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Goods Relocation Management in City Fashion Retailers with an Incentive System

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Abstract

The goods relocation among fashion retailers located in the same city is a daily activity carried out by trucks. The related transport externalities in the urban area have a significant weight for the citizen quality of life. The reduction in the use of heavy and polluting vehicles through innovative sharing strategies is one of the most promising strategies to minimize externalities in urban areas.
In this paper a goods relocation management approach for city fashion retailers involving customers is presented. The idea is to propose to loyal customers a voucher to be spent in the store as a reward (prize in the following) for the package delivery from one shop to another; this system can be developed by an app. In the case that no customer accepts, the company trucks will perform the service. This method allows having a double advantage: customer loyalty and externalities reduction caused by moving the trucks in the city. To this aim, an integer linear programming problem is formalized to manage the involve users in the goods relocation process by the proposed prizes. A simulation is presented to show the application of the methodology in the fashion retailers.

Keywords: Relocation Management, Incentive system, optimization.

1. Introduction

Freight transport in urban area is a very important issue due to the growing logistics related to globalization and the online market [1]. The reduction of production costs caused by manufacture of items in developing countries and the evolution of logistics services are encouraging an increase in product sale, particularly in the fashion industry.

Human activities generate positive and negative impacts [2]; these negative impacts are defined also externalities. The transport sector is one of the main responsible for externalities [3], especially in urban areas [4].

EU definition of an external cost, also known as an externality, is a cost arising "when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group" [5]. The externalities caused by transport sector can be classified in air and noise pollution, land use, accidents congestion and oil dependence. In the urban areas live high number of inhabitants and vehicles therefore these issues are stressed in [6] - [9]. European Commission stressed the need to charge logistic players for the external costs they generate (internalization of external costs) since 1999 [10], and different internalization strategies have been proposed in [11]. At current, however, they are often limited to extra-urban transports.

An IT-enabled open innovation is crowdsourcing. According to [12] and [13], open innovation is considered as a paradigm in which organizations systematically look for outside ideas relevant to their internal problems and/or

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external ways to market their own ideas. Crowdsourcing is defined by [14], [15] as a process in which organization outsources tasks that have traditionally been performed by the organization's members to a crowd of external individuals. In [16] a crowdsourcing definition, based on a review of more than 200 definitions, is proposed as: a type of participative online activity in which an individual, an institution, a non-profit organization, or a company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task.

In the last few years several fashion brand opened different stores in many cities [17] ensuring their customers the same items. Very often in the same city there are more stores of the same fashion brand; some of these are smaller stores, while others are larger ones and used by the company as a hub to supply other stores.

It is often necessary to move the goods from one store to another, even in the same day, in case of lack of products in some stores. This service improves customer satisfaction. Therefore frequently company trucks are used to carry out this logistic service.

The goods relocation among fashion retailers located in the same city causes transport externalities in urban area.

Literature review proposes several solutions to reduce such externalities [18] mainly related to the use of more ecological vehicles, such as Electric Vehicles (EVs), Hybrid Electric Vehicles, Fuel Cell Electric Vehicles [19] – [24], or to innovative methods and strategies, both in warehouse activities [25], [26] and freight transport [27] – [29] as well as in last mile delivery, such as collaborative and cooperative urban logistics [30], [31], optimization of transport management and routing [32], [33], and proximity station [34], [35], with the common aim of achieving a smart city vision [36] – [40].

Differently, in this work, we propose a method based on crowdsourcing paradigm with the involvement of loyal customers through an incentive system with awards [41] in the form of a discount to purchase goods in the fashion store.

The purpose of the paper is to develop an innovative relocation method base on an incentive system implemented with an interactive assignment algorithm that could be developed by an app for smartphone. The approach provides information to customers about the prize granted to them if they move a package from one store to another, by notification on smartphone. An integer linear programming (ILP) problem is formalized to manage the involve users in the goods relocation process in order to minimize the relocation costs.

Simulation results show the application of the methodology in the fashion retailers sector.

The paper is organized in five sections: the Goods Relocation in a City Fashion Retailers Problem is shown in section 2; section 3 describes an optimization problem to solve the Goods Relocation Problem. Section 4 proposes a case study and the potential advantages of the proposed approach to the Goods relocation in city fashion retailers, involving loyal customers. Finally, section 5 presents conclusions and future works.

2. Goods relocation in a city fashion retailers problem

The presence of several stores within the same city of fashion brands allows the movement of goods if requested for different reasons: missing sizes, different color and limited edition in some retailer.

In this context, goods relocation management is a very important daily activity to provide consumers with a more efficient sales service. The fashion companies use trucks to relocate goods to one retailer to another, and in many cases they are heavy and polluting vehicles.

New concepts of transport are proposed and transform it in a service: transport is no longer address to a mean of transport but is seen as a service.

Furthermore, incentive system approach to engage the customers are used in different fields and also in mobility sector there are some experience [42], [43].

Based on these concepts, an innovative approach is proposed to relocate the goods in the different city fashion retailers involving loyal users with an incentive system.

The proposed approach aims to reduce the transport externalities in urban area, relocation costs for the fashion company, and attracting and retaining customers through an incentive mechanism. The loyal customers of a fashion brand become active part of the relocation process with awards for both fashion company and customers.

The idea is to propose to loyal customers a prize in the form of a discount on the purchase of goods in the retailers as a reward for the package delivery from one store to another.

The proposed loyal customer incentive system can be provided through an IT application for smartphone and is illustrated by the procedure in fig. 1. In the first phase, an incentive value is proposed to the loyal customers who want to participate in the goods relocation process. Two cases can happen: 1) at least one user agrees to pick-up the goods from one store and leave them to an other one for a reward in the form of voucher on purchases within the stores of the same brand (if more than one user wants to participate in the relocation, the proposed method will choose the first one has accepted); 2) no user agrees in the relocation process, therefore a new increased inventive values is proposed to all users with a notification (this step can be repeated several time if the company propose more incentive levels). If the second step is concluded and no user has accepted the incentive, the company will use the trucks to perform the relocation activity.

The goods relocation service is implemented with loyal customers to avoid problem with deliver and with the integrity of items. The company has all info about these customers and if problems are encountered, they will charge the goods value and will no longer use them in the relocation service.

The goods relocation cost can be reduced by the proposed incentive system or at least keep them unchanged. The goods relocation process in city fashion retailers with an incentive system is shown in Fig. 1. The set of incentive proposals (levels) is $\mathcal{U} \in \mathbb{Z}^+$, with cardinality $|\mathcal{U}|$. The incentive levels designed by the company is $u \in \mathcal{U}, u = 1, \dots, |\mathcal{U}| - 1$. In addition, the last element of $\mathcal{U}$ does not represent an incentive value for customer but it is used to enable the relocation process performed by the company trucks.

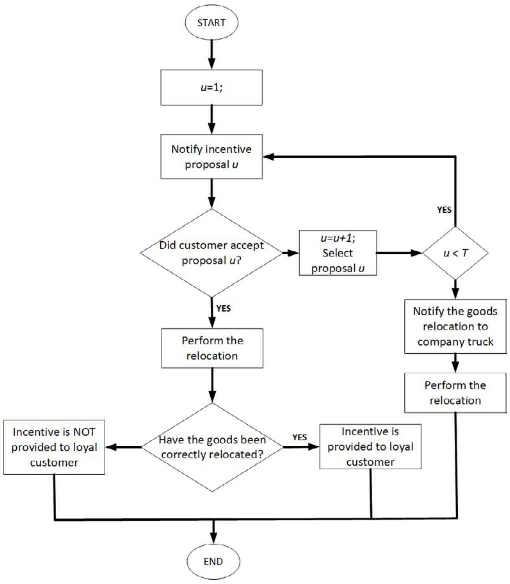

Fig. 1. Algorithm of incentive system process.

3. Optimization approach for goods relocation

An optimization approach to solve the goods relocation problem for city fashion retailers involving loyal customers with incentive system is proposed in this section. The optimization models are formulated under the following assumptions:

- the relocation cost related to the company truck is proportional to the distance from one store to another based on a destination-source matrix; it is a variable cost and does not include the fixed relocation cost of the company;
- the external costs are related to congestion, accidents, air pollution, noise pollution and climate change as reported in [2]. The values are considered for a Light Commercial Vehicle in case of company truck and car in case of loyal customer;
- the number of daily relocations is always the same both in case of using only company truck and in case of involving loyal customers;
- the relocation process involving loyal customers is performed from one store to another through the shortest route;
- the capacity constraint is not considered both for trucks and loyal customers;
- the goods to be relocated are only the ones indicated by the fashion company.

3.1. Goods relocation problem performed by company truck

The goods relocation problem is formulated as an integer linear programming (ILP) problem that aims to minimize the cost of the goods relocation for a company performed by its own trucks. Given a set $\mathcal{K} \in \mathbb{Z}^+$ of goods to be relocated, with cardinality $|\mathcal{K}|$, and the set $\mathcal{J} \in \mathbb{Z}^+$ of stores, with cardinality $|\mathcal{J}|$, the cost of the goods relocation process is related to the number of relocation and from the distance among the stores. The binary decision variables are $x_{i,j,k}, \forall\, i,j \in \mathcal{J}, \forall\, k \in \mathcal{K}$, where the departure store is identified with i and the arrival store is identified with j and the good is identified with k, and $Y_{i,j}, \forall\, i,j \in \mathcal{J}$, to linearize the problem. It represents the package of goods $x_{i,j,k}$, to relocate from i to store j.

The integer variables are $r_j, \forall\, j \in \mathcal{J}$, denoting the number of goods to relocate in each retailer after the relocation process. The known parameters of the problem are:

- $\hat{r}_j$ as the number of goods in retailer j before the relocation process;
- $\hat{r}_i$as the number of goods in retailer i before the relocation process;
- the minimum number of fashion goods in each retailer is defined as $N_{min} \in \mathbb{Z}^+$.

Thus, the following variables and parameters are defined:

- TRC is the total relocation cost, including the external costs [€/day];
- c is the cost per kilometer for the relocation task [€/km];
- e is the external costs per kilometer for the relocation task [€/km];
- $D_{i,j}$ is the distance from retailer i to the retailer j [km];
- $x_{i,j,k}$ is the binary decision variable indicating the k –th good relocated from retailer i to retailer j in a day [day-1];
- $Y_{i,j,}$ is the binary decision variable indicating the relocation of the package with goods from retailer i to retailer j in a day [day-1];
- r_j is the number of goods in the retailer j after the relocation process;
- $\hat{r}_j$ is the number of goods in the retailer j before the relocation process;

On this basis, the ILP1 (1)-(6) is formulated as following:

$$TRC = \min(c+e)\cdot \sum_{i=1}^{|I|} \sum_{j=1,i\neq j}^{|I|} \sum_{k=1}^{|K|} D_{i,j} \cdot Y_{i,j} \tag{1}$$

s.t.

$$kY_{i,j} \geq \sum_{k=1}^{|K|} x_{j,i,k}, \forall i,j \in I \tag{2}$$

$$r_j = \widehat{r}_j + \sum_{i=1}^{|I|}\sum_{k=1}^{|K|} x_{i,j,k} - \sum_{i=1}^{|I|}\sum_{k=1}^{|K|} x_{j,i,k}, \forall j \in I \tag{3}$$

$$r_j \geq N_{\min}, \forall j \in I \tag{4}$$

$$x_{i,j,k} \in \{0,1\} \tag{5}$$

$$Y_{i,j} \in \{0,1\} \tag{6}$$

$i,j \in I \qquad k \in K$

The problem admits always feasible solution. The numerical complexity is exponential.

3.2. Goods relocation problem performed by involving loyal customers

Involving loyal customers in the relocation activities leads to a new mathematical formulation of the optimization problem (1)-(6). Considering the incentive proposal levels set, described in Section II, we define $N_{lc} \in \mathbb{N}$ as the number of loyal customers in the relocation activities. The acceptance of these customers is based on the proposed level of incentive and in the formulation is considered as a rate of acceptance: $r_u \in \mathbb{R}^+$ is the acceptance rate of the loyal customers for each level of incentive. The number of goods relocatable is $Gr_u = N_{lc} * r_u, u = 1, \dots, |\mathcal{U}| - 1$. It is noted that, in the proposed approach, the goods transfer activity can be performed both by loyal customers and company trucks in order to reduce the relocation cost for the company.

The variables and parameters of the problem are defined as following:

- TRC' is the total daily relocation cost for the fashion company including the incentive system [€/day];
- in_u is the incentive rate for the incentive level u;
- $x_{i,j,k,u}$ is the binary decision variable indicating the k -th good relocated from retailer i to retailer j under incentive level u in a day [day-1];
- $Y_{i,j,}$ is the binary decision variable indicating the relocation of the package with goods from retailer i to retailer j in a day [day-1];
- e_u is the external costs per kilometer for the relocation task related to the incentive level u [€/km].

The new optimization problem is formulated as the following ILP2 (7)-(13):

$$TRC' = \min \sum_{i=1}^{|I|} \sum_{j=1, i \neq j}^{|I|} \sum_{u=1}^{|U|} (in_u \cdot D_{i,j} \cdot Y_{i,j,u}) \cdot (c + e_u) \tag{7}$$

s.t.

$$kY_{i,j,u} \geq \sum_{k=1}^{|K|} x_{j,i,k,u} \forall i,j \in I, \forall u \in U \tag{8}$$

$$r_j = \hat{r}_j + \sum_{i=1}^{|I|} \sum_{k=1}^{|K|} \sum_{u=1}^{|U|} x_{i,j,k,u} - \sum_{i=1}^{|I|} \sum_{k=1}^{|K|} \sum_{u=1}^{|U|} x_{j,i,k,u}, \forall j \in I \tag{9}$$

$$r_j \geq N_{\min}, \forall j \in I \tag{10}$$

$$\sum_{i=1}^{|I|} \sum_{j=1}^{|I|} \sum_{k=1}^{|K|} x_{i,j,k,u} \leq Gr_u, \forall u \in U \tag{11}$$

$$x_{i,j,k} \in \{0,1\} \tag{12}$$

$$Y_{i,j} \in \{0,1\} \tag{13}$$

$i,j \in I \qquad k \in K$

The problem admits always the feasible solution. The numerical complexity is exponential.

It is worth noted that it is expected that the relocation cost obtained by solving the ILP2 problem is less or (at least) equal than the same cost obtained by solving ILP1.

The proposed optimization approach can be applied to real cases with different fashion retailers operating in the same city for the relocation of goods.

4. Case study

In this section, a case study is simulated to demonstrate the advantages of the proposed approaches.

The formulated ILP problems are solved by a standard solver, i.e. MatLab (LinProg), on a Intel-Core i5, 2,7 Ghz CPU with 8 GB RAM. All the performed tests are solved in less than 2 seconds.

The ILP1 and ILP2 problems are solved based on the following parameters: $|\mathcal{I}| = 5$; $|\mathcal{K}| = 30$; $N_{min} = 5$; $N_{lc} = 200$; $\hat{r}_j, \forall j \in \mathcal{I}$ as defined in Table 1; $c = 2$ [€/km]; $D_{i,j}$ $\forall j \in \mathcal{I}$, $\forall i \in \mathcal{I}$ are defined in a destination-source matrix and reported in Table 2.

The proposed incentive system is based on two incentive levels and the rates in_u are set as follows:

i) reward equal to 50% of the company relocation service cost;
ii) reward equal to 80% of the company relocation service cost.

Thus, the cardinality of set U is |U| = 3. In Table 3 the acceptance rate of loyal customer, r_u, u = 1,2 is shown.

The external costs for the relocation task are estimated with values in [2]. In particular, company trucks are compared with diesel Euro 3 light commercial vehicle, while loyal customer mean to diesel Euro 3 car in urban area. A synthetic estimation is presented in Table 4.

Table 1. Initial number of Goods per retailer.

Retailers	Goods initial number
Retailer 1	1
Retailer 2	7
Retailer 3	11
Retailer 4	0
Retailer 5	11

Table 2. Distance between retailers in km.

	R1	R2	R3	R4	R5
R1	-	5	12	8	15
R2	5	-	9	4	18
R3	12	9	-	13	30
R4	8	4	13	-	17
R5	15	18	30	17	-

Table 3. Acceptance rate of loyal customers and relocatable fashion goods.

Incentive level	Acceptance rate of loyal customers	Relocatable fashion goods (Gr_u)
1	0,5%	1
2	1%	2

Table 4. External costs for the relocation task

	Company truck [€/km]	Loyal customer [€/km]
Congestion (Table 9 in [2])	0,925	0,487
Accidents (Table 11 in [2])	0,135	0,053
Air pollution (Table 17 in [2])	0,046	0,026
Noise Pollution (Table 29 in [2])	0,0018	0,0015
Climate change (Table 35 in [2])	0,028	0,021
Total External Costs	1,1358	0,5885

By solving the ILP1, the total relocation cost (TRC) with the use of the company trucks is equal to 137,98 €/day. This cost includes the relocation operative cost for the company and the external costs as social cost (not paid by the company).

The relocation solution is drawn in fig. 2: the red line shows the relocation performed by the company trucks. Note that the minimum number of goods required in each store, does not allow to move all the goods from a single store but requires reallocation process from multiple stores.

Solving the second problem ILP2, involving loyal customers, the new total relocation cost (TRC') is equal to 76,08 €/day. This cost includes the external costs as social cost (not paid by the company), the relocation operative cost for the company divided in incentives for loyal customers and relocation cost with trucks. The incentives are provided to loyal customers in the form of voucher to purchase goods in the stores of the fashion company are equal to 40 €/day.

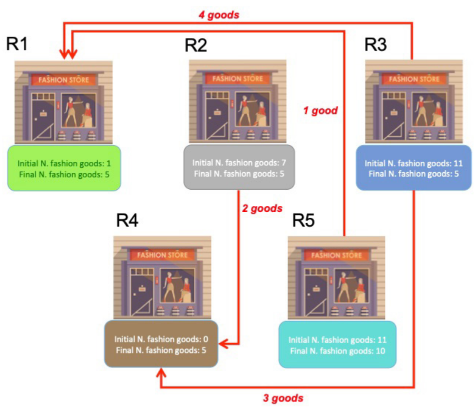

Fig. 2. Goods relocation in city fashion retailers by company trucks.

The relocation solution of ILP2 is drawn in fig. 3: the green lines show the relocation performed by the loyal customers while the red line shows the relocation performed by the company trucks.

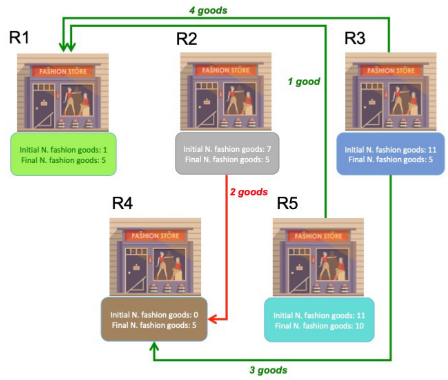

Fig. 3. Goods relocation in city fashion retailers by company trucks.

Analyzing results of the proposed optimization approach to the goods relocation problem, a reduction of the external costs and company relocation operative cost is noted. In the simulation case more than 45% of the total relocation cost is obtained. Considering external cost, data shows a reduction of about 50%, limiting the use of trucks for this task; indeed the external costs linked to the transport means and trucks are more impactful than the ones linked to cars. Involving customers, the relocation cost for the company is cut off. In addition, the fashion company can increase customer loyalty with more budgets to spend in its stores through the provided incentives.

Table 5. ILP1 and ILP2 simulation results.

	ILP1: Relocation by company trucks [€/day]	ILP2: Relocation involving loyal customers [€/day]
External costs	49,98	28,08
Relocation cost for fashion company	88	48
Incentive values for loyal customers	-	40

It is noted that, in case of customer unavailability in the relocation process, the fashion company can anyway perform it thanks to the company trucks.

5. Conclusion

In this paper an innovative goods relocation approach is proposed to minimize the total relocation cost in the task performed in the same city. It is based on an incentive system involving loyal customers in the relocation activities, with rewards in form of a voucher to purchase goods in the fashion company stores.

To this aim, two Integer Linear Programming problems are formulated (ILP1 and ILP2). More in detail, the ILP1 allows to model and solve the goods relocation problem performed by the company trucks while the ILP2 upgrades ILP1 by adding the loyal customers in the relocation process through an incentive approach. In this context, the loyal customers can pick-up a package with goods by one fashion retailer and leave it to another fashion retailer receiving rewards. Therefore, the availability of loyal customers will allow the reduction of the total relocation cost with a lower social cost (external costs) and company cost; besides will generate benefits for the customers. In case of unavailability of the loyal customers, company trucks will ensure the relocation service. A case study demonstrates that with loyal customers involved in the process, the total relocation cost is lower than in the case of only company trucks. The incentive mechanism mainly involves the loyal customers to participate in the relocation activities.

In future works, a capacity constraint related to the truck and the loyal customer will be included in the model. In addition, a decentralized optimization approach will be performed to solve the goods relocation problem.

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