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A conceptual model for intermodal freight logistics centre location decisions

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Abstract

The persistent growth of freight traffic congestion and air pollution in urban areas and the increase of imbalance and inefficiency in land use development drive public authorities and users to find alternative logistics solutions to ease the freight traffic problem. Intermodal freight logistics centres play an important role in achieving socio-economic and environmental sustainability by enhancing an optimal integration of different modes to provide an efficient and cost-effective use of the transport system through customer-oriented, door-to-door services while favouring competition among transport operators. An efficient logistics centre structure may lead to a significant profit and return on investment as well as a significantly increased competitive advantage in the market place by meeting strategic commercial objectives, where determination of the location is a key factor in enhancing the efficiency of urban freight transport systems and initializing relative sufficient supply chain activities. Hence, public authorities should consider the importance of this topic by any given decision in terms of strong economical, social and environmental implications before announcing an area as a logistics centre. The objective of this study is to explore the applicability of the way for the development of a conceptual model based on a combination of the fuzzy-analytical hierarchy process (AHP) and artificial neural networks (ANN) methods in the process of decision-making in order to select the most appropriate location. A numerical example is provided to demonstrate the concept of proposed model.
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Keywords: Location problem; intermodal freight logistics centre; selection; decision-making; fuzzy-AHP; ANN

1. Introduction

Intermodal freight logistics and passenger transport in today's highly competitive environment are gaining a remarkable profile in the planning of Europe's city regions. Their roles in shaping cities driven by congestion and environmental concerns, the changing requirements of global supply chain systems and the rapid advancement of information and communication technologies (Zografos and Regan, 2004) are also being examined more closely by investors, city planners and environmental lobbyists.

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The European traffic predictions show a significant growth of traffic levels by 2020 which is expected to be 30% in freight logistics and 20% in passenger transport. However rapid growth in transport is deteriorating cities (like pollution, traffic congestion, accidents, environmental emissions, dependence on fossil fuels etc.), freight transport is a key support system has become a more and more central issue to resolving conflicts between economic development, sustainability and social equality. Moreover, environmental problems concerned with transport could be ameliorated through the improvement of transport efficiency and carefully located logistics centres.

One of the main objectives of the sustainable long term transport development program is to develop a framework for an optimal integration of different modes of transport in the regional logistics centres so as to enable efficient and cost-effective use of the transport system through seamless, customer-oriented door-to-door services, favouring competition among transport operators (Babkock and German, 1989). In the scope of the European Union (EU) transport policies, in order to enhance intermodality and interoperability, many logistics centres are formed. These centres play a critical role in optimizing and intensifying logistic services along supply chains, presenting a practical means to solve urban traffic congestion while increasing the efficiency of the freight transport, thus encouraging innovation and lowering of the transportation cost that focus on intermodal operations, and logistics activities.

An intermodal freight logistics centre is a cluster of quality industrial/intermodal /distribution/logistics buildings located within a secure perimeter where a range of support services are provided by every user. It enables a high degree of accessibility and transfers freight from one mode to another with generating less negative environmental impacts (McCalla, 2001; Weisbrod et al., 2002).

The location of the logistics centres is a key element in enhancing the efficiency of urban freight transport systems and initializing relative supply chain activities sufficiently; thus, the location of a intermodal freight logistics centre should be selected carefully; otherwise it may cause irreversible consequences in the city planning and also it may create bottlenecks that lead to rapid increase in cost in providing transport solutions. All influencing factors for the determination of a location should be considered and well planned. Hence, public authorities should consider the importance of this topic by any given decision in terms of strong economical, social and environmental implications before announcing an area as a logistics centre.

Facility location and capacity planning problems have been solved using different operational research techniques for years where the selection of logistics location has been long considered one of the most important complex decision-making problems to analyze. In real-world systems, selecting the “most appropriate” location should be considered and evaluated in terms of many different influence factors resulting in a vast amount of information which are most of uncertain and imprecise. Furthermore, the determination of dependent and independent relationship between selection criteria for location problem is very difficult to classify. Most of the conventional decision-making models like linear programming (LM), mixed integer programming (MIP) and goal programming (GP) etc. have limitations to enlighten the interrelations among the sub-criteria of the given context by the validity of the additivity and independence assumptions and moreover the application costs are very high in terms of limited data handling capabilities of the approaches, therefore they can only be applied in solving the medium-sized simple problems.

The objective of this study is to explore the applicability of the way for the development of a conceptual model based on a combination of the fuzzy-analytical hierarchy process (AHP) and artificial neural networks (ANN) methods in the process of selecting the location of an intermodal logistics centre. In this study, the relative dependence and interdependence influence factors based on well-organized literature review are identified. Here, the fuzzy extension of the AHP technique is used to derive the priorities (relative weights) of each selected criterion. ANN are used to alleviate the multi-criteria decision-making (MCDM) and to obtain the best model configuration for the location problem. Matlab v. 6.5 is used for the ANN application. The model presented helps practitioners (i.e. decision-makers - public, regional and municipal authorities) to make a decision with respect to the considered criteria and contributes city logistics relative issues. Furthermore, the results of the model can be used to develop a software solution for location-selection problems in complex decision-making environments. Finally, the proposed conceptual model is illustrated to demonstrate an empirical case study to show the best solution among given alternatives. Further, the results provide some critical evaluations on how to improve each sub-criterion to reduce the gap between real and desired performance values to determine the most appropriate intermodal freight logistics location in any urban area.

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