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How to anticipate the level of activity of a sustainable collaborative network: the case of urban freight delivery through logistics platforms

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***Abstract*—In this paper, we elaborate a methodology to study a particular case of collaborative network: city logistics. We identify that many solutions for urban logistics are, most of time, badly evaluated. Indeed, the theory often predicts a positive effect but the reality is most of time counterbalanced. We tried to fill this gap by making use of innovative methods. To do so, we mobilize several domains of knowledge: operational research, game theory and transportation studies on real cases. We suggest a solution to anticipate the level of activity of an Urban Consolidation Center and determine the condition under which it generates benefit for a carrier using or not, the collaborative network. We present the result obtained by application of our method on the real case of the city of Saint-Etienne.**

Keywords—Sustainable collaborative network; Urban consolidation center; Games theory; City logistics

I. INTRODUCTION

City logistics are the last link of complex supply chains and involve numerous stakeholders: carriers, shopkeepers, e-customers, inhabitants, public administration, etc. It is a small part of the total traveled distance, nevertheless it can represent until 28% of the total transport cost [1]. Moreover, air pollution emissions related to urban freight transport is estimated between 16% and 50% of the global pollution made by transport activities in a city [2]. So, it is necessary to think about solutions to relieve the traffic congestion on the city center and reduce the environmental impact of urban freight transport. Regarding the complexity of the urban logistic system and associated collaborations, we have to identify innovative and "smartly" ways to support economic activities of city centers.

Lots of solutions are available in the literature. Most of them are the results of experiments which make difficult determining characteristics to provide sustainable models to public Decision Makers (DMs) who aim at implementing innovative collaborative ecosystems in terms of urban freight transportation. Indeed, there is a need to establish models which allow ex ante assessment. Russo and Comi [3] have identified the necessity of an *ex ante* approach and they proposed a classification of city logistics solutions in four classes: measures related to material infrastructure, measures related to equipment, measures related to Intelligent Transportation Systems and measures related to governance.

We choose studying a measure related to material infrastructure which represents a particular node of the urban logistic system: an Urban Consolidation Center (UCC). This type of measure is the solution the most considered in European cities and several questions appear with such projects.

Actually, theoretically speaking, UCCs are very efficient but most of time the practice produces the opposite of expected results [4]. Probably this gap can be filled with an in-depth and sustainable *ex ante* evaluation of the impacts of a UCC. Our challenge is to answer the following questions: How is it possible to anticipate the activity level of a UCC? Which level of sustainability can be reached? Our approach is to determine the flows that the UCC will be able to capture. In other terms, we seek at characterizing the different situations inciting local carriers to change their behavior and so to subcontract their freight delivery by collaborating or not with UCC. Finally, we aim to purchase a help to answer the question of Make or Buy: under which conditions have I an interest to do by myself or to pay somebody?

To this goal, we propose to study particular games defined by this situation where economic players (local carriers) have to choose between two decisions: whether to use or not the collaborative logistic network proposed in order to deliver the city center. At this step, the target is not to perfectly optimize particular delivery routes in a city center. We are faced with decision consisting on evaluating the potential attraction of a collaborative network according to the local stakeholders' (mainly carriers) interests. Consequently, we suggest using simulation (coupling with operational research in order to represent rational behavior of carriers) so as to explore different demand scenarios (rather than a unique route). The demand is modeled as the number of delivery points that have to be visited by carriers. It describes solicitation scenarios of the logistic network.

We first present the background about UCC, vehicle routing and game theory. We then describe the proposed approach. Finally, an example is developed just before giving some conclusions and perspectives.

II. BACKGROUND

A. Urban Consolidation Center (UCC)

The different experiments in the literature show that although the potential of UCCs seems to be significant, it is not always true in real life. Actually, it is very often the opposite: most of UCC failed. This is probably due to the fact that cases are not based on realistic estimates [5].

We intend to elaborate a model to determine the quantity of flow that a UCC is able to capture. We consider the UCC as a part of an urban system which is composed by carriers and delivery points. It has been showed that the chosen strategy in an UCC scheme is extremely important to guarantee the carriers 'adoption to the project [6]. That is why it is primordial to define correctly the relative position of an UCC in the whole system. In the literature (eg [7], [8]), we distinguish several attributes which describe UCC. We classify these attributes in two categories: those in relation with the location of the UCC and those in relation with the area serviced. In the former, we classify the distance between UCC and the city center, the distance between the UCC and other carriers. In the latter, we find the spatial coverage (the area serviced), the number of kilometers per vehicle, the number of vehicle routes, travel time, number of delivery points, number of parcels per day and operating cost. This allows describing the behavior and interactions of such urban logistic base.

In this paper, we choose studying a reduced system including an UCC in order to qualify, step by step, its effect on city flows. For this first study, we will include two attributes describing the location of the UCC: the distance between UCC and the city center and the distance between UCC and other carriers; as well as attributes describing the area serviced: the number of vehicle kilometers, the number of vehicle routes, the number of delivery points and the spatial coverage.

B. Vehicle routing

An important step in the decision making process is to define the routes for product delivery. This problem is usually solved as a vehicle routing problem (VRP). The VRP is a complex optimization problem known to be NP-hard. Most of solution approaches are based on approximate algorithms providing a good feasible solution. In the literature, a lot of works have been proposed to solve the VRP and some of its variants. State of the art surveys can be found (see for example [9], [10], [11]). Regarding the applications in urban logistics, less number of papers have been published (see for example [12], [13], [14], [15]). Hence, an important contribution to research in this area concerns the definition of routing strategies for such complex freight delivery within urban areas. Indeed, as vehicle routing is a complex problem, particular constraints of routing in urban areas (in comparison with interurban freight transport) have to be taken into account when solving goods distribution problems in city centers. This paper shows how a well-known heuristic named GRASP can be used in this context.

C. Games theory

Many real-life situations, such as those encountered in Supply Chain Management (SCM), present multi-actor confrontations and collaboration levels. In this context, the consequence of a decision for a given DM is a function of: (i) its own future decisions; (ii) the future (and uncertain) events that will occur; (iii) decisions of other DMs that may have indirect consequences for him [16]. Consequently, the optimal choice for a DM depends on those of the other DMs. The DMs are described as being in strategic interaction. This clearly defines a game theory context where each DM may be seen as a player seeking to maximize his own profit. Potential consequences for each player are called payoffs.

A game can be *cooperative* or *non-cooperative* [17]. In the former, all players are linked with restrictive agreement(s). They define a coalition (such as the Selves in the Veto-Process method above). In the latter, no coalition can be organized. Non-cooperative games can be described in two different ways:

- *Strategic form* game: a collection of strategies defining all possible actions of each player in all possible situations with associated profits (payoffs).

Payoffs: (Player 1, Player 2)		Player 2	
		Decision 1	Decision 2
Player 1	Decision a	(a_1, a_2)	(b_1, b_2)
	Decision b	(c_1, c_2)	(d_1, d_2)

Table 1: Strategic form game

- *Extensive form* game: a tree describing how the game is played. It is a dynamic description of the game because it specifies the sequence of decisions made by players. Each decision node represents a player who has to make a decision, using the information available at this time. Payoffs associated with each scenario (a particular sequence of decisions and events) are represented by leaves.

In this paper, the problem under study is close to a non-zero sum (the interest to one of the carrier to participate to the collaborative network should not be exactly opposite to the interest to the other carrier) non-cooperative (carriers have to be willing to take the risk to participate without knowing if the other will either) game with information that is perfect (no simultaneous decision), symmetrical (same knowledge for all players) and complete (each player knows all strategies and associated payoffs). Furthermore, this game is not repeated.

III. SOLUTION APPROACH

A. Global approach

As illustrated in the Figure 1, our approach is composed by five main steps:

(1) The city center is represented as graph $G = (N, A)$ defined by a set of nodes N and a set of arcs A. It represents the road network and the potential delivery points;

(2) Demand scenarios (subset of the set of potential delivery points) are randomly generated (could be based on particular attribute of each point, such as the frequency of deliveries);

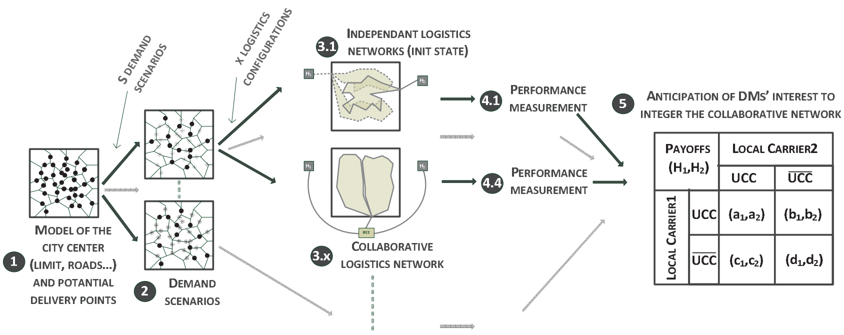

Figure 1: Global approach

(3) For each demand scenario, several logistical configurations are simulated where routes in the network are generated, going from the classical configuration where each carrier has its own route (they do not use the UCC), to the complete collaborative logistics network use where carriers deliver through the UCC, as well as partial utilizations of the collaborative network where some carriers do use the UCC;

(4) Each logistic configurations of each scenario is evaluated (in terms of total km); and

(5) Results from demand scenario are aggregated (equal probabilities for each scenario) and the game is analyzed in order to anticipate the DMs' interest to join the collaborative network. The aim is to identify classes of game situations.

B. Model of the urban logistic system and notations

The object under study is a city center. Figure 2 represents one configuration of the city center as it can be used in the study. The model is however general and this is a schematic representation that has been simplified for a better comprehension of the system and its different parameters.

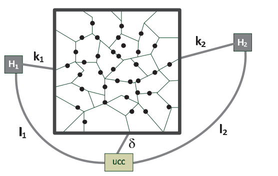

Figure 2: Model of the urban logistic system

As show in Figure 2, two kinds of zones are defined in our approach:

(i) An external zone (from the city center point of view) where local carriers (we note *H* the set of carriers) and UCC are situated (H_1 and H_2 in the Figure 2). We make the hypothesis that each carrier and the UCC have a single entry/exit point into the city center area. Each carrier/UCC position is characterized by its distance from its entry/exit point (k_1, k_2, δ). Carriers (noted *i*) are also defined by the distance from the UCC (l_i). Each carrier (*i*) has two possible choices in terms of UCC service utilization: it decides to perform all its routes to the UCC (UCC_i) or not ($\overline{UCC_i}$). A partial affectation of the carrier flow to the UCC is not considered in this study. When UCC_i is chosen, the carrier has the possibility to mutualize the delivery to the UCC (for example, a big truck can be used to deliver the items instead of having two littler trucks). We note as $Nb_{mut}^{i \to ucc}$ the number of trucks needed to deliver the UCC from the carrier *i*.

(ii) The city center where roads network and potential delivery points are modeled with precision through a graph $G = (N, A)$ defined by a set of nodes N (including roads intersections and delivery points) and a set of arcs A (roads characterized by distance).
A given number of delivery points $\left(Nb_{Pt}^{i}\right)$ in the city center area is randomly selected with replacement and affected to each carrier. All rounds of each carrier (noted $r_{1,2\ldots}^{i}$) or UCC (noted $r_{1,2\ldots}^{ucc}$) go through the associated entry/exit point and is characterized by a maximum number of delivery points (noted $Max_{r_{1,2\ldots}^{i}}$ and $Max_{r_{1,2\ldots}^{ucc}}$) and a total distance $Km_{r_{1,2\ldots}^{i}}$ and $Km_{r_{1,2\ldots}^{ucc}}$). We note R_i(resp. R_{ucc}) the set of rounds associated to the carrier *i* (resp. to the UCC) and Nb_r^i the number of rounds associated to the carrier

C. Model of the carrier behavior (vehicle routing)

Based on the graph representation of the city, it is then possible to implement a strategy for product delivery in the city center that is to solve the vehicle routing problem. The solution procedure for each instance was defined as follow:

Step 1: Initialize number and location of depots, vehicles assigned to each depot and nodes to be visited by each depot.

Step 2: Assign nodes to each vehicle in each depot. This assignment tries to minimize the average distance between the starting point for each vehicle (depot location) and all nodes assigned, ensuring that the vehicles will stay near the depot and will travel similar distances.

Step 3: For each vehicle in each depot, determine the order in which the assigned nodes should be visited. This is done by solving a TSP (Travelling Salesman Problem) using GRASP (Greedy Randomized Adaptive Search Procedure), for each vehicle.

A GRASP algorithm was employed to define the routes for product delivery [18]. GRASP is a multi-start meta-heuristic algorithm consisting of two phases (construction and local search) for each iteration. The construction phase builds a feasible solution, whose neighborhood is investigated until a local minimum is found during the local search phase. The best overall solution is kept as the result [19].

To carry out the Constructive Phase, the definition of a utility or cost function is necessary. This evaluates all possible elements that could be part of the solution. When all elements are evaluated, a Restricted Candidate List (RCL) is populated with those elements that exhibit the best values of the utility function. After the RCL is full, an element is selected at random to be added into the problem solution. This procedure is repeated until an initial solution is created. For this particular problem, the utility function was defined as [18]:

$$g(x) = \frac{\sum_{e \in E \setminus \{x\}} d(x,e)}{|E|} \tag{1}$$

Where x is a node to include in the vehicle route; $d(x,e)$ is the distance between nodes x and $e$and E is the set of nodes not yet visited. At the initial stage none of nodes has been added to the initial solution. After the Constructive Phase the solution neighborhood is investigated during the Local Search phase in order to improve the solution, while maintaining it into a feasible domain. This is done by reorganizing and swapping the order in which a vehicle visits the nodes assigned using 2-Optimal moves [20].

D. Evaluation of the catching

To estimate the flow catch by the UCC we study the game where the set of players are the set of carriers H, the set of decision of each players is $X_i \in \{UCC_i, \overline{UCC_i}\} \forall i \in H$. Players want to minimize the cost function ($f: X, S \mapsto \mathbb{R}$ with X the set of strategy and S the set of scenarios of delivery points). The cost function evaluates the truck travelled distance per total number of deliver points. Indeed, based on carriers' interviews, even if the price range is given by delivery point, it is generally calculated by estimating travelled kilometers for one position. That is why we determine the cost function as follow: when the carrier does not use the UCC, the cost function is defined by the sum between two times the product of the distance between his platform and the city center and the number of rounds, and the sum of travelled distance to do rounds, divided by the number of delivery points (see (2)). We consider that the carrier go back to his platform after delivering the city center which is translated by the coefficient "2" in the first member of (2).

In the case where carrier gives all his rounds to the UCC, the cost function (3) is similar as (2) except the introduction of a distance from the carrier's platform to the UCC and between the UCC and the city center. Moreover, as explain in section III.B., we consider that carrier can mutualize his rounds to transport the freight to the UCC. For the decision $\overline{UCC_i}$ the function (2) depends only on itself. Otherwise the cost function (3) depends on itself and the delivery points carrying by the UCC.

$$f_i^{\overline{UCC}} = \frac{2Nb_r^i}{Nb_{Pt}^i} k_i + \frac{\sum_{m=1}^{m=card(R_i)} Km_{r_m^i}}{Nb_{Pt}^i} = \alpha_i k_i + \beta_i \tag{2}$$

$$f_i^{UCC} = \frac{2Nb_{mut}^{i \to ucc}}{Nb_{Pt}^i} l_i + \frac{2\, Nb_r^{ucc}}{Nb_{Pt}^{ucc}} \delta + \frac{\sum_{m=1}^{m=card(R_{ucc})} Km_{r_m^{ucc}}}{Nb_{Pt}^{ucc}} = \gamma_i l_i + \mu_{ucc}\delta + \sigma_{ucc} \tag{3}$$

To evaluate the cost function over all scenarios we assume

- The equal probability over scenarios
- The DM minimize him expected cost (see (4) and (5))

$$\mathrm{E}\left[f_{i,s}^{\overline{UCC}}\right] = \alpha_i k_i + \frac{\sum_{s \in S} \beta_{i,s}}{|S|} \tag{4}$$

$$\mathrm{E}\left[f_{i,s}^{UCC}\right] = \gamma_i l_i + \mu_{ucc}\delta + \frac{\sum_{s \in S} \sigma_{ucc,s}}{|S|} \tag{5}$$

So from the simulation we compute for each scenario the cost and then we compute the expected cost of each player for each strategy. We are therefore in a particular form where (with the notation of the Table 1) $c_1 = d_1$ and $b_2 = d_2$. The evaluation of each strategy is the expected cost function. With the notation introduced above, the strategic form of the game is:

		i=2	
		UCC_2	$\overline{UCC_2}$
i=1	UCC_1	$\mathrm{E}\left[f_{1,s}^{UCC}\right]; \mathrm{E}\left[f_{2,s}^{UCC}\right]$	$\mathrm{E}\left[f_{1,s}^{UCC_1/\overline{UCC_2}}\right]; \mathrm{E}\left[f_{2,s}^{\overline{UCC}}\right]$
	$\overline{UCC_1}$	$\mathrm{E}\left[f_{1,s}^{\overline{UCC}}\right]; \mathrm{E}\left[f_{2,s}^{\overline{UCC_1}/UCC_2}\right]$	$\mathrm{E}\left[f_{1,s}^{\overline{UCC}}\right]; \mathrm{E}\left[f_{2,s}^{\overline{UCC}}\right]$

Table 2: strategic of the UCC game

As in real life, the initial state is $\overline{UCC_1}$ / $\overline{UCC_2}$. We are seeking equilibrium for carriers' strategy. The target is to identify situations when the initial state is no more an equilibrium. There are two cases. The first one is to look for situations in which all carriers have an interest joining the UCC (corresponds to (6)); the second one is to identify situations in which one carrier can have an interest collaborating with the UCC (representing by (7)). These cases are translated by knowing when:

$$\forall i \in H, \mathrm{E}\left[f_{i,s}^{UCC}\right] < \mathrm{E}\left[f_{i,s}^{\overline{UCC}}\right] \forall X_j \in \{UCC_j, \overline{UCC_j}\} \forall j \in H, j \neq i \tag{6}$$

$$\exists i \in H, \mathrm{E}\left[f_{i,s}^{UCC_i/\overline{UCC_j}}\right] < \mathrm{E}\left[f_{i,s}^{\overline{UCC}}\right] \forall X_j \in \{UCC_j, \overline{UCC_j}\} \forall j \in H, j \neq i \tag{7}$$

IV. Experiments

A. Presentation

In order to illustrate the implementation of the proposed approach, experiments were carried out using real data from the city of Saint-Étienne, France, which is a city in eastern central France. It is located in the Massif Central, 60 km southwest of Lyon in the Rhône-Alpes region. Saint-Étienne is the capital of the Loire Department and has a population of approximately 175000 inhabitants in the city itself, expanding to over 400000 inhabitants in the metropolitan area (2010).

B. Characterization of the case

The study takes into account a system composed by two local carriers: H_1 and H_2. Consequently we evaluated 4 ($2^{card(H)}=2^2=4$) different logistic configurations from a graph defined by 200 nodes, which correspond to the potential demand points, and 40000 (200×200) arcs.

We consider that each carrier organizes two routes ($\forall i, Nb_r^i = 2$), each with 40 delivery points ($\forall i, Nb_{Pt}^i = 80$). However, if two trucks are necessary to deliver the 80 points, we assume that one truck is able to deliver the whole freight from the carrier to the UCC, so that means ($Nb_{mut}^{i \to UCC} = 1$) for each carrier H_i. Indeed, often city centers' roads are really small and make carriers do use small trucks to access delivery points. When carrier chooses collaborating with the UCC, he can be able to use bigger truck to transport the same freight. We also assume that when a carrier decides to give some freight to the UCC, it performs all its routing, i.e. 80 delivery points. This hypothesis is justified by the fact that even if the activity of carrier is not just the city center but also the suburb and other city, in this paper we are just interested by rounds for which he wonders: Can I do by myself or pay somebody to do for me (make or buy)? That is why the hypothesis that he gives all his freight is suitable. So when one carrier entrusts its routing to the UCC's service, then $Nb_{Pt}^{UCC} = 80$; when both carriers subcontract their routing to the UCC then $Nb_{Pt}^{UCC} = 160$, even if a single delivery position is visited by both carriers. Thus UCC can benefit from concentration of delivery point to propose services with attractive prices.

To obtain data as close as possible from reality, we simulated ten different replicates of customer location. For each replicate, delivery points were randomly selected for each carrier within a list of 200 possible location points on the network. This allows us to obtain averaged parameters more representative of reality than just a single random distribution. Moreover it characterizes correctly the fact that carriers do not always use the same routes in the city center. In our decision level, we are not able to say the exact location of delivery points. However we can try to obtain a model of a possible general activity.

		i=2	
		UCC_2	$\overline{UCC_2}$
i=1	UCC_1	(0.025*l_1 +0.05*δ+0.92) ; (0.025*l_2+0.05*δ+0.92)	(0.025*l_1 +0.05*δ+1.21) ; (0.05*k_2+1.12)
	$\overline{UCC_1}$	(0.05*k_1+1.19) ; (0.025*l_2+0.05*δ+1.16)	(0.05*k_1+1.19) ; (0.05*k_2+1.12)

Table 3: Resulting cost functions

The result of simulation is represented by the below table of game (Table 3). These first results give some interesting information. Indeed, it shows that if one carrier collaborates with the UCC then he has no interest to go back alone if the other comes also. It can be see with results for carrier 2 (resp. 1) where $(\sigma_{ucc}^{a}(UCC_1, UCC_2) = 0{,}92 < \sigma_{ucc}^{a}(UCC_1, \overline{UCC_2}) = 1{,}21)$ and $(\sigma_{ucc}^{b}(UCC_1, UCC_2) = 0{,}92 < \sigma_{ucc}^{b}(\overline{UCC_1}, UCC_2) = 1{,}16)$. Finally, we are able to conclude yet that our situation corresponds to equilibrium in pure strategy.

The next step is to find the different values of k_i, l_i and δ which resolve (6) and (7).

C. Results / Discussion

The solution space for each equation ((6) and (7)) can be represented by a tetrahedron possibly truncated (see Figure 3 and Figure 4). The grey shaded face corresponds to the case where we have equality (i.e. same price for UCC and $\overline{UCC}$). Below this surface, carrier has an interest to subcontract his freight to the UCC. The tetrahedron is completed by additional implicit constraints that prevent distance from being negative ($k_i>0$, $l_i>0$ and $\delta>0$). The graphic represents the general case from our simulations.

It is possible to obtain a better view of the solution space by fixing k_i, and representing it on a 2D graph. That gives an appropriate means to visualize the admissible domains for a particular carrier. This admissible domain has a triangular shape. For each carrier it is possible to superimpose the result of (6) and (7) (see Figure 5). Two triangles appear. The small one corresponds to the case where carrier 1 uses alone UCC's service, the big one is the case where both carriers entrust their freight to the UCC.

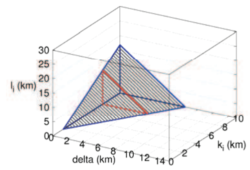

Figure 3: One carrier uses UCC

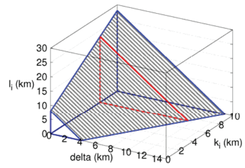

Figure 4: Both carriers use UCC

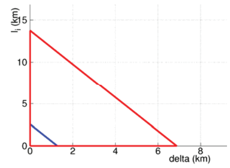

Figure 5: Surface area which describes the profit's zone for one carrier

The straight line corresponds to positions where the cost function is equal, i.e. no profit is made by the carrier when going by UCC but no money is lost either. Points under this straight line depict UCC's possible locations where the carrier would benefit from joining the UCC. Outside this joining UCC would result in extra cost and the carrier will rather not join it. In the present case, the surface area corresponding to the scenario when the carrier comes alone is actually very difficult to satisfy. Indeed, for any possible set of value for l_i and δ lying in the favorable domain, UCC location is constrained to a narrow region close to the carrier itself and UCC entrance point for touring. On the other hand, it is interesting to note that the size of this domain is considerably larger when both carriers use UCC's service. Note also that $l_i$and δ axes do not have the same scale or the same impact in term of cost. Concretely, it is more beneficial to enlarge l_i and keep δ as low as possible. This can be explained by the fact that the distance l_i is realized with a single big truck whereas δ is made once per routing.

The situation may correspond to a classic problem of Stag Hunt Game. Indeed, each player (carriers) may have no interest to play alone because this situation would result in an increase of his own costs. But if both carriers decide to join the collaborative network, then their respective gains will increase in comparison with the initial situation. This type of game is non-cooperative which means that carriers have to be willing to take the risk to participate without knowing if the other will either.

To give a better understanding of this result, it is possible to represent on a map the set of points for each carrier (resp. UCC) not located further than a given distance l_i (resp. δ) on the network. This results in pseudo-circles are delimited by iso-distance contours. Points located in the intersection of the three circles (l_1, l_2 and δ constant) are the set of favorable location for UCC for each carrier. We present in the map below (Figure 6) the case of two existing local carriers ($k_1 = 1{,}485\ km$ and $k_2 = 7{,}42\ km$). We considered that carrier 1 enters from a west point in city center and carrier 2 from an east point. In this case l_1, l_2 and δ were chosen such as the involvement into UCC is the favorable domain (inside the triangle) for both carrier. One of them is represented in white and the other in black. The grey color corresponds to the area where it is necessary to install the UCC if we want that carriers are interesting by using it. The white area with small black points is the city center.

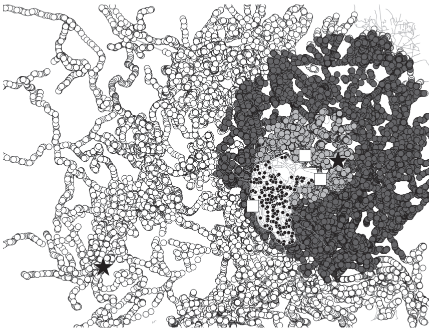

Figure 6: Illustration of profit's area on the road map

V. Conclusions and Perspectives

In this study, we elaborate a methodology to characterize situations inciting carriers to collaborate with an UCC and change our conception of urban logistics in term of service. We showed that an efficient collaborative logistic network is possible. We enlighten the existence of areas where UCC can be implemented in a sustainable way according to a given cost function. Our method is really positioned as an ex ante decision making tool. It can be used to help the stakeholder in a beforehand phase to identify a costly efficient UCC's locations. We end up to a graphic representation of this admissible set of location using Geographical Information System. That gives an important and pragmatic help to DMs who do not necessarily have the in depth experience of city logistics projects.

The defined function allows anticipating the behavior of carriers. Nevertheless, it can be improved. It would be necessary to take into account the time dimension. Indeed, if the kilometer per parcel is a good indicator, the notion of time is not described in our model. It could results in a more precise anticipation of carriers' behavior. Transport companies look for the best way in term of kilometers and time. Thus, a choice is made by the carrier to find the best compromise. Another field of investigation may concern the evaluation of pollution emissions in the model. Full sustainability can only be achieved through an evaluation of environmental impact of city logistics measures and generated traffic flows. Including this dimension in our analysis could help DM to make environmental friendly decision.

It could also be relevant to investigate scenarios with more actors and to refine our evaluation of each carrier needs. Involvement of a whole set of carrier could lead to complex situations in which various strategies for carriers may occur. Another perspective is to study the effect of public subvention. This could be a way to go to a stable configuration in which every carrier collaborates with little risk.

Our work tries to give a new way to anticipate the construction of city logistics measures such as UCC by adopting a logistics' point of view. We elaborate a global approach and investigate the question of UCC sustainability. We show that possible way to achieve this goal can be obtained by a combination of operational research, games theory, GIS and transportation studies on real cases experience.

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