City logistics: Are sustainability policies really sustainable?
Logística Urbana: ¿Son realmente sostenibles las políticas sostenibles?

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Abstract: Road Freight transport is causing a number of social, environmental and economic negative impacts in many cities around the world. Therefore sustainable city logistics must be the solution to the problems of urban centers, with the main objective of researchers reduce these impacts, without penalizing the needs of cities. Cause of this several sustainable initiatives and policies have been implemented to help reduce them. But are the sustainable policies really sustainable? So this paper aims to evaluate one of these policies in a quantitative way to answer the question. Therefore be presented and implement a model based on VRP logic to evaluate the differences between the distances traveled by vehicles of a logistics company in a city with a policy regulating access and the distance traveled without such regulation. And based on the results obtained attempt draw conclusions to answer the question.

Keywords: City logistic, Sustainable policies, Vehicle routing, Access time windows, Genetic Algorithms, City centers

Resumen: La Logística Urbana sostenible debe ser solución ante los numerosos problemas sociales, medioambientales y económicos causados por el transporte de mercancías por carretera en las ciudades. De hecho son varias las iniciativas y políticas sostenibles que se han llevado a cabo para intentar reducir estos problemas. Pero ¿son realmente sostenibles estas políticas sostenibles? Este trabajo tiene como objetivo evaluar una de estas políticas de forma cuantitativa para poder responder a dicha pregunta. Así se evaluaron las diferencias entre las distancias recorridas por los vehículos de una empresa de logística en una ciudad con y sin una política de acceso regulado.

Palabras clave: Logística Urbana, políticas sostenibles, enrutamiento de vehículos, ventana de acceso temporal, algoritmos genéticos, centros urbanos.

1. Introduction

Road Freight transport is causing a number of social, environmental and economic negative impacts in many cities around the world (Anderson et al., 2005; Muñuzuri et al., 2005). Some of these may be traffic congestion, air pollution, noise pollution, and safety-related problems such as traffic accidents. In addition, these transport systems contribute to emissions of greenhouse gases, and thus in a global scale these negative externalities are important because contribute to climate change effects. Also all towns and cities require the provision of goods and services and the elimination of waste products, and therefore depend on urban freight transport (Muñuzuri et al., 2012). And these impacts have been increasing in recent decades as a result of a growth in goods flows demand by consumers and businesses (Cherrett et al., 2012). The determining factor in this increase is that the urban population is growing at an exponential rate, and as a result of economic development and urbanization is expected to continue the growth, by 2030 it is estimated that urban areas account for 56 per cent of the population of the less developed regions, and 81 percent in the more developed regions (United Nations, 2006).

Therefore sustainable city logistics must be the solution to the problems of urban centers, with the main objective of researchers reduce the impacts of urban freight transport, without penalizing the needs of cities (Chang and Yen, 2012; May, 2013). Moreover, policy makers and decision makers aim to decrease the above mentioned variety of negative social, environmental and economic impacts of urban freight transport. Cause of this several initiatives and policies have been implemented to help reduce them (temporal regulation of access, promotion of cooperation between public and private sector, etc.). Some of the objectives of these policies are to improve the environment (air and noise quality), securing pedestrian's space and the prevention of accidents. Definitely have sustainability as the ultimate goal (Dalkmann and Brannigan, 2007).

In this situation, and in City Logistics researchs, raises the question of the impact of these policies on the different areas and interests of the stakeholders involved in urban areas and its centers (citizens, residents, merchants, transporters, local authorities, etc.). This is a field that has been investigated in recent years (Quak et al., 2009; Gonzalez-Feliu et al., 2012; Stathopoulos et al., 2011 and 2012). As known the heterogeneity of the interests of these stakeholders makes coordination very complicated, so generally act independently and without any centralized control. But this paper seeks to answer a less particular issue; a question witch captures the overall interests of all stakeholders involved (general interests should be above individuals): are sustainability policies really sustainable?

So this paper aims to answer the previous question, at least partially. To answer this question should be starting from the concept of sustainability in all its scope and all its implications. Subsequently assess the impact of one of the aforementioned policies in a European city in particular: Sevilla. This policy is being implemented in some European cities lately. To end with the conclusions that may be drawn from the results seen from the perspective of sustainability.

2.   Sustainability and sustainability policies

To answer the goal question should be starting from the concept of sustainable development. From the report of the Brundtland Commission on Environment and Development in 1987 the concept of sustainable development has been attracting worldwide attention. Sustainable development has proved an enduring and compelling concept because points in a clear and intuitive political direction, and is also flexible enough to adapt to new challenges, to the technological, economic and social aspirations. It is appealing to the general public and the scientific community in particular, as it implies a systemic view of the economy and ecology, and requires solutions that protect the interests of future generations.

Sustainable development meets the needs of the present without compromising the ability of future generations to do the same. Making a deeper analysis of this concept emphasizes the fact that there are different systems, such as environmental, economic and social, interact for mutual benefit or detriment within different scenarios and scales operation (TRB, 1997). And this representation of the «three pillars

of sustainability» (social, economic and environmental, see Figure 1) include the fact that the concept of sustainability itself is the result of interactions between the three dimensions or pillars that overlap , which is why cannot be, or rather must not be, analyzed separately (Rossi et al., 2012). This is a key concept of sustainability, but not always taken into account when using sustainability as an adjective.
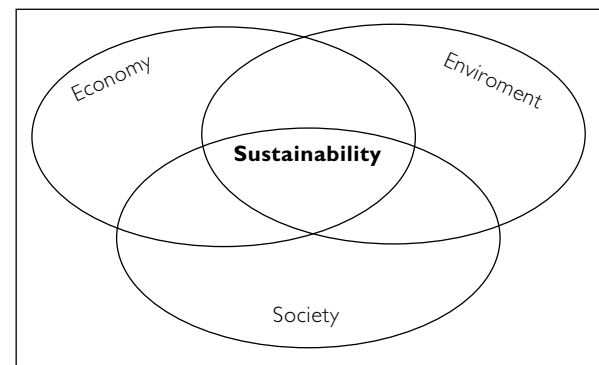

Fig. 1
Representation of the «three pillars of sustainability»

Focusing on the concept of sustainability in the context of cities, particularly in European cities, local authorities and municipalities are taking appropriate policies to increase such sustainability. These measures are, above all, environmental sustainability and social sustainability. Environmental sustainability seeks to reduce emissions and pollution caused by vehicle traffic, increasing air quality in cities, with measures such as promoting use of public transport or the creation of bicycle lanes. And social sustainability seeks a set of purposes such as increasing the accessibility of cities, reducing noise, increasing quality of life of these, conservation of historic centers, reducing the number of vehicles and so on.

These policies on urban logistics of goods tend to fall into six categories (Stathopoulos et al, 2012), which exhibit some examples below:

• Market-based policies: these aims to modify the market prices of goods whose production and/or consumption arise negative external costs. The congestion ecotax is a measure economically attractive and has a positive impact on traffic congestion in city centers. However transport pricing policies requires a prior understanding of the complementary, and sometimes contradictory, roles of transporters and receptors.

- Regulating policies: refer to the rules and regulations applied by a control system or by local authorities. Times windows and access restrictions such as access time windows are the most frequently used measures. The results of studies on various European cities suggest that the specific regulation on the environment for the entry of transport is one of the most effective ways to reduce emissions.

- Land use policies: these have a major impact on the logistics of the city, and typically zoned economic and non-economic activities, as the concentration of commercial activities that can facilitate the streamlining of the supply, thus benefiting both operators and residents.

- Infrastructural policies: are intended to promote the change of transport mode, attempting to eradicate the domination of the road as the main means of transporting goods. One of the most common policies to streamline the flow of goods is the urban distribution centers, which are aimed at consolidating deliveries and pickups. Although the sustainability of these distribution centers depends on a delicate balance between private and public incentives, so that there is a progressive decrease in the participation of private distributors, due to low profitability and lack of support at the local politicians.

- Policies based on information: these measures focus on the exchange of information between agents, in order to support the programming and planning of routes for goods vehicles.

- Management policies: conducted by private and public actors, and are designed to promote cooperation between operators.

3. Research Methodology

These sustainability policies lead local authorities to increasingly restrict the access of vehicles to the central area of cities by means of pedestrianisation schemes, parking space elimination or access restrictions. One of the measures imposed by the local authorities, which is one of the most used towards greater sustainability of their cities, is the pedestrianization of the historical city centers or imposing access time windows. The vehicle access restriction reduce the impact of traffic in these places of cultural interest and increase livability, but also increases the regulatory pressure on private motor vehicle. But besides the tourist, historic city centers are often places where the concentration of commercial and office buildings is high. It follows that these areas needs the goods supply highly, and this makes city logistics continue to have the same importance in these places, if not more, than before the imposition of restrictions. In addition, such restrictions are imposed on accessibility normal business hours, this time being the only ones that can receive goods retailers (Muñuzuri et al., 2012a).

These access restrictions are often applied in the form of time restrictions, establishing time windows for passenger cars and delivery vehicles to access the restricted area. This type of time window differs from the ones found in the Vehicle Routing Problem with Time Window (VRPTW) which is not imposed by the customer, but the local authorities. Besides, the time window is not only related to accessing the customer's premises, but in general to the overall restricted area, also forbidding delivery vehicles to cross it or wait inside of it, even if no delivery operations are in progress. We will refer to this planning process as a Vehicle Routing Problem with Access Time Windows (VRPATW), which combines the zonal and the time factors affecting equally all the customers established inside the restricted area (Muñuzuri et al., 2012b).

We consider our vehicle routing problem defined on a graph: [N, L], where N is the set of nodes and L is the set of links communicating them. The set of nodes N contains one node d with a positive level of supply (depot), a subset C of nodes with a positive level of demand (customers), and another subset $\bar{C}$ of nodes with zero levels of supply and demand, so that $N = (C \cup \bar{C}) \cup d$. A number V of vehicles (where V is a variable) will travel through the graph visiting all the different customers, only one vehicle per customer. We do not consider capacity restrictions on vehicles, which is a realistic assumption in the case of less-than-truckload urban freight deliveries, where vehicles are rarely full.

The problem is defined inside a predefined time horizon, corresponding to the day's working hours, and the objective is to minimize the number of vehicles that need to be used and the cost (in time units) of transporting goods from the depot d to the nodes of C, crossing along the way the necessary nodes of the subset $\bar{C}$.

We also define a set *T* of time costs associated to the different links in the graph. These costs depend only on the transit of vehicles through links, and not on the amount of freight carried by those vehicles. In general, we will incur in cost t_{ij} when travelling from node *i* to node *j*. We will also compute the unloading time at each customer as a time cost *h*, incurred every time a vehicle visits one of the customer nodes contained in *C*.

Within the set of nodes *N*, we also consider a subset *RZ* of nodes that correspond to the restricted zone, and which cannot be crossed or visited during a pre-specified closed time window period (*CWT*), which period will obviously be smaller than the overall time horizon. We assume that $C \cap RZ \neq \emptyset$ and that $\bar{C} \cap RZ \neq \emptyset$ (see Figure 1).
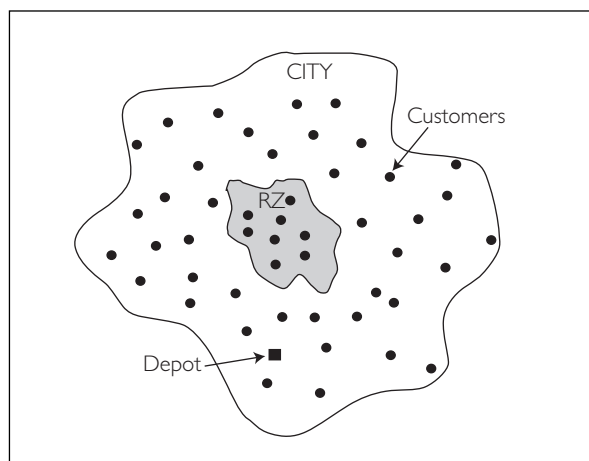

Figure 1

Schematic representation of a city where a VRPATW applies

In terms of the solution approach, we have used a standard Genetic Algorithm to determine the impact of the access time. Algorithmically, we believe the main methodological contribution lies in the computation of the fitness function, specifically designed for the characteristics of the VRPATW. We applied the aforementioned algorithm to the real case of a company operating in the city of Seville, in the South of Spain, transporting less-than truckload deliveries to around 100 customers daily from its premises located in an industrial area in the outskirts of the city. Many of these customers are located inside or near the city centre, and the company's operations are greatly affected by the access time window restriction imposed by the local authorities. In order to prevent high pollution levels and to avoid their interac-

tion with passenger flows and with tourists visiting the monuments located there, accessing, or remaining in, the centre is forbidden for delivery vehicles between 12.00 and 16.00 every day. And, within an intense campaign of pedestrianisation and promotion of clean transport systems like bicycles, the local authorities are considering to extend these forbidden hours, and even to extend the restricted area on which the access time window is applied. But no actions have been taken towards evaluating the effect of these policies on the costs of transport operators and on the environmental cost in all over the city (Muñuzuri et al., 2012b).

4. Experiments and results

It was designed a battery of experiments based on statistics derived from the company consulted and in a Seville network. With these and some estimates data was designing 30 different configurations intended to meet most of the real situations in which a freight delivery company can find in a city like Seville. At first were designed generating the location of the depot and different clients randomly, except that imposed a higher percentage of those in the restricted zone to simulate the largest number of customers in the city center. Later were designed 10 different variants of each configuration. In search of more general results and not fall into wrong conclusions derived from particular inputs, which resulted in a total set of 300 problems.

Table 1 displays the excess costs forced upon the case study delivery company with respect to the base scenario without access time window. These excess costs are expressed in kilometers and then transformed to monetary values assuming fixed costs for a van (105.06 €/day) and average costs per km (0.163 €/km) (Spanish Ministry of Public Works, 2011). The increases in the total distances covered and the subsequent cost are obviously larger for larger restricted zones and closed-window times, but are in any case significant for all the different scenarios considered.

5. Conclusions

This problem provides several interesting findings:

- The scenarios with the current size of the restricted zone (RZ=2) show small cost increments with respect to the base (no-window) scenario, but these increments grow larger as the length of the time window (TW) increases.

Table 1
Average time and cost increases with respect to the scenario without access time window

		Average Time and Cost Increases								
		RZ = 2			RZ = 5			RZ = 9		
		TW=2	TW=4	TW=6	TW=2	TW=4	TW=6	TW=2	TW=4	TW=6
50 C	Δ Km(%)	7.2%	7.1%	9.5%	10.5%	18.2%	53.6%	46.8%	112.8%	280.1%
	Δ€(%)	23.4%	26.0%	29.6%	36.3%	68.8%	169.9%	69.5%	145.0%	311.7%
100 C	Δ Km(%)	11.2%	13.1%	19.2%	19.6%	29.2%	103.0%	50.7%	137.3%	352.3%
	Δ €(%)	15.2%	25.0%	40.1%	43.9%	75.6%	211.6%	62.9%	162.0%	370.2%
150 C	Δ Km(%)	16.5%	19.2%	33.5%	36.8%	71.3%	209.8%	51.7%	115.7%	313.3%
	Δ €(%)	19.3%	14.0%	26.2%	31.7%	60.5%	198.9%	40.0%	99.2%	277.5%

- The scenarios with RZ=5 do show significant differences with respect to the base scenario like a large increase in the number of vehicles required in the fleet, which represents overall cost increments of up to 400%. As expected, these differences increase with the length of the time window.

The influence of the RZ and TW parameters are larger when the number of customers is larger, despite the possibility of having more options to configure near-optimal routes, entering and leaving the restricted zone, when the number of customers increases.

The scenario with RZ=5 and TW=4 shows better results than the scenario with RZ=2 and TW=6. This indicates that the influence of the length of the time window increases as the size of restricted zone grows.

Based on the results provided by the scenarios analyzed in the test problem, we can conclude that the VRPATW algorithm constitutes a sound technique to assess the introduction of access time window policies from the point of view of sustainability. We have shown the influence of the three parameters considered (number of customers to visit, size of the restricted zone and length of the time window) and the fact that a small increase in one of them does not significantly affect the results, but bigger increases in at least two of them causes relevant extra distance traveled.

These conclusions cannot be considered obvious when these extra distance traveled are neglected by local authorities when implementing access time window policies, while considering externalities like pollution, congestion or visual intrusion. The contribution of Operations Research techniques provides a powerful tool to evaluate the impact of these sustainable policies and incorporate them to the analysis. The model presented with its test problems show the need for more vehicles and more route time than in the case of no time window scenario. The implications of this fact in terms of extra cost and pollution suggest that, as conclusion and as answer to the question in the title, this policy in particular is no really sustainable even been calling like a sustainable policy. Since it only takes into account the social dimension and not economic and environmental.

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