 doi:10.20944/preprints201912.0234.v1

Determination of Key Factors Affecting Transient Seaport Selection for Landlocked Countries in African Continent

Ibrahim Badi [a], Dragan Pamucar [b]

[a] *Misurata University, Mechanical Engineering Depatement, 2429 Misurata, Libya, ibrahim.badi@hotmail.com*

[b] *University of Defence in Belgrade, Department of Logistics, Pavla Jurisica Sturma 33, 11000 Belgrade, Serbia, dpamucar@gmail.com*

***Abstract**: Many countries around the world suffer from the lack of a sea port directly linked to the rest of the world. Such countries are called "landlocked countries". This leads to Weak competitiveness of their products in the global market, as well as to the high cost of the imports. Africa has the largest share of these countries, with 16 of the 43 landlocked countries around the world. The aim of this paper is to propose a general framework for criteria that can be used to choose between ports in transit countries that can be used for import or export. These criteria are related to the assessment of the sea ports in terms of infrastructure and tariffs. It is also related to transport infrastructure from the transit country to the landlocked country and the level of safety. The study identified nine criteria that could be used to compare between ports in transit countries. Using Full Consistency Method (FUCOM) to evaluate those criteria showed that the number of navigation lines is the most important criteria followed by the port service level.*

***Key words:** land locked countries; Africa; supply chain management; sea ports*

1. Introduction

Maritime shipping accounts for around 80% of global trade by volume (Dellink et al., 2017). That means being a landlocked country will add more burden on trading beyond national boundaries. The economic power of the country is affected by its geographical location. It can be said that each country has its own geographical characteristics. The landlocked countries are those countries which landlocked from all directions and have no maritime performing. Thus, landlocked countries rely on neighboring countries for their trade, by exploiting the shores of these countries in the conduct of their trade. The landlocked countries seek access to facilities from coastal countries ports and to means of transport to these ports. Problems become more difficult when the number of neighboring countries of the landlocked countries increases, or when they are surrounded by other landlocked countries. This entails high transport costs and difficulty in importing and exporting, and these countries will be held to ransom by coastal countries.

There are currently 43 landlocked countries in the world. 16 of them are in the African continent: Botswana, Burundi, Central Africa, Chad, Lesotho, Malawi, Mali, Niger, Zimbabwe, Rwanda, Swaziland, Uganda, Burkina Faso, Zambia, Ethiopia and South Sudan. See figure 1, which illustrates these countries. The geographical conditions of Africa, which is characterized by low-lying coasts, have hindered establishing natural ports, In addition to its coastline which contains high mountains without passages, coastal areas of sand dunes, wetlands and forests. There are many factors affecting the logistics operations of African landlocked countries among of them transportation capability, external risks, information

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integration, logistics infrastructure, local agents' logistics capability, and national law and policy (Yang and Chang, 2019).

Figure 1: Landlocked countries in African continent.

One of the problems facing landlocked countries is the distance between the capital and the nearest seaport. According to Kashiha et al. transportation costs influence the decisions by shippers of which port of export to use (Kashiha et al., 2016). Figure 2 illustrates the distances between the capitals of the landlocked countries and the nearest seaport in Africa continent. There is no doubt that the distance will directly impact on the costs, but the nature of relations with neighboring countries also have a direct impact on the adoption of transport decisions as we will see later.

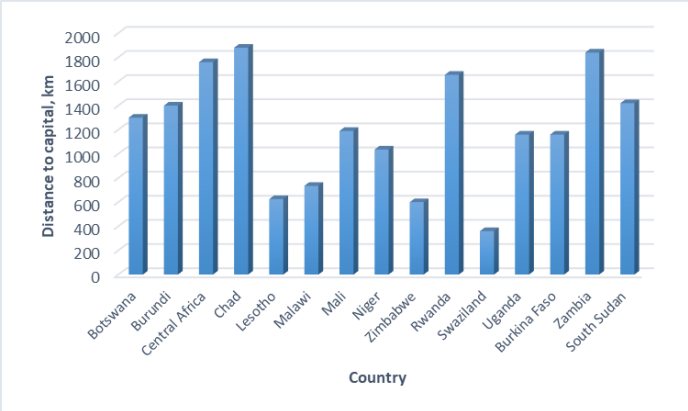

Figure 2: Distance between landlocked countries capitals and the nearest seaport.

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It is noted that most of the exports of landlocked countries in Africa are raw materials, where agricultural exports account for 60% of total exports. The reason for this is that these countries are very poor and have an increasing illiteracy rate, which in turn makes industrial production and thus industrial exports very weak. It can be said that the exports of landlocked countries are less competitive, and their imports have high costs. Poor infrastructure in Africa, whether at the port level or at transport networks between countries level may exacerbate the crisis of the landlocked countries.

Faye et al. (Faye et al., 2004) discussed four types of dependence on transit neighbours: dependence on neighbours' infrastructure; dependence on sound cross-border political relations; dependence on neighbours' peace and stability; and dependence on neighbours' administrative practices. The aim of this paper is to propose a general framework for criteria that can be used to choose between ports in transit countries that can be used for import or export. Another purpose is to evaluate those criteria using FUCOM algorithm to evaluate those criteria.

2. Methods

The Multi-Criteria Decision Making (MCDM) problems have received considerable attention from various researchers over the past decades (Badi et al., 2018); (Radović et al., 2018). One of the newer models that is, as well as Analytical Hierarchy Process (AHP) and Best Worst Method (BWM), based on the principles of pairwise comparison and validation of results through deviation from maximum consistency is the Full consistency method (FUCOM) (Pamučar et al., 2018). FUCOM is a model that to some extent eliminates the stated deficiencies of the BWM and AHP models. Benefits that are determinative for the application of FUCOM are a small number of pairwise comparisons of criteria (only *n-1* comparison), the ability to validate the results by defining the deviation from maximum consistency (DMC) of comparison and appreciating transitivity in pairwise comparisons of criteria. As with other subjective models for determining the weights of criteria (AHP, BWM, etc.), the FUCOM model also has a subjective influence of a decision-maker on the final values of the weights of criteria. This particularly refers to the first and second steps of FUCOM in which decision-makers rank the criteria according to their personal preferences and perform pairwise comparisons of ranked criteria. However, unlike other subjective models, FUCOM has shown minor deviations in the obtained values of the weights of criteria from optimal values (Đorđević et al., 2019). Additionally, the methodological procedure of FUCOM eliminates the problem of redundancy of pairwise comparisons of criteria, which exists in some subjective models for determining the weights of criteria. FUCOM has been used in many applications such as forklift selection (Fazlollahtabar et al., 2019), ranking the airlines (Badi and Abdulshahed, 2019), service quality measurments (Prentkovskis et al., 2018), occupational safety and health climate (Stefanović et al., 2019), service quality of rail transprort (Đorđević et al., 2019), and supplier selection (Durmić, 2019); (Matić et al., 2019).
Assume that there are *n* evaluation criteria in a multi-criteria model that are designated as *wj*, *j* = 1,2, ..., *n*, and that their weight coefficients need to be determined. Subjective models for determining weights based on pairwise comparison of criteria require a decision-maker to determine the degree of impact of the criterion *i* on the criterion *j*. In accordance with the defined settings, the next section presents the FUCOM algorithm (Pamučar et al., 2018).

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Algorithm: FUCOM

Input: Expert pairwise comparison of criteria
Output: Optimal values of the weight coefficients of criteria/sub-criteria

Step 1: Expert ranking of criteria/sub-criteria.
Step 2: Determining the vectors of the comparative significance of evaluation criteria.
Step 3: Defining the restrictions of a non-linear optimization model.
Restriction 1: The ratio of the weight coefficients of criteria is equal to the comparative significance among the observed criteria, i.e. $w_k / w_{k+1} = \varphi_{k/(k+1)}$.
Restriction 2: The values of weight coefficients should satisfy the condition of mathematical transitivity, i.e. $\varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} = \varphi_{k/(k+2)}$.
Step 4: Defining a model for determining the final values of the weight coefficients of evaluation criteria:

$$\min \chi$$

s.t.

$$\left| \frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{k/(k+1)} \right| \le \chi, \ \forall j$$

$$\left| \frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} \right| \le \chi, \ \forall j$$

$$\sum_{j=1}^{n} w_j = 1, \ \forall j$$

$$w_j \ge 0, \ \forall j$$

Step 5: Calculating the final values of evaluation criteria/sub-criteria $\left(w_1, w_2, ..., w_n\right)^T$.

3. Case Study

Determining a set of criteria to choose between ports is essential. Perhaps this is the main objective of this paper. We have developed a proposal for a suitable set of criteria to the situation of the African continent based on the previous studies in this field, as well as the views of a group of experts in the field of maritime transport and supply management. We concluded by defining eight criteria:

C1: Number of navigation Lines
C2: Port's service-Level
C3: Port fees
C4: Distance between the seaport and the capital of the landlocked country
C5: Transport Infrastructure Availability
C6: Safety-Level and relations with neighboring countries
C7: Number of countries through which the shipment will pass
C8: Nature of the terrain
Where Ci is the criteria number i.

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It can be observed that the first three criteria are criteria relating to transit country's ports. These criteria are focusing on the service-Level provided at these ports and the value of customs duties, in addition to the existence of regular shipping lines on these ports. The rest of the criteria are related to the transport from and to the landlocked country, such as the distance from the port to the capital of landlocked country, as well as the infrastructure availability such as, roads, railways and ground transportation fleet.

Step 1. In the first step, the decision-makers performed the ranking of the criteria: C1> C2> C4> C7 >C3>C5>C6>C8.

Step 2. In the second step, the decision-maker performed the pairwise comparison of the ranked criteria from Step 1. The comparison was made with respect to the first-ranked C2 criterion. The comparison was based on the scale $[1,9]$. Thus, the priorities of the criteria ($\varpi_{C_{j(k)}}$) for all of the criteria ranked in Step 1 were obtained (Table 3).

Table 3. Priorities of criteria

Criteria	C_1	C_2	C_4	C_7	C_3	C_5	C_6	C_8
$\varpi_{C_{j(k)}}$	1.0	2.6	3.5	4.0	5.0	6.0	6.5	7.0

Based on the obtained priorities of the criteria, the comparative priorities of the criteria are calculated:

$\varphi_{C_1/C_2} = 2.6/1.0 = 2.6$, $\varphi_{C_2/C_4} = 3.5/2.6 = 1.35$, $\varphi_{C_4/C_7} = 4.0/3.5 = 1.14$

$\varphi_{C_7/C_3} = 5.0/4.0 = 1.25$, $\varphi_{C_3/C_5} = 6.0/5.0 = 1.2$, $\varphi_{C_5/C_6} = 6.5/6.0 = 1.08$

$\varphi_{C_6/C_8} = 7.0/6.5 = 1.08$

Step 3. The final values of weight coefficients should meet the following two conditions:

a) The final values of the weight coefficients should meet the condition (3), i.e. that:

$$\frac{w_1}{w_2} = 2.6, \frac{w_2}{w_4} = 1.35, \frac{w_4}{w_7} = 1.14, \frac{w_7}{w_3} = 1.25, \frac{w_3}{w_5} = 1.2, \frac{w_5}{w_6} = 1.08, \frac{w_6}{w_8} = 1.08$$

b) In addition to the condition (3), the final values of the weight coefficients should meet the condition of mathematical transitivity, i.e. that

$$\frac{w_1}{w_4} = 3.5, \frac{w_2}{w_7} = 1.54, \frac{w_4}{w_3} = 1.43, \frac{w_7}{w_5} = 1.5, \frac{w_3}{w_6} = 1.3, \frac{w_5}{w_8} = 1.17$$

By applying the expression (5), the final model for determining the weight coefficients can be defined as:

min χ

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$$s.t\begin{cases}\left|\frac{\omega_1}{\omega_2}-2{,}6\right|\le\chi,\left|\frac{\omega_2}{\omega_4}-1{,}35\right|\le\chi,\left|\frac{\omega_4}{\omega_7}-1{,}14\right|\le\chi\\ ,\left|\frac{\omega_7}{\omega_3}-1{,}25\right|\le\chi,\left|\frac{\omega_3}{\omega_5}-1.2\right|\le\chi,\left|\frac{\omega_5}{\omega_6}-1{,}08\right|\le\chi\\ \left|\frac{\omega_6}{\omega_8}-1{,}08\right|\le\chi,\left|\frac{\omega_1}{\omega_4}-3{,}5\right|\le\chi,\left|\frac{\omega_2}{\omega_7}-1{,}54\right|\le\chi\\ \left|\frac{\omega_4}{\omega_3}-1{,}43\right|\le\chi,\left|\frac{\omega_7}{\omega_5}-1{,}5\right|\le\chi,\left|\frac{\omega_3}{\omega_6}-1{,}3\right|\le\chi\\ \left|\frac{\omega_5}{\omega_8}-1{,}17\right|\le\chi;\\ \sum_{j=1}^{5}\omega_j=1,\omega_j\ge0,\forall j\end{cases}$$

By solving this model, the final values of the weight coefficients and DFC of the results $\chi = 0.00$ are obtained. The value of the criteria according to the marks given at the beginning is shown in figure 3. The model is solved using the MS excel solver.
From obtained results it can be concluded that the most important criterion is C1, followed by the criterion C2.

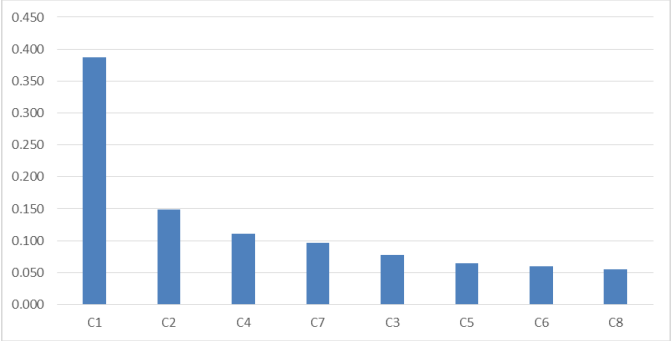

Figure 3: The value of decision criteria

4. . Conclusion

Many African countries suffer from being landlocked countries with no direct sea ports. This leads to many problems such as the high cost of imports, and the inability of these countries' exports to compete in world markets. In order to alleviate these problems, there is an urgent need to develop strategies for the integrating the regional infrastructure in order to develop international trade and expand the access to these landlocked countries. The matter also requires concluding bilateral or regional agreements between landlocked and transit countries. The development of African ports is also a key to the growth of international trade of the African Countries. This paper presents the most important criteria that influencing transient seaport selection for landlocked countries in the African continent. FUCOM model was used to calculate the criteria weights. The significance of eight criteria were evaluated by a group of experts. Future research regarding this paper is to evaluate some selected seaports as a potential transient seaport for one or more landlocked countries.

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