A hierarchic sustainability dashboard to evaluate logistics pooling

Joëlle Morana, Jesus Gonzalez-Feliu

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Laboratoire d'Economie des Transports, 14 Avenue Berthelot, 69363 Lyon Cedex 07, France
jesus.gonzalez-feliu@cnrs.fr; joelle.morana@let.ish-lyon.cnrs.fr

Abstract

Logistics pooling is now a major challenge in supply chain management, though it remains a little known activity in which the different actors involved use different approaches whose objectives are not always the same and with sometimes conflicting standpoints. This purpose of this article is to define, on the basis of a detailed analysis of the literature, a grid for interpreting and a dashboard for evaluating the sustainable performance of pooled delivery systems. Firstly, an analysis of the main works on the subject is proposed, regarding three complementary aspects: organisational efficiency, logistic performance and the evaluation of urban logistics projects. Then, the method for defining the dashboard derived from a collaborative decision-aid approach is proposed. Lastly, the dashboard is described and commented followed by conclusions and the outlook for further developments in view to a practical application of the approach.

Keywords: logistics pooling; sustainable development; collaborative decision support; freight transport management.

1. Introduction

Despite the fact that economic considerations predominate in business relations, everyone is aware that their growth relies on the raw materials composing the goods offered for sale, the stakeholders involved and the consumers of these goods. Companies cannot and must not therefore succumb to the temptation of wearing them. Furthermore, even if the factors underlying sustainable development are constraints, their construction is an obligation that must be fulfilled if companies wish to avoid jeopardizing their own survival. What more, aid from outside is becoming rarer, thus companies can only rely on themselves or on corporations with common interests if they wish to become sustainable in the 21st century.

The problem of evaluating logistics is nowadays part of this movement of "sustainability". Thus, from the perspective of sustainable development, texts consider the performance of Supply Chain Management from the economic angle, of Green Supply Chain Management from the environmental angle and Social/Societal Supply Chain Management from the social/societal angle. This has led to the emergence of Sustainable Supply Chain Management whose aim is combine these three aspects (Seuring and Müller, 2008; Morana, 2013). Moreover, within logistics, increasing interest is being focused on urban logistics and last mile logistics, which is now an essential element of global and, of course, sustainable logistics.

The aim of this paper is to draw up a sustainable dashboard applicable to logistics pooling on the basis of a field experiment. The paper is structured as follows. The first paragraph of the next section presents several reference works on the notion of performance and a synthesis of performance indicators. The second paragraph then underlines works on measuring performance related to logistics. Lastly, the third paragraph takes stock of the sustainable performance indicators of urban logistics. A sustainable dashboard of urban logistics is recommended in view of the feedback gained from the LUMD project (Sustainable Pooled Urban Logistics).

2. Background

Collaboration is one of the most promising areas of study in supply chain management (Lambert, 2008) and can take place at different stages (Gonzalez-Feliu and Morana, 2011):

- The transactional level, the most basic level of collaboration, involves mainly coordination and standardization of transactions and administrative practices, requiring information systems.
- The second level is the informational one, and concerns the mutual exchange of sales and logistics information. It is important to note that here, confidentiality and competition have to be taken into account explicitly.
- The third one is that of decisional collaboration, which involves different planning and management decisions (Crainic and Laporte, 1997), and is divided into three stages: (1) operational planning, related to daily operations, (2) tactical planning, or middle-term horizon, related mainly to sales forecasts, route configurations, inventory management and quality control, and (3) strategic planning, related to long term planning decisions like network design, logistics platform location, finance and commercial strategies.

Logistics sharing is a specific form of collaboration based on resource sharing. Sharing resources in freight transport is related to three main issues:

- Vehicle sharing, which follows a logistics organization similar to car-sharing or bike-sharing systems (Dablanc et al., 2011). In such systems, different stakeholders use the same vehicles on the basis of a shared rental system.
- Infrastructure sharing, with or without consolidation, like that of logistics or activity zones (Boudouin, 2006) or shared warehouses.
- Logistics chain merging or pooling (Pan et al., 2010), also called logistics pooling (Gonzalez-Feliu et al., 2013b).

In the distribution industry, logistic pooling as the mutual and contemporary use of a part of a supply chain, i.e. a path, a vehicle and /or a logistics facility by two or more actors, all of them being well informed and having direct influence on decisions concerning the relevant organizational aspects of this supply chain subsection. Note that in the use of a freight forwarder or integrated logistics provider (4PL, LLP), a usual approach in distribution logistics, responsibility and decision making issues are relayed to a third party, who assumes the consequences. Indeed, in those cases, the transport carrier takes decisions and organizes all the distribution processes, each shipper being considered as a customer and not having a decision voice on organizational aspects. As with car-pooling, freight transport pooling involves deliveries with a common trip chain in their overall itinerary and follows the same principles of multi-echelon transport with cross-docking.

To evaluate logistics pooling on a sustainable development viewpoint, it is important to be placed on a Sustainable Supply Chain Management (SuSCM) perspective (Morana, 2013). According to Morana and Gonzalez-Feliu (2010), is important to take into account the three components of sustainable development when evaluating urban logistics solutions. It becomes then convenient to conceptualize a specific aspect for each of its spheres, i.e.

economic SCM, green SCM and social/societal SCM (Morana, 2013) which include sustainable transport. However, we should not forget that SCM (and also SuSCM) is a transverse concept, so each dimension has to be inter-connected (see Figure 1). To evaluate the performance of logistics pooling, it is then important to take into account sustainable performance evaluation.

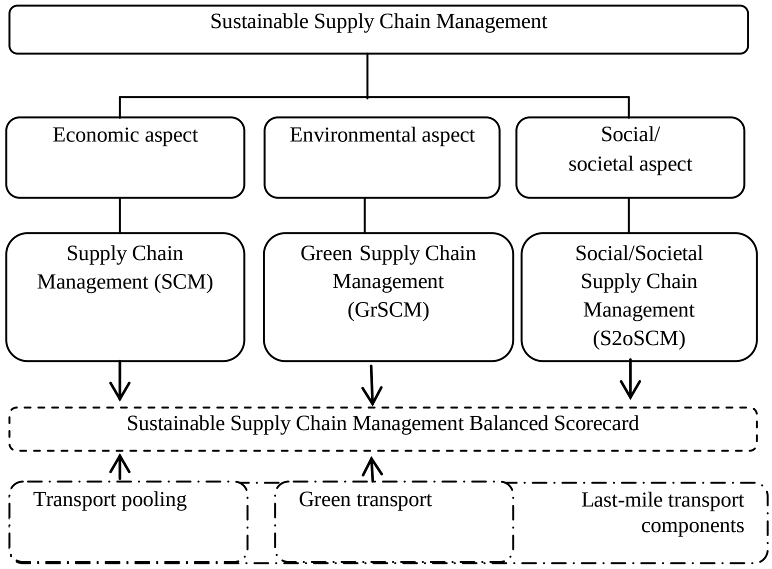

Fig. 1 : Main components of the SuSCM (adapted from Morana, 2013)

In logistics, the aim of measuring performance is in general directly linked to a goal of ensuring permanent improvement that leads to the conceptualisation and implementation of measurement systems combining diagnostics and decision-aids. If we focus on evaluating SCM with key indicators (KPI: Key Performance Indicators), we find two interesting references among the most updated works on the subject, which are also the most cited: (1) the work of Gunasekaran and Kobu (2007) with a list of 26 indicators; and (2) the work of Griffis et al (2007) with 14 indicators. Merging those works, we can define a list of 40 indicators to represent SCM performance. Table 2 gives a classification according to the economic / environmental and social/societal rationales of such indicators. Although this list does not include any environmental indicator and that economic indicators are over-represented, it can be used as a basis for a first sustainability evaluation (Morana, 2013).

This non exhaustive panorama of the use of indicators in companies and from the viewpoint of logistics is, according to us, in line with the evaluation constraints imposed by companies. Indeed, we found that cost control leads to placing economic items foremost followed by quality and lead time management and social and societal items whose value can be assessed when examining the social and societal audit[1]. From the different analyses presented above, we retain two main learnings. The first is the preponderance of qualitative economic indicators in the logistic measure. Thus 10 out of 33 indicators have a quantitative bias, i.e. 30%. The second is that little or no attention given to the definition of environmental indicators.

[1] The social audit has been obligatory since the law of 12 July 1977 in companies with over 300 employees while the societal audit, although not obligatory, has been existence since 1996 (Source: http://www.cjdes.org).

Table 1. Main key indicators in Supply Chain Management

ECONOMIC INDICATORS (cost / quality / lead time) (number = 33)	
Precision of scheduling; Average time for fulfilling pending orders; Average rate of fulfilling order by item; Average order cycle time; Order management cycle time; Utilisation of capacities; Rate of fulfilling whole order; Days delay in fulfilling order; Delivery reliability; Precision of forecasts; **Inventory costs**; Rate of inventory turnover; Procurement lead time; Production lead time; **Ratio of logistics costs over sales;** **Logistics costs per unit**;	**Obsolescence costs**; Percentage of deliveries within lead times; Variability of order cycle time; Process cycle time; Product development time; Variety of products/ services; Flexibility of production; Return on investment; **Sales lost due to inventory shortage;** **Sales price**; Cost of inventory shortage; Supply chain response time; **Transport costs**; **Added value**; Weeks procurement; **Cost of guarantee;** **Operating expenses**.
ENVIRONMENTAL INDICATORS	
Non enumerated	
SOCIAL / SOCIETAL INDICATORS (number = 7)	
Conformity with specifications; Conformity with regulations; Items picked up per person and per hour; Labour efficiency.	Perceived quality; Perceived value of product; Percentage of pick-up errors.

Legend: the quantitative economic indicators taken from accounting documents appear in bold type.

Whereas supply chain management obeys business management principles, urban logistics is generally linked to the actions of several actors, so that “business” perceptions are confronted by those of “local authorities”, i.e. the actions and objectives of the public authorities. Furthermore, urban logistics projects involve very different sectors, raising questions of feasibility, acceptability and impact of very different natures. Consequently, it is important to take these sectors into account in the quest for performance indicators and choose those that respond to the needs and objectives of each of the parties involved. These indicators are sometimes difficult to measure and access.

Many of the indicators of urban logistics concern goods transport. Indeed, the question of urban logistics inevitably includes that of last mile deliveries to recipients. However, the traditional indicators of long distance goods transport (tons transported, tons*mile, quantity of energy consumed per ton*mile, mile travelled empty, etc.) appear relatively irrelevant in the urban environment. The number of shipments, vehicle sizes (accepted), the number of packages, the variety of actors concerned, etc. change the way in which this measure is seen.

Different authors propose sets of transport sustainability indicators for urban logistics (Taniguchi et al., 2001; Behrends et al., 2008; Patier and Browne, 2010; Melo and Costa, 2011; Morana et al., 2014). Based on these works we propose the following table, inspired by that proposed above:

Table 2. The key indicators of urban logistics

ECONOMIC INDICATORS (cost / quality / lead time)	
Distance travelled; Vehicle fill rate; Warehouse fill rate; Ratio of loaded miles over travelled miles; Return on investment; Stopping time.	Service rate; Turnover generated; Number of packages/pallets delivered/picked up; Number of positions, stops; Trading area; Vehicle capacity.
ENVIRONMENTAL INDICATORS	
Greenhouse gas emissions; Pollutant emissions; Noise; Road congestion and occupation.	
SOCIAL/SOCIETAL INDICATORS	
Customer satisfaction; Rate of absenteeism; User acceptability	Number of jobs created, destroyed or converted; Training; Stress management.

This non exhaustive panorama of the use of indicators in urban logistics and from the viewpoint of collective utility presents some differences with respect to that of supply chain management. Thus, two main learnings can be retained. The first is the preponderance of quantitative indicators in all three spheres. Thus 20 out of 22 indicators have a quantitative bias, i.e. about 91%. The second is that although environmental indicators are less numerous than economic or social, they are the main attention of public authorities (Vaghi and Percoco, 2011), and we observe in some cases a predominance of environmental-social evaluation that can be dangerous to the continuity of urban logistics solutions since their economic viability has not been evaluated in-depth (Gonzalez-Feliu et al., 2013a, 2014).

3. The proposed method

The purpose of this paper is, on the basis of a field experiment, to draw up a sustainable dashboard applicable to urban logistics. This can be done with two prerequisites:

- The consideration of a minimum number of indicators, as recommended by Bouquin (2001), since, as an instrument of action, a dashboard includes a "relatively small number of indicators (five to ten) [integrated] to inform managers of the state and evolution of the systems they control and identify the trends that will influence these systems over a time scale consistent with the nature of their functions" (Bouquin, 2001, pp. 397-398);
- The display of three types of measurement that reflect three dimensions of sustainable development, i.e. economic, environmental and social/societal.

The proposed dashboard and the indicators that feed it are proposed to evaluate the sustainability of a French National Project of logistics sharing schemes in urban areas. The LUMD project (Logistique Urbaine Mutualisée Durable, or Sustainable Urban Logistics Sharing) is a collaborative project financed by the Unique Investment Fund of the French Government. This project started in November 2008 and finished in October 2011. Moreover, a post-project evaluation was performed between December 2011 and March 2012). The objective of the project was twofold:

- To propose a collaborative solution as an alternative to the City Distribution Centre, with a unique operator, by providing an Information System-based virtual platform for warehouse and transportation sharing.
- To standardize urban logistics concepts in order to transfer the LUMD solution (virtual platform) to different cities in Europe.

The project instigated by Presstalis involved several partners, including one logistics consulting agency, two software development companies, one geographical information service company, four research units of different natures and three other logistics providers. The main phases of the project were related to the development of a technological solution. In this work, we will explore the organizational aspects related to the implementation and deployment of this solution.

In order to offer a set of sustainable performance indicators, a scientific state of the art of the subject was written in the framework of the LUMD project (Morana and Gonzalez-Feliu, 2010). On the basis of these two works, we chose to follow an approach adhering to the principles of sustainable development. To do this, we defined four categories of indicators, one for each element of the 4A's vision (awareness, act and shift, avoidance and anticipation). In addition to take into account the two different visions in the evaluation of logistics systems in the urban environment (private companies and local authorities), a set of subcategories is also proposed.

From the initial list of indicators (65) presented above, a list of 90 possible indicators (both quantitative and qualitative) was defined and proposed at the session of the scientific committee held on 31 March 2011, along with a presentation of the methodology and paths of reflection. It was agreed to reduce the number of indicators to thirty so they could be examined in detail during the session held on 3 May 2011, when these indicators were debated and commented. The following conclusions were drawn from the meeting:

- It is necessary to propose a dashboard for the sustainable performance of LUMD. It should contain a maximum of 5 main criteria, each linked to 1 to 3 indicators. We once again find the first prerequisite mentioned in the introduction regarding the need for a minimum number of indicators;
- Two types of indicators can be defined: those that measure the performance of the LUMD system itself, and those that measure the effects on the system. Since the second section was difficult to measure and quantify (especially in the definition of the reference situation), we privileged the indicators of the first section, and then compared them to the averages of the sector to evaluate the performances in comparison to non pooled transport;
- The main indicators underlined by the persons present in the room were those of logistic performance (fill rate and number of miles travelled) and the environmental effects (greenhouse gas emissions (GHG) and other pollutants. What is more, changes to jobs (increase, decrease and job conversion) were also important. Here we find our second prerequisite in an architecture with three directions in line with a rationale of sustainable development.

Next, two types of work were performed. On the one hand, economic performance and customer satisfaction indicators were identified in two work documents (a textual document and a presentation). On the other hand, an in-depth study was performed on the calculation and validity of environmental and social/societal indicators (two sheets of calculations and a text document).

During the meeting of the scientific committee of 7 June 2011, the indicators and their applicability were updated. A work meeting then led to establishing a synthetic dashboard proposed for the prototype LUMD version 1. This dashboard was then presented, by defining the different indicators chosen. After the exchanges made at several meetings held through June, the need for a synthesis and a validation was emphasised at the scientific committee sitting on 15 September 2011. This document sums up the main indicators that have to be validated by a group composed of the following actors (non exhaustive list): Three logistics managers of a press distribution company (instigator of the project), a logistics consulting expert, ten representatives of research in transport and logistics from five different institutions, four information science experts, one transport standardization expert.

4. Results presentation and discussion

We propose a hierarchical dashboard. To offer an easy-to-read tool usable by the different actors of the platform, we propose 5 categories of indicator and 7 main indicators (3 economic, 1 quality and 3 environmental and societal).

Table 3. The key indicators of urban logistics in a sustainability viewpoint

Section	Category	Main indicator	Secondary indicator
Economic	Logistic	Ratio of loaded miles over travelled miles (weight)	Ratio of loaded miles over travelled miles (volume)
			Loading rates (weight and volume)
	Logistic	Warehouse fill rate	
	Audit	Financial indicators	
Economic and social/societal	Service quality	Service rate	Service rate deliveries
			Service rate deliveries in time
Environmental	Environmental effects	Greenhouse gas emissions	Emissions of CO_2
			Emissions of CH_4, CO
			Emissions of NO_x
Environmental and social/societal	Congestion gains	Saving in number of trucks used	
Social/societal	Social/societal effects	Rate of jobs to be converted	Rate of transporter loyalty
			Rate of transporter loyalty

We observe that the indicators are in general more specific than those proposed in literature. The needs of the project imply the definition of detailed indicators, on a way both public and private stakeholders can understand. For example, logistics indicators are related to transport loading rates, with and without reporting them to traveled distances. However, such indicators need to be associated to warehousing performance (in terms of loading rates) and to general financial balance. No inventorying performance indicators have been appointed since the system aims to make collaboration among transport carriers or their directly associated parties (i.e., 2PL and 3PL mainly), so inventorying is not included in decisions here. Environmental and social/societal indicators show the importance of greenhouse gas and pollutant emissions (noise has not been selected since transport and logistics practitioners are less sensible to the societal issue than public authorities), but also of two questions that where more attributable to public stakeholders: gains in congestion (reported to a reduction in number of trucks, which is more speaking to private stakeholders) and the importance of converting the potential number of employees to be reduced into new and added-value jobs.

Finally, it is important to note that to evaluate the sustainable performance of the prototype, it is necessary to establish identify a grid of reference performances in order to have points of comparison. To do this, we have prepared a database of urban routes in order to define their main characteristics in terms of size in number of delivery points, type of vehicle in weight capacity, type of freight delivered, mode of management, travelled distances and loading factors, which would allow to define the proposed indicators for different types of routes in an initial situation.

This database was obtained from the National Survey Database on Urban Goods Transport in France (Gonzalez-Feliu, 2013), from where data on 2111 routes was collected in three different cities between 1995 and 1999. From those routes, taking into account the data quantity and quality collected in the different surveys, 778 routew were selected. A typology of routes taking into account the criteria presented above has been obtained, and their main results are synthesized in Table 4.

We observe that own transport deliveries mobilize less commodities than third party transport. TL transport and small LTL routes have similar deliveries in weight but the vehicles are sometimes different. Concerning third party transport, the average capacity of vehicles making FTL and LTL routes up to 10 stops is about 9t, i.e. a total weight of about 19t, whereas LTL routes with more than 11 stops are made with single trucks of smaller capacity, about 6-7t, i.e. a single truck of 13t. Concerning average quantity of freight unloaded at each stop (in weight), FLT and small routes (up to 10 stops) involve respectively about 4t and 1t per stop, average weight that decreases strongly for bigger routes (for 11 to 20 stops, the average weight is about 500 kg and for bigger routes of 50-60kg). Regarding small parcel deliveries, no FTL routes are found, and the average number of stops is higher than that of pallet and parcel deliveries (the first category). Weights are small (15 kg in average) with a decreasing trend when number of stops increase (express deliveries, which are in general characterised by routes with more than 30 stops, involve average weights of 8kg/stop, whereas small parcel non express routes involve 10 to 25 kg).

Own account transport follows diffferent trends, and depends strongly on the activity of the sender. Sender's own account follo similar trends than third party pallet and parcel deliveries, but with lower weights, except for FTL transport, where weight are similar. However, since the number of routes for this category is higher than that of classical third party transport, the number of deliveries of sender's own account are higher. Receiver's own account presents two trends : FTL transport (half of the total number of routes in this category) presents higher weights (about 4t/stop) then small pickup routes (up to 20 deliveries) with collected weights about 61 kg for routes up to 10 pickup points and higher ones (about 116 kg in average) for routes from 11 to 20 pickup points.

Table 4. Main characteristics of urban routes according to the proposed database

	Average load of a stop (in kg)				
Route size category (in number of deliveries)	**Classical third party transport**	**Small parcel LTL transport**	**Consigner own account**	**Consignee own account**	**Average**
TL routes (1 delivery)	3937		3469	3940	3782
2 to 10 deliveries	1336	25	352	1023	684
11 to 20 deliveries	489	16	103	56	166
21 to 30 deliveries	62	11	30		34
31 deliveries and more	52	8	4		21
Overall average	1175	15	791	1673	937
	Average number of stops				
Route size category (in number of deliveries)	**Classical third party transport**	**Small parcel LTL transport**	**Consigner own account**	**Consignee own account**	**Average**
TL routes (1 delivery)	1		1	1	1
2 to 10 deliveries	6	8	6	3	6
11 to 20 deliveries	15	16	16	11	14
21 to 30 deliveries	25	25	25		25
31 deliveries and more	37	42	36		38
Overall average	17	23	17	5	17
	Average load of a route (in kg)				
Route size category (in number of deliveries)	**Classical third paty transport**	**Small parcel LTL transport**	**Consigner own account**	**Consignee own account**	**Average**
TL routes (1 delivery)	3937		3469	3940	3782
2 to 10 deliveries	5804	113	1794	61	1943
11 to 20 deliveries	3898	247	1440	116	1425
21 to 30 deliveries	1140	249	1753		1048
31 deliveries and more	1181	406	1143		910
Overall average	3192	254	1920	1372	1822
	Average capacity of vehicles (in kg)				
Route size category (in number of deliveries)	**Classical third paty transport**	**Small parcel LTL transport**	**Consigner own account**	**Consignee own account**	**Average**
TL routes (1 delivery)	9708		7646	9000	8785
2 to 10 deliveries	8479	7669	6469	5643	7065
11 to 20 deliveries	5824	5145	6658	5872	5875
21 to 30 deliveries	5721	6373	4976		5690
31 deliveries and more	5815	4832	3200		4616
Total	7109	6005	5790	6838	6406

5. Conclusion

The evaluation of urban logistics projects should be seen from the perspective of sustainable development. Consequently, three dimensions (economic, environmental and social/societal) must be taken into account. Likewise, It is advisable to enumerate a limited though sufficient number of indicators for decision making, according to the principle of fast but efficient reading (Bouquin, 2001). In addition, the specific characteristics of urban logistics and the two predominant visions (those of private enterprise and public authority, respectively) regarding the problem of goods mobility in urban zones confer strong potential to the evaluation and communication of urban logistics projects.

From the economic standpoint, the perspective of private enterprise must predominate. Two main groups of economic indicators are evaluated in the different works (dealing equally with the efficiency of the company as a whole and with global logistics in the case of urban goods transport): the macroscopic indicators of a company's economic continuity and the indicators of logistic economic performance. Regarding the environmental dimension, the main variables to be studied are the following: energy consumption, variations of pollutant emissions in comparison to an initial situation and to all urban transport emissions (people + goods). The social/societal dimension is more difficult to characterize and requires more in-depth study. Nonetheless, identifying social/societal factors within the company and variations in the number of jobs and their reassignment appear to be the main variables involved in the search for social and societal indicators. Finally, questions linked to congestion and conformity with regulations should also be taken into account in a systemic approach to urban logistics.

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