# Setting of weighting factors influencing the determination of the location of Dry Ports using a DELPHI methodology

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*Abstract*— **Dry Ports are designed as a solution to increasing road congestion, lack of open spaces in port installations and the significant environmental impact of seaports, due to the complexity of the transport sector and the increased volume of transported goods. In addition, Dry Ports are also presented as an opportunity to strengthen intermodal solutions as part of an integrated and more sustainable transport chain for transporting goods by rail. However, not all of its potential is used because there is no planning methodology to help decision-making. The aim of this research is to gather all the factors influencing the determination of the location of Dry Ports and set the weighting of each factor using DELPHI methodology. The results give greater importance to the aspects considered in the classical theories of industrial location. However, setting the most appropriate location to place a Dry Port is a geographical multidisciplinary problem, with significant economic, social and environmental implications.**

***Key words-Logistics; Intermodal Transport; Sustainability; Dry Ports; Industrial Location***

## I. INTRODUCTION

The global economic structure, with its decentralized production and intake entails increased cargo flows and transport distances which complicate freight transport [1]. Therefore, shipping has become the most suitable and cheapest way to meet the needs generated by mobility of goods over long distances. Thus, ports are configured as nodes with capital importance in the logistics chain as a link between two transport systems, sea and land [[2] and [3]].

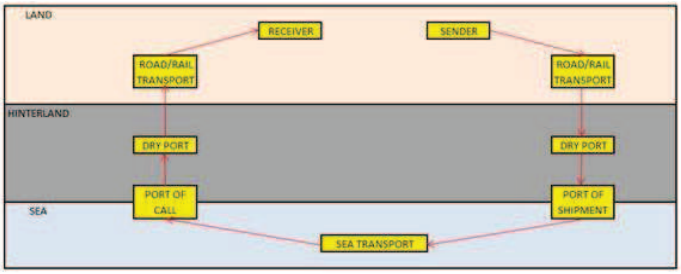


Figure 1. Dry Port in the transport chain [4]

In this sense, implementation of logistic platforms offers the opportunity to discretize each of the links of the transport chain. This allows for more polluting means of transportation which have a lower transport capacity to make several itineraries on the road which are as short as possible. Also, they could be used to transport goods with high added value [5].

For flows of incoming and outgoing goods, the Dry Port acts as the first level of a functional hierarchy of the transport chain within the country [6]. Fig. 1 shows the role played by dry ports within the integrated transport chain, both in receiving and sending products.

As the transport market is becoming increasingly competitive, has lower profit margins and the pursuit of efficient and high quality services for the user seems to be the most adequate way to achieve greater participation of the most sustainable transportation modes. Some authors, like [7], suggest that Dry Ports are an adequate intermodal solution to relieve traffic congestion in seaports and provide on-site service to different transportation modes that therefore can be used in the most competitive segments. Consequently, the choice of their location is a decisive strategic element which determines the success of the logistics function.

## II. TERRITORIAL PLANNING AND INFRASTRUCTURE PLANNING MODELS

The decision between purely technical considerations and the project costs has traditionally been made by means of Cost-Benefit Analysis [8]. Since the last decades of the 20th Century, the environmental variable has gained importance in the planning and construction of transportation [9]. Therefore, an Environmental Impact Assessment was later added to the Cost-Benefit Analysis, which contributed decisively to the formalization of a decision-making system based on the use of multi-criteria analysis systems [10]. A complementary assessment which is not as structured and is not formalized and which is linked to territorial effects is gradually taking shape. While some of these effects are sometimes included within the Cost-Benefit Analysis or contained within the Multi Criteria

Analysis, is a lack of systematic analysis [8]. The effects on the territory therefore become the most uncertain aspect of major transport infrastructure.

There are also some newer techniques that attempt to solve the problems of localization. The most important which have been implemented are: Cluster analysis, classification trees and Decision, Future Scenario Analysis (Simulation), DELPHI, Expert Systems (Bayesian Networks and Neural Networks) and Geographic Information Systems [11]. This research has selected the DELPHI method in order to establish the weights of each of the factors that have an influence when deciding on the location of a dry port. Its foundation is the analysis of the ideas of a group of experts who are specialized in a field of knowledge in search of a consensus of opinion [12].

In the field of industrial location using the DELPHI methodology, MacCarthy and Atthirawong [13] present a wide range of factors that can influence the determination of a location by consulting an international panel of experts. The five main factors identified that may strongly influence international location decisions generally were cost, existing infrastructure, job characteristics, political factors and economic factors. The factors identified have implications on the management of the company that intends to settle in a particular place and on the formulation of policies of local governments.

## III. INDUSTRIAL LOCATION

The optimal location for any industrial activity is the place that gives the maximum benefit to the company, or, for a given income, involves minimal cost [14]. Thus, industrial location therefore has implications for the levels of economic growth and social welfare at the territorial level. As a result, it changes environmental conditions and therefore one should not speak about optimal points, but rather satisfactory points [15].

The diversity of the factors involved in the location of industry has caused a number of economists in the last century to build theories and models that attempt to explain the complexity of the real world by necessarily simplifying it and using some factors as constants and others as variables. The different visions of the theory have been evolving and increasingly complex, in relation to changes in economic theory. We understand each step of this theory in its historical context, without being able to separate from the social context in which they are part [16]. For [17], the main objective when deciding on the location for any industry is to reduce the production costs and, in particular, transport and labor costs. Subsequent studies [[18], [19], [20] and [21]] include the presence of competitors, access to the greatest number of competitors possible, the minimum demand in order for the location to be profitable, location interdependence between the competitors, and the relationship between population size and type of industry. [22] also introduces the concept of " subtracted value" which consists of the negative effects that must be considered against the positive effects and that might create negative externalities.

In recent years, [23] has rescued articles by various authors and theoretic schools, according to which a core-periphery system tends to consolidate, which results in the region with the greatest advantages to attract economic agents at the expense of less desirable locations. Therefore, a peripheral situation generally prevails in industries, reaching an agreement between urban land use (tertiary, transport, residence) and rural uses (agriculture). If several companies conclude that, they can save money, for example on production costs, and if they work together they will relocate to the place where the savings exceed the additional transportation charges [24].

According to [25], there is the need to achieve a situation that has the best accessibility to and from the centers of origin and destination of the various flows, which is achieved by means of the connection with the transport and communication systems. Therefore, industries are generally located near the centers of transport. It can be said that accessibility increases around major urban centers and decreases as the distance increases. In addition, facilities must have the least impact on citizens, with minimum disruption, and minimizing lifestyle changes, always seeking the welfare of the community. A good planning should first understand the idiosyncrasies of the place, integrating cultural values and customs of the place, which allows rapid and deep acceptance [26]. So, this planning process requires consideration of the possible impact on the territory [27] and the possible synergies between the other components of the logistic system, including the population and social aspects [28]. As [29] noted, by incorporating not only economic criteria, but also environmental and social criteria in the planning process, it is moving towards a sustainable territorial development which aims to "achieve long-term balance between economic development, environmental protection, efficient use of resources and social equity ".

## IV. DRY PORT LOCATION

Following the literature review summarized in the preceding sections, it is possible to determine the factors that influence the determination of location of Dry Ports in terms of their characteristics and assess the constraints faced by its location planning. The variables used in location problems may respond to the "carrying capacity" or "use restriction" of the location. Furthermore, as proposed [30], in the design of a methodology for the location of an unwanted plant, a series of steps is carried out:

- Exclusion phase: defining a set of exclusion criteria, whose application determines the elimination of zones in which the location of this kind of installations is not acceptable.
- Definition phase: the definition of a set of factors that allow us to measure the adequacy of the different places that have passed the previous restriction criteria.
- Selecting assessment phase: selecting the most suitable alternative from the different territorial areas which were found adequate for the location of the installation by means of applying endpoints.

In this paper we only consider factors related to the use restriction which correspond to the phases of exclusion and definition. These factors are presented in Table 1.

TABLE 1. FACTORS RELATED TO THE USE RESTRICTION.

| no. | Factor name | Observations |
|---|---|---|
| * | Environmental Protection table | Binary variable automatically discarded protected areas |
| 1 | Noise on natural environment | Noise level measured in dB (A) on the natural environment |
| 2 | Noise on urban environment | Noise level measured in dB (A) on the urban environment |
| 3 | Hydrology | Presence of vulnerable areas such as rivers, streams or lakes |
| 4 | Land price | Measurement of investment to make |
| 5 | Hosting municipality range | Considering the size of the municipality, the future development of urban centers and centers nearby and the demographic and economic potential |
| 6 | Accessibility to the rail network | Accessibility to freight and passenger transport networks |
| 7 | Accessibility to high capacity roads | Accessibility to high-capacity motorway networks |
| 8 | Accessibility to airports | Accessibility to air cargo terminals |
| 9 | Accessibility to seaports | Connection with one or more Seaports |
| 10 | Accessibility of supplies and services | Accessibility to communication networks and the electrical grid and any other necessary utilities such as water, sanitation, etc |
| 11 | Weather | The climate's appropriateness for the activities the greatest number of days per year. |
| 12 | Orography | Topography of the land on which the facility is located |
| 13 | Geology | Mechanical characteristics of the land on which the facility is located |
| 14 | Distance to other logistics platforms | Overlap between hinterlands and the agglomeration of industries according to the principle of Spatial Justice [31] |

Source: Based on information gathered by the author

## V. QUESTIONNAIRE

The DELPHI questionnaire consists of two rounds. It has selected a wide range of experts from the different disciplines that come together in this research: logistics, sustainability, environmental impact, transport planning and geography. The first round consists of a table with the selected factors which the experts were asked to order from most to least important and give a weight. After analyzing the information provided in the first round of the questionnaire by all the experts that made up the DELPHI panel, a second round is was performed. In the second round, they were asked to review the weightings for the first round due to the differences between their responses and those of other experts. In this second round, the weight could be the same as each expert proposed in the first round or different if their opinion varied depending on the findings contained in the annex to the questionnaire. The aim of this second questionnaire is to try to achieve a consensus among experts, and to highlight the convergence of views.

## VI. RESULTS

For the analysis of the data the arithmetic mean, median, first quartile, third quartile and the interquartile range are selected.

We used mean and median simultaneously to exploit the potential of each. The arithmetic mean is very intuitive for the expert group, being the measure of central tendency which is used most. However, it is very sensitive to the presence of outliers. Hence, the median was used for rigorous statistical analysis of the data. Interquartile range is selected as a measure of variability of the data. This is used to measure the consensus as it offers a very intuitive data deviate from the median.

The descriptive analysis of the data from the first round is done using box and whisker diagrams, which provide an overview of the symmetry of the distribution of the data and permit locating the presence of outliers.

Fig. 2 shows the box and whisker diagrams obtained after the first round of the questionnaire.

As shown in Fig. 2, in the first round there is almost complete agreement that Dry Ports need to be accessible by rail and road, as well as well-connected with seaports. There is also agreement on the importance of the availability of services and facilities and the influence of the distance to other logistics platforms. For other variables, the interquartile range shows that there is some dispersion in the answers. These factors also have a minor accordance with the views expressed by the expert group.

Although the theoretical formulation of the DELPHI method itself comprises several successive stages questionnaire shipments, drain and operation, this study is limited to two stages, which nevertheless does not affect the quality of the results as shown by the findings of similar studies [32].

The box and whisker diagrams obtained after the second round of the questionnaire are summarized in Fig. 3.

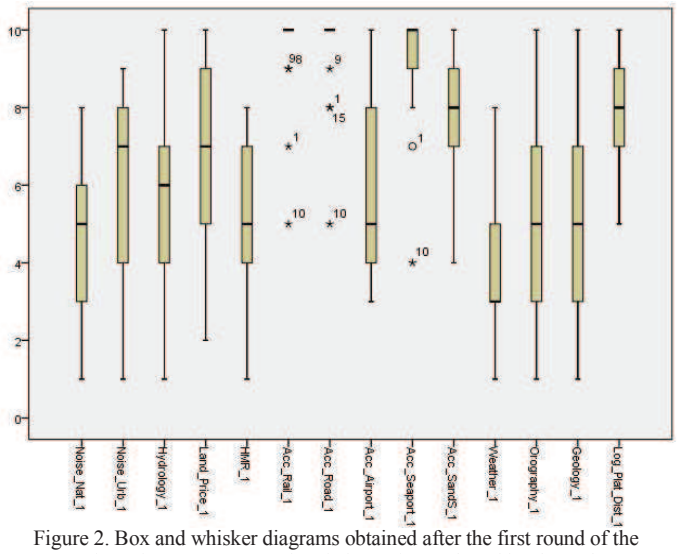


Figure 2. Box and whisker diagrams obtained after the first round of the questionnaire. Source: Based on information gathered by the author.

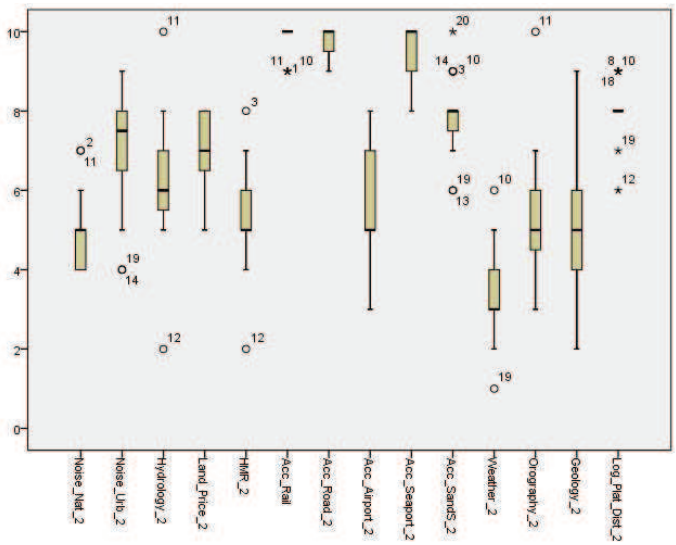


Figure 3. Box and whisker diagrams obtained after the second round of the questionnaire. Source: Based on information gathered by the author.

## VII. CONCLUSIONS

The DELPHI Questionnaire results show the importance of several variables that this study proposed for the exclusion and definition phases of the problem of Dry Port location.

Comparing the results of the first and second rounds has shown a significant decrease in interquartile ranges for all variables. The mean values of these ranges in the second round are good enough to stop the process of consulting experts here. Fig. 4 shows this decrease graphically.

Fig. 5 shows deviations above the mean, median and interquartile range of the results obtained in the first and the second round. There is an adjustment of the mean, while the median is fairly constant, except for the noise in the urban environment that fits only 0.25 units.

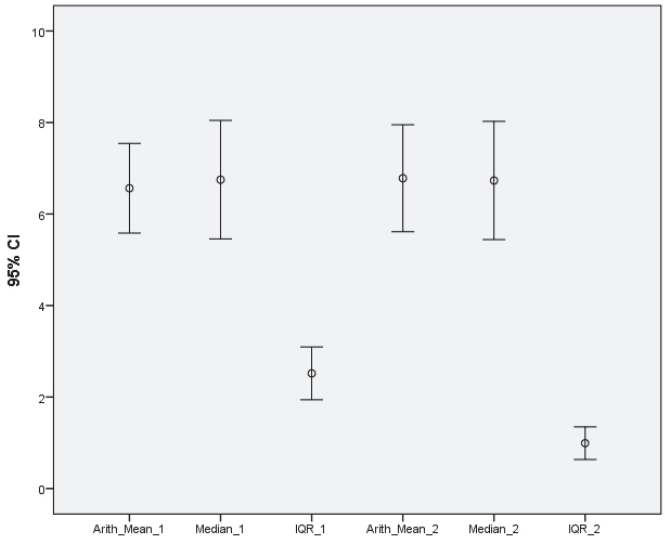


Figure 4. Mean value and 95% CI deviation on weights Arithmetic Mean, Median and Interquartile Range of the first and second rounds. Source: Based on information gathered by the author.

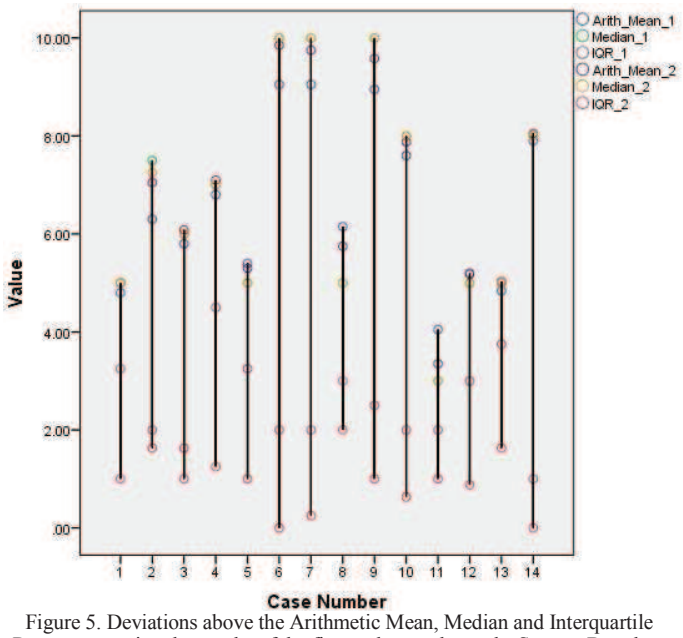


Figure 5. Deviations above the Arithmetic Mean, Median and Interquartile Range comparing the results of the first and second rounds. Source: Based on information gathered by the author.

Fig. 5 also shows that the most important factors indicated are related to the accessibility of the facilities, and present a near-consensus. In particular, the most important factors considered by the expert panel are: accessibility to the rail network, accessibility to high-capacity main roads and accessibility to seaports. However, accessibility to airports was hardly given any importance. Also, the experts reached least agreement on this factor after the second round. This is because air travel is a form of transportation of goods which is still used little and which is very specialized in urgent transport of quickly perishable goods (flowers, newspapers, etc.) and live animals.

The fact that the factors related to accessibility are given greater importance confirms, as proposed by [25], the need to find a situation that has maximum accessibility to and from the centers of origin and destination of the various flows.

These results also confirm the possibility offered by Dry Ports to increase the efficiency of transport modes, , both individually and in the context of intermodal integration to achieve an optimum and sustainable use of resources which passes through a modal shift to increase the contribution of freight by rail, such as exposed [5] [5].

By contrast, the factor that is given least importance is the climate. Undoubtedly, this is because almost all the experts of the group are Spanish and the country's good climate leads them to think that this will not affect the operation. It is conceivable that if there were more experts from other nationalities this result would be different.

The interquartile range of each factor showed in Fig. 5 demonstrates that the factor which underwent the greatest decline between the first and the second round is the price of land. By contrast, the factors which were reduced least were accessibility to the rail network (because of the near-consensus

reached in the first round) and accessibility to seaports and hydrologic condition.

As shown in Fig. 3, in fact, the lack of consensus on some factors responds primarily to the presence of outliers which are far away from the mean which greatly alters the value of the interquartile range, rather than the lack of convergence in the opinion of most experts on the panel.

Moreover, the presence of these outliers can be explained in all instances by the experts' specialism. For example, experts on issues related to the environment and sustainability in the study have been the most reluctant to change their opinion about the noise in the environment, hydrologic affection, orography and geology, because of environmental costs involved in earthmoving (excavation, landfill, leveling and grading of construction sites).

A surprising result of the study is that less importance is attached to noise in the environment than to noise in the urban environment, while in many countries the law establishes much more severe noise limits in environmentally protected areas than in cities. In any case, this indicates a concern for inconvenience which can be generated in the city by any industrial installation and hereby it is confirmed by [23][23] and [24] [24] that peripheral location prevails on the core location.

In this article we have tried to convey the idea that the determination of the most appropriate location to place various types of facilities is a geographic and multidisciplinary problem, with economic, social and environmental repercussions. Although the results show a greater importance in the search for the location of a Dry Port to the aspects considered in the classical theories of industrial location, we should not lose sight of the other aspects, since no weighting factor is so unimportant as to be removed. In this sense, the results help to achieve sustainable development as quoted by [[27] and [29]].

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