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Towards a taxonomy of City Logistics projects

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Abstract

We present a three-layer taxonomy of City Logistics projects that provides the means to explore the similarities and differences in the elements characterizing the various City Logistics initiatives as a step towards better understanding and predicting their performance. To illustrate its interest, the taxonomy is used to describe well-known systems and identify a number of trends in the evolution of City Logistics.

Keywords: City Logistics; project taxonomy; trends

1. Introduction

Urban population is steadily growing (OECD, 2003) and cities around the word face continuously increasing challenges in terms of efficient transportation of persons and goods, while controlling and ideally reducing its negative impacts, e.g., congestion and pollution, on the quality of life of their citizens. Freight transportation appears prominently on both sides of this equation. The *City Logistics* concept has emerged as a comprehensive approach aimed to mitigate the negative impact of urban freight transportation without penalizing the city's many economic, social, administrative, cultural, touristic, and other activities.

The nineties have seen a significant increase in the general awareness regarding these issues and many initiatives, henceforth identified as City Logistics Projects (CLPs), have been undertaken, mainly in Western Europe and Japan (Dablanc, 2003). Numerous projects have been contemplated or undertaken since, both in these initial regions and elsewhere around the world. As most logistics-related decisions were (and are) made on the basis of the experience and intuition of experts, skilled operators, and planners (Taniguchi et al., 2006), these CLPs experimented with various business and organizational models. Private companies initiated most CLPs in Germany and Switzerland, with public authorities providing little support (Visser et al., 1999). City Logistics concepts found more support from public authorities in Japan and The Netherlands through subsidies or rules favouring participating companies. In Monaco and France, urban distribution is considered as a public service and CLPs had to complete for

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government support. Success has been varied, e.g., from approximately 200 projects planned or carried out in Germany during this period, less than 15 were still in existence by the end of 2002 (Browne et al., 2005). "Success" was also more marked for small to medium cities than for large ones. New projects are being proposed, however, revisiting "traditional" models and experimenting with new ones is common.

It is not without interest to explore in some depth the similarities and differences in the elements characterizing the various CLPs as a step towards understanding better the reasons behind these results. It may also help identify trends in the evolution of CLPs, in the way they are designed, evaluated, and operated. The time is particularly right given the steady development of CLPs observed around the world. At our best knowledge, no CLP classification in the literature provides a systemic and complete view of these issues. The few contributions one may find often use criteria, e.g., "based on Urban Distribution Centre" or "based on carrier cooperation", which are much too aggregated for a comprehensive analysis. Moreover, factors not often used in the first wave of City Logistics projects, e.g., integration of Intelligent Transportation Systems concepts and technology or the utilization of advanced methodologies and instruments for analysis, planning, and management, do not appear in most published classifications. This makes it difficult to identify major characterizing factors, to point to evolution in concepts and practice, to single out and understand success factors, to extract and analyze trends.

The goal of this paper is to contribute to fill this gap. It introduces a taxonomy of CLPs based on a comprehensive set of parameters providing the means to achieve these goals. The taxonomy is based on the analysis of a large number of CLPs and is organized according to three increasingly more detailed levels: five *components*, each being structured at the second level through a number of *criteria*, for which more precise information is given at the third level by *items.*

The next section presents our methodology, including a brief review of previous classification efforts and the description of the sample of some 70 CLPs used to define our classification rules. The taxonomy is detailed next. To illustrate the interest of the proposed taxonomy, we then describe two well-known CLPs in Monaco and Amsterdam, followed by a discussion of emerging trends in CLPs.

2. Methodology

The first issue to be addressed in designing the taxonomy is the specification of its object: what are we trying to classify? It is not, for example, a survey of City Logistics literature, although such a survey was part of the work. It also became rapidly apparent that a city-based classification is not satisfactory because, on one hand, several cities have experimented with various systems during the years and, on the other hand, several systems may exist simultaneously in the same (large) city. We thus decided on the *City Logistics Project* (CLP) as taxonomy unit, each representing a system proposed or implemented for a given city, or part thereof, and time period. A City Logistics system may evolve, of course, e.g., from a study phase, to a pilot implementation, to full-scale deployment. Due to their different characteristics, such phases are considered separate CPLs.

The second issue is the information required to specify the taxonomy. The level of information dissemination varied greatly from project to project, and gathering the documentary records presented significant challenges. We examined over 100 CLPs and decided to restrict our study to those for which pertinent and useful information was available. The final set contains 70 CLPs undertaken in 13 countries (Table 1) in the period, 1976-2007 (Figure 1).

We analysed qualitatively the information relative to the selected projects from the websites of the corresponding cities and projects, published papers, conference presentations, governmental communications, and consulting reports. We then organized the information by categories and subcategories.

Table 1 Projects by country

Country	Germany	Denmark	Spain	France	Holland	Italy	Japan
# Projects	13	2	5	9	8	8	4
Country	Norway	Portugal	U.K	Slovenia	Sweden	Switzerland	
# Projects	3	1	10	1	5	1	

We started from the existing CLP classifications. We rapidly observed, however, that these did not allow for the level of description we were looking for. Thus, for example, Taniguchi et al. (1999) and Goldman and Gorham (2006) focused on the “functional tools” used to (re-)organize urban freight distribution. The former used 5 “schemes”, regulation, cooperative systems, intelligent transport systems, public freight terminal, and infrastructure provision, while the latter defined 4 “families”: neighbourhood drop-off points, centralized urban distribution and logistics centres, construction logistics, and environmental zones. We notice the lack of many aspects, including legal, financial, technological, and so on.

A different and rather widespread classification consists of 3 models: German, Dutch, and Monaco. Other that it does not cover all proposed systems, this definition concerns almost exclusively the public support given to projects and to some extent their financing. Kohler (2001) focused on cooperation among stakeholders and described six forms for City Logistics in Germany, based on how flows and responsibilities were divided among carriers. The website of the French “Ministère de l’Équipement” presents a description of French CLPs, based on six axes, general description, stakeholders, stages and evolution, management-financing and regulation, activities, and transferability. These classifications are limited geographically, and the absence of a number of factors, in particular those related to information and decision technologies is noticeable..

Browne et al. (2006) proposed a classification of CLPs with Urban Consolidation Centres (UCCs; also called Urban/City Distribution Centres) according to 17 items based on an analysis of factors influencing the nature of UCCs and the options available within each factor. Yet, projects may be based on the same UCC organisation and still differ in many other important characteristics. Thus, associating all CLPs with UCCs into one category is too restrictive (Benjelloun and Crainic, 2008). Quack et al. (2008) independently developed a richer set of classification elements, which addressed several of these shortcomings, but still does not cover all relevant topics, their scope being the classification of papers in the proceeding books of past international conferences on City Logistics.

3. Taxonomy Dimensions

We propose a taxonomy based on the information available for the selected CLPs, as well as on a number of proposals in the literature not yet implemented in practice. It describes projects according to three, increasingly more detailed levels. The first level is made up of five *components*, each component being structured at the second level through a number of *criteria* representing its subcategories, for which more precise information is given at the third level by *items*. The taxonomy has twenty-two criteria and seventy two items. This section presents each component in turn, briefly describing its object and scope, as well as its corresponding criteria and items. The five components are *Description*, *Business model*, *Functionality*, *Scope*, and *Technology*. The first three are present in classifications present in the literature and we added the last two. The items are defined based on the study of the 70 projects, the criteria representing the result of our aggregation into homogeneous groups, coherent with the five components.

3.1. Description

Description gives the CLP context through five criteria: *Objectives*; *Status* giving its type; *Evaluation tools* referring to how implementation decisions are undertaken and the impact on the urban freight transport system is measured; S*takeholders* and *Project initiator* detailing the participating entities and leadership, respectively.

3.1.1. Objectives

The major objective of City Logistics is to significantly mitigate the negative impacts of urban freight transportation through sustainable freight-transport systems. Economic objectives may also be aimed for when companies are created to take advantage of business opportunities. The items thus are:

- *Economics*: Exploit business opportunities by creating companies or dedicated entities within existing structures likely to produce a financial benefit;
- *Environmental*: Reduce the impact of urban freight movements on the environment, in particular, emissions of various gazes and particles and noise;
- *Congestion*: Reduce traffic congestion and its effects;
- *Energy consumption*: Reduce the energy needed to transport the same quantity of commodities.

3.1.2. Status

City Logistics systems and projects may be in various stages. The first two refer to projects undertaking theoretical or field analyzes regarding the design and viability of the system. The last two concern its planned temporal horizon:

- *Study*: Technical, legal, financial analyses to determine and document system design, evaluation, planning, operations, implementation or abandonment;
- *Pilot/Experimental*: To find out whether the considered solution can be implemented on a long-term basis;
- *Permanent*: Projects conceived to function on a long-term basis with no termination planned. Study or Pilot CLPs, or both, have probably been performed previously to assess its probable success;
- *Temporary*: A CLP for a fixed period of time, generally to mitigate the effect of a temporary event (e.g., building sites).

3.1.3. Evaluation tools for City Logistics initiatives

In many cases, decisions were taken on the basis of the experience and intuition of the decision makers. A formal evaluation process involves precise numerical objectives and procedures. The three items correspond to the most important established objectives:

- *Financial analysis* examines a system's financial viability, profitability, solvability, cost-benefit balance, etc.;
- *Traffic analysis*: The most commonly used indicators are changes in vehicle trips and kilometres, traffic speed, congestion, etc. The impact on customer service, e.g., on-time deliveries and costs, should also be addressed;
- *Environmental assessment*: Common indicators for the likely environmental impact: fuel consumed, pollutant emissions, freight-vehicle related accidents.

3.1.4. Stakeholders

Several institutions, organisations, and people may be involved in a CLP, each with its own objectives and interests. Some may be involved actively in the project and participate to decision making, e.g. shippers and carriers, while others, e.g., citizens, may benefit or suffer from its results and may participate directly or indirectly (vote). Five items:

- *City*: Always an active member in a CLP; Assumed to be neutral, hopefully a driving force;
- *Government*: National and regional governments may be active in problem analysis and encourage the implementation of promising solutions;
- *Shippers and consignees*: Have always been involved in the projects; Lately, more present as active member in the decision processes;
- *Carriers*: Carriers and warehousing companies are usually involved in CLPs;
- *Others*, e.g., citizens, consultants, universities, etc. may also participate.

3.1.5. Project initiator

Traditionally, City Logistics initiatives were launched by the public sector, which initiated projects and offered incentives (e.g., financing and regulations). Recently, enterprises are launching CLPs to profit from business opportunities following from new customer needs or emerging priorities in the city. Two items:

- *Public sector*: City council or a government entity;
- *Private sector*: One or group of enterprises.

3.2. Business model

CLP need to address critical financing and viability issues related to the project's planned infrastructure facilities, operations, management and responsibilities. Four criteria:

3.2.1. Infrastructure financing

- *Public*: The government or the city provides the funds to build new infrastructure. The CLPs may also use existing public infrastructure.
- *Private*: Necessary infrastructure is built by private firms.

3.2.2. Operation financing

Operation financing for the entire duration of the CLP:

- *Autonomous*: Everyday operations are financially viable over the long term;
- *Initial*: An initial and unique contribution to insure a viable start;
- *Unconditional subsidy*: A sum of money is periodically (yearly) granted to help the system function. The sum does not depend on the level of operations;
- *Conditional subsidy*: Participation for the cost of an operation when realized.

3.2.3. Management

Management defined according to three items:

- *Public*: The city or a public entity manages the CLP;
- *Private*: The CLP is managed by a private company in an autonomous way;
- *Concession*: In a PPP approach, the city (government) grants the right to use public facilities to a private company; The grant is for a given number of years and fixed objectives, the degree of success in reaching these objectives conditioning the renewal of the contract.

3.2.4. Competitive advantage

Competitive advantage describing how the City Logistics system is supported:

- *None*: No distinction between the participating companies and the others;
- *Partial*: Participating companies benefit from specific measures, e.g., longer delivery hours, use of pedestrian areas, use of bus lines, etc.
- *Total*: Participating companies are the unique service providers in the area.

3.3. Functionality

Functionality describes the CLP main operating principles through 5 criteria:

3.3.1. Consolidation

Consolidation of the loads of different shippers, consignees, and carriers into the same vehicles is used very often in City Logistic systems. Consolidation takes place at UCCs and can be voluntary on a cooperation basis or imposed by the system configuration (Criterion 3.5). Three items:

- *None*: No dedicated physical UCC. Consolidation is achieved through information sharing on origins, destinations, and products, and integrated construction of pickup and delivery routes;
- *Single-level*: Consolidation takes place at physical UCCs from where vehicles distribute loads within the city. Loads transit through one UCC only;
- *Two-level*: UCCs form the first level of the system, generally located on the outskirts of the city. The second tier of the system is constituted of satellite platforms, where loads coming from the UCCs are transferred to and consolidated into vehicles adapted for utilization in dense city zones (see Crainic et al., 2009, for a review).

3.3.2. Modal shift

Most urban freight transportation issues are linked to the utilization of trucks. The idea is to reduce this impact by transferring part of the freight to other modes:

- *Underground system*: Dedicated or sharing an existing passenger system;
- *Pipeline*: To convey specific commodities in particular areas;
- *Water*: Use of water-channel networks and rivers;
- *Rail*: Use of the heavy or light rail networks for urban freight transport.

3.3.3. Regulation

Regulation passed by the city to organize and manage freight movements through incentives and restrictive measures:

- *Time windows*: Specific periods for deliveries or transit;
- *Lane and space use*: Permission to use specific arteries (bus lanes) and reserved spaces for loading, unloading, and delivery operations;
- *Environmental standards*: Limits on vehicle characteristics, e.g., energy consumption, engine power, emissions, and so on;
- *Weight/volume/load factor*: To limit access to particular zones;
- *Access charges*: To address traffic congestion (also known as *congestion pricing*) and contribute to improving urban mobility, through the management of demand for transport. It may target all vehicles or particular groups only and may be modulated according to the time of day, congestion level, type of vehicle (to account for environmental externalities related to heavy polluters and/or privileged access for low-emitting vehicles), etc.

3.3.4. Intelligent Transportation Systems (ITS)

The core of ITS consists of obtaining, processing and distributing information for a better use of the transportation system, infrastructure and services (Crainic et al., 2008). ITS are deployed as interconnected applications using a number of related technologies (communications, computing, decision-support, sensing, etc.). For City Logistics, ITS supports other functional tools, e.g., number-plate recognition, controlled access to Limited Traffic Zones (LTZ), tracking/tracing to better optimize routing operations of cooperating carriers. Four items:

- *ATIS/ATMS*: Advanced Traffic Management Systems (ATMS) collect real-time traffic conditions, analyze data, predict travel times, manage emergency responses, control traffic-management devices (highway accesses, traffic lights, etc.), and conceive guidelines to be transmitted to the users of the system through Advanced Traveller Information Systems (ATIS). The objective is to provide better information on traffic-conditions resulting in better mode choice, route, and driving decisions with less miles travelled, fuel consumed, and pollution.
- *E-payment and AVI*: For City Logistics, these systems correspond to the electronic payment of tolls or congestion-related fees and Automatic Vehicle Identification (AVI) systems used to control access to LTZ.
- *AFMS*: Carriers interact with the city ATMS/ATIS and may use the data, together with optimization techniques and algorithms, to better plan the allocation and utilization of the fleet and to efficiently control it in real-time. Such Advanced Fleet Management Systems (AFMS) can significantly contribute to the efficiency and ultimate success of City Logistics systems.

3.3.5. Cooperation

Cooperative transport systems have the potential for achieving many of the aims of City Logistics (Taniguchi et al., 1999). Traditionally, carriers were mainly involved but, lately, shippers and consignees are initiating the cooperation. Cooperation is strongly linked to consolidation. Two items:

- *Carriers*: Carrier fleets and customer demands are cooperatively managed;
- *Shippers/Consignees*: The pooling concerns products and destinations. Often, the cooperative system goes beyond transport to other value-added services.

3.4. Scope

This component classifies CLPs according to five criteria: *geographic coverage*, *transport modes*, type of *products*, type of *customers* and *logistics services*.

3.4.1. Geographic coverage

The CLPs might concern the entire city or a specific area only where congestion and pollution issues related to freight transportation are particularly relevant. We distinguish four items:

- *Corridor*: The concerned area is organized along a major artery in the city;
- *Shared zone*: A delimited zone accessible to all participating carriers;
- *Parcelled zone*: The area is divided into parcels, each serviced exclusively by one or a group of enterprises involved in the distribution process;
- *Town*: The entire city

3.4.2. Transport mode

Intermodal rail/water–road transport could address many City Logistics objectives. Intermodal terminals are required as transfer points.

- *Unimodal*: Road only;
- *Multimodal*: More than one mode.

3.4.3. Product

Different types of products require different handling, storage conditions, and vehicles. We distinguish two items:

- *Product spec*ific: Fleet and facilities dedicated to the product;
- *Non-product-specific*: Heterogeneous fleet and multi-purpose facilities.

3.4.4. Customers

Customers of CLPs usually are commercial firms or residents. Some projects are however implemented to mitigate the effect of a particular event (e.g., construction site). Three items are therefore considered: *Residents*, *Commercial*, and *Other/Specific.*

3.4.5. Services

We introduce four items to differentiate the transportation services provided by a particular City Logistics system:

- *Delivery*: Freight movements from outside the city toward the CL target zone;
- *Pick up*: From the city to the exterior;
- *Delivery and pick up*: Both movements are provided; It also includes movements within the controlled zone;
- *Additional* logistics services.

3.5. Technology

Technology refers to hardware and software and the intelligence imbedded herein. It may significantly contribute to a sustainable urban freight transportation system. Three criteria are proposed relative to *vehicles*, *information and communication*, and *decision* technologies.

3.5.1. Vehicles

Most CLPs encourage the utilization of alternative motorizations to attain the environmental objectives of City Logistics. We distinguish three items:

- *Standard*: No specific regulation regarding engines;
- *Low-emission*: The objective is to reduce pollutant emissions. Standards for light commercial vehicles were initiated in the EU in 1993. Among possible approaches: liquefied petroleum and compressed natural gas considered less polluting than fossil fuels; bio-fuels produced from any carbon source that can be replenished rapidly; hybrid motorizations; etc.;

- *Clean*: Electric or hydrogen-powered vehicles or human-powered delivery for short distance links. Electricity is currently preferred, in spite of important drawbacks (e.g., production may be based on fossil fuels, energy storage, driving range, cost, and low component durability), hydrogen being still at the proposal stage.

3.5.2. Information and communication

Information and communication technologies are at the core of our economic and social life, e-business, ITS, and City Logistics in particular:

- *Internet and EDI* providing a worldwide interconnected computer network and a set of standards and procedures for structuring information that is to be electronically exchanged between and within businesses, organizations, government entities, and other groups, and enabling web sites and e-markets where stakeholders can exchange data and information and participate in the cooperative decision processes (Crainic et al., 2008).
- *Wireless communications* eliminate the constraints of physical connections and support mobility and real-time access to information from "anywhere", through Wireless Local Area Networks (WLAN), Dedicated Short-Range Communications (DSRC) systems, satellites for communications and localization (GPS, Galileo), etc.
- *Computational technologies*. Advances in computing power (including in vehicles) allow the efficient processing of complex logistics and transportation planning and operations problems. They support the issues addressed in Criterion 5.3, as well as those of the ATMS/ATIS and. AFMS;
- *Sensing technologies* provide bi-directional infrastructure-to-vehicle communication and identification, e.g., inductive loop detection, video vehicle detection, automatic number plate recognition, etc.

3.5.3. Decision technologies

Decision technologies for the design, analysis, planning, management, and control of City Logistics systems, which require powerful models and methods embedded into decision-support systems (Benjelloun and Crainic, 2008; Crainic et al., 2009). Operations research, simulation, statistics, and econometrics are among the major methodologies supporting this criterion. Three items refer to the main decision levels: *Strategic/evaluatio*n; *Tactic/exploitation*; *Real-time*.

4. Using the Taxonomy

We believe the taxonomy will prove useful in extracting success factors for City Logistics projects and in defining operational and business models for "new" regions, e.g., North America. This development is beyond the scope of the present paper, however. Therefore, to illustrate its interest, we use the taxonomy to describe two well-known but different projects. We then present a trend analysis based on the projects studied in building the taxonomy.

Monaco represents one of the first CLPs and it went through two major changes during its life, at the management and consolidation levels.

- *Description*: In 1989, the government of Monaco decided to organize the freight movement in the city using an UCC to address environmental and congestion concerns. This permanent CPL concerns all stockholders and was evaluated through environmental assessments;
- *Business model*: The infrastructure facilities are owned by the city. The CPL was managed by a public entity from 1989 to 2000, and by a private company under a concession contract since then. The project benefits from regulation regarding time windows and volume/weight of the vehicles allowed entering the city. Moreover, the city subsidies operations (by parcels transported);
- *Functionality*: A single-level consolidation system initially, it changed to a two-level one;
- *Scope*: The town is serviced by trucks for all products except fuels, indivisible loads and special products. Value-added logistic activities are also offered;
- *Technology*: Low emission and electric vehicles

The Amsterdam CityCargo project is one of the recent CLPs and an example of the utilisation of alternate transportation modes and of public-private partnerships:

- *Description*: After a pilot-project phase, the City Cargo Tram is set to function as a permanent CLP (the current status is unclear, however). It is a PPP initiated by the private sector. It aims to reduce pollution by 20% and the number of trucks by half (currently 5,000);
- *Business model*: The infrastructure facility is city owned and there is no help for everyday operations;
- *Functionality*: The two-level project currently involves two cargo trams, operating from a UCC and delivering to "satellites" (non-passenger tram stops), from where electric trucks deliver to final destinations. A significant increase in vehicles and facilities is planned;
- *Scope*: The target zone is the inner city of Amsterdam. Bars, restaurants, and shops are the main customers; No specific product types are mentioned;
- *Technology*: Trams and electric trucks as vehicles. Optimization of schedules and routes is mentioned but no specifics are available.

The way City Logistics projects are conceived, evaluated, and managed evolves with the social, political, and technological environment. Innovative ways to organize the physical flow of products through the city may be observed, as well as the increased utilization of alternate modes of transportation. We used the taxonomy and our sample of 70 projects to identify some of these changes and trends (see also Benjelloun and Crainic, 2008). It rapidly becomes obvious that, 1) the number of projects is increasing steadily, and 2) projects are undertaken around the world. Table 2 displays the evolution in the number of CLPs, while Table 1 shows the geographical distribution of these projects. The growth of the urban population and the general awareness of urban freight transport effects on the city and its habitants are the main reasons given in most project descriptions.

Figure 1 details the CLPs objectives over time. As the base number is different from one period to another, we represent each objective as a fraction of the entire set for the period (relative weight). We notice two interesting trends. The first City Logistics initiatives aimed mainly to avoid congestion. Environmental issues appear in the 1990s. Second, by implementing more constraining regulations for urban freight distribution, cities create new business niches for the private sector. In France, for example, private companies are generally involved in the CLPs of the last decade. Actually, cities increasingly allow companies to use public premises (parking, tram networks, bus stations, etc) when innovative and green schemes are proposed. Thus, companies avoid heavy investments and benefit from financially viable projects and the cities can attain their objectives in term of reduced congestion, pollution, and energy consumption.

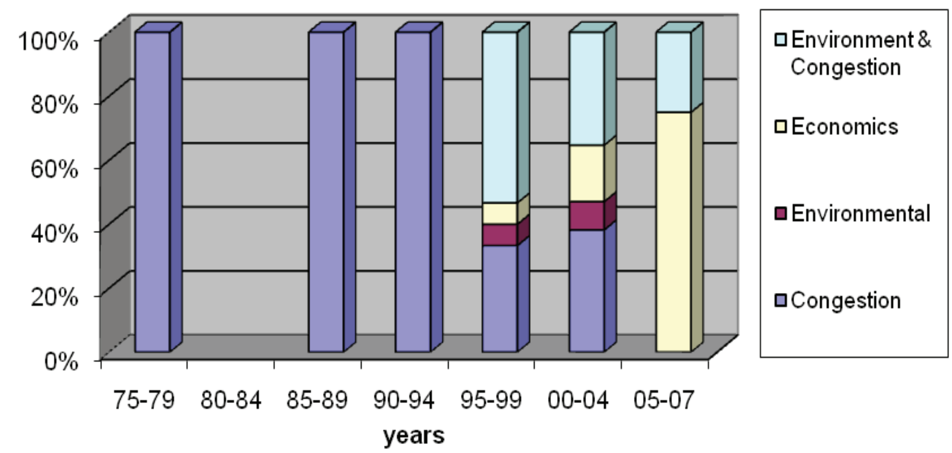

Figure 1 CLPs temporal distribution and objectives

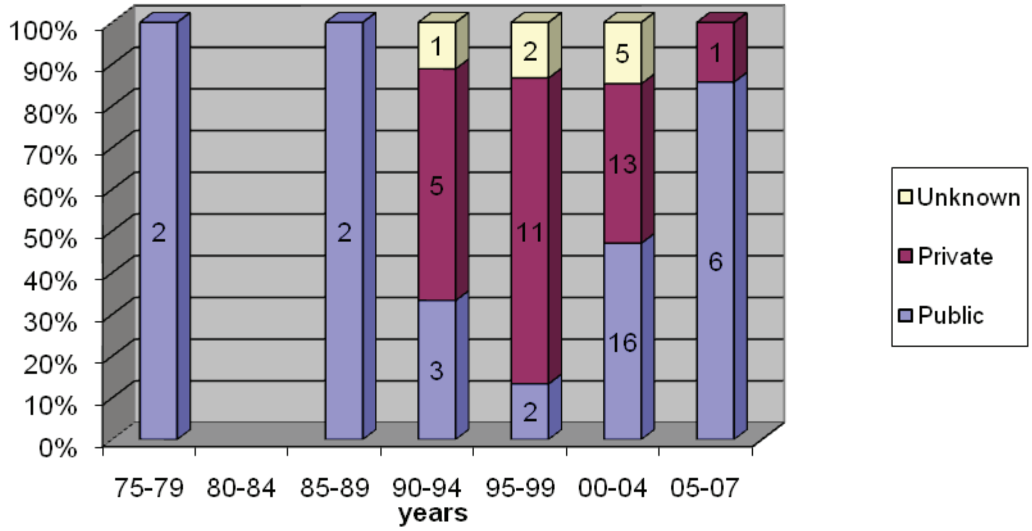

Figure 2 Evolution of infrastructure financing

Heavy investments regarding CLPs infrastructure make the financial viability of projects more challenging. This explains the evolution of infrastructure financing displayed in Figure 2. The public sector was the main, often the only, support of such financing. From the early 1990s this involvement has decreased significantly. The public sector assumes a more important role in the projects initiated from the year 2000 on, but within partnerships where the private sector is involved as well.

Figure 3 displays the evolution of the functionality component of CLPs. One observes that the UCC and regulation were the exclusive operating principles of the early initiatives. The large part of cooperation in the mid 1990s corresponds to the many projects undertook in German-speaking countries. From 2000 on, one observes that cooperation is still part of the system functionality but its nature has evolved toward a Monaco-style participation. The consolidation facility, the UCC, re-affirms its central role, even though its relative importance decreases because other instruments, modal shift and ITS, notably, begin to consistently appear.

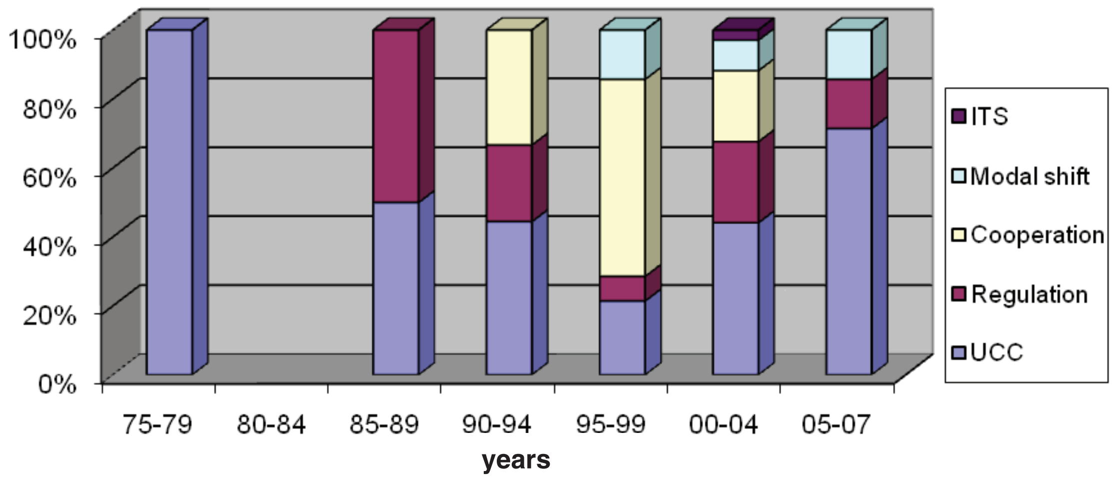

Figure 3 Evolution of the functionality elements of CLPs

As mentioned, gathering information on CLPs is very challenging. Even for the projects for which good information was found, it was not complete. For the description component, we had difficulty getting information on evaluation tools, be it for launching the CLP or for measuring its performance. Regarding the business model, the main omissions were data on subsidies and who paid what. Functionality and scope were well documented, but only vehicles were generally mentioned with respect to technology. Little information was available on information technologies and almost none on decision technologies. We notice, however, that ITS appears in CLPs from 2000 on. The original City Logistics definition (Taniguchi et al., 1999) was actually revised in 2001 (Taniguchi et al., 2001) to account for the support of advanced information systems in the process of optimizing logistics and transport activities. Examples of ITS within CLPs include e-payment for city-access, control systems for accessing restricted zones, and web-based applications promoting communication between stakeholders. AFMS is still a challenging area for City Logistics. To our knowledge, there are no implementations of such management systems and very few research contributions, e.g., evaluation and planning of two-tier systems (Crainic et al., 2009) and probabilistic vehicle routing and scheduling with ITS (Taniguchi and Ando, 2006).

5. Conclusions

We presented a three-layer taxonomy of City Logistics projects that provides the means to explore the similarities and differences in the elements characterizing them, and contributes toward a better understanding of performance and success factors, which should lead to better preparation and design of new initiatives. It also provides the means to identify trends in the evolution of City Logistics as well as challenging research directions.

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References

Benjelloun, A., & Crainic, T. G. (2008). Trends, challenges and perspectives in City Logistics. In *Transportation and land use interaction, proceedings TRANSLU'08* (pp. 269-284). Editura Politecnica Press, Bucharest, Romania.

Browne, M., Allen, J., Andersen, S., & Woodburn, A. (2006). Urban freight consolidation centres. In E. Taniguchi, & R. G. Thompson (Eds.), *Recent advances in city logistics* (pp. 253-265). Elsevier, Amsterdam.

Crainic, T. G., Gendreau, M., & Potvin, J.-Y. (2008). Intelligent freight transportation systems: an historic assessment and the contribution of operations research. *Transportation Research C: Emerging Technologies*, available on line at Articles in Advance doi 10.1016/trc.2008.07.002.

Crainic, T. G., Ricciardi, N., & Storchi, G. (2009). Models for evaluating and planning City Logistics systems. *Transportation Science,* available on line at Articles in Advance doi 10.1287/trsc.1090.0279.

Dablanc, L. (2003). *Le transport de marchandises dans les villes allemandes; Compte rendu du voyage d'études du GART en Allemagne sur le transport de marchandises en ville*. Ministère de l'Écologie, du Développement durable et de l'aménagement du territoire, Paris, http://www.recherche-innovation.equipement.gouv.fr/H

Goldman, T., & Gorham, R. (2006). Sustainable urban transport: four innovative directions. *Technology in Society,* 28, 261-273.

Kohler, U. (2001). City-logistics in Germany. In E. Taniguchi, & R. G. Thompson (Eds.), *City Logistics II: 2nd International conference on city logistics* (pp. 203-214). Institute of Systems Science Research, Kyoto.

OECD (2003). *Delivering the goods: 21st century challenges to urban goods transport*. Publication, OECD Publishing, Hhttp://www.oecdbookshop.orgH.

Quack, H., van Duin, R., & Visser, J. (2008). City logistics over the years … lessons learned, research directions and interests. In E. Taniguchi, and R. G. Thompson (Eds.), *Innovations in city logistics* (pp. 37-53). NOVA Publishers.

Taniguchi, E., & Ando, N. (2006). An experimental study on the performance of probabilistic vehicle routing and scheduling with ITS. In E. Taniguchi, & R. G. Thompson (Eds.), *Recent advances in city logistics* (pp. 59-73). Elsevier, Amsterdam.

Taniguchi, E., Thompson, R. G., & Yamada, T. (1999). Modelling city logistics. In E. Taniguchi, & R. G. Thompson (Eds.), *City Logistics I: 1st International conference on city logistics* (pp. 3-37). Institute of Systems Science Research, Kyoto.

Taniguchi, E., Yamada, T., & Tamaishi, M. (2001). Dynamic vehicle routing and scheduling with real time informations. In E. Taniguchi, & R. G. Thompson (Eds.), *City Logistics II, 2nd International conference on city logistics* (pp. 111-125). Institute of Systems Science Research, Kyoto.

Taniguchi, E., Thompson, R. G., & Yamada T. (2006). Data collection for modelling, evaluating and benchmarking city logistics schemes. In E. Taniguchi, & R. G. Thompson (Eds.), *Recent advances in city logistics* (pp. 1-14). Elsevier, Amsterdam.

Visser, J. (2001). Underground logistics systems for goods distribution in urban areas: Perspectives in The Netherlands. In E. Taniguchi, & R. G. Thompson (Eds.), *City Logistics II: 2nd International conference on city logistics* (pp. 387-301). Institute of Systems Science Research, Kyoto.

Visser J., Binsbergen, Av., & Nemoto, T. (1999). Urban freight transport policy and planning. In E. Taniguchi, and R. G. Thompson (Eds.), *City Logistics I : 1st International conference on city logistics* (pp. 39-69). Institute of Systems Science Research, Kyoto.