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Evaluation of Production Management Tools in Urban Logistics

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Abstract: Urban cargo transportation (U.C.T.) has been studied with the objective that urban logistics meets at local economy needs. The increased supply of jobs makes families want to live in cities and, therefore, they need schools, commerce, laser areas and products that meet more than their needs. As a reflex, the concentration of more companies has been increasing, more jobs and more families, generating the need for more UCTs. The purpose of this theoretical essay is to use *kanban* techniques to rhythm the UCTs, as a way of maintaining an acceptable number of vehicles and loading and unloading operations in the urban environment. The *kanban* can synchronize deliveries, so as not to leave idle loading and unloading points, contributing to urban mobility and the reduction of UCTs costs with a more timely delivery.

Key words: urban cargo transportation. kanban, urban mobility

1. Introduction

Logistics represents a part of the supply chain that plans, implements and controls the flow and storage of goods, services and information from the point of origin to the point of consumption, meeting customer requirements [1]. In the urban environment, Taniguchi et al. (2001) [2] defined city logistic as the process of optimizing logistics activities, considering factors such as: traffic, congestion and energy consumption.

The urban cargo transportation (U.C.T.) is one of the elements of urban logistics that has been intensively studied due to the growth of cities. Fig. 1 shows the evolution of research in the last twenty years and was developed from data searched on Google Scholar website. The terms were searched “city logistic” and “urban freight transportation” in Google Scholar. The first term, being more generic, obtains a much higher result than the second term, but both demonstrate an accelerated evolution in number of searches.

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Where there is a population, there are businesses that need to buy inputs to sell products and give jobs to that same population. They are the needs of families, society, the State, and the products bought and sold need to be transported from one place to another. The easiness and greater offer of jobs make families seek to live in the cities, because there they find schools for their children, commercial establishments that offer them the goods they need, laser areas where they can have fun and, eventually, consume products that serve more that your needs.

As a result of this intensification of urban life, there is a greater need for UCT. When you have companies and families, selling and buying products from other companies and families, the products need to be transported between these agents. In a spatial organization, most cities grow in layers around a central region, generating a greater concentration of population in the central regions and, consequently, a greater number of UCTs [3].

This theoretical essay deals with the use of techniques used in the production and operations management to control the cargo movements in the

urban area. The objective is to systematize operations so that they result in less impact on urban mobility. The proposal is to use the *kanban* techniques to pace the UCTs, in order to maintain an acceptable number of vehicles and loading and unloading operations in the urban environment.

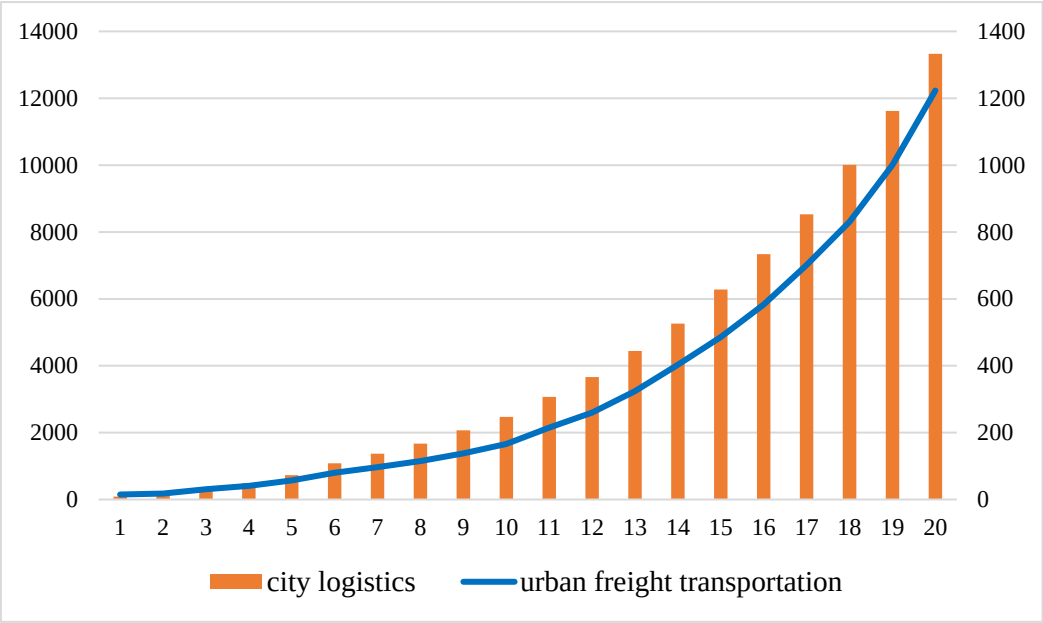

Fig. 1 Research Evolution in last 20 years.

The concepts of *kanban*, UCT and urban mobility are studied, in order to evaluate how the use of the technique developed by Taiichi Ohno, and applied in the 1950s Toyota [4], can be practiced in the urban cargo transport management to optimize urban mobility.

2. Research Problem and Objective

Based on Marconi & Lakatos (2017) [5], the research aims to understand and solve problems, which arise from the difficulty, practical or theoretical, from understanding something of real importance, for which the solution is sought.

In some situations, such as the one presented in this research, the practical study becomes unfeasible, as it would entail such a significant series of measures and resources that it would make the real test of the researcher's proposals unfeasible. On other hand, the theoretical analysis deductively subsidizes the hypotheses raised by the researcher, suggesting experiences and possible results to be achieved through the segment of routines defined in the experiment.

The problem situation is configured by the low supply of loading and unloading points in urban centers, associated with the high demand for these same spaces by transport vehicles. Currently, there is no regulation, or public or private management mechanism, that orders the flow of transport vehicles and the use of available spaces, thus, it is possible to find available spaces and, also, transport vehicles traveling at random in search of the specific place.

The research problem is configured by the need to plan and order the flow of UCT without it being an agent that maximizes traffic, congestion and energy consumption, factors that generate difficulties for the population to reach their jobs, schools for their children, commercial establishments that meet their needs, and all the necessary facilities for the urban population.

As an objective, this research intends to test theoretically the use of an essentially practical technique, used as a regulatory mechanism of the

productive processes (*kanban*) to regulate the set of components of the UCT, which, initially, is concerned with meeting the demand for products and then, takes care of overcoming the restrictions arising from the delivery of these products.

3. Theoretical Basis

3.1 Kanban

In an ideal production process, serving a single customer with a specific product, within a pre-established period, would guarantee maximum efficiency. So when the customer needs it, production produces the right product in the time needed. This is the just in time concept, disseminated by the Toyota production system, which foresees that the production processes are "pulled" by the customer's order, assuming intermediate stocks that only meet the order being worked on [6].

Thus, the production would be "lean" and free of waste, guided by the management mechanism called *kanban*, which originates from control cards that change positions on the production line and give the command to carry out the various production steps [7]. When the control card reaches the operator for a specific task, it indicates that pre-established actions are performed, and, only with the control card in hand, the operator can perform his task. The *kanban* system is characterized as a control, in real time, of the production flow that allows a fast and precise replacement capacity of inputs [8].

Considering that the cards originate from the customer's request, and that the number of possible cards represents the productive capacity of the factory, the calculation of the number of cards should dimension how much the factory produces according to its capacity. In this way, the *kanban* controls the operations and also scales them, so that the production capacity is maintained [9].

The *kanban* control works with an "invisible belt" that controls the operations of the production stages, leaving one literally "tied" to the other. Using this premise, it can be inferred that the technique can be used in several processes, in which, the principle is the same that the receipt of a *kanban* card triggers the activity of transportation, production or replenishment of stocks, for example [4].

In the context of card-based control systems, *kanban* has been widely recognized as a simple and effective tool for production control, with many new versions developed for different manufacturing scenarios. Its most representative evolution was the development for *e-kanban*, which consists of the incorporation of card-based control systems with information technologies [10], directed to the "Internet of Things", able to enable controls over long geographic distances, in real time [11].

3.2 Urban Cargo Transport (UCT)

Behrends et al. (2008) [12] define UCT as the delivery of consumer goods, by retail and manufacturing sectors, to urban and suburban areas, including the reverse flow of used goods. But, admittedly, this definition excludes expressive traffic of goods in the urban area, such as products made outside and sent to urban areas, that is, products purchased from different areas around the world and sent to customers in urban areas. There are also goods produced within urban areas and transported outside, and transport activities in close relationship with the provision of any service.

Ogden (1992) [3] says UCT is essential for modern civilization, where a large number of people are accumulated in areas far from their sources of food, raw materials, and industrialized products, causing a large flow of displacements within and to these areas. Thus, infrastructure resources for roads, terminals and vehicles are necessary to keep people supplied.

Completing the definition, Behrends et al. (2008) [12] claim that UCT is defined as "the transport of goods carried out by or for professionals in an urban environment", not including shopping trips made by families with their cars, but home deliveries made by

delivery operators. However, it still includes cargo traffic that crosses the urban territory without making deliveries (freight in transit).

In the research Oliveira et al. (2016) [13] identify 16 challenges for UCTs, of which the following stand out: the intensification of traffic congestion (79%); the space-time restriction on the circulation of cargo vehicles (76%); promoting the reduction of environmental and social impacts resulting from the activity of cargo transportation (69%) and the lack of interaction between the actors involved (52%), which are the carriers, customers, cargo operators, the government, and others.

Regarding the good practices found, the authors identified 26 good practices, of which the following stand out: implementation of distribution centers in urban areas (38%); the use of different types of vehicles for delivery and collection (31%) and the use of information systems for tracking and monitoring the fleet (28%).

In this work, UCT refers to the transportation of goods that have their loading and unloading within the same urban environment, characterized by the use of small trucks and alternative transport, whose dependence on specific spaces for this purpose has hampered its activity.

3.3 Urban Mobility

Pereira (2015) [14] compares the city to a living organism, in which, in order to carry out urban planning, it's necessary to understand urban geography and propose solutions to mobility problems without compromising the city's shape, through policies of transport, circulation, accessibility and traffic. According to the author, the "main objective of an urban mobility policy would be to prioritize the citizen in the realization of his desires and needs, improving the general conditions of displacement in the city".

Pero & Stefanelli (2015) [15] analyze a model inhabitant of a city, in which his time from home to work depends on the distance traveled, the mode of transport used and the level of congestion he goes through. Thus, there is a sensitive relationship between job opportunities and the possibility of housing in the various current cities, where the best urban mobility would be a consequence of public policies that address the best possible alternatives to reduce travel time.

Camagni et al. (2002) [16] show that studies must respect different patterns of urban expansion, associated with specific environmental costs, defining different types of urban expansion, with different impacts, making a single development pattern associated with land use and occupation practices inadequate. As an example, public transport is directly influenced by the development of the urban area, and the more dispersed and less structured its development, the lower the level of efficiency and competitiveness, and, consequently, its mobility.

In this perspective, Costa et al. (2017) [17] perform a collection of several examples of indicators that can direct a possible urban mobility plan, of which, as they are of interest to this study, are cited:

Mobility Impact Index (MII) — Analyzes the environmental impact of mobility and characterizes the variables with the soil.

Sustainable mobility rates — Evaluates the spatial distribution based on the sustainable mobility index.

Mobility Index for Environmental Effects (MOXE) — Quantify sustainable urban mobility.

Sustainable Urban Mobility Index (IMUS) — Supports decision-making in the context of urban planning.

Index for strategic management of sustainable urban mobility (IGEMUS) — Offers subsidies to strategic decision makers in the decision-making process.

Mobility Impact Index (MII) — Establishes different types of urban development and the relationship between different mobility patterns.

3.4 Theoretical Essay

The theoretical essay explores new approaches on a subject, proposing to carry out a

hypothetical-deductive approach based on a bibliographic research. Marconi & Lakatos (2017) [5] define that the bibliographic research deals with the survey, selection and documentation of the bibliography already published on the subject in question, reviewing books, magazines, newspapers, theses, dissertations, and others. Exploratory research, according to Gil (2010) [18], aims to approach the problem, with the aim of making it more explicit and clear.

For Severino (2007) [19], the theoretical essay consists of a study developed in a logical and reflective, discursive, conclusive and formal way, presenting a high level of argument and coherence, with extreme logical rigor. For him, the theoretical essay consists of a "logical and reflective exposition and rigorous argumentation with a high level of interpretation and personal judgment".

In the essay, there is freedom for the author to defend his positions because it is based on logical-reflective exposition with an emphasis on personal argumentation and interpretation. The essay discusses a certain theme, based on books, magazines and articles, in order to clearly express the defended idea and encourage readers to draw their own conclusions. Its reflective and interpretative nature is limited, not requiring empirical evidence, but only confirming assumptions [20].

According to Meneghetti (2011) [21], essays are widely used in the field of social sciences, where social scientists, politicians and sociologists produce reflections on the most relevant events of their time, taking Marx, Weber, Norbert Elias, and others as an example. In the essay, a formal conclusion is not necessary, because in the essay development, the conclusions are generated based on reflections and questions.

Finally, in an essay the author proposes theories that could influence other theories, without empirical evidence, but based on the study of bibliographic material, suggesting a result from hypothetical deductions.

4. Discussion

According to Triana & Beatrix (2019) [22], *kanban* thinking reflects the mechanism that occurs in supermarkets, where purchased goods are checked and registered by the cashier, who feeds the supply department with information about the type and quantity of items purchased, and , with this information, the items are automatically replaced according to five fundamental rules [23]:

1) The subsequent process (customer) must remove the necessary products from the previous process (supplier) in the necessary quantities at the necessary time;
2) The previous process (supplier) must produce its products in the quantities withdrawn by the subsequent process (customer);
3) Defective products should never be placed for subsequent processing (customer);
4) The number of *kanbans* should be minimized;
5) The *kanban* should be used to adapt to small fluctuations in demand (fine tuning of production by *kanban*).

Fig. 2 illustrates the technique in four stages, the first being (Stage 1), when the customer orders a product and the entire production chain is mobilized to deliver the product to him and produce a new one for replacement (Stage 2). Then (Step 3), the supplier provides a new product, replacing what generated the need, until another order is placed by a customer (Step 4), and the process again returns to Step 1. An "Intermediate Stock" point is indicated in the illustration, which in practice may represent a Distribution Center, or simply a stock in transit, depending on the Supplier's administrative structure.

The five fundamental rules of Monden (1994) [23] are met:

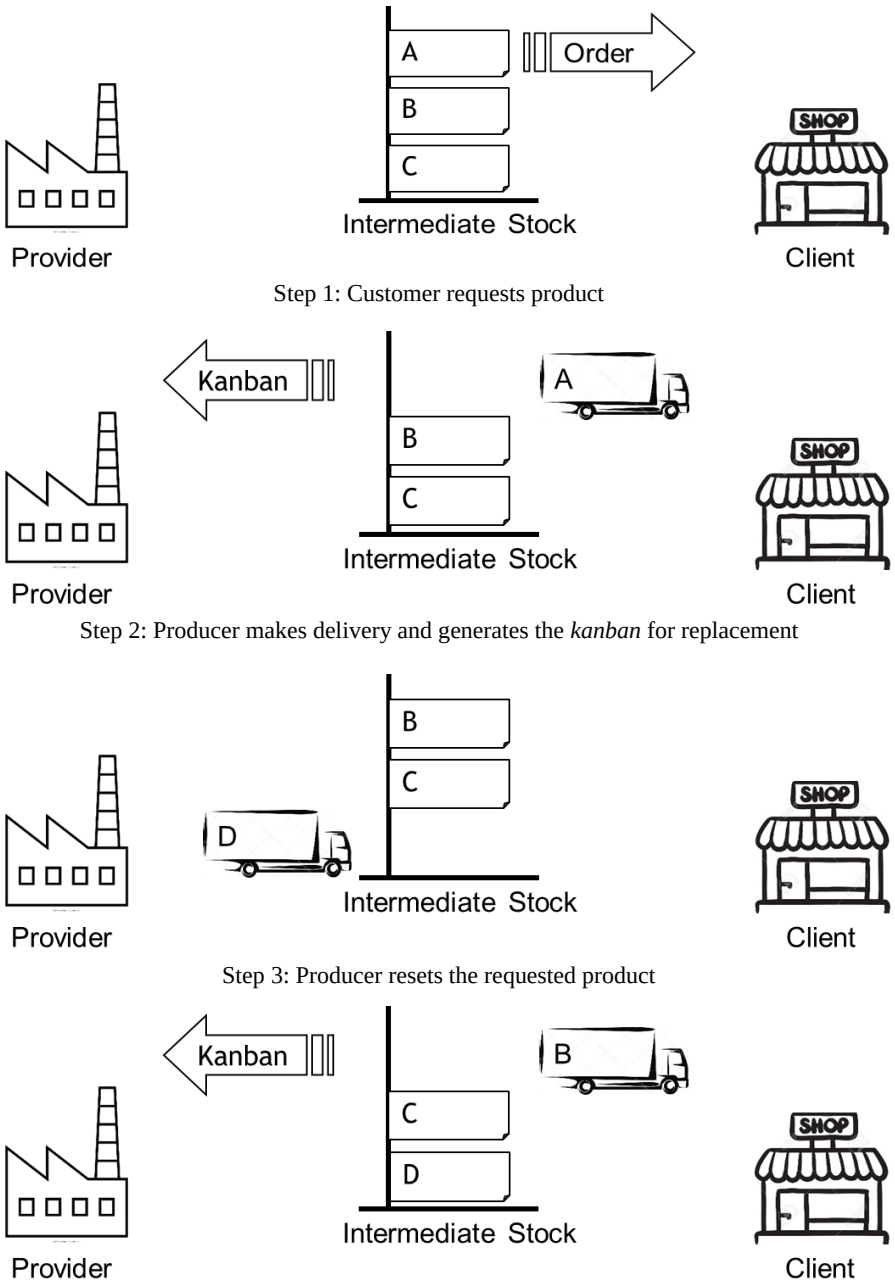

Fig. 2 Kanban technique illustration.

1) The customer orders the products from the supplier, in quantities and at the time he needs (Step 1);
2) The supplier delivers the products in the quantities withdrawn by the customer and, at the same time, generates the production order for replacement (Step 2);
3) The supplier restores the products to the same specifications accepted by the customer, so that he can find the same products again, with the same quality (Step 3);
4) The number of *kanban* commands must be adjusted to the supplier's production capacity, as, in the example, a purchase generates a production;

5) The *kanban* is used to adapt to small fluctuations in demand, which, in the example, would accept a variation of up to three concurrent sales.

The five rules are met, which confirms the correct use of the *kanban* system. It is noticed that if there is no customer, the product is not requested, and nothing happens. When the product is removed by the customer, the system commands that a new product be produced and made available to a new customer, and so on, successively. It is a perfectly synchronized relationship between the customer's product demand and its production. It is suggested that such synchrony contributes to the management of processes where there is a distortion between demand and supply, such as, for example, the demand for spaces for loading and unloading products in the urban environment.

The loading and unloading points in the urban environment are insufficient from the point of view of the demand requested by the cargo transporters, since there are not enough allocations, in the spaces and times requested, for all interested parties. Inverting the analysis, the loading and unloading points demand transport vehicles to feed them, and these transport vehicles do not arrive within the ideal operational expectation, causing congestion and loss of time.

With some investment in control and technology, the *kanban* system could synchronize deliveries, so as not to carry out unproductive transport and leave idle loading and unloading points, thus contributing to urban mobility, reducing UCTs costs and punctuality of deliveries.

In a certain restricted area of an urban region, the loading and unloading points A, B, C, D, are registered. As in some shopping mall garages, when the available vacancies are known in real time, these points would be monitored and controlled, in order to allow cargo carriers to enter only when vacancies are available [24]. Transport vehicles interested in using spaces A, B, C or D, would enter a row outside the restriction area, adopting their respective *kanbans* A1, A2, A3 ... B1, B2 ... C1, C2, C3 ... D1 ..., and would be allowed to travel to the point of interest only when A, B, C or D, are available.

As in production processes, when space for loading and unloading is available, transport T1 is activated (Step1), and the entire production chain is mobilized to deliver and produce a new T2 for replacement (Step 2). Then (Step 3), the supplier provides a new product for replacement until another order is placed by a customer (Step 4), and the process works again. Thus, if there are no vacancies available, there will be no transportation until a vacancy is made available (Fig. 3).

Here, too, the five fundamental rules of Monden (1994) [23] are met:

1) The availability of a vacancy generates the need to transport T1 cargo (Step 1);
2) The supplier delivers the T1 cargo to the customer and, at the same time, generates the T2 transport order for replacement (Step 2);
3) The supplier provides the load of new products contracted by respecting the availability of space to carry out the delivery (Step 3);
4) The transport command must be adjusted to the availability of spaces so as not to underuse transport services;
5) The *kanban* system represents the control between availability of vacancies and deliveries, which, in the example, would allow three concurrent loads.

As mentioned, a similar technique already occurs in shopping centers and parking lots where there is a specific technology in place, which signals the existing spaces and their location. Thus, the vacancy is only empty if there is no one interested in using it, and those interested are organized in such a way as not to waste time looking for a vacancy that may not exist [24].

It is evident that, for this routine to be implemented, more than the will of the Urban Cargo Carrier and its Customers, it would also be necessary [24]:

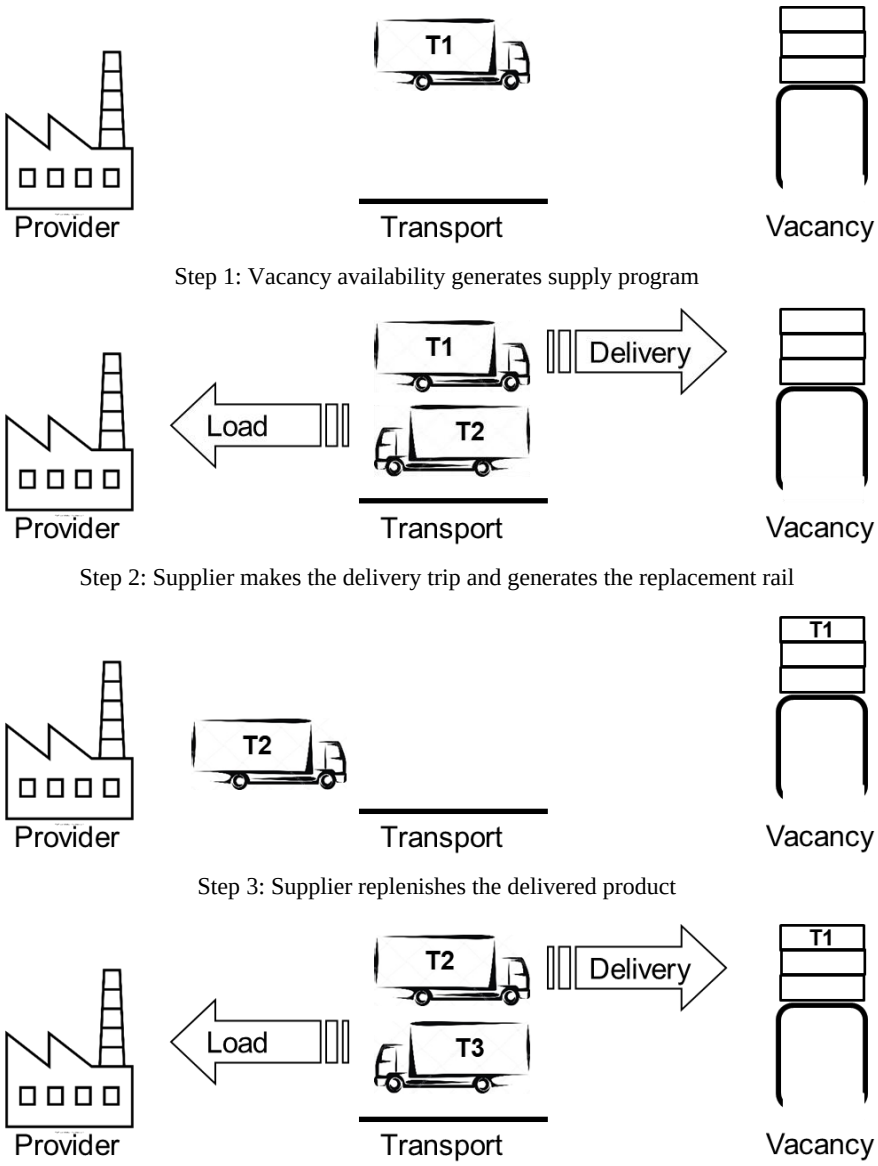

Fig. 3 Illustration of the *Kanban* technique applied at UCT.

- *Public regulation* — officialize appropriate loading and unloading points, located at strategic points for deliveries;
- *Implementation of technologies* — implement vehicle control systems that would make the identification and indication of available points;
- *Delivery flexibility* — predict the integration of UCTs to the system, allowing deliveries at different times.

With the implementation of the *kanban* technique to control the access of cargo transport vehicles in urban areas, there would be a perfect synchronization between the trips for deliveries and their conclusion in the loading and unloading of products, without transport vehicles looking for or waiting for places to perform the delivery. Furthermore, there would be a better occupation of the available loading and unloading points, valuing urban mobility and the well-being of the population.

5. Conclusion

The theoretical essay was the means found by the author to scientifically analyze the possibility of using a technique designed in industrial production lines, for the management of the processes of transport and loading and unloading of products in the urban environment, since no empirical means were found that would prove the assumptions.

The analysis is coherent and, from the hypothesis of using the *kanban* technique in the management of the UCT, what is deduced is that this is fully possible, obviously supported by factors such as Public Policies, Technology and Business Management.

The study shows that there is a possible technique to be used, which should achieve an expected result, with future studies identifying ways to use the technique in practice.

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