A Multi-Stakeholder and Multi-Criteria Decision-Making Approach for Evaluating the Performance of Urban Consolidation Centres

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Logistical activities contribute about 10% to 30% of the total volume of traffic in urban areas (Agrebi *et al*., 2015). Such activities generate approximately 25% of CO_2, 30% of NO_x, 40% of noise due to city traffic (Lebeau *et al*., 2017). Evidence from many urban areas shows that urban logistics generates about 40% of the total logistics cost in the supply chain and causes 50% of the road accidents in the city centre (Lebeau *et al*., 2017).

Within this context, *pooling solutions* proved to be an efficient way for alleviating environmental and congestion problems in urban areas. The significant feature of this method is to implement consolidation models within city areas. In this, different organisations (e.g. shippers, carriers, customers) collaborate in the common use of logistics resources regarding materials, equipment, and human resources (Jesus *et al*., 2014). As a pivotal type of facility within such models, Urban Consolidation Centres (UCCs) have received increasing interests from both the academic community and practitioners.

An UCC is *a facility involving the transhipment of goods directed to urban areas, aiming to consolidate deliveries, and thus provide greater efficiency (and effectiveness) in the distribution process by increasing the truckload factor and decreasing the number of trucks used, which help mitigate urban congestion and air pollution* (Tario *et al*., 2011). Normally, an UCC delivery network (Figure 1) is composed of different participants such as operators, shippers, carriers, UCC administrators. Furthermore, two more kinds of stakeholders: goods suppliers and consumers are involved in this delivery system (Wang *et al*., 2015).

Physically, goods from different origins should be gathered at the UCC before they move into urban areas. After this intermediate step, goods will be sorted depending on their destination and due date; finally, goods will be allocated for final deliveries in the city centre through the

usage of smaller vehicles. The key objective of UCC facilities is to achieve a higher truck loading rate, along with a lower number of utilised trucks (Nguyen *et al*., 2015).

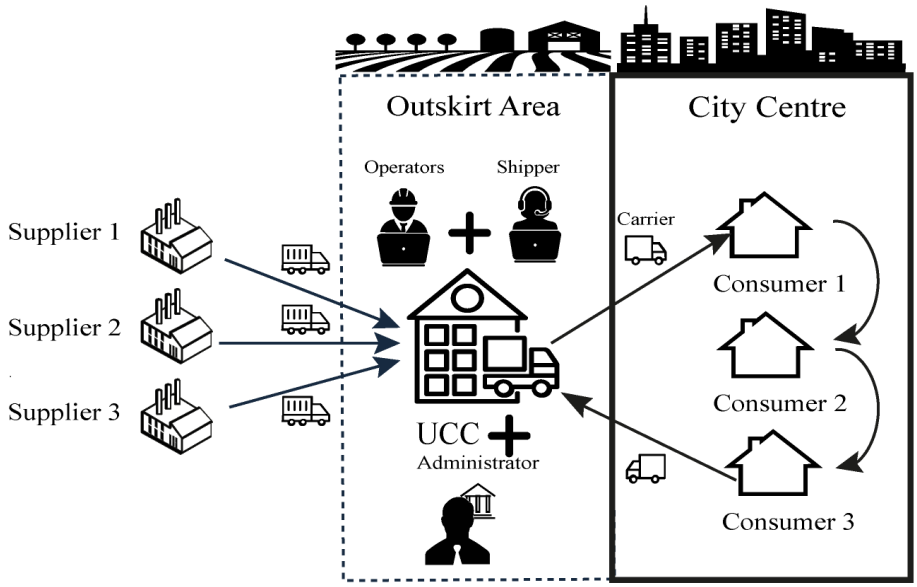

Figure 1 - A typical UCC delivery network

UCCs have become a popular research topic since the late 1990s; in particular several approaches have been developed in order to evaluate the performance of UCCs (Browne *et al*., 2005). Most of the papers produced within this research strand concentrate on the evaluation of the environmental performance of UCCs, investigating how operating models (Finnegan *et al*., 2005), locational decisions (Lindawati and De Souza, 2017) and technological choices (Allen *et al*., 2011) affect the performance of UCCs across several environmental indicators (such as fuel consumption, gas emission, pollution).

However, in the context of urban logistics, the performance evaluation of the UCCs should not ignore the economic and social perspectives. As highlighted by Lagorio *et al*. (2016) and Kin *et al*. (2017), to date UCCs effectiveness has been assessed mainly through multiple or single case studies analysing best practices and pilot projects. However, little is reported about the reasons for the high failure rate registered in projects adopting such facilities and the financial difficulties being often encountered.

The availability of adequate tools, capable of addressing, from a multi-stakeholder perspective, also strategic issues (for instance, related to the investment planning phase) rather than just operational ones (concerned with the day-to-day functioning of already established logistical platforms) could be of interest to stakeholders involved in the policy and decision-making processes that guide UCC initiatives.

In addition to this, the evaluation of the performances of UCCs according to a triple bottom line perspective remains a challenging taks, given the conflicting essence of involved criteria and the multi-stakeholder nature of the problem (Gonzalez-Feliu and Morana, 2014).

Within this context, this study will be aimed at developing a multi-criteria decision-making (MCDM) approach for evaluating the performance of UCC systems. The approach will combine and elaborate economic, environmental and social indicators arising from previous research (Patier and Browne, 2010, Allen *et al*., 2011, Gonzalez-Feliu and Morana, 2014, Harrington *et al*., 2016, Gogas and Nathanail, 2017) and seek to capture the perspective of the multiple stakeholders involved in UCC systems. Table 1 shows the indicators for the performance evaluation of UCC.

Dimension	Criterion	Indicator
Economic	Operating Cost	Annual Operating Cost(AOC)
	Profitability	Annual Revenues
	Pricing Policy	Typical Delivery Price
	Infrastructure Usage Efficiency	Infrastructure Surface Usage Rate
	Goods Handling Efficiency	Goods Handled per Full-Time Equivalent Employee
	Delivery Efficiency	Delivery Accuracy Rate
	Service Level	Lead Time of Delivery Goods from UCC to its Users
Environmental	Eco-Vehicle Equipment	Percentage of Alternative Vehicles
	Rational Vehicle Utilization	Truck Loading Rate
	Emission Generation	Travel Miles in Urban Areas
	Delivery Trips	Number of Delivery Trips per day
Social	Public Support	Public Financial investment
	Workers' salary	Average staff salary
	Fair Labour	Workers' overtime utilisation
	Approachability	Typical Workers' commute Time
	Traffic Volume Generation	Total Travel Time in City Centre
	Congestion Generation	Time for on-street Parking

Table 1- List of the Criteria and Indicators for the Evaluation of the UDC

Real-world UCC cases from UK, Sweden, Italy and China will be evaluated based on the above indicators. These four cases will reflect the diversity of UCCs performance across identified dimensions within different socio-economic contexts, including free-market economies with different degrees of state intervention (UK, Italy, Sweden) along with centrally-planned economies (China). For each case, a synthesis of UCC performances will be performed by aggregating indicators according to MCDM methodologies (such as Analytic Hierarchy Process and TOPSIS).

The research will allow the identification of strengths and weaknesses of the different surveyed UCCs, establishing a benchmarking tool (also usable by decision- and policy-makers) that will contribute to a better understanding of UCCs functioning and to the identification of potential improvement areas.

Acknowledgments

This research was partially supported by the project "*Promoting Sustainable Freight Transport in Urban Contexts: Policy and Decision-Making Approaches* (ProSFeT)", funded by the H2020-MSCA-RISE-2016 programme (Grant Number: 734909).

References

AGREBI, M., ABED, M. & OMRI, M. N. Urban distribution centers' location selection's problem: A survey. 2015. Institute of Electrical and Electronics Engineers Inc., 246-251.

ALLEN, J., BROWNE, M., LEONARDI, J. & WOODBURN, A. 2011. The role of urban consolidation centres in sustainable freight transport. *Supply Chain Innovation for Competing in Highly Dynamic Markets: Challenges and Solutions.* IGI Global.

BROWNE, M., SWEET, M., WOODBURN, A. & ALLEN, J. 2005. Urban Freight Consolidation Centres Final Report.

FINNEGAN, C., FINLAY, H., O'MAHONY, M. & O'SULLIVAN, D. 2005. Urban freight in dublin city center, Ireland: Survey analysis and strategy evaluation. *Transportation Research Record.*

GOGAS, M. A. & NATHANAIL, E. Evaluation of Urban Consolidation Centers: A Methodological Framework. *In:* KABASHKIN, I., PRENTKOVSKIS, O. & YATSKIV, I., eds., 2017. Elsevier Ltd, 461-471.

GONZALEZ-FELIU, J. & MORANA, J. 2014. Assessing urban logistics pooling sustainability via a hierarchic dashboard from a group decision perspective. *Transport and Sustainability.* Emerald Group Publishing Ltd.

HARRINGTON, T. S., SINGH SRAI, J., KUMAR, M. & WOHLRAB, J. 2016. Identifying design criteria for urban system 'last-mile'solutions–a multi-stakeholder perspective. *Production Planning & Control,* 27**,** 456-476.

JESUS, G.-F., FRÉDÉRIC, S. & JEAN-LOUIS, R. 2014. *Sustainable urban logistics: Concepts, methods and information systems,* Springer.

KIN, B., VERLINDE, S. & MACHARIS, C. 2017. Sustainable urban freight transport in megacities in emerging markets. *Sustainable cities and society,* 32**,** 31-41.

LAGORIO, A., PINTO, R. & GOLINI, R. 2016. Research in urban logistics: a systematic literature review. *International Journal of Physical Distribution & Logistics Management,* 46**,** 908-931.

LEBEAU, P., VERLINDE, S., MACHARIS, C. & VAN MIERLO, J. 2017. How can authorities support urban consolidation centres? A review of the accompanying measures. *Journal of Urbanism***,** 1-19.

LINDAWATI & DE SOUZA, R. Determining urban freight facility locations using post-evaluation deliberation. *In:* YANG, L. T. & CHEN, J., eds., 2017. Institute of Electrical and Electronics Engineers Inc., 1297-1303.

NGUYEN, D. T., LAU, H. C. & KUMAR, A. Decomposition techniques for urban consolidation problems. 2015. IEEE Computer Society, 57-62.

PATIER, D. & BROWNE, M. A methodology for the evaluation of urban logistics innovations. Procedia - Social and Behavioral Sciences, 2010. Elsevier Ltd, 6229-6241.

TARIO, J. D., ANCAR, R., PANERO, M., SHIN, H.-S. & LOPEZ, D. P. 2011. Urban Distribution Centres A Means to Reducing Vehicle Miles Traveled (Final Report).

WANG, C., LAU, H. C. & LIM, Y. F. 2015. A rolling horizon auction mechanism and virtual pricing of shipping capacity for urban consolidation centers. *In:* VOSS, S., NEGENBORN, R. R., CORMAN, F., NEGENBORN, R. R. & NEGENBORN, R. R. (eds.). Springer Verlag.