXPECTED IMPACT ON RESPONSE VARIABLE
POPULATION	The resident population in the urban area served by each service trip	The larger the catchment population, the greater the number of customers and the number of services during tours. The number of stops tends to increase and, in turn, the productivity. In fact there will be more B2C-generated home pick-up and delivery services
FAMILIES	The total number of households in the urban area served by each service trip	The productivity of the driver should be positively influenced by the number of families, again due to an increase in B2C pick-up and delivery services
TOTAL INCOME	The amount of available income of a specific urban area, expressed in Euro amount	The greater the TOTAL INCOME, the higher the spending power and the higher the probability the LSP serves more customers in the area. The number of stops and the productivity tend to increase
FAMILY INCOME	The available income, expressed in Euro amount, produced by the families of a specific urban area	If the value is high the driver is expected to make more stops because of a wealthier area
SPENDING	The expenditure on goods and services for a population of a specific urban area	The more the spending, the higher the B2C services performed by drivers, the larger the number of stops, and the higher the productivity. Being more productive in terms of stops does not always imply an increase of profitability for the company because usually B2C services are less profitable
REVENUES < 5	The number of companies available in an urban area with less than 5 million Euro revenue	The larger this number, the higher the business volume of such companies, the larger the number of stops, and the higher the productivity
REVENUES 5-10	The number of companies in the area with revenue from 5 to 10 million Euros	The productivity should be positively affected by this variable
REVENUES 10-50	The number of companies in the area with revenues from 10 to 50 million Euros	For this variable, the same behaviour of previous ones is expected. Moreover, the stops made in this area should be more

		profitable for the LSP given the increased available income
REVENUES > 50	The number of companies in the area with incomes greater than 50 million Euros	The number of stops is negatively influenced by the number of large firms, because the time spent by drivers in providing a service for large companies is usually longer due to a greater amount of items moved at each pickup and delivery service
POPULATION DENSITY	The number of inhabitants per km2 of the area served by a driver	For high values of this variable, the area served by the driver should have more potential customers and, consequently, the number of stops should be larger
COMPANIES DENSITY	The number of companies for square kilometre of the area served by the driver	High values of this variable are usually characteristics of commercial districts (e.g. main streets or shopping malls). In such cases the vehicle productivity might be lower because more than one service might be managed during a single stop in a B2B environment. This variable is somehow a counterintuitive measure of how a loss of productivity may still provide for an increase in revenue

4.1. Data analysis

Data have been collected for as long as 2 weeks (namely weeks 15 and 16 of 2013) from all of the 94 Italian urban warehouses of the company under analysis. In particular, together with the company we have recorded all the data associated with the trips that every driver makes. 11,060 observations have been totally gathered in order to get a more comprehensive view of the all issues under study. A member of the research team went with several drivers to understand how the process is run. The period under study appears to be representative of the workload usually carried on by the company, because it is not influenced by special events such as bank holidays, or adverse weather conditions. Furthermore the company under study can be considered representative of the Italian market because it is one of the major players in the national logistics service provider arena and also its warehouses are located in every area of the country.

Table 4 summarizes the independent variables that are supposed to have an influence on the level of productivity for the company under study. The columns report the mean, the standard deviation, the quartiles, and both the minimum and maximum value, respectively. The bottom line reports the response variable.

Table 4. Summary of the dataset

VARIABLE	MEAN	ST DEV	Q1	Q2	Q3	Q4	MIN	MAX
FIRST DELIVERY TIME (min)	598.55	75.09	556.00	589.00	628.00	1.230.00	421.00	1.230.00
REACH TIME (min)	21.13	16.55	9.00	16.00	29.00	89.00	0.00	89.00
WORK TIME (min)	502.32	74.02	456.00	501.00	549.00	985.00	128.00	985.00
WEIGHT (Kg)	589.29	366.84	373.16	516.04	702.67	9.268.73	0.35	9.268.73
WEIGHT SATURATION	0.50	0.35	0.30	0.42	0.60	9.27	0.00	9.27
VOLUME (m3)	5.58	94.63	2.52	3.49	4.83	8.59	0.01	8.59
DISTANCE TRAVELLED	138.77	81.51	79.81	121.41	165.60	182.09	4.82	182.09
ROUTING EFFICIENCY	1.62	0.44	1.31	1.53	1.84	4.89	0.00	4.89
FAILED STOP	1.80	1.90	0.00	1.00	3.00	18.00	0.00	18.00
TOTAL SERVICES	78.34	24.83	63.00	78.00	93.00	275.00	3.00	275.00
SERVICE LEVEL	0.97	0.03	0.96	0.98	1.00	1.00	0.62	1.00
STOP RATIO	5.36	5.55	2.56	3.80	6.00	67.00	0.06	67.00
STORAGE AREA (m2)	4.134	3.095	1.725	3.264	5.191	11.937	640	11.937
ITEMS’ DENSITY	1.17	0.39	0.85	1.11	1.40	3.27	0.34	3.27
POPULATION	19.072	11.010	11.702	17.826	24.822	81.672	18	81.672
FAMILIES	7.990	4.271	5.145	7.723	10.351	34.243	8	34.243
TOTAL INCOME (k€)	278.031	143.667	183.742	267.587	354.870	1.336.407	219	1.336.407
FAMILY INCOME (k€)	35.6	6.4	32.5	36	39	63	15	63
SPENDING (k€)	245.139	125.385	161.898	237.567	316.441	1.167.945	202	1.167.945
REVENUES < 5	1.517	788	1.011	1.416	1.848	7.660	0	7.660
REVENUES 5-10	12	12	6	10	16	177	0	177
REVENUES 10-50	11	13	4	8	14	242	0	242
REVENUES > 50	3	5	0	8	14	242	0	88
POPULATION DENSITY	475	732	78	165	471	5.103	6	5.103
COMPANIES’ DENSITY	68	172	8	15	46	2.537	1	2.537
NUMBER OF STOPS (response)	**60.51**	**18.53**	**50**	**61**	**73**	**150**	**3**	**150**

To explore the relationship of the productivity performance, the analysis focuses on understanding what 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 in Table 4 are significant factors and whether they have positive or negative impact on the response variable (Tukey, 1977). To this end, first, a normality test on the response variable is performed. Second, all the independent factors are normalized for a better comparison and comprehension of the results. Then, a multicollinearity check is performed via calculation of the Variance Inflation Factor (VIF) and variables with VIF greater than 5 are discarded (Tabachnick and Fidell, 2001). In order to perform a more accurate analysis the predictors have been removed one by one from the regression model based on the value of VIF observed.

Table 5. Multicollinearity

Predictor	VIF	Predictor	VIF
FIRST DELIVERY TIME (min)	1.237	ITEMS' DENSITY	1.228
REACH TIME (min)	1.479	POPULATION	**28.205**
WORK TIME (min)	1.259	FAMILIES	**75.531**
WEIGHT (Kg)	**22.947**	TOTAL INCOME (k€)	**125.172**
WEIGHT SATURATION	**23.037**	FAMILY INCOME (k€)	**5.145**
VOLUME (m3)	1.006	SPENDING (k€)	**116.409**
DISTANCE TRAVELLED	1.890	REVENUES < 5	3.959
ROUTING EFFICIENCY	1.328	REVENUES 5-10	**5.228**
FAILED STOP	**6.115**	REVENUES 10-50	**7.203**
TOTAL SERVICES	1.574	REVENUES > 50	3.643
SERVICE LEVEL	**5.969**	POPULATION DENSITY	3.228
STOP RATIO	1.246	COMPANIES' DENSITY	3.633
STORAGE AREA (m2)	1.678		

Finally, a regression analysis is performed using Minitab software tools, as given in Table 6.

Table 6. Results of the regression analysis

Predictor	Coef	P-value	VIF
Constant	0.053773	0.000	

FIRST DELIVERY TIME (min)	-0.005571	0.269	1.255
REACH TIME (min)	0.011565	**0.021**	1.485
WORK TIME (min)	0.024812	**0.000**	1.265
WEIGHT SATURATION	-0.142540	**0.000**	1.117
VOLUME (m3)	-0.081070	**0.017**	1.028
DISTANCE TRAVELLED	0.028413	**0.000**	1.914
ROUTING EFFICIENCY	0.037441	**0.000**	1.306
TOTAL SERVICES	0.898099	**0.000**	1.247
SERVICE LEVEL	-0.040659	**0.000**	1.118
STOP RATIO	0.008289	0.107	1.196
STORAGE AREA (m2)	-0.005589	0.279	1.535
ITEMS' DENSITY	0.006892	0.117	1.188
FAMILY INCOME (k€)	0.001132	0.838	1.707
REVENUES < 5	0.139770	**0.000**	1.433
REVENUES > 50	-0.088356	**0.000**	1.356
POPULATION DENSITY	0.041792	**0.000**	3.378
COMPANIES' DENSITY	0.004070	0.697	3.317

R-Squared: 82.6%

R-Squared Adjusted: 82.5%

The output of the regression shows that the REACH TIME, the WORK TIME, the WEIGHT SATURATION, the VOLUME, the DISTANCE TRAVELLED, the ROUTING EFFICIENCY, the TOTAL SERVICES, the SERVICE LEVEL, REVENUES < 5 MLN, REVENUES > 50 MLN, and the POPULATION DENSITY are significant factors of the level of productivity of the LSP. Thus, 11 out of the 17 selected variables prove significant impact of productivity. This result makes the model reliable, as shown by the valued assumed by the R-Squared and R-Squared Adjusted that explain the percentage of variability that a model is able to capture (Everitt, 2002).

5. Discussion of results

The results of the regression analysis originate some considerations on the relationships between the productivity of a LSP and both operational and context variables. In particular, the REACH TIME has a positive influence on the productivity. This is probably due to the fact that a driver knows she has to make a long run to perform the first delivery, and she will organize her activities in order to complete deliveries and pickups faster, so that her productivity could in turn increase (Ehmke et al., 2012b; Wasner and Zäpfel, 2004).

Concerning the SERVICE LEVEL, the model shows a negative relationship with the number of stops and this could be explained because the drivers are rewarded based on the successful deliveries that they perform. Therefore, a driver is likely to spend a long time of its workday to successfully delivery a parcel and trying to avoid failures, especially for B2C services, and this negatively affects the productivity (Domingues et al., 2015).

The positive impact of the WORK TIME shows that the productivity can increase if the driver is able to saturate the eight-hour shift. This finding is supported by the existing literature studying the link between labour hours and third-party logistics efficiency (Hamdan and Rogers, 2008).

Similarly, high WEIGHT SATURATION and VOLUME loaded on the vehicle reduce the potential number of stops, because the number of items that the driver could effectively load is lower. This result indicates that it is better to have a vehicle saturated in weight, but with lower volume. A similar proportion of weight and volume is already adopted by literature on vehicle routing with loading constraints, for instance by Männel and Bortfeldt (2016). For this reason the company should study alternative methods for vehicle loading.

Then, with regard to the DISTANCE TRAVELLED and the ROUTING EFFICIENCY, the analysis has confirmed that the driver is productive if one travels more distance and this is due to the fact that there is a higher opportunity to meet more customers.

The connection between the distance travelled and the efficiency is addressed by several authors assessing logistics service providers' performance (e.g. Hamdan and Rogers, 2008; Wanke, 2013; Wanke and Correa, 2012).

The positive influence of REVENUES < 5 has also been confirmed. In fact, this variable represents the number of small businesses, like bars, pubs and tobacconists, and it is obvious that the driver could be more productive because in this environment there are higher opportunities to deliver services. Coherently, REVENUES > 50 show a negative influence on the level of productivity. This is probably due to the fact that this variable refers to large firms for which more time is needed to complete each stop usually made up of many services. Such an outcome is supported by the contributions in literature that consider the revenue of customers as a factor influencing LSP efficiency (e.g. Min and Joo, 2006). The relationship between the POPULATION DENSITY and the productivity confirms the intuition that areas with a huge number of citizens offer the opportunity to carry out more services because the number of customers tends to increase (Wanke, 2012).

On the contrary, FIRST DELIVERY TIME does not significantly affect the productivity. This is probably due the fact that in a CL environment the first stop usually occurs approximately at the same time every day. Therefore this variable can be considered as a constant (Freight Best Practice, 2006). Similarly, the STOP RATIO is not significant in the presented study since the time absorbed by stops is probably the same of the time required for performing a delivery (Desaulniers et al., 1998). Thus, the variable that expresses the ratio between the times for these two activities cannot be significant. The not significant influence associated with STORAGE AREA and ITEMS DENSITY depends on the fact that these two variables are more related to the warehouse operations and coherently their impacts could be more evident in in-house activities (Hamdan and Rogers, 2008; Bard and Nananukul, 2009). The FAMILY INCOME has not shown a significant influence since there could be urban residential areas within a city with wealthy families, (Eurostat, 2015), but with a not relevant number of commercial activities. At the same time in the city centres there are a lot of shops together with wealthier families. These two situations neutralize the effects of this variable on the level of efficiency. Finally, the COMPANY DENSITY does not show any significant relationship with the productivity. This result is associated with the results of the model in the sense that the impacts related to the revenues of the companies that are served demonstrate that the crucial productivity lever is not related to the number of companies within an area, but to their revenues. Areas with high concentration of businesses are likely to offer higher levels of productivity, but, at the same time, these areas are more congested with likely negative impacts in terms of time required for performing a service (Jayaraman, 1998; Cachon, 2014). This leads to a sort of balancing effect that is likely to make the COMPANY DENSITY not significant.

In summary, eleven out of seventeen variables appear to have a significant impact on the number of stops. This shows the high level of complexity of the urban distribution system under analysis: it reveals that the fleet productivity can be hardly described by just a limited number of significant factors, as also highlighted by Tamagawa et al., (2010), and that a variety of overlapping factors must be taken into consideration by a city LSP when adopting strategies and actions to improve the productivity of urban distribution fleets. However, for the purpose of making improvements, some levers of managerial design and control can be subsumed out of the results of the analysis, namely in the areas of designing the distribution network, loading the vehicles, and addressing the market structure.

The first one, associated with the design of the network, encompasses the REACH TIME, the WORK TIME, the SERVICE LEVEL, the DISTANCE TRAVELLED, the ROUTING EFFICIENCY, and the number of TOTAL SERVICES that are completed. In particular, a more efficient location of the warehouses, an extension of the area covered by each driver and a more efficient routing pattern can significantly improve the level of productivity. In fact, warehouses close to customers allow decreasing the travelling time and give more time to perform service stops during a day. Also, a wide area served by a driver provides more opportunities to visit more customers. Finally, an efficient routing allows saving time that can be spent on pickup and delivery services.

The second lever refers to the vehicle loading strategy. It includes the WEIGHT SATURATION and VOLUME variables. Both variables show a negative influence on the productivity, thus the analysis indicates that vehicles should not be excessively loaded, especially with bulky packages, so that the business can be performed more efficiently.

The last lever is related to the business environment wherein a driver operates. The socio-economic variables are not under the direct control of the company, even if they affect its level of productivity. This relation is actually not cost-associated, but revenue-associated. A rich environment, with high POPULATION DENSITY positively influences the productivity of a LSP’s fleet. In the light of these results, a city LSP should develop strategies able to orient the demand through price policies and to expand the B2B service, in particular for small businesses that can largely contribute to enhancing its productivity.

6. Implications

This model highlights some theoretical and practical implications associated with the design of a distribution system of a LSP. In fact, especially in recent years, the strong competition has led higher demand for efficiency in particular in terms of customer service and cost reduction (Hoff et al., 2010). Efficient distributions systems are becoming more and more important considering that transport costs can account for up to 20% of the total cost of a product. This aspect appears to be crucial, since a company can increase the customer satisfaction by reducing the delivery time, but this could easily bring to increased logistic costs (Soderberg and Bengtsson, 2010).

In this context, strategic fleet decisions involve considerable capital investment, and vehicles are generally long-lived assets and there is an intrinsic uncertainty about demand they will serve over their lifetime, and about the condition they will operate. These conditions make the risk associated with these decisions very high. Thus, it is more and more important to properly design the vehicle fleet in order to better exploit such investments.

From a theoretical point of view, the main aspect presented by this work is that not only the operational variables can influence the productivity, but also various context variables are likely to influence the distribution service productivity. This is due to the fact that the proposed model does not only consider the costs of the business, but also the structure and source of revenues. Furthermore, this paper can be considered as a basis for connecting the enhancement of the efficiency of a LSP and the improvement of performance of a whole CL system. In addition, the results can be of value not only to third party logistics service providers, but also to own freight carriers for improving their performance. Also, these can be used by public authorities as a support in designing their policies for urban logistics activities.

This study is an attempt to develop a comprehensive panel of both operational and context variables with the purpose of helping city LSPs to more efficiently manage their urban distribution fleets and better measure the main aspects that affect the last-mile transport service productivity.

This is a very important aspect that leads to another practical feature related to the structure of the urban environment and to its design. In urban areas, LSPs should develop proper strategies able to fit with the urban aspects in terms of number of customers, distances, density of companies, and population. On the one hand, contextual aspects impact on the cost structure. For instance, densely populated areas are often more congested with a negative impact on travel times, and, in turn, on productivity.

On the other hand, high densities usually offer more business opportunities in the light of the high number of activities that are carried out, and the proposed model demonstrates that this second aspect is predominant for the productivity of a LSP. Thus, LSPs may increase their revenues through the optimization of pickup and delivery services in congested areas.

Enhancement of productivity brings not only economic, but also environmental benefits. Nowadays, pollution and, more in general, climate change issues have become significant drivers towards seeking more efficient transportation policies and systems. An improved level of productivity for a LSP, in terms of number of stops for pickup and deliveries activities, directly reflects into a decreased number of vehicles needed in a LSP's fleet. In fact, an optimized routing, together with a proper location of the warehouses and a better loading strategy can significantly increase the number of stops.

Thus, a lower number of properly loaded vehicles that cover more efficiently a specified urban area lead to a lower level of CO_2 and green house gas emissions. Therefore, a CL system seeking for fast, accurate and reliable pickup and delivery activities (Ehmke et al., 2012a) appears to be an important component in achieving better air quality and reduced traffic congestion in urban areas.

However, urban freight distribution systems are often characterized by a high level of complexity, with limited knowledge on the factors of efficiency to help managers and city policy makers to implement improvement actions. Therefore, high is the need for easy tools to support standards, procedures, solutions and good practices (Witkowski and Kiba-Janiak, 2012). Hence, the proposed model identifies a few selected areas of managerial actions in order to improve the productivity of a LSP's vehicle fleet with positive effects on efficiency, cost, business, and, ultimately, the environment.

7. Conclusions

In this paper, an analysis of the productivity of a LSP has been conducted. In particular, the objective is the identification of the main operational and context factors that are likely to have significant influence on the productivity of a city LSP's distribution fleet.

To this end, a case LSP, operating in the Italian territory, has been analysed. Several operational and context variables have been selected and a regression analysis has been performed to highlight the main levers that impact the distribution fleet's productivity. The analysis shows that many of the variables significantly influence the level of productivity, thus reaffirming a high level of system's complexity.

However, out of the number and complexity of the factors, three main subsets of homogeneous variables can be grouped to identify some main levers of managerial control that can be activated for enhancing the efficiency of an urban distribution fleet. In particular, the extension of the distribution areas assigned to each driver, the routing and organization of service trips, the vehicle loading policy, and the business characteristics of the distribution areas play a crucial role in enhancing the level of fleet's productivity and, consequently, in improving both economic and environmental efficiency of the last-mile urban distribution system.

From a theoretical point of view, the present work contributes to expand the stream of research about LSP efficiency from two main perspectives. First, it proves that there are specific parameters characterising CL contexts that influence LSP productivity, which might be not so relevant in different freight transportation environments such as, for instance, in transportation among cities. Thus, the proposed study can constitute a starting point for deeply investigating the efficiency of transportation operations in the CL arena. Second, by focusing on operational and context variables, it fosters research on variables affecting LSP performance other than economic and financial ones, which underpin a relevant portion of the mainstream literature on the topic. Additionally, based on this contribution academicians may carry out analyses on how the efficiency of freight transportation impacts on the overall efficiency of urban logistics and can be a lever for improving such a system.

As far as managerial contributions are concerned, the present study provides LSPs and own freight carriers with practical guidelines about how to effectively manage CL activities. This is also ensured by the focus on operational variables already monitored by a prime LSP. Furthermore, public authorities might find the developed analysis useful to set appropriate CL policies that do not conflict with carriers' goals but on the contrary, they synergize with them. Finally, the discussed operational and context variables can be part of evaluations of CL strategies, in particular when they specifically address transportation issues. Future research will be addressed to test the proposed model in other LSP environments in order to understand whether and how the main results obtained in this work change. Furthermore, other specific business contexts and other geographical areas will be analysed. In this way, it will be possible to have a better understanding of the main aspects associated with different markets, and to perform comparisons across various regions and countries.

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