A Taxonomy Proposal on Criterion Structure for Evaluating Freight Village Concepts in Early-Stage Design Projects

Rıza Gürhan Korkut, Metin Çelik, Süleyman Özkaynak

Abstract—The early-stage design and development projects for the freight village initiatives require a comprehensive analysis of both qualitative and quantitative data. Considering the literature review on structural and operational management requirements, this study proposed an original taxonomy on criterion structure to assess freight village conceptualization. The potential challenges and uncertainties of the developed taxonomy are extended. Besides requirement analysis, this study is also expected to contribute to forthcoming research on benchmarking of freight villages in different regions. The methodology used in this research is a systematic review on several articles as per their modelling approaches, sustainability, entities and decisions made together with the uncertainties and features of their models taken into consideration. The major findings of the study that are the categories for assessing the projects attributes on their environmental, socio-economical, accessibility and location aspects.

Keywords—Freight village, logistics centers, operational management, taxonomy.

I. INTRODUCTION

DEFINITION of a logistics center is so important such that certainly effects planning process, process scope, selection framework and analysis criterion. If you want to compare the Logistics Centers built in several European countries with each other, then you might find differences in the names and in their concepts as follows: Freight Village, Plate Forme Logistique, Plate Forme Multimodals, Güterverkehrszentrum (GVZ), Interporto, Rail Service Centre (RSC), and Transport Centre [25]. In the Turkish language, it is referred to generally as a Lojistik Merkez (logistics center) or sometimes Lojistik Köy (logistics village). There are differences that are not limited only with the naming, where conceptual and service differences exist. For example, in Germany, each GVZ is designed for a concentration and clustering center, whereas port services are privatized for each Interporto in Italy so there is commercial competition among them sustaining export business and transit trade through Italian ports.

EUROPLATFORMS EEIG's (European Association of Freight Villages) general assembly in 2015 approved the definition of a logistics center as in the following sentence:

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"Centre in a defined area within which all activities relating to the transport, logistics and distribution of goods, both for national and international transit, are carried out by various operators on a commercial basis" [26].

The goal of this paper is to introduce a taxonomy of Freight Village Concepts comparing the decisions made regarding to the locations, infrastructure, managerial structure and human resources organization, investors or participants, services and all business activities that are shaping their related projects. One of the crucial subjected matters is the location of the facility where the establishment of the project takes place. The key attributes of each project identifying their conceptual and operational characteristics are also considered as important as the others which are incorporating the commercial, business and socio-economic aspects of each project from their customers' view point; integration built in logistics service operations, business development opportunities and competitiveness for partners and customers, resources available for participants, etc.

We focused on what might be the solutions and ways to make, in general, Logistics Centers, and particularly Freight Villages, more efficient through their operational processes starting from investment planning and through to the implementation stage. The operational functions, internal organizations and design of their processes, type of services offered and infrastructure of all those centers are evolving in recent decades. This is mainly because of the goals and aims of the investors, including private companies and their partners, as well as local authorities who influence the investment decisions chasing answers to the satisfy socio-economic environment including urban and industrial regions surrounding them.

II. METHODOLOGY

The research has taken place over a period of seven months starting from March 2017 to October 2017, through multiple accesses to academic research databases such as Science Direct. The process of research has been realized in the English language through the articles based on the following keywords; logistics center, freight village, distribution center, dry port, logistics platform. At first glance, a concrete analysis of the building blocks of any business model is required for logistics centers as per their current level of service demanded by the worldwide customers. Those elements are listed in brief by the following section named "business model elements of any logistics center".

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After having an exposure on logistics center's business model, the systematic review of selected articles found in the database has shown the similarities, differences as well as their elements of performance characterizing the initial stages of logistics center projects. This is explained in the section named "review of studies".

III. Logistics Centers Business Model Elements

The most effective framework that is needed when developing a specific business model of logistics center should include intermodal transportation opportunities coupled with reverse logistics, customs operations and last-mile production or assembly services beside almost all other traditional logistics services such as transportation and warehousing management. It is necessary to consider freight villages as a complex system covering many processes at one location [1]. It is like one-stop shop where all the logistics services are provided as per the customers' expectations even in a tailor-made style for some customers.

It is also important to have a clear conceptual view on the full description of the logistics center, understanding and presenting this context at the design stage. One of the crucial aspects of that view is other the major objectives of the project that mitigate the negative impacts of logistics operations on natural resources. Investors might change their decision already made about the location of the logistics center just because of conservative thinking about the natural resources.

Stakeholders of any logistics project might be directly the government, local municipality, as well as shippers themselves or carriers whose ideas affect the final decision on the initial design of the business model.

Project initiators determine the model's elements that compromising the project structure from scratch. Those initiators are generally belonging to public or private, and sometimes public private, partnerships.

The Business Model and Scope of the Operations are the important pillars of any logistics project and financing model of the project investment is one of those. Decision makers should group the target customers and their probable segments of them with their common needs, behaviors or other attributes and then contemplate the services to be offered as per the spotlighted customers' requirements. This is needed either for customer acquisitions through the start-up period of the project or boosting up the retained sales volumes at the upcoming stages of the project.

The value proposition of the project should create, deliver and capture value at economic, environmental and social context for a sustainable competitive business model and this element of the model reflects the reasoning behind the customer's expectations from the model's owners.

The business model of any logistics center needed to be designed in such a manner benefiting from having network of suppliers and partners of their own work. Several partnership opportunities with some other logistics centers located at strategic routes of any transportation modes and cost-effective logistics service operators should be sought and developed. This may strengthen the logistics center's ability for providing services in a much more effective and efficient way, while reducing risks and uncertainties through the end-to-end logistics process.

Technology is one of the key elements to be integrated in all processes of any logistics center project, since monitoring all the services and operations in supply chain is the major aim for a successful directorship. Transparency in process monitoring and availability of information improve the supply chain process efficiency and effectiveness, where information and communication technologies and their developed applications integrated into the processes.

The business competitiveness of the model might easily be increased by means of applied innovative technologies, which are illustrated by evolving existing logistics infrastructure for better competitiveness of intermodal transport operations.

IV. Review of Studies

In this section, we present the outcomes of the review process applied through the selected articles having focused on the location selection problem, which is one of the early stage design aspects of any concept proposed for freight villages. Similarities, differences and the elements of performance characteristics of freight village projects are revealed.

The location of a logistics center was investigated, and importance given to the planning activities of the center in a study [1]. Several effects of these activities on the site selection were also analyzed by a novel approach named multiple criteria location modelling. On the other hand, as comprehensively conducted in [2], the location selection problem of a logistics center is a four-phase process. In the first phase, GIS (Geographical Information Systems) was used, and data were compiled. In the second phase, the places with alternative qualities were selected by their criterion weighting. By using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and with the help of weighted criteria prepared by ANP (Analytic Network Process), the best of the alternatives was selected by means of GIS based on a MCDM (Multiple-Criteria Decision Making) approach. Previously, location selection for the logistic center is studied while optimizing the size of center at the same time. An approximate solution has been wisely sought with a heuristic method called genetic algorithm which is modelled with Queuing Theory and Nonlinear Programming [3]. In another research [4], the factors, might affect the activities in the logistics center to ensure the sustainability of the natural environment, were addressed. In that study, MCDM method, initiated for scoring, is supported with the Bayesian Network to avoid the arbitrary weight determination and prioritized each variable according to the set of variables.

As it is stated in [5] that in any logistics center location problem, the expert groups have given greater significance to the aspects considered in the classical theories of industrial location selection. Assigning the most appropriate location to a logistics center is a geographical multidisciplinary problem with economic, social and environmental implications. In the same article [5], it was also asserted that most of the logistics

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centers already built in Spain were not satisfactory in terms of many technical criterions and even might be assessed as weak or inadequate. The MADM (Multi-Attribute Decision Making) method was used instead of the MCDM method with quantitative and qualitative, softened assessments of decision makers who were referred to their opinions due to their qualifications such as adequacy or suitability of alternative locations in a research [6]. On the other hand, the objective and subjective ideas of the managers and experts who were referred to in their opinion were translated into quantitative form with AHP (Analytic Hierarchy Process), and then the alternatives were sorted with PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) and then concluded with the MCDM in an evaluation study of the potential freight villages in Istanbul [7].

The evaluation of factors affecting the sustainability of a Dry Port is the focal point of an article proposing a methodology for measuring sustainability of dry ports locations [8]. A novel methodology comprising MCDA (Multi-Criteria Decision Analysis) and BN (Bayesian Networks) has been suggested. It is tried by using MCDA to prevent the orientation of arbitrary results with a BN-based "artificial intelligence" software. A scoring methodology with MCDA has been evaluated, and the relationship of each variable with BN to others. The value of each variable is analyzed with ArcGIS which is an online mapping tool for applying location-based analytics.

A feasibility study of solar farms deployment analysis has been mentioned in an article focusing on investments in the solar energy industry and the location selection of this purpose-oriented installation has gained importance in terms of social-technical-economic-environment and political factors [9]. The hybrid methodology used in the location selection of solar farms by the use of MCE (Multi Criteria Evaluation), AHP (Analytical Hierarchical Process) and FTOPSIS (Fuzzy Technique for Order Preference by Similarity to Ideal Solution). The approach in this research has been suggested to be used by many other policy planners working for location selections in different geographies and qualifications. In another article, optimal site selection for electric vehicle charging stations (EVCS) is chosen as an inspiring study for the researchers whose aiming an analysis from the sustainability perspective [12]. The location selection problem of an electric vehicle charging station is an analysis within which the choice of conflicting criteria required. Presented alternatives are carefully examined from the perspective of 11 environment-economic-social criteria, and then performance and weights of the criterion judged by 5-different specialist groups.

It is communicated by during 16th Conference on Reliability and Statistics in Transportation and Communication proposing that the urban consolidation centers are required to be examined as per their supply chain integration with each other [10]. It was suggested that optimization to be done through the following 3-successive steps: (1) choosing the most suitable residential area of each of the facilities, (2) determining the characteristics of each facility responding to the needs, (3)

evaluation of the design as part of other local policies and to be developed in accordance with the requirements. A solution has been achieved by an assessment methodology strengthened with the support of some selected performance indicators taking into consideration the business models and objectives of several beneficiaries having conflicting objectives. In another article, the effects of local policies are taken into the account while selecting the best suiting candidate [11]. It is realized as a fact that there are known and common corporate values and principals in the company in relation to human resources, and recruitment process required to comply with these rules in the selection. It is emphasized that local values affect such a selection and so the judgment of independent and consistent decisions are also sought to be taken.

In the literature, there are such studies focusing on the sustainability and societal equity perspective for the freight villages [13]. The purpose was to present a literature review on freight villages from the sustainability and equity perspective by discussing the impacts of freight villages and their corresponding location in logistics networks.

The City Logistics concept is a good example for aiming at a solution for a specific logistics problem, while aiming to mitigate any negative impact of freight transportation on economic, social and cultural activities of the same region. So, it was worth to mention such an article as having a 3-layer taxonomy about a city logistics model having been prepared based on five components and 22 criteria with 72 informative items gathered as precisely as possible about 70 sample cities [14]. The description, business model, functionality, scope and technology of the model are all involved in the design of this model as its components. On the other hand, a New Taxonomy of Smart City Projects was introduced at 17th meeting of the EURO Working Group on Transportation in Spain [15]. The major aim of this taxonomy was to specify a tool for comparing projects in terms of their success factors, potential gaps, business models and information that is available in public. They identified a criterion that enlightened several aspects through three axes such as description, business model and purpose of the project.

Intermodal transportation is one of the crucial elements of contemporary logistics models and is directly involved in any freight village design problem. A cluster analysis-based taxonomy with common characteristics was conducted for the sake of simulation of intermodal freight transportation [16]. The research question of this study was defined in terms of network description and planning aspects of the systems and the main finding of the same was that most of the literature proposes the simulation model for comparing the alternatives. Location selection decision of logistics hubs considering the structure of the alternatives was the subject of a study which proposed that such a decision was strategic and dependent enough on many aspects affecting the final decision of experts either quantitatively or qualitatively that required to be assessed for a successful comparison [17].

A GIS (Geographic Information System) based multi-criteria decision analysis was conducted by a team of

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researchers [18]. First, a group of experts organized defining logistics performance dimensions and evaluation criterion, and then geographic information for each province mapped by using GIS generating optimum location which satisfies all criteria. Evaluation criterion is weighted and then ranked by AHP-ANP-TOPSIS consecutively. AHP is used to do a pairwise comparison, ANP took the problem as a network modelling and finally TOPSIS showed the positive ideal solution that indicate the criteria on which the best alternative is required to be improved. A model is proposed based on freight distribution planning for dry ports in an article [19]. It is intentionally planned to focus on a tactical planning consisting in the definition of the optimal schedule for the railway network connecting seaport terminals and dry ports. Candidate terminals were compared with their space, time and pick-up and delivery figures for each cargo demand. Three decision levels are specified, and the location-allocation-design-layout of the dry port were as classified as strategic and included in the first level. Several cost items and operational limitations are considered as vital in the model optimization. On the other hand, a conceptual model for intermodal freight logistics center location decisions was proposed by a research paper [21]. The objective of this study was to explore the applicability of the way for the development of a conceptual model based on a combination of AHP and ANN (Artificial Neural Networks) methods in the process of decision-making to select the most appropriate location. The evaluation criteria and sub-criteria for fuzzy AHP hierarchical structure were selected according to the interviews with experts and literature review. Finally, an evaluation criterion having included the environmental effect, international market location, intermodal operation and management, national stability and economical scale, is determined.

A multi-objective location selection decision model for biomass power plants is proposed in an article which was classified as an inspiring model for freight village location selection problem [20]. The aim of the research was to minimize logistics cost together with pollutant emissions during biomass feedstock transportation. There was a linear relationship found between the transportation cost of biomass and distance between the biomass collection stations and the bioenergy plant. Design of a biomass feedstock supply chain was also included in the model, and bi-objective 0-1 integer programming was applied for seeking the solution.

A dyad development of seaports and dry ports was studied based on cases from Northern Europe by a group of researchers in 2014 [22]. The value-added services included in dry ports and the intensive integration with the intermodal transportation, were classified as highly important role players in the dry port development and on the process of location selection decisions. Postponement concepts take place in contemporary supply chains and some value-added services needed to be performed as customized as per the consumers' preferences. So, dry-ports are becoming a direct client of sea ports where assembling, re-packing, labeling, sorting and sequencing services are needed but not possible to be performed because of the sea-port's conceptual design. An

article subjecting the directional development of intermodal freight corridors in relation to dry ports [23] was one of the reference studies of [22]. The development process mentioned in this paper had a twofold concept: inside-out and outside-in. Inland intermodal terminals seek greater integration with their sea ports, often driven by public body intervention in the inside-out concept. The problem of such a development concept is to have conflicting priorities at different scales and the danger of subsidizing sub-optimal facilities needs to be addressed. In the outside-in concept, development is displayed by the conscious use of an inland node as a tool for sea port actors to expand their hinterland and capture discretionary cargo. This type of development is rare since port authorities, terminal operators or shipping lines are reluctant to promote their interests in any development.

By the last quarter of 2017, a novel intuitionistic fuzzy integrated methodology for a freight village location selection problem was proposed and which was a multi-expert and multi-criteria decision-making problem to be solved [24]. In the mentioned methodology, there were three phases. In the first phase, DEMATEL (Decision Making Trial and Evaluation Laboratory Model) is used for finding the most appropriate and influential factors to use in the ANP method. In the second phase, the Super-Matrix Network is prepared, and Service Level furnished with Outer and Inner Dependencies. Finally, TOPSIS is used to find the best alternative among the eligible ones.

Papers gathered and reviewed for this study are all focused on the decision stage of projects taken from several industries, a logistics center or an electric vehicle charging station. For each of those projects from different industries, the criterion proposed, and the methodologies used for finding the ideal solution are mentioned and then compared with each other. Their similarities, differences and performance characteristics are also pointed out.

V. Conclusion

There is never ending concern about the evaluating of logistics center concepts in their design stages. This is because of decision makers and policy planners requiring guidance and justification on which is the ideal alternative of any element in an investment. Investment budgets are high and the final decision on each project can affect the trade world, the natural environment and the quality of life of millions of people, as well as their socio-economic status. Classifying and investigating decision criterion and methodological frameworks is performed from the point of view of decision makers who need facility location alternatives. Decision making tools and methodologies providing guidance and justification aiming to find the best alternative are also discussed in this paper. There are several analysis and assessment methodologies mentioned in the paper such as DEMATEL, ANP, AHP and FAHP, ANN, BN, TOPSIS and FTOPSIS, Bi-objective 0-1 Integer Programming, GIS, MCE, MCDA, MCDM, MADM, Genetic Algorithm, Queuing Theory, Nonlinear Programming. The following criterion groups which are not limited to those are mentioned across the

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review: regional and geographical impacts, infrastructure of the facility, services and operational activities, design of integration with logistics systems, benefits and competitiveness, partnerships and governmental involvements. However, listed criterion and tools need to be tested in real life applications of new projects and re-assessment studies of existing facilities.

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