A METHODOLOGICAL DECISION FRAMEWORK FOR THE DEVELOPMENT OF FREIGHT VILLAGES WITHIN THE GLOBAL LOGISTIC SYSTEM

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ABSTRACT

The continuous evolution of production processes at an international level, the globalisation of markets and the need to ensure ever-greater competitiveness, have significantly influenced the freight market today. Thus, in order to guarantee effective management of supply and distribution chains and make them more resilient, the creation of technologically advanced and efficient instruments to support logistic systems is essential. Today, this role is played by the freight villages and logistic centres, which will require large public and private investments. On the other hand, due to their complexity and the need to follow the market requirements and demand, it is certainly one of the most ambitious and important infrastructure initiatives in the region, where they are located. Their creation is also influenced by the development of logistics at world level, which are affected by a combination of macroeconomic, business and consumer trends. From the macroeconomic point of view, the increasing globalisation of flows of goods, the relocation of production units and the increasing specialisation of production markets have generated the lengthening of freight movement distances. The scope of the proposed methodology is to provide a common framework for the development of a freight village or logistics center network, taking into consideration al, the above. It sets the priorities for developing freight villages based primarily on geo-political, demographic and regional dimensions. In addition, the proposed methodology takes into account the different factors affecting decision-making. The Decision to go ahead with the development od a specific freight village is based on the following criteria: socioeconomic viability, political/regional dimensions, transport and infrastructure planning for each freight village, quality of transport networks, interconnection of all economic and transport activity centers within the region and their connection to those of the neighbouring countries. To accomplish this, a Multicriteria Analysis (MCA) is proposed that includes the above-mentioned criteria. The proposed methodology framework is applied to two cases of freight village development in Greece and results are presented.

Keywords: Freight Villages, Transport logistics, evaluation

INTRODUCTION

The continuous evolution of production processes at an international level, the globalization of markets and the need to ensure ever-greater competitiveness and effective management of supply and distribution chains, renders the creation of efficient instruments to support logistic systems essential. Against the competition and pressure on profits, transportation – necessarily enriched and integrated into a logistics approach – is gaining particular importance, as being part of the cost structure and value chain of goods, and thus contributing to their competitiveness. In this regard, the coordination of transportation and logistics infrastructures are a key contribution to securing the country's economic and territorial development *(MOPTC, 2007)*.
On the other hand, due to their complexity and the need to follow the market requirements and demand, it is certainly one of the most ambitious and important infrastructure initiatives in the region, where they are located..
The logistics centers functions, includes as the most important one, the transferring points of freight from one mode to another (Figure 1).

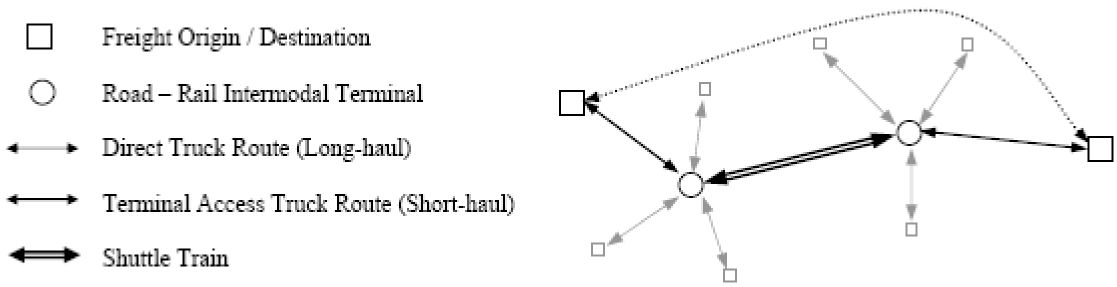

Figure 1 – Road – rail Terminal *(Sirikijpanichkul et al, 2005)*

Most of the logistics centers consist of road-rail freight transportation, which is competitive with road only over longer distances and characterized by the combined advantages of rail and road, mainly: a rail for long distances and large quantities, road for collecting and distributing over short or medium distances *(Nierat et al, 1992; Slack, 2004; Arnold et al, 2004)*.
Location of logistics centers is one of the most crucial success factors in freight transportation and needs to be considered very carefully as it has direct and indirect impacts. For example, financial, economic, social, and environmental impacts on different stakeholders involved including investors, policy makers, freight operators, industry, and the community (*Sirikijpanichkul et al, 2005)*.
Traditionally, warehouses and other types of industrial spaces were concentrated near manufacturing centers. Today, deciding where to locate a logistic center depends largely on access to suppliers and consumers *(Belmonte, 2004)*. Large-scale distribution is increasingly dependent on major hubs such as airports, seaports, railway and highway networks.
The scope of the present paper is to prioritize the locations of logistics centers at the national land use planning, which will constitute the national logistics centers master plan. The

selection of the most appropriate location for the development of a logistics center will contribute to the achievement of a logistics network and the improvement of the national economy and could place the country within the global logistics network.

THE ELEMENTS OF LOGISTIC CENTERS

Activities at logistic centers

Every step of the supply chain process – the system of moving goods form produces to end user – requires an area in order to store and distribute products. The factories, warehouses and distribution centers that support global supply chains are an important segment of commercial real estate. To meet the challenges associated with the need of speed, the supply chain has become a highly complex process dependent on sophisticated technologies and logistics *(Frej, 2004)*.

Logistics, a specialty within the supply chain process, is defined by the Council on Logistics Management as “that part of the supply chain processes that plans, implements, and controls the efficient, effective forward and reverse flow and storage goods, services and related information between the point of origin and the point of consumption in order to meet customer’s requirements”.

Ensuring that the right goods are at the right place at the right time in the right quantity involves a complex planning matrix that includes forecasting, procurements, production planning and scheduling, inventory control, warehousing, transportation, customer service and related information systems *(Mentzer et al, 2001)*.

The logistics equation thus comprises two separate but interrelated activities: transportation/distribution and warehousing. Transportation managers must make decisions on optimal freight modes, factoring the company’s cost/efficiency matrix in scheduling pickups and deliveries. Warehouse management functions include location strategy for distribution centers, inventory management and control, facilities management, and loading dock strategies in order to achieve optimal design for loading docks and coordinate delivery schedules and carrier loading for maximum efficiency *(Moline, 2004)*.

An efficient logistic center requires absolute coordination and full integration between and among all the stakeholders that play a role in a supply chain. Companies that are involved in the supply chain, cooperate with partners who can add value to the entire enterprise by effecting savings, enhancing earnings, and getting goods to market in better, faster and cheaper ways, thus making it more attractive to customers.

The logistics related to infrastructure become increasingly important, since the companies are outsourcing the logistics functions to third-party logistics providers, or “3PLs”, such as DHL and Exel. While many 3PLs began as freight transporters, they now provide everything form various transportation options to inventory management and warehousing services to distribution.

Additionally, organizations create value for their customers either by increasing the level of “benefit” that they deliver or by reducing the customers’ costs. In fact customer value can be identified as *(Christopher, 2003)*:

Customer value = Perceived benefits/Total cost of ownership (1)

Characteristics of logistics centers or freight villages are described as *(McCalla et al, 2001)*: transfers of freight from one mode to another; requiring large amount of land and a high degree of accessibility; having a low rental which is affordable by every user; and generating negative environmental impacts especially noise and traffic congestion *(Slack et al, 1997)*.

Location Decisions for logistic centers

The logistics centers have direct and indirect impacts on land use and business development *(McCalla et al, 2001)*. A number of factors influencing terminal location decisions can be viewed from different perspectives, as shown in Figure 2.

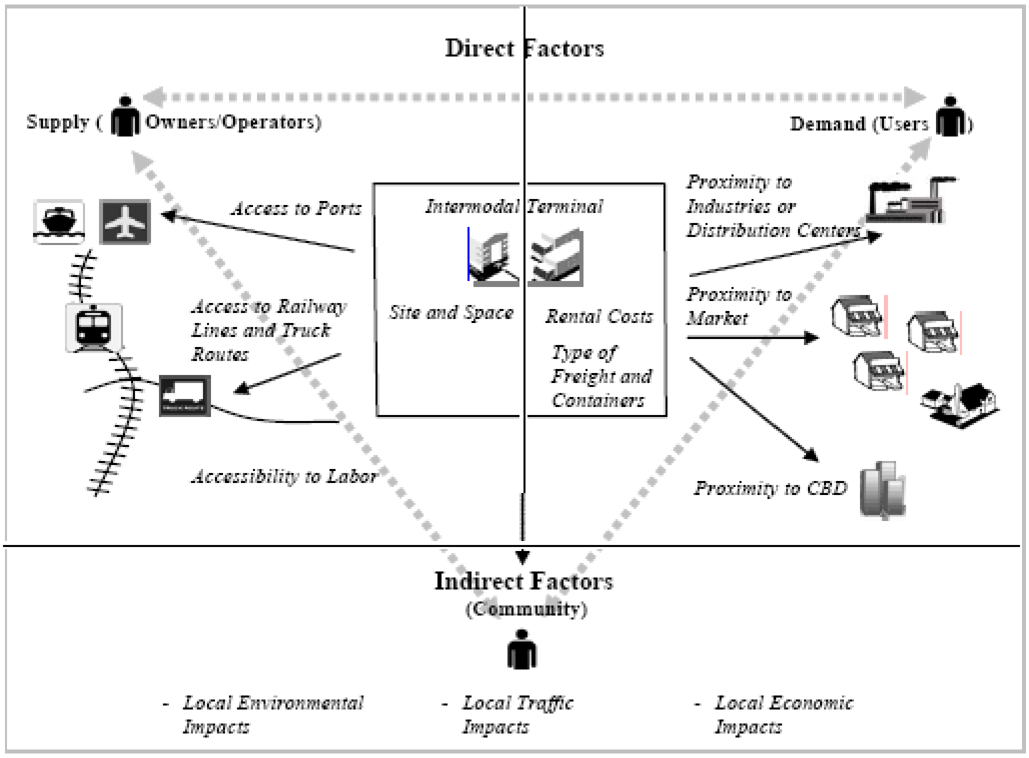

Figure 2 – Location Decisions *(McCalla et al, 2001)*

In a user's or demand perspective, the major determinants include proximity to industries; market; rental costs and types of intermodal freight; containers and vehicle characteristics *(McCalla et al, 2001)*. For an owner/operator or supply perspective, site and space, access to transportation infrastructure (e.g. truck routes, railway lines, port etc.), and accessibility are the predominant ones.
Many impacts especially externalities have still not been fully evaluated for the development of a logistics center. Externalities, for example, environmental impacts, energy usage impacts, and social impacts, are impacts felt by those who are not transport users (e.g. third

parties who are not compensated if it is a cost; or asked to pay if it is a benefit) (*Sirikijpanichkul et al, 2005)*.

Transportation factors

Transportation accounts for 62 percent of logistics costs. Freight is transported by air, rail, maritime, road, or a combination of these. The choice of which mode to use is determined primarily by tradeoffs between speed and cost. Road transportation accounts for the majority of freight tonnage, excluding deep-sea/transcontinental traffic. Rail companies have been able to offer competitive pricing, making rail another cost-effective option for long distance transportation of goods. The air mode continues to grow in importance, in part owing to increased demand for individual package deliveries, and in part driven by increased demand for airfreight services for high-value products. Containers are on-and off-loaded from ships using mechanized equipment, reducing loading times and making more efficient use of space on the ships.
The complexity of today's supply chain requires a combination of the transportation modes in order to achieve the desired efficiencies. Intermodal transportation constitutes an important element for the necessity of a logistics center, since it involves the transfer of cargo between vehicles of different modes, while it enables shippers to take advantage of the cost and service benefits of each mode, driving down costs while enhancing efficiency and competitiveness *(Muller, 1999)*.

National land use planning

Another important factor that influences the location decisions of the logistics centers is the land use planning at a national level. Increasing competition has prompted businesses to step up efficiency throughout the value chain, namely by reducing logistics costs. This trend has led to an ever-growing number of industrial and commercial companies to subcontract their logistics operations to large specialist companies. In order to perform their tasks efficiently, these companies require integrated logistic facilities, sometimes on a large scale, with access to efficient multimodal transport structures and to a range of shared services.
European countries with major port logistics platforms have been strengthening their competitive advantage by setting up large-scale logistics centers on their land, at strategic locations close to significant traffic catchment areas and road and rail nodal points *(MOPTC, 2007)*.
At the same time, increasing environmental and quality of life concerns have also been influencing logistics. Efforts to reduce road transportation through a transfer to other, more environmentally sustainable, modes of transportation can be seen all across Europe. In response to these trends, a number of European countries have taken active steps to create logistics centers networks, opening the way not only to more efficient logistics flows and higher value logistics services, but also an improved environment. Concerning the development of logistics centers, a national strategy needs to incorporate the following:

- Rationalise logistics activity and assist in carrying forward territorial planning, creating attractive conditions for new market players
- Encourage intermodality, upgrading existing structures and networks, and creating a conductive climate for the development of rail transport and increased use of installed port capacity
- Promote environmental gains by reducing air pollution
- Develop the national economy and certain specific territorial areas, generating employment and new forms of wealth-creation

The choice of the most appropriate policy for the development of a network of logistics centers involves balancing engineering, economic and environmental considerations, as well as their spatial and social distribution. Hence, the issue of public policy evaluation emerges, which is a complex and problematic, since the consideration of "what works" is at least partially determined by decision-makers' philosophical starting point *(Parsons, 2002)*.
The standard framework for evaluating transportation projects and policies from an economic perspective, especially if the public funding is available, is Cost Benefit Analysis (CBA) *(Voogd, 1983)*. Additionally, an increasing emphasis is placed on analytical methods, such as multicriteria analysis (MCA), due to the increasing need to "suggest – or prescribe – how a decision maker should think systematically about identifying and structuring objectives, making vexing trade-offs, and balancing risks" *(Keeney et al, 1976)*. MCA is often presented as an alternative to CBA in cases where the majority or an important set of relevant effects cannot be monetised. An important, albeit not unproblematic, assumption entailed in MCA is that weights applied to different impacts – to reflect their degree of importance on the impact scale – can be established with reference to decision-makers' opinions. On the other hand, the latter also truly represent the views of consumers and citizens. Such method, being applicable to different situation, is chosen to be applied for the prioritization of the logistics centers development.

METHODOLOGICAL FRAMEWORK

Overview

Prior to any Decision, an assessment/evaluation of proposed alternatives/scenaria is required. Thus, all the necessary information will be available to render the decision sound. Assessment of transport projects have been carried out using a variety of methods. Clearly, there is no single evaluation method that can evaluate satisfactorily all complex aspects of a transport alternative *(TRANS-TALK, 2001; Tsamboulas et al, 2000)*.
The development of a project such as a logistic center/freight village follows a sequence of steps that can be identified but are rarely straightforward or linear. At minimum, development requires the following elements: coming up with a concept idea; refining it; analyzing its feasibility; negotiating contracts; making a formal commitment; implementing/constructing the project; completing, marketing and opening it; and managing the new project (presented in Figure 3). At almost all stages, the developer must have an exit strategy *(Miles et al, 2000)*.

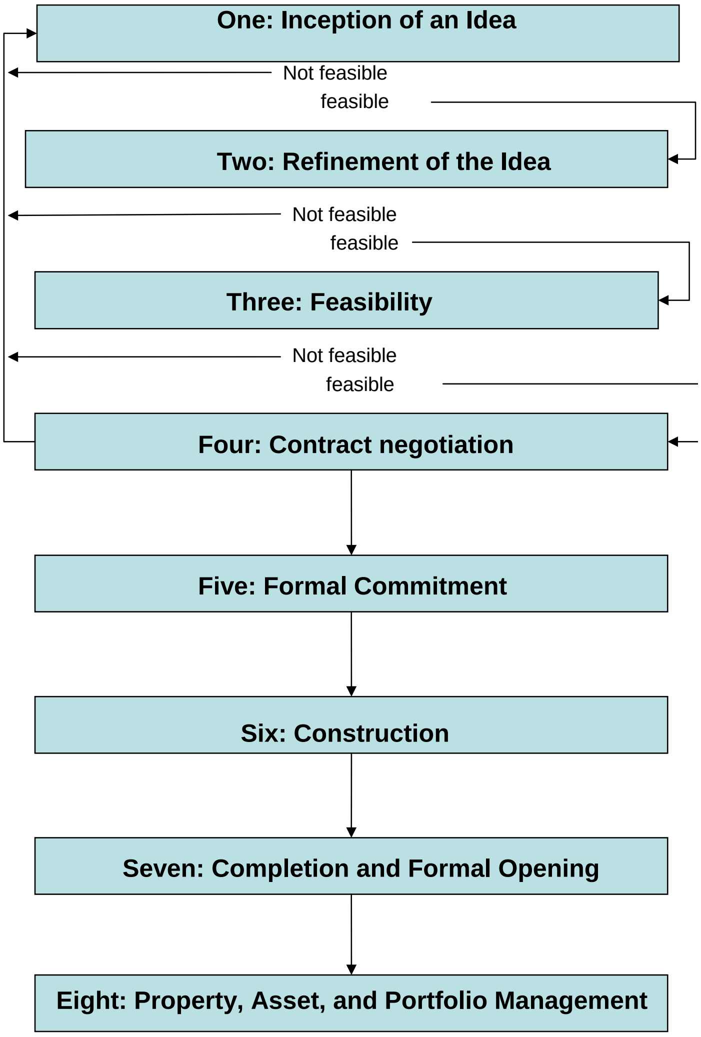

Figure 3 – Eight – Stage Model of Real Estate Development

The financial evaluation of a new Logistics center is mainly performed based on the viewpoint (and interests) of the private investor. The return on the private sector investment is the major criterion for assessing the feasibility of a project financed by private and possibly public funds, provided that the project is beneficial for the society. Any financial cost-benefit analysis for the estimation of the return on investment depends on the variable and fixed costs, as well as the revenues of the logistic center. These revenues depend on the location and operation of various companies within the logistics center, their particular commercial relationship with the owner of the logistic center, as well as the use of the services offered *(Tsamboulas et al, 2003)*.

The methodology introduces an approach to perform such an evaluation, which is the core activity for the development of logistics centers national network, constituting the master plan. It is capable of receiving inputs concerning preferences of the actors involved and it can generate outputs permitting the evaluation/appraisal of direct impacts as well the assessment of indirect effects on social and physical environment.

It must be noted that CBA method has limitations, especially if other criteria besides the monetised criteria are introduced in the evaluation. On the other hand, since there is a need to prioritize the projects related to logistics centers (and combinations of them) the MCA is more appropriate *(Cook et al, 1978; Keeney et al, 1976)*.

Formulation of the methodology

Overview

The framework of the proposed methodology comprises the following seven general stages:

Stage 1: Definition of basic goal(s) and/or objective(s)
At this stage, the proposed framework provides the Decision-Maker with a set of criteria for evaluating, with reference to high-level objectives. In this Stage the selection and assessment of impacts are considered.
Quantifiable objectives are necessary, which can be specified in terms of criteria associated with indicators to measure the impacts. The criteria to be used must meet at least the following requirements: Firstly, they must be comprehensive and reflect fully the objectives to which they relate; secondly, they must avoid double counting; and thirdly, they should be sensitive to changes in the policy instruments under implementation *(Tsamboulas et al, 2003)*.
It must be noted that the specific objectives of a National Master Plan on the development of logistics centers network will contribute to the achievement of common political goals with other national strategies *(Tatsi et al, 2007)*.
The result of this stage is the creation of an extensive list of criteria, which will reflect the national goals and the national land use planning along with the relevant indicators, to be used in the methodological framework. These are based on outputs and knowledge generated either and/or by the European Transport Policy Framework, priorities of local Politicians and local public opinions, specific local conditions, if they exist, and experts' opinions and valuations demonstrated through research or studies *(EUNET, 1998; KonSULT, 2002)*.

Stage 2: Market Analysis
Unless a developer already owns or controls a site suitable for development, a market screening or macroeconomic analysis is undertaken to identify areas with strong potential for a proposed logistics center. Market dynamics in two or more locations are compared to set the stage for the next step which is the site selection. The market analysis will be carried out separately for each location of potential logistics centers.
The Market Analysis generally focuses on broad elements such as the market area's underlying economy and its prospects for growth. Several criteria are most relevant to market analysis for potential freight village locations, such as:

- **Growth trends**: metropolitan areas witnessing increases in population, employment opportunities, and trade are preferred over markets with no growth.
- **Development climate**: both a community's regulatory climate and its attitudes can influence a project's schedule and its eventual size and appearance.
- **Infrastructure**: well-developed infrastructure such as interstate highway systems, airports, rail service, and fully developed utility networks is fundamental to a competitive industrial market.
- **Available land at a suitable price**: an adequate supply of developable land at a reasonable price is necessary for development to proceed.
- **Labor**: an expanding and well-qualified labor force is critical to industrial development.
- **Development incentives**: incentives, such as tax abatement programs and public infrastructure loans, can be used in order to promote the type of development considered desirable for a specific location.
- **Quality of life**: factors which define an area's livability are important for the location of a project.
- **Current leasing activity**: locations that are already attracting the types of businesses targeted for industrial development are preferred.

The market analysis will contribute to the evaluation of the specific locations and the analysis of the demand and supply in the area where the logistics centre will be located. Supply analysis requires the collection of data on similar existing and proposed facilities in the market area, while demand analysis relies on a variety of economic indicators in order to predict the demand for the proposed projects. Additionally, the market analysis will provide the Decision-Maker with data, which concerns the pricing, as well as the costs of the properties and real estate of the area.

Stage 3: Definition forecasted volumes for the specific logistic center in a network
Regarding the forecasted volumes to be attracted by the specific logistics center, this is estimated with the application of appropriate models, mainly based on the Four-Step approach. A requirement for such a model application is the determination of the transportation network. Thus, besides the infrastructure and services for the transport modes, the existence (and related throughput and services) of other logistic centers in the transport network are considered. In these models configuration, the provision for unitized or non-unitized cargo volumes must be made, since for logistics centers the unitized cargo is of concern. However, in order to apply these models an assumption about the costs of the services provided by the specific logistics center is needed. Hence, this is a dynamic process that influences the size of the logistics center, its revenues and in return (based on the introduced costs for the provision of services) the attracted traffic. Usually the produced outputs of the models comprise *(Tsamboulas et al, 2003)*:

- estimations of daily freight volumes in tones and number of truck/rail vehicles per category of goods types
- estimated distribution of the total traffic among commodities

- estimation of loading transport units (e.g. containers, swap bodies).

Stage 4: Required services

Once the volumes per commodity types attracted by the logistics center are estimated, the various services to be offered can be determined. They are related to warehousing and storage, parking areas, rail/road terminal and needed equipment, loading/unloading, administration, customs, medical services, banking, food and lodging, gas refueling, vehicle maintenance, container maintenance, security, etc.

The surface Sj needed for service j (e.g. warehousing and storage) corresponding to goods of commodity i is estimated by:

$$Sji = f\,(Ti, Qij, CCij) \qquad (2)$$

Where:

Sji the needed surface for service j for commodity i
Ti daily traffic of the commodity i, in tonnes per day
Qij average time to provide the service j to commodity i
CCij other characteristics of the commodity i relater to the provided service j

The needed surface Sj for service j is the summation of surface per commodity:

$$Sj = \sum f\,(Ti, Qij, CCij) \qquad (3)$$

Stage 5: Criteria for the Selection of location

The location where the logistics center is situated directly influences the project's attractiveness to potential users, the rate at which space can be absorbed during leasing, and the rents that can be achieved. At this stage, a location selection is done at two steps: one at a 'macro-level' and the other at the 'micro-level'.

The location identification at the macro-level, is the choice of a location with no specific land boundaries, but only a broad area, usually identified with a name of a nearby locality. The criteria for the selection of the location of a logistics center at macro-level are based on the national strategy and planning, and the market analysis as well. Certain criteria should be considered:

- **Public policy**: planning and zoning regulations
- **Employment**: increasing of the employment of the area and creating of new job positions, in order to contribute to the improvement of national economy
- **Economic development**: enhancing the competitiveness of the area and increasing the human resources, especially in regional areas, in order to contribute to the regional development
- **Accessibility**: improving accessibility and services of general economic interest
- **National cooperation**: strengthening cross-border, trans-national and trans-regional cooperation through the increase of imports and exports

Once the traffic forecasting is done, then the site selection at the micro-level follows. It is concerned with the determination of the land boundaries of the logistics center and it can be elaborated with methods of location selection, employing in some cases Multicriteria Analysis.

A variety of critical factors must be considered for the evaluation of alternative locations. These criteria have often different weights, depending on the type of the project and the goals. Certain criteria should be considered for the case of logistics centers:

- **Site configuration and size**: size, dimensions and shape of a land parcel
- **Land topography**: visual survey and topographic maps
- **Transportation access**: sites with accessibility to major transportation and freight-handling centers, including airports and ports, are highly favored. Public transport and access for the future employees should also be considered.
- **Utilities**: water supply, treatment, distribution facilities, natural gas, telecommunications services, electricity etc.
- **Future expansion capacity**: availability of land to accommodate future building expansion (e.g. parking, truck storage etc.)
- **Services**: availability of nearby services such as restaurants, shopping facilities, hotels etc.
- **Links with other industries**: locating near suppliers or other companies can reduce the production costs for goods and services.

Stage 6: Logistics centre's data for the evaluation

Following the previous stages of the methodology, the feasibility study of the logistics center will provide data, which will be used for the evaluation of the logistics center. Feasibility study is a systematic approach to determine the profitability of a proposed investment. The data of the feasibility study are: the logistics center's development budget (construction costs, land and equipment acquisition costs) and the operational costs. Additionally, the feasibility study will estimate the benefits of the logistics center's development, as well as the Internal Rate of Return (IRR). The calculation of the IRR allows an investor to determine the discount rate that reduces a future stream of cash flow to the initial cash investment.

Stage 7: Selection of the location

The final stage is the location selection. This is done by the Decision maker, when all available inputs from the feasibility study as well as from the assessment of proposed locations are available. In the following paragraph the methodology for such location selection is presented.

Methodology for the location selection

Overview

Once the alternative projects and locations of logistics center are set and the characteristics and services of the logistics centers are defined as well, the methodological framework establishes the relationships between criteria and projects. This is accomplished with the estimation of criteria weights and the scores for each logistics center. These scores reflect

the degree by which an alternative project fulfils a certain criterion. Hence, the relative importance of criteria is reflected by priorities or weights. It is evident that the weights have a major effect on the final evaluation results. There are many different weighting techniques and their choice depends on the characteristics of the project/program/policy under evaluation and on the data available *(Tsamboulas et al, 2003)*.
The REMBRANDT process *(Lootsma, 1992)* can be completed in the following steps:
The user states his/her preferences for each pairwise comparison on an -8 to +8 scale, (with zero for indifference), as presented in Table I:

Table I – Criteria

Criteria	C1	C2	C3	...	Cj	...	Cn
C1	v11	v12	v13	...	v1j	...	v1n
C2	v21	v22	v23	...	v2j	...	v2n
...	...	...	...	...	...	...	...
Ci	vi1	vi2	vi3	...	vij	...	vin
...	...	...	...	...	...	...	...
Cn	vn1	vn2	vn3	...	vnj	...	vnn

After the ration matrix is obtained, its elements vij are transformed using the operator exp (0,347vij) to generate a set of values rij on the logarithmic scale, as presented in Table II:

Table II - Criteria on logarithmic scale

Criteria	C1	C2	C3	...	Cj	...	Cn
C1	r11	r12	r13	...	r1j	...	r1n
C2	r21	r22	r23	...	r2j	...	r2n
...	...	...	...	...	...	...	...
Ci	ri1	ri2	ri3	...	rij	...	rin
...	...	...	...	...	...	...	...
Cn	rn1	rn2	rn3	...	rnj	...	rnn

The geometric mean of the rows (Table II): $w_i = \left(\prod_{j=1}^{n} r_{ij} \right)^{1/n}$ (4) then gives the solution which minimizes the sum of squared errors from a logarithmic regression designed to best fit the decision-maker's expressed preferences *(Lootsma, 1992)*.
In many cases however, (e.g. sensitivity testing) it will be necessary to re-scale weights if any single weight is changed. This should be done automatically, according to a simple proportionality formula, leaving the relativities between all other weights.
The evaluator will also be involved in inputting investment costs, which will normally be project-specific, and inputting the appraisal parameters including the Investment Start Year, Investment Period, Opening Year, Operating Period, Appraisal Period and Discount Rate.
The selection of the appropriate aggregation function depends on the objective. The aggregation function is of the form:

$$O_i = \sum_{j=1}^{n} w_j c_j \left(x_{ij} \right) \qquad (9)$$

The scores are assessed independently with respect to weights. Their scale is used as a quality index where higher numbers mean preferable projects. Score levels may be estimated either directly or judgementally on to the 0→100 scale, or by using the cj functions (usually for criteria which have some direct interval/ratio scale measurement).
Finally, for the evaluation and ranking of the alternatives each alternative gets a final score as derived from the function O (cij) and thus, they are ranked first, second, third and so on. The core approach, apart from being a reasonably common form of aggregation within the multicriteria literature, is also consistent with the idea that the relative influence of different dimensions of impact should be constant and predictable.

The methodology's application steps

The methodology of the selection of the location of a logistics center consists of four steps:

Step 1: Estimation of criteria weights
At this step, for establishing the criteria weights the general objectives are indirectly taken into consideration. By using Saaty's Analytical Hierarchy Process (AHP), criteria weights will be derived. It should be noted that in addition to reasons –identified above – for the choice of this weighting technique, there are also theoretical considerations that support such choice. The AHP develops a linear additive model, but it uses -in its standard format- procedures for deriving the weights and the scores achieved by the alternatives. These are based on pair wise comparisons between criteria and between options respectively.
The existence of Eigen vector method in AHP is the basic one, since it provides fast and reliable weights: fast is expressing the short time necessary for its application; and reliable is associated with the minimising the subjectivity of weights' values.
As it has been documented *(Tsamboulas et al, 1999)*, Linear Additive Models, Analytical Hierarchical Process and Multi-attribute Utility Theory are well established and widely applied methods. Consequently, they are the most appropriate methods to be used in the proposed framework, and therefore they will be applied at different stages of the framework.

Step 2: Estimation of criterion Scores
At this step the scores (degree of performance) of each alternative location for each criterion are calculated. Criterion scores can be derived in many different ways and can be expressed in qualitative or quantitative terms. To make the various criterion scores compatible it is necessary to transform them into one common measurement unit, for example *(Voodg, 1983)* forcing each criterion score to take values between 0 and 1.
The quantitative criteria scores will be derived using utility functions of a crooked linear form, such as:

$$UCj = \begin{cases} +PCj/A, & \text{if } P > 0 \\ 0, & \text{if } P = 0 \\ -PCj/B, & \text{if } P < 0 \end{cases} \qquad (10)$$

Where:
j: criterion number

Cj: criterion j
PCj: Physical (real) performance of criterion j (measured as a change and not as an absolute value)
UCj: Artificial (after transformation) performance of criterion j
A, B: Constant variables that either depends on measurement thresholds or they are set by the relevant policy/decision makers

Step 3: Estimation of Weighted Alternatives Scores
Weighted summation of a specific criterion scores will take place by applying MAUT. The final score of each alternative transportation policy instrument will be calculated by equation 2, using the results of Stages 2 and 3 for the policy priorities:

$$T.P._{i} = \sum_{j=1}^{J} W_{j} * U_{j,i} \qquad (11)$$

Where:
j criterion number
Wj criterion weight
Uj,i Artificial performance of criterion j for scenario i
T.P.i Total performance of scenario I
For all calculated weights, the following equation should be considered:

$$\sum_{i=0}^{N} Wj = 1 \qquad (12)$$

Where:
N number of criteria and
0 < Wj ≤ 1

Step 4: Hierarchy of Alternatives – Final Choice
Based on the results of Step 3 the final ranking and therefore the selection of the appropriate location for the development of the logistics center will take place. Consequently, the best scenario will be the one with the maximum T.P.

APPLICATION

Brief description of the Case Study

The application of the methodological framework is carried out for the case study that includes the implementation of two freight villages in Greece. The case study attempts to evaluate alternative locations for the development of a freight village based on a national land use planning. The criteria of the highest level that set the criteria which will be calculated are related to:

- National planning use

- Market Analysis
- Location
- Financial Feasibility
- Or a combination of the above that constitute the “bundles”.

The project scenarios which have been considered are the following:

PS0: Maintain current situation
This scenario serves as a reference scenario. Current trends are used to make forecasts. The main purpose is to evaluate the situation where there are no changes in current trends and policies, and thus no freight village is developed.

PS1: Investments to implement the Logistics Center/freight village of Thriassio Pedio, Athens
The logistics center/freight village of Thriassio Pedio is located in Attiki and will be served by the highway Attiki Odos and the national highways Athens – Thessaloniki and Athens – Patra. Additionally, it will have access to the railway network of Aharnes (SKA) Thriassio – Korinthos (total length 105 km), the Athens International Airport and the suburban railway of Attiki. Furthermore, the particular logistics center will connect to the port of Neo Ikonio, where a transportation freight terminal is located. The implementation of Thriassio Pedio logistics center is of great importance, since it will be connected to the main railway, highway and maritime corridors of Trans-European Networks (TEN-T) (Figure 4).

Figure 4 – The position of Thriassio Pedio Freight Village

According to the feasibility study of the logistics center *(DE-Consultant, 2001)*, the forecasts for the freight volumes are 792.634 tonnes in 2006 from the port of Neo Ikonio to the logistics center of Thriassio Pedio and 157.766 tonnes in 2006 from the logistics center of Thriassio Pedio to the port of Neo Ikonio.

PS2: Investments to implement the logistics center/ freight village of Igoumenitsa, Thesprotia
The logistic center of Igoumenitsa will be located in Thesprotia nearby the port of Igoumenitsa. It will be connected to the Egnatia Odos highway, the West Axes (Ionia Odos highway) and the Railway West Axes, which is one of the priority projects of TEN-T and is planned to be constructed under TEN-T funding. Additionally, the port of Igoumenitsa is of great importance, since it is directly connected to main ports of Italy, such as Bari and Ancona. Thus, the implementation of a logistic center in Igoumenitsa will contribute to the improvement of the freight transportation between West and East Europe and the Mediterranean area as well (Figure 5).

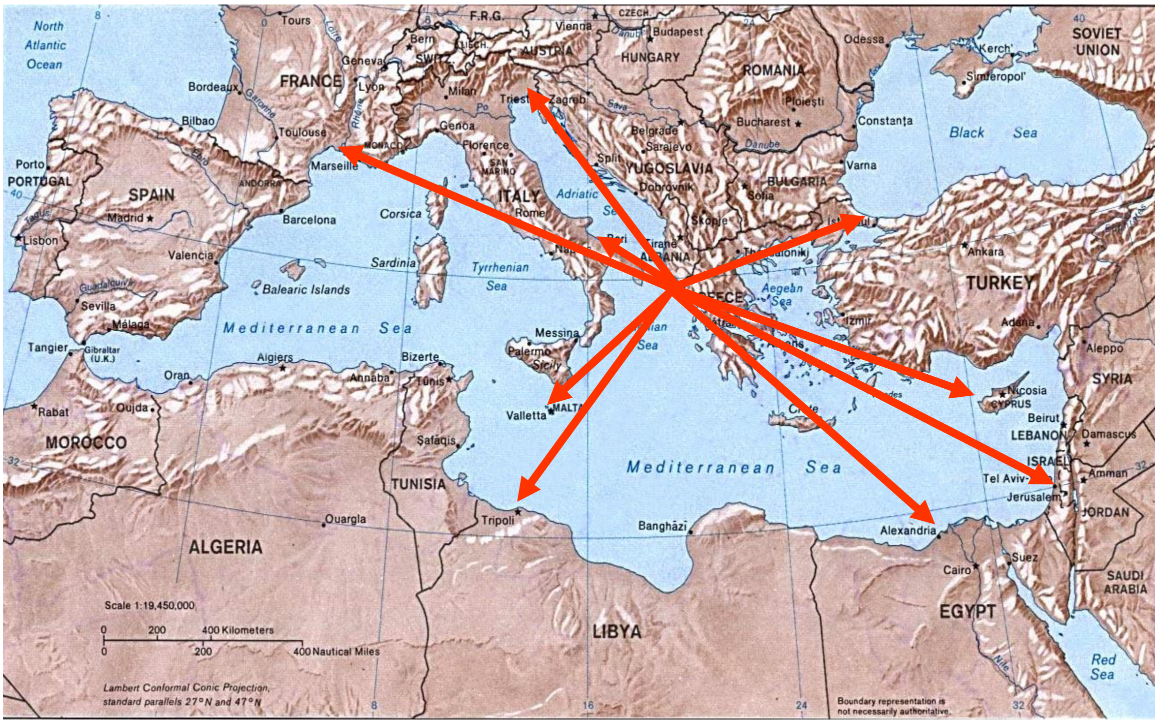

Figure 5 – The position of Igoumenitsa area between West and East Europe

Definition of Criteria and Scores

The choice process for the location of the logistics centers against the high-level objectives should be based upon a broad set of criteria which allows simultaneous consideration of the impacts from different viewpoints, notably economical, social, and environmental.

- Criterion 1: Number of job positions created by the development of the logistics center

- Criterion 2: Accessibility (measured with the average speed -km/h) - Access to railway network, port, airport
- Criterion 3: Costs of properties and real estate in the particular location
- Criterion 4: Construction and Operational costs of the logistics center
- Criterion 5: Number of services in the logistics center
- Criterion 6: Environmental impacts by the development of the logistics center (Air pollution)

The criteria artificial performances/scores are shown in Table III for each scenario.

Table III - Criteria scores

Criteria		**Scores**
Scenario 0	C1	+1
	C2	+0.56
	C3	-0.66
	C4	+0.44
	C5	+0.5
	C6	-0.25
Scenario 1	C1	+1
	C2	+0.80
	C3	-0.66
	C4	+0.92
	C5	+0.75
	C6	-0.25
Scenario 2	C1	+1
	C2	+0.72
	C3	-0.66
	C4	+0.72
	C5	+0.5
	C6	-0.25

Final Rank of Alternative Locations

The total performance of each alternative scenario is the weighted sum of the criteria s for the specific scenario. Thus, the final scores for each Scenario are:

- T.P. Scenario 0 = 0.323
- T.P. Scenario 1 = 0.568
- T.P. Scenario 2 = 0.522

Consequently, the final ranking among the alternative scenarios is:

Scenario 2>Scenario 3>Scenario 1

This implies that the development of Logistic Center in Thriassio will be first, and the one at Igoumenitsa will be developed afterwards.

CONCLUSIONS

The aim of this paper is to offer decision-makers a methodological framework for the evaluation of specific logistic centers/freight villages within a transport logistics network. The main conclusions arising from the methodology and its application can be summarized as follows:

- An effective appraisal framework and methodology is presented which is technically and scientifically sound, and it aims to support decision making in strategic planning.
- The methodology is capable of receiving inputs concerning preferences of the actors involved and it can generate outputs permitting the evaluation/appraisal of direct impacts as well the assessment of indirect effects on social and physical environment.
- The methodology is easy to use by the decision-makers and has the potential to be a decision support tool for the selection among different initiatives.

The proposed methodology shares the characteristics of multicriteria and cost/benefit analysis. It is based on the assumption that the decision-maker has originally a clear picture of his/her preferences, which can be subject to change in the light of new information during the decision process. The decision maker can choose between default structures of generic strategies or create new weight profiles.

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