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A hybrid approach integrating Affinity Diagram, AHP and fuzzy TOPSIS for sustainable city logistics planning

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ABSTRACT

City logistics initiatives are steps taken by municipal administrations to ameliorate the condition of goods transport in cities and reduce their negative impacts on city residents and their environment. Examples of city logistics initiatives are urban distribution centers, congestion pricing, delivery timing and access restrictions. In this paper, we present a hybrid approach based on Affinity Diagram, AHP and fuzzy TOPSIS for evaluating city logistics initiatives. Four initiatives namely vehicle sizing restrictions, congestion charging schemes, urban distribution center and access timing restrictions are considered.

The proposed approach consists of four steps. The first step involves identification of criteria for assessing performance of city logistics initiatives using Affinity Diagram. The results are four categories of criteria namely technical, social, economical and environmental. In step 2, a decision making committee comprising of representatives of city logistics stakeholders is formed. These stakeholders are shippers, receivers, transport operators, end consumers and public administrators. The committee members weight the selected criteria using AHP. In step 3, the decision makers provide linguistic ratings to the alternatives (city logistics initiatives) to assess their performance against the selected criteria. These linguistic ratings are then aggregated using fuzzy TOPSIS to generate an overall performance score for each alternative. The alternative with the highest score is finally chosen as most suitable city logistics initiative for improving city sustainability. In the fourth step, we perform sensitivity analysis to evaluate the influence of criteria weights on the selection of the best alternative.

The proposed approach is novel and can be practically applied for selecting sustainable city logistics initiatives for cities. Another advantage is its ability to generate solutions under limited quantitative information. An empirical application of the proposed approach is provided.

1. Introduction

Modern cities are facing congestion, lack of public space, huge waiting times, air pollution, and noise arising air from goods movement in cities. To maintain the economic growth of cities and meet customer demands, organizations are continually involved in production and distribution of goods; however, this has come at an unexpected cost of degradation of quality of life in modern cities [1]. To cope up with this growing crisis, municipal administrations are investing in

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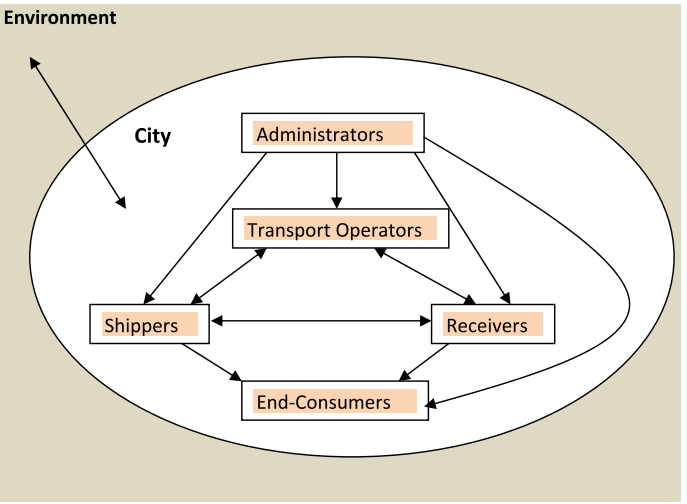

Fig. 1. City logistics stakeholders.

sustainable city logistics initiatives to ameliorate the condition of goods transport in cities and reduce their negative impacts on city residents and their environment. Examples of these initiatives are urban distribution centers, congestion pricing, delivery timing and access restrictions.

According to the Council of Logistics Management, [2], "Logistics is that part of the supply chain process that plans, implements, and controls the flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customer's requirements". The logistics associated with consolidation, transportation, and distribution of goods in cities is called city logistics. From a systems point of view, city logistics consists of many subsystems involving different stakeholders namely shippers, receivers, end consumers, transport operators and public administrators (see Fig. 1). The end-consumers are residents or the people that live and work in the metropolitan areas. Shippers (wholesalers) supply good to the receivers (retailers, shopkeepers) through transport operators (or carriers). Administrators represent the government or transport authorities whose objective is to resolve conflict between city logistics actors, while facilitating sustainable development of urban areas.

In recent years, several studies have been conducted by researchers on city logistics planning and evaluation. Munuzuri et al. [3] presents a compilation of solutions that can be implemented by local administrations in order to improve freight deliveries in urban environments. Visser et al. [4] present a classification of public, private and public-private measures related to urban freight. The COST 321 Action [5] report categorizes urban freight transport measures as promising and less promising measures based on experts survey. Dablanc [6] brings forth difficulties in implementing logistical measures in European cities and proposes consideration of stakeholder involvement and interests in devising new policies and regulations. A detailed study of modeling approaches for evaluating and planning city logistics measures can be found in Taniguchi et al. [7] and Crainic et al. [8].

The existing studies on city logistics planning can be mainly classified into (a) survey based approaches, (b) simulation based approaches, (c) multicriteria decision making based approaches, (d) heuristics based approaches and (e) cost-benefit analysis based approaches. Allen et al. [9] conducted group discussions with companies to analyze the potential impacts of sustainable distribution measures in UK urban areas. Esser and Kurte [10] use empirical data from customer survey to analyze the impact of B2C e-commerce on transport in urban areas in Germany. Anderson et al. [11] conduct a survey study to investigate the operational, financial and environmental effects of city logistics policy measures. Thompson and Hassall [12] use ratings scores for evaluating urban freight projects. Patier and Alligier [13] use Delphi study and Structural Equation Modeling to assess the current and future effects of online retailing on city logistics in France. Quak et al. [14] use case studies of 14 Dutch organizations to investigate the impact of governmental time-window pressure on retailers' logistical concepts and the consequential financial and environmental distribution performance.

Studies on simulation based approaches involve simulation of urban freight over the road networks to assess their impacts. Barceló and Grzybowska [15] combine vehicle routing models and microscopic traffic simulation to model and evaluate city logistics applications. Taniguchi and Tamagawa [16] proposed a simulation based approach for evaluating city logistics measures considering the behavior of several stakeholders. Yamada and Taniguchi [17] use bilevel optimization model for representing the behavior of stakeholders associated with urban goods delivery. Taniguchi and Van Der Heijden [18] present a methodology for evaluating city logistics initiatives using a dynamic traffic simulation with optimal routing and scheduling. Awasthi and Proth [19] propose a system dynamics based approach for city logistics decision making. Segalou et al. [20] propose a traffic simulation model for environmental impact assessment of urban goods movement. Marquez and Salim [21] use scenario analysis to investigate the sensitivity of urban freight patterns to various greenhouse gas abatement policy measures.