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Assessing model for adoption of new logistical services: An application for small orders of goods distribution in Brazil

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Abstract

The distribution of goods in urban areas is characterized by a concentration of residences and commercial activities. However, the impacts of distribution reduce the welfare and related attractiveness of urban areas. To face such as impacts, the development of the concept of city logistics may produce a reduction of diseconomies in the urban context, in order to provide an efficient good distribution system. Thus, this work aims to present a methodology to evaluate the viability of implementing intelligent delivery points in Brazil, analyzing the economic and ambient adhesion to the service and their impacts. For the development of this methodology two theories have been applied: the diffusion of the innovation and system dynamics, which were validated throughout an application for the Metropolitan Region of Florianopolis (Santa Catarina State). The results suggest that the adoption of the service, as well as the use of alternatives logistics may be well applied into the concept of city logistics.

Keywords: E-commerce; goods distribution; intelligent delivery points

1. Introduction

The urban distribution of goods occurs in areas characterized by concentration of residences and commercial activities. However, the impacts of distribution reduce the welfare and related attractiveness of urban areas. To face such as impacts, the development of the concept of city logistics may produce reduction of diseconomies in the urban context, in order to provide an efficient good distribution system.

The problems generated by urban distribution have become more critical with the increase of the e-commerce, which has low density of customers with high geographic dispersion. Such a phenomena usually produces an increase upon distribution costs. To reduce this problem, it is suggested that intelligent delivery points be implemented that, located strategically, would allow an increase in the distribution efficiency, with customer flexibility to remove orders.

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2. E-Commerce and Its Impacts in Logistics

E-commerce is an expanding market throughout different types of products and services, which has generated gaps in urban distribution. This type of commerce offers new possibilities to commercialize products and services without requiring physical space to display and to sell products to the customers. Moreover, it facilitates the purchase of products and the delivery to the consumers at their homes. In such a way, electronic commerce and home deliveries are strongly related (Visser and Nemoto, 2003).

There has been an increase of home deliveries from e-commerce. This costs substantially increases when customers are not at home and multiple attempts of delivery occur. Moreover, the economic costs associates to this kind of delivery cause an impact in the average distance covered for order/vehicle, in the number of orders/truck and in the attempts of delivery/order (Laseter and Shapiro, 2003).

As the physical distribution of goods to the customer becomes a critical factor for the success of such as business model, transportation operators have a commercial interest in handling the "last mile" efficiently, in order to control overall costs (Huschebeck and Allen, 2005).

Amongst the logistics solutions there would be improvement in the supply chain to reduce costs with intelligent delivery points and the quality of the service provided, mainly in the home deliveries, which would have the assurance of service quality on the assumption that the customers pay more for a better service. Here, home deliveries can reduce total number of trips and the average vehicles/kilometres travelled.

In Brazil, the implementation of intelligent delivery points are a way to minimize the impact of the high urban distribution cost of products from e-commerce, which are strategically located at high-generation travel on places such as shopping malls, convenience stores, supermarkets and others.

Anyone could use the delivery points. To use the delivery points it is necessary to perform your registration on the company website which is offering the required service. After performing the registration, users are be sent an electronic card containing the customer information and an alpha-numeric password. With the card and the password, the customer will be able to receive, at the intelligent delivery point systems, products purchased in e-commerce. The receipt of the purchase is made throughout the confirmation of the customer identity by inserting the card in the equipment and entering the password. With the identification of the client validated, the compartment containing the purchases will open. After the order is withdrawn, the compartment is closed automatically.

Delivery points require special logistics for their products. Therefore, a limited time delivery is also required in the e-commerce strategy. When an individual becomes able to use the intelligent delivery point, a map with points of delivery will be processed by the virtual store, and sent to the people in charge by the logistics of distribution, which seeks to place the order specified by the customer in the shortest time possible. When the product is deposited at the intelligent delivery point, the equipment, which is connected to the Internet, will send via an SMS (short message service via mobile phone or pager) or email, as acknowledgment that the product is available. The suggested operation of the equipment and logistics of products destined for intelligent delivery points is shown in Figure 1.

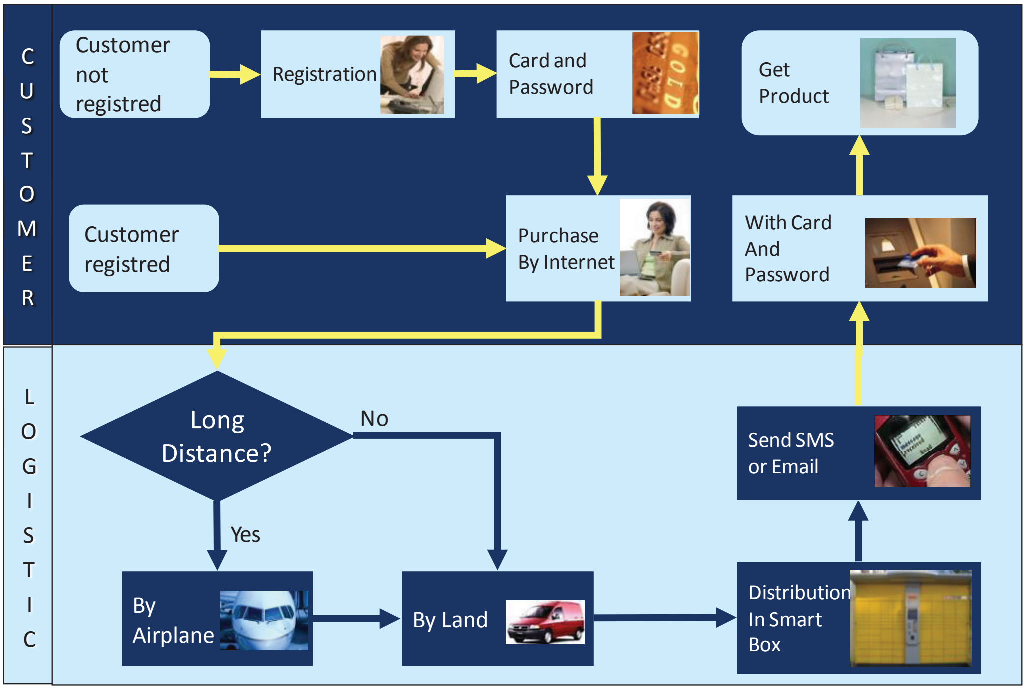

Figure 1 Flowchart of the operations and logistics of the equipment (Oliveira, 2007)

3. Methodology

A model such as the one discussed throughout this work, aims to access the viability of implementing intelligent delivery points in Brazil. The model is composed of four phases which enable us to access the customer's behaviour related to the new system, by providing preliminary information with respect to the amount of equipment, facilities and vehicles required to implement the service. Each phase is presented with their respective models of loop causal, stock and flow, the relationship among them and related variables, as explained below.

3.1. Phase I: Scheme of adhesion process to the proposed new system

Figure 2 shows the second phase, in order to analyze the electronic customer's behaviour to join the new system of intelligent delivery points, based on goods purchase and market competition. At the beginning all individuals are considered as potential customers of the new system. The new system's customers, according to the Bass model (Bass, 1969), are those which propose to use the new system, being motivated to do so by external influence such as publicity, social interaction and costs.

In this phase, the stock is represented by variables expressing potential customers as well as those already using the system. Potential customers are those individuals which remain in the usual delivery services of small electronic commerce orders, e-Sedex. The new system's customers are those adopting the intelligent delivery points. Flow is represented by a variable representing customer's adhesion, which is related to the number of individuals who migrate from the e-Sedex system to the new intelligent delivery points.

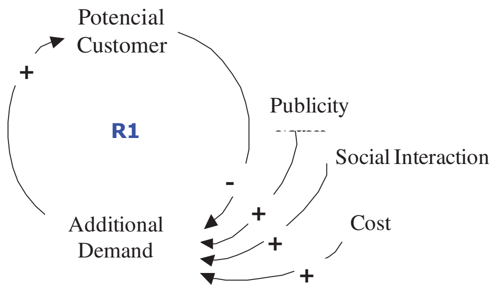

Figure 2 Casual loop diagram related to the innovation diffusion process

As the adhesion process does not occur right away, the information provided by publicity, social interaction and through perceived cost needs some time to be assimilated by new customers. Thus, the adhesion flow shows the elapse time required for potential customers to understand the new idea and becoming use to the service. The system connection is represented by variables which affect the adhesion flow. The customers who join the service as a result of publicity are related to the efficacy of the propaganda message. In other words, propaganda influences the potential customers decision to join the new system. The adhesion process by social interaction occurs throughout the information passed by people with respect to the new system efficacy. The adhesion process as a result of perceived costs occurs when potential customers seek an economic advantage by using the new system (collect points) compared to e-Sedex. The population for the experience was taken as those internet customers which may use the intelligent delivery points.

3.2. Phase II: Demand analysis

Demand analysis aims to identify the additional demand of future customers, which has been represented in Figure 3 by a casual loop diagram. This figure shows that the additional demand is positively influenced by variables of innovation and the rate of projection. In other words as the customers adhesion increase (decrease), higher (lower) will be the additional demand.

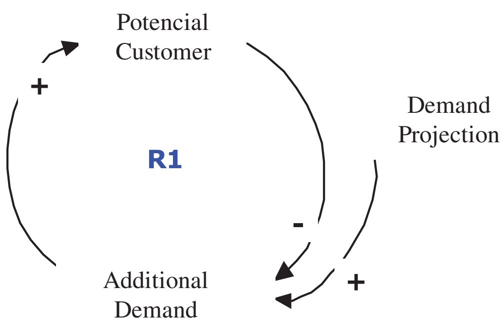

Figure 3 Casual loop diagram of demand analysis

3.3. Phase III: Dynamic of urban distribution of small orders

At this phase, the modelling proposed was developed to analyze the behaviour of variables related to urban distribution. As long as the demand was defined on previous phases, the vehicles and equipment required can be also determined.

The amount of goods ordered for each system may be also analyzed at this phase, as shown in the diagram presented in Figure 4.

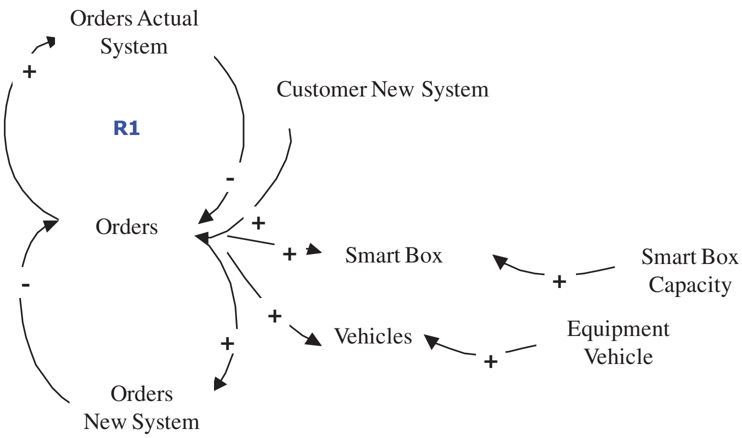

Figure 4 Casual loop diagram for the urban distribution model

There is a negative relationship between the "variables order" e-Sedex and those from the new system. Or, as e-Sedex orders are higher (lower), lower (higher) will be the number of orders from the new system. Furthermore, another important aspect relates positively the variables in the new system, the number of vehicles and equipment required is related to the number of orders generated in the new system.

3.4. Phase IV: Economical and environmental evaluation

Throughout an economical and environmental evaluation it is possible to identify if the new system produces any benefit to the society. Such as economic approach is usually undertaken through a viability study.

The environmental evaluation, otherwise, analyzes the amount of pollution emissions from each system. According to Vasconcelos and Lima (1998), the coefficients of pollution emissions caused by vehicles depends on the type of propulsion, vehicles conditions and the fuel used. This analysis will focus on three main polluters which are harmful to public health, Carbon Monoxide, Hydrocarbon and Nitrogen Oxides (Ibama, 2006). Table 1 presents the amount of pollution for each type of vehicle (Ibama, 2006) considered in this study.

Table 1 Rates of pollution emission (g/km) by vehicle type (Source: Ibama, 2006)

Pollutant Type	Light Commercial Vehicle up to 1700 kg (g/km)	Light Commercial Vehicle more than 1700 kg (g/km)
Carbon Monoxide	2,00	2,70
Hydrocarbon	0,60	1,00
Nitrogen Oxide	0,30	0,50

Furthermore, equations which relate the emissions of Carbon Monoxide, Hydrocarbon and Nitrogen Oxides with speed were derived using data from CETESB (Technology and Environmental Company) for an average size of vehicle operating in São Paulo (SP) (CETESB, 1994). In the case of vehicles with gasoline propulsion, the following equations for pollution emissions were defined:

Considering V, a speed variable (km/h):

$$\text{Carbon Monoxide (g/km)} = -4{,}51 + 726 \times V^{-1} + 1{,}34 \times 10^{-3}\, V^{2} \quad (1)$$

$$\text{Hydrocarbon (g/km)} = -02{,}8 + 62{,}48 \times V\text{-}1 \quad (2)$$

$$\text{Nitrogen Oxide (g/km)} = 1{,}03 + 7{,}477 \times 10^{-5}\, V^{2} \quad (3)$$

According to Vasconcelos and Lima (1998), the monetary evaluation of environmental pollution is a very complex subject, because it requires an approach relating to the effects of pollution upon human beings which may vary in many ways.

Carbon Monoxide may cause dizziness, headaches, sleep, and reduction of reflexes and loss of time notion. It is considered to cause more traffic accidents in urban areas, with old people being the main victims. Hydrocarbons irritate the eyes, nose, skin and the breathing system, it reduces visibility, causing accidents. Nitrogen Oxides also cause health problems, mainly with respect to the breathing system, reducing body defences. According to Vasconcelos and Lima (1998), there has not been any study deriving monetary values for pollution in Brazil. The figures adopted for this study are those suggested by the authors, based on American and European environmental costs, which may approach the situation in Brazil when income per capita is considered.

According to Vasconcelos and Lima (1998), the following values may be adopted:

Carbon Monoxide = R$ 0,19/kg (4)

Hydrocarbon = R$ 1,14/kg (5)

Nitrogen Oxides = R$ 1,12/kg (6)

4. The Florianopolis (SC) Metropolitan Region

The Florianopolis Metropolitan Region is comprised of nine cities, approaching 821,423 inhabitants, which represents 14% of the state of Santa Catarina's population.

That region was selected because of its potential to implement the new system. The main reason was the higher rate of access to internet from households which, according to the National Survey of Domiciles Sample – PNAD (PNAD – IBGE 2006), is 19.7%. Furthermore, that region shows a higher Index of Human Development and Gross Domestic Product per capita in Brazil, which may raise the electronic commerce consumption in the region. Besides, traffic congestion is frequent as a result of population growth.

4.1. Premises considered

The data were obtained by the Collision Process developed by Kaiser Associates, which matches data obtained from literature available, against interviews with experts in the area. Such as methodology was used because there are not any intelligent delivery points in Brazil at this moment. Thus, the information used was taken from Lamin (2005) combined with data from Santa Catarina Postal Service, obtained through interviews.

For this study, the Florianopolis Metropolitan Region the population with age superior to 18 years old, were used which, according to IBGE (2000) is approximately 543,763 inhabitants. The population growth rate of 2.98% per year, was also taken for the study (IBGE, 2000).

The collection points were related, in this study, exclusively to electronic commerce products, which, in general, have virtual companies headquarters placed in São Paulo or Rio de Janeiro. Thus, the cities were considered as the main origin points for the flow of products. Furthermore, the same cost applied to the e-Sedex service was taken as the transfer cost of products between those cities and Florianopolis.

The Florianopolis Metropolitan Region receives about 177 orders on a daily basis, from electronic commerce. The maximum volume of orders is about 0.052 m^3 and the capacity of vehicles undertaking the distribution of goods is around 8 m^3 (Renault Utilitarian Cargo), each vehicle operates 8 hours per day.

The equipment size and cost to be applied at the collection points were estimated together with a specialized company in Santa Catarina, which has the capacity to store 76 orders by equipment, with an average cost of R$ 30,000 per unit (US$1 is estimate R$1.90). Seven days was the maximum time allowed for clients to retrieve their purchase from the equipment without extra charges (Oliveira, 2007).

4.2. Results with moderate strategy of publicity

In this context, the adhesion to a new system occurs in six years, as shown in Figure 5, suggesting that moderate policies and well placed focus may represent an interesting strategy to spread knowledge about the new system. In other words, the publicity strategy has to concentrate on classes who acquire products from electronic commerce, as a previous condition to the system's success.

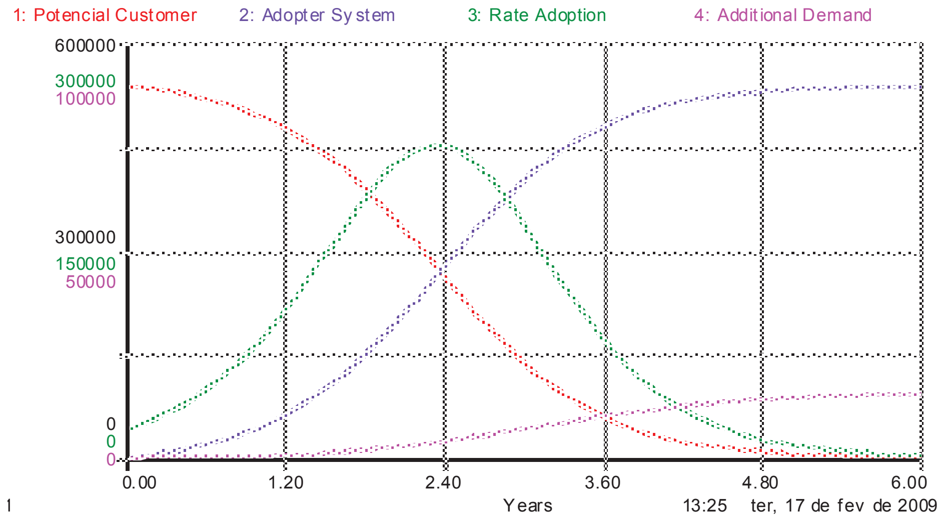

Figure 5 Results of dynamic modelling for the adhesion process and demand analysis

Furthermore, because of the model diffusion there is a tendency for orders to be reduced in the current distribution system and a rise in orders into the new system.

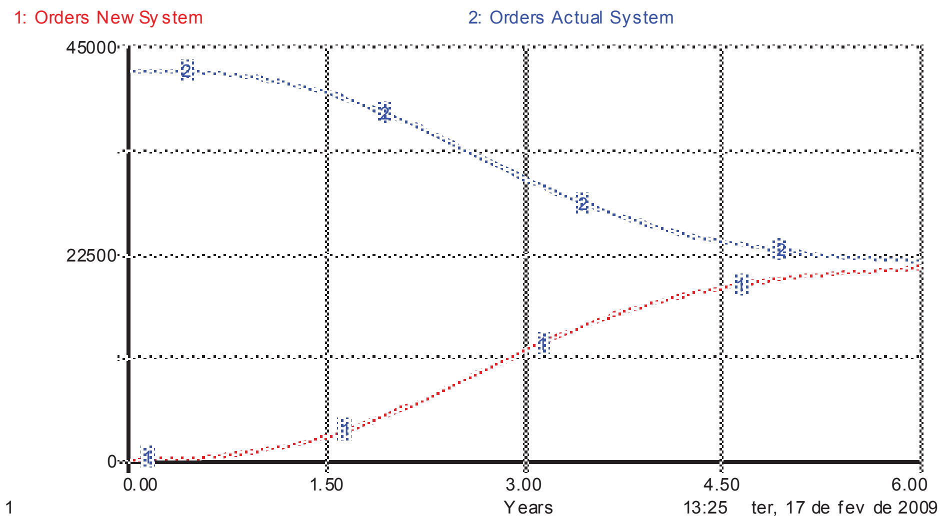

Figure 6 Results of urban distribution dynamic modelling for small orders – average number of orders

Aiming to attend the orders demanded from phase I and II, the model estimates the amount of equipment and vehicles required by year of implementation (Figure 7).

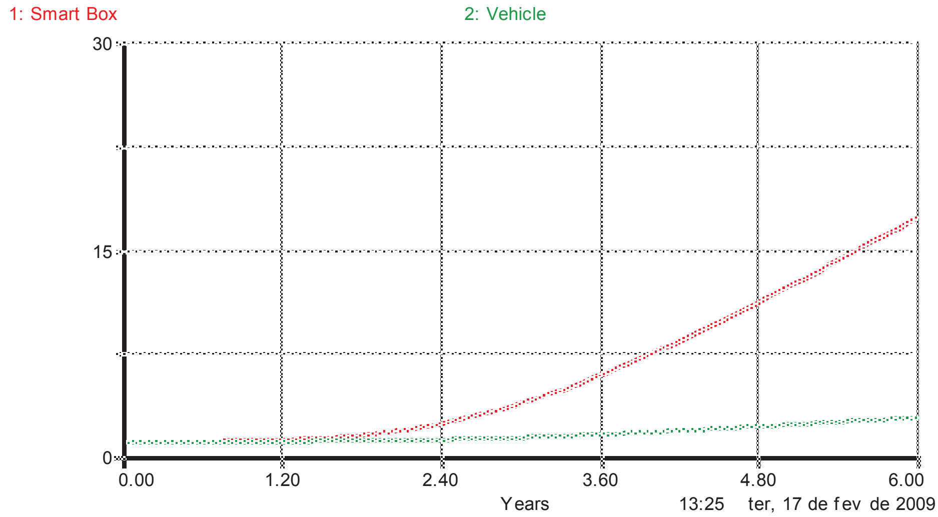

Figure 7 Results of dynamic modelling of urban distribution of small orders – average number of equipments, facilities and vehicles

4.3. Results of economic viability study

The Florianopolis Metropolitan Region is divided into 9 delivery zones nominated as distribution centres. Each one will receive throughout the delivery points system an average amount of orders per day, being the required amount of equipment and vehicles as shown on Figure 8. The choice of vehicle was based on information provided by Novaes (2003) and the model applied to specify the fleet size and the routes length in the delivery areas was based on Novaes (1989).

Considering the amount of equipment to be implemented for each year of analysis and the number of orders in the new system, it was possible to develop cash flow information, within the economical viability study. Thus, a value of R$ 1.89 was defined as the minimum fare to be applied for each equipment, in order to achieve a viable system.

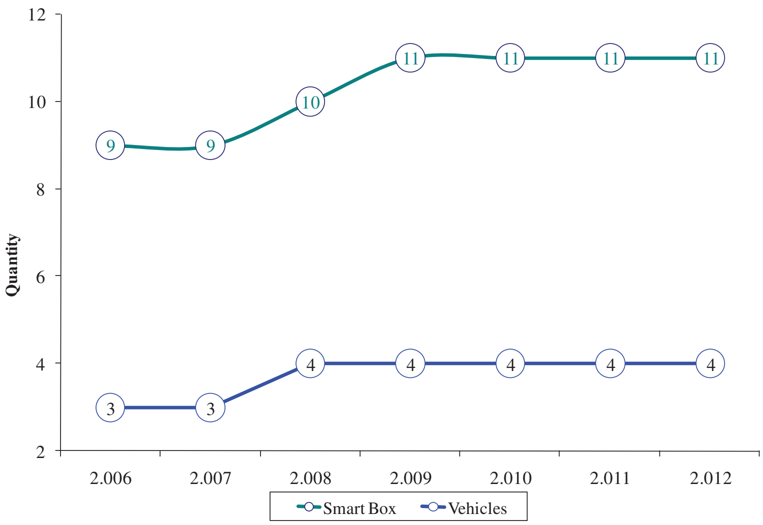

Figure 8 Equipments and vehicles dimension

4.4. Estimating minimal cost of distribution in the Florianopolis metropolitan region

The delivery systems proposed fare throughout this work is composed of distribution costs plus equipment operation costs. The distribution costs is the result of the sum of the product transfer cost from the origin (São Paulo and Rio de Janeiro) to the destination (Florianopolis) and the distribution cost into the Florianopolis Metropolitan Region. The first one was defined based on Postal service information. The second one was estimated by considering the average distance of operation per day and the reported average cost/km operated (Lamin, 2005), which was R$ 0.11/km operated. Table 2 shows the costs of distribution according to the origin.

Table 2 Distribution costs (Source: Postal service, 2006)

	Rio de Janeiro	São Paulo
Transfer Cost	R$ 11.50	R$ 5.50
Distribution Cost	R$ 1.39	R$ 1.39
TOTAL	R$ 12.89	R$ 6.89

When deriving the costs, a minimum fare suggested for the new system can be observed on Table 3. Comparing the current system of delivery with the electronic commerce system is possible to find an average reduction of 32% in the fare applied, without considering profits.

Table 3 Minimal fare suggested to the Florianopolis metropolitan region

Cost Composition	Rio de Janeiro	São Paulo
Equipment operation costs	R$ 1.89	R$ 1.89
Distribution Costs	R$ 12.89	R$ 6.89
TOTAL FARE	R$ 14.79	R$ 8.79

4.5. Environmental evaluation results

The fares value presented above become strongly appropriated when pollution emissions are calculated, considering the reduction of the number of vehicles operating. An important gain is related to the vehicle speed, because when operating a route with no stops, the average vehicle speed is higher, reducing emissions (Figure 9).

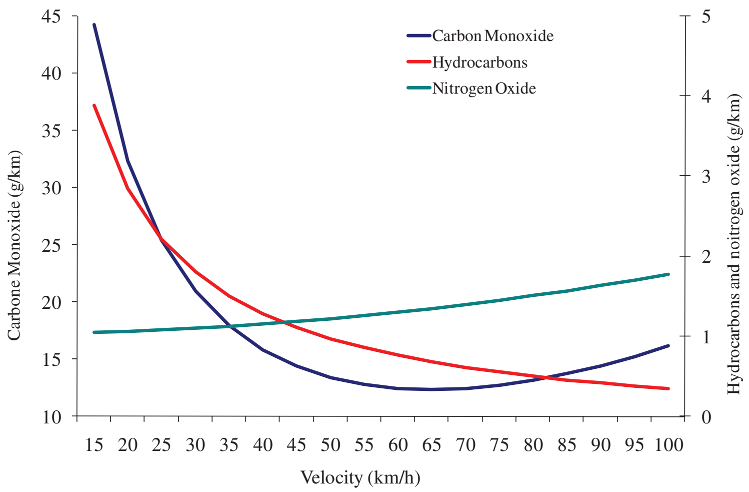

Figure 9 Relationship between speed and pollution emission

Another important issue is the average annual emission of pollution, considering the distance operated. The consolidated delivery allows a considerable reduction on average distance operated, reducing, consequently, the amount of emissions. It is worthwhile to say that the pollution emissions diseconomy may reach R$ 1,610.

4.6. Customer costs

Customer costs are an important factor to be considered, since all costs not related to the system are, automatically passed on to customers. One way to identify customer costs is using the trip cost model (Moons et al., 2000, Bateman et al., 2002), which is applied to estimate the economic value associated with a specific place. The basic model premises is that the spent time and trip means the place access price. Furthermore, what individuals are prepared to pay to have the service available can be estimated by the numbers that the service is used or by the advantage customers perceive when using the service.

Trip cost is comprised of expenditure with fuel and vehicle utilization, which includes maintenance and insurance, etc. In this work the fuel costs were only used, which was obtained by multiplying the distance operated by the fuel price (R$/km). A maximum distance of 5 km to the delivery point was used (Dutra, 2004). Then, the customer costs associated at such a distance will be R$ 2.60, representing an additional cost to customers who decide to use the delivery points. Otherwise, the customers would not have any costs if they are doing usual trips and take a chance to collect their orders, or when the service is perceived as a benefit when compared with environmental costs.

5. Conclusions

This work has presented the results of applying a methodology developed to evaluate the impacts generated when implementing a new distribution system based on electronic commerce orders, as way to reduce urban distribution problems, mainly associated with home deliveries. The new delivery system suggested is based on the concept of city logistics, which aims to reduce externalities and, become more efficient.

When applied to the Florianopolis Metropolitan Region, it was observed that, delivery points are viable to be implemented in the region. The viability was supported by the adhesion and the viability studies. The model efficacy was tested through sensitivity analysis. These results are very important to the planning phase, since it provides guidelines to evaluate the advantages of implementing a new logistic service to reduce home deliveries, and their related impacts.

The model application to real Brazilian situation becomes very important when considering that there has been only a limited amount of research considering logistics in urban areas. Furthermore, the model's application focuses one sector which has been considered as the most important in the Brazilian commerce, and the one responsible for the increase in home deliveries. A more efficient way to distribute goods in Brazil, focusing on traffic congestion reduction, has been considered as significant to make urban distribution more sustainable.

Relating to data applied in the model, considering the nature of the service proposed, the results provide planning guidelines and suggest the need for further research, mainly with respect to demand.

Finally, it was observed that in Brazil there are not many sources of information concerning the evaluation of emissions caused by urban distribution. However, the values obtained are considered important to perceive their effects on the environment.

References

Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Lee, M. J., Loomes, G., Mourato, S., Ozdemiroglu, E., Obe, D. W. P., Sugden, R., & Swason, J. (2002). *Economic valuation with stated preference techniques: A manual.* Department for Transport. Edward Elgar.

Browne, M., Allen, J., Anderson, S., & Jackson, M. (2001). *Overview of home deliveries in the UK (A study for DTI).* Freight Transport Association, University of Westminster.

Dutra, N. G. S. (2004). *Enfoque de "City Logistics" na distribuição urbana de encomendas.* Dissertation for the degree of Doctor of Industrial Engineering. Florianopolis, Brasil.

Huschebeck, M.,. & Allen, J. (2005). *Urban consolidation centres, last mile solutions.* BESTUFS Policy and Research Recommendations I. Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)

Ibama (2006). PROCONVE: Programa de controle da poluição do ar por veículos automotores e motocicletas.

IBGE (2000). Censo demográfico. Instituto Brasileiro de Geografia e Estatística.

Moons, E., Loomis, J., Proost, S., Eggermont, K., & Hermy, M. (2001). Travel cost and time measurement in travel cost models. *Working Paper Series*, n. 2001-22. Energy, Transport and Environment.

Nemoto, T., Visser, J., & Yoshimoto, R. (2001). Impacts of information and communication technology on urban logistics system. *OECD/ECMT Joint Seminar*, 5-6 june 2001, Paris.

Novaes, A. G. (2003). *Veículos leves para deslocamento de mercadorias no meio urbano: evolução e tendências*. Lecture in workshop "Tendências da Distribuição em Rotas Urbanas", Fiat, Minas Gerais, Brasil

Novaes, A. G. (1989). *Sistemas logísticos: Transporte, armazenagem e distribuição física de produtos*. São Paulo, Edgard Blücher.

Punakivi, M. (2003). *Comparing alternative home delivery models for e-grocery business*. Dissertation for the degree of Doctor of Science in Technology. Helsinki University of Technology, Department of Industrial Engineering and Management, Finland

Oliveira, L. K. (2007). *Modelagem para avaliar a viabilidade de implantação de um sistema de distribuição de pequenas encomendas dentro dos conceitos de city logistics.* Dissertation for the degree of Doctor of Industrial Engineering. Florianopolis, Brasil.

Rogers, E. M. (1995). *Diffusion of innovations*. Free Press.

Rogers, E. M. (1976). New product adoption and diffusion. *Journal of Consumer Research*, 2, 290-301.

Russo, F., Comi, A. (2004). A state of the art on urban freight distribution at European scale. *ECOMM 2004 - European Conference on Mobility Management*, 5-7 may 2004, Lyon.

Sterman, J. D. (2000). *Business dynamics: Systems thinking and modeling for a complex world.* Boston, Massachusetts, McGraw-Hill.

Taniguchi, E., Thompson, R. G., Yamada, T., & Duin, R. V. (2001). *City logistics: Network modeling and intelligent transport systems.* Pergamon.

Taniguchi, E. (2003). Introduction. In E. Taniguchi, & R. G. Thompson, (Eds.), *Innovations in freight transport*. WIT Press, Boston.

Vasconcelos, E. A., & Lima, I. M. O. (1998). *Redução das deseconomias urbanas pela melhoria do transporte público.* IPEA/ANTP, Brasília.

Visser, J. G. S. N., & Nemoto, T. (2003). E-commerce and the consequences for freight transport. In E. Taniguchi, & R. G. Thompson (Eds.), *Innovations in freight transport*. WIT Press, Boston.