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Location of logistics hubs at national and subnational level with consideration of the structure of the location choice

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Abstract: The location of logistic hubs is a strategic decision made after multicriteria analysis. This requires first the definition of quantitative or qualitative criteria that can be independent or partially conflicting. The decision of location can be made at different geographical levels (countries or regions). In this paper, we suggest a generic structuration of criteria by geographical level and by family for choosing hubs location, taking into account the involved structure of location choice, which is rarely done in the literature: sequential assessment (choice of a country, then of a region of this country) or simultaneous assessment (direct choice of a location among several regions belonging to different countries).

Keywords: hub location, multicriteria analysis, structure, location choice, geographic level, sequential assessment, simultaneous assessment.

1. INTRODUCTION

In a globalisation context, firms are perpetually looking for new markets or new production resources. This implies to define efficient supply chains. In that purpose, the implementation of networks of logistic hubs usually allows to decrease the transportation costs in comparison with direct source/destination transportation (Alumur and Kara, 2008). Implementing a hub requires a huge investment. The choice of a location is therefore a problem that has drawn a large attention from both practitioners and academics.

On the base of a literature survey, this communication suggests a hierarchical definition of families of criteria, then of criteria, that can be adapted to specific purposes. The main originality of the proposal is that it may allow to take into account the sequence of decisions resulting in the choice of a hub location, which is seldom done in the literature. Criteria are in that purpose defined either at the national or subnational level. The choice of a location can then be done by choosing first a country, then a region/city of the country, or by choosing directly a region/city among a set of areas located in different countries. Another originality is the reuse of indexes published by international entities (World Bank, World Economic Forum for instance) for assessing some of the considered criteria.

2. STATE OF THE ART

2.1 Problem statement

Logistic hubs allow to consolidate material flows coming from different origins, and to send them to their respective

destination using unimodal (i.e. with a single type of transportation resources) or multimodal (i.e. with several types of resources) transport (Farhani et al., 2013; Campbell and O'Kelly, 2012).

Modern logistic hubs may play different roles according to the services they provide: standard functionalities (international/national transport, distribution, warehousing, inventory management...) or high added-value ones (orders assembly, co-packing, and post-manufacturing). Global Logistic Hubs (GLH) are usually located near ports or international airports. They may manage important flows of various types of goods (raw materials, semi-finished products, finished products...) at an international level but such hubs can also be used as transshipment resources only, linking national suppliers/producers to consuming areas. A Regional Distribution Centre (RDC) manages and gathers flows of goods, imported from international logistic centres or locally produced, in order to distribute them on a whole national territory using long distance transportation means. An Urban Distribution Centre (UDC) is a logistic platform located in the vicinity of an urban area, insuring the management and concentration of good flows coming from senders or RDC, for distributing them in the centre of the city. This includes the well-known "logistic of last kilometre" problem.

The location of logistic hubs is a specific case of the « facility location problem », intensively studied in the literature on transportation and logistics domain (see for instance (Owen and Daskin, 1998)). This decision is strategic and the comparison between several potential locations includes many

aspects that can be either quantitatively or qualitatively assessed. In the last case, qualitative assessment based on expertise should be possible. Assessment criteria may be partially conflicting, which still increases the complexity of the decision-making.

The choice of implantation of a hub may be done according to various sequences of decision influencing the definition of the assessment criteria: choice of a country or region, with a sequential (country, then region of the chosen country) or simultaneous choice (choice among regions belonging to several countries). The sequence of decisions is chosen by the stakeholders (government, logistics operator, manufacturer...) according to their objectives. An assessment of possible locations at the national level requires to assess criteria denoting the global attraction of a country, which is often difficult in quantitative terms, especially for large and/or developing countries, that often have heterogeneous characteristics. The assessment at the regional level consists in comparing cities or regions of the same country. Most of the literature on hub location is either at the national or subnational level. Sequential (or hierarchical) assessment, consisting in comparing first countries, then regions/cities of these countries may nevertheless be found in (Daganzo, 1996; Mayer and al., 1999; Mataloni, 2011). A simultaneous assessment may also be relevant: this would mean to compare regions belonging to several countries, resulting in less biases than the sequential assessment. In that case, criteria allowing to choose a country should be added to the regional ones.

In that context, we shall analyse in the next section the location criteria often suggested in the literature. We shall also review some indexes published by economical entities that can be reused as location criteria. We shall finally suggest to group location criteria in categories and will show how they can be implemented on sequential and simultaneous assessment, which is seldom done in the literature.

2.2 Survey of logistic hub location selection criteria in the academic literature

In this survey, we have considered articles suggesting criteria for hub location but also for foreign investment, using keywords like: *hub location selection criteria*, *hub location decision*, *locational determinant*, *location criteria evaluation*. We have excluded many articles dedicated to comparisons of the competitiveness of existing ports or hubs, since they consider performance criteria of existing entities and not criteria related to the attractiveness of a potential location. The selected papers involve either national evaluation based on national criteria (N), subnational assessment over regional criteria (R) or simultaneous assessment (SM) or sequential choice decision. Furthermore, in order to avoid giving too much consideration to very specific studies, we have finally only selected criteria cited at least by two different authors.

The criteria selected by the identified studies are summarized in Table 1 where the last column is related to this work.

Table 1. Main hub location selection criteria of analysed papers

Paper	Oum and Park 2004	Eskilsson and al 2010	El-nakib 2010	Yang and Chen 2016	Tongzon 2004	Muhoza and al 2010	Lipscomb and al. 2010	Lee 2007	Lu and Yang 2006	Kayikci 2010	Long and al. 2012	Uysal and yavuz 2014	Teng and al 2007	Bohla and al 2008	Da Silva and al 2011	Skowron-Grabowska 2007	Roso et al 2015	Zak and Weglinski 2014	Awasthi and al 2011	US
Sequence of decisions	N	N	N	N	N	N	S	M	S	M	S	M	R	R	R	R	R	R	R	Sequential /SM
Location Object	R	R	R	G	G	G	G	L	L	L	G	G	G	G	U	R	G	G	U	GRULC
	D	D	D	L	L	L	L	L	L	L	D	L	L	L	D	D	L	L	D	
	C	C	C	H	H	H	H	H	H	H	H	H	H	H	C	C	H	H	C	
Availability and Quality of Infrastructure	X	X	X	X	X	X	X				X									X
Connectivity										X										X
Border administration Efficiency		X		X	X				X	X										X
Openness to trade									X											X
Geographic location	X	X			X				X											X
Land Availability	X	X																		X
Domestic Market size	X	X							X	X										X
Foreign market size									X	X										X
Availability of Skilled labour	X	X		X																X
Labour market flexibility																				X
Customs barriers				X						X										X
Port/airport charges				X				X	X											X
Labour cost			X	X																X
Input Cost	X	X						X												X
Transport & Distribution cost			X					X	X											
Land price	X	X	X																	
Political stability	X	X	X	X	X			X	X	X										X
Macro-economic stability					X			X	X	X										X
Safety & Security								X	X	X										X
Country Resilience								X												X
Corruption control		X	X	X	X			X												X
Property rights					X			X												X
Reglementation transparency				X	X			X												X
Burden of reglementation			X	X	X			X												X
Incentives availability	X	X	X	X	X			X	X											X
Quality and availability of infrastructure							X			X	X	X	X	X	X	X	X	X	X	X
Land Availability							X		X	X						X				X
Location /land cost									X				X	X		X	X			X
Availability of skilled labor						X	X	X	X	X	X	X			X	X				X
Market size											X					X				
Labor Cost															X		X			X
Proximity to consumption market						X			X	X	X	X	X	X	X	X	X	X	X	X
Proximity to Manufacturing Market						X			X	X	X	X	X	X	X	X	X	X	X	X
Proximity to Port/Airport									X	X	X	X	X	X	X	X				X
Availability of regional incentives						X			X								X			X
Pollution		X									X						X	X		X
Safety and Security		X							X	X				X			X	X		X
Life Cost/economic development									X								X			X
Extra services		X												X						X
Transportation cost							X	X	X	X	X	X	X	X	X	X				
Congestion level						X			X	X	X	X	X	X						

2.3 Review of logistic hub location selection criteria on world organization indexes

Several worldwide organizations, like the World Bank or the World Economic Forum, regularly publish indexes aiming at comparing the attractiveness of the countries for foreign

investments. Those indexes are assessed based on international surveys involving multinational experts such as freight forwarders or main express carriers that evaluate countries over qualitative or quantitative basis. Even if these indexes are not dedicated to hub location, some of them are close to criteria considered as relevant in the literature on the location topic. These indexes may therefore provide an easy and recognized way to quantify some criteria which assessment would be difficult by individuals (Table 2).

Logistic Performance Index (LPI): this index is developed by the World Bank ranged from 1 (weak performance) to 5 points (high logistics performance). It evaluates the performance of several countries on trade logistics based on worldwide surveys of logistics providers and covers six criteria, namely: *efficiency of customs and border management clearance; quality of trade and transport infrastructure; ease of arranging competitively priced shipments; competence and quality of logistics services—trucking forwarding, and customs brokerage; ability to track and trace consignments; frequency with which shipments reach consignees within scheduled or expected delivery times.*

Global Competitiveness Index (GCI): this index has been created by the World Economic Forum in order to evaluate the overall competitiveness of countries. It is ranged from 1 to 7 points. It is a benchmark tool that helps leaders to identify and overcome many hindrances to their competitiveness. Basically, this index covers twelve main criteria, each composed of several sub-criteria. The main criteria are related to: *public and private institutions; infrastructure; macroeconomic environment; health and primary education; higher education and training; good market efficiency; labour market efficiency, financial market development; technological readiness; market size; innovation.*

Enabling Trade Index (ETI): this index is developed by the World Economic Forum in order to compare the ability of countries to benefit from trade, using a 1 to 7 points scale. It offers a comparative tool to companies, guiding their investment decisions strategies. It covers four main criteria: *market access; border administration; infrastructure; operating environment.*

Worldwide Governance Index (WGI): it is proposed by the World Bank in order to assess the governance of 200 countries. It includes six major criteria: *voice and accountability; political stability and absence of violence/terrorism; government effectiveness; regulatory quality; rule of law; control of corruption.*

Corruption Perception Index (CPI): it is established by Transparency International. It measures how corrupted public sectors of countries are, on a scale of 0 (highly corrupt) to 100 (very clean).

Liner shipping connectivity index (LSCI): it is evaluated by the United Nations Conference on Trade and Development (UNCTAD) and measures how countries are connected to global shipping networks, from 0 to 100 points. It includes five components of the maritime transport criteria, namely: *number of ships; container-carrying capacity; maximum vessel size;*

number of services and number of companies that deploy container ships in a country port.

Better Life Index (BLI): it is established by OECD in order to assess the well-being and the quality of life level on a country ranged from 0 to 10 points.

2.4 Limits of the literature

As already stated, we can say that 1) very few studies have considered the use of assessment criteria within a sequence of decisions at national and subnational levels, 2) few studies have proposed a sequential choice strategy to locate logistic hub, while some notable ones used a simultaneous strategies 3) few studies (Lee, 2007; Lipscomb, 2009; Kayikci, 2010; Shiau and al., 2011, Yang and Chen, 2016), have suggested a typology of criteria that would facilitate the adaptation of the criteria to a specific case, or would allow to better assess the impact of each category of criteria on the final choice.

To our best knowledge, there is not yet other study suggesting 1) criteria adapted to various sequences of decision 2) a taxonomy of criteria 3) the reuse when possible of existing validated indexes.

Table 2. Criteria based on world organization indexes

	IPL	GCI	ETI	WGI	CPI	LSCI	BLI
Availability and Quality of Infrastructure	X	X	X				
Connectivity						X	
Border administration Efficiency	X	X	X				
Openness to trade			X				
Domestic Market size		X	X				
Foreign market size		X					
Availability of Skilled labour		X					
Labour market flexibility		X					
Political stability				X			
Macro-economic stability		X	X				
Safety & Security		X					
Country Resilience							X
Corruption control		X	X		X		
Property rights		X	X				
Reglementation transparency		X	X				
Burden of reglementation		X	X	X			
Incentives availability							
Customs barriers			X				
Port/airport charges			X				
Life quality							X

3. LOGISTICS HUBS LOCATION SELECTION CRITERIA

We suggest a generic structuration of the reviewed criteria (Tables 1 and 2) by geographical level and by family, in order to facilitate sequential and simultaneous assessment. When considering the criteria listed in Table 2, it is rather clear that the following main categories are assessed:

- attractiveness of the local institutions,
- stability of the area,
- market accessibility,
- easiness of access to local resources (land, workers etc.).

In sections 3.1 and 3.2, these categories are instantiated at the national and subnational levels with additional details.

3.1 National level criteria

We have grouped national level criteria on seven categories, each one denoting the global attraction of a country:

Quality and efficiency of public institutions: It assesses the ability and willingness of a country to establish a good public policy to attract, facilitate drainage and protect investments. It reflects the regulatory, institutional, legal and tax system effectiveness. It includes sub-criteria such as: corruption control, property rights and intellectual property protection, government policies transparency, efficiency and simplification of business regulations, availability of governmental incentives to investors.

Stability of the country: It is related to how healthy and reliable the business environment is. It includes political stability, macro-economic stability, safety and security and resilience to natural risks. Political stability is defined as the probability of political risks occurrence such as political violence and terrorism, or sudden and unpredictable change of democratic power. Macro-economic stability is related to the stability and strength of macroeconomic policies such as inflation control, creditworthiness, reduction of public debt. Resilience to natural risks measure the ability of a country to overcome the main shocks and incidents related to natural disaster risk.

Market accessibility: It assesses the capacity of a country to facilitate the access to domestic and foreign markets to industrial exporters/importers. This accessibility relies basically on the availability and quality of the infrastructure (roads, highways, rail, ports, airports, telecommunication for transport), on the connectivity level, either maritime or by air (which reflects the existence of service based on the infrastructures), the efficiency of border administration and the openness to trade (existence of free exchange, burden of customs barriers).

Market potential: It denotes the overall size of the target market of industrial firms or logistics providers. It includes the domestic market size of the host country and/or the foreign accessible market from this country. The domestic market size assesses the amount of flow of goods imported or produced locally that will be distributed internally, while the foreign market size is related to the amount of goods that will be exported from the host country.

Labour market attractiveness: It measures the overall potential of labour market of the host country. It is based on the availability of qualified workforce and on the flexibility of the labour market in terms of flexibility of wage determination, hiring and firing practices, cooperation in labour-employer relations etc.

Geographical location attractiveness: It assesses how strategic the geographical location of the host country is. Besides, it includes also the availability of land and the possibility of expansion.

Competitive costs advantages of the country: This criterion covers all cost factors that can influence the hub location choice. It can include customs barriers (financial and non-financial barriers), port/airport charges (costs for documents, administrative fees for customs clearance and technical control, terminal handling charges and inland transport), labour cost and energy costs.

3.2 Subnational level criteria

We have organized criteria belonging to the subnational level in four categories, each reflecting the attraction of a city or region within a chosen country:

Availability and quality of infrastructure: This criterion assesses the availability and quality of transport infrastructure within a specific city/area. The importance of assessing this criterion on a subnational level is justified by the fragmentation of infrastructural coverage in some countries.

City/region's land attractiveness: It evaluates the attractiveness of land in the city in terms of availability of empty lands at a convenient price and possibility of land extension and development. It can be relevant to consider this criterion at the city level since cost and availability of land may differ considerably among cities in the same country.

Workforce attractiveness: It assesses the potential of the labour market within a specific region/city, in terms of the availability of qualified manpower depending on skills required by logistics hub and cost of the workforce. These criteria differ from city to city and have to be taken into consideration as they impact the city choice.

Proximity to markets: It evaluates the proximity of local markets such as consumers or industrial zones, and proximity to major ports/airports.

Quality of life: It assesses the quality of life within a specific region/city, which affects the human resources welfare. It may rely on pollution level, safety and security, life cost, existence of extra services (schools, hospital) etc.

Regional incentives: As there may be great differences among cities in the same country, the local authorities may offer some incentives in order to boost the economic development of landlocked cities.

3.3 Simultaneous assessment criteria

This sequence of decisions consist of comparing cities/regions of different countries over national and subnational criteria simultaneously (Lipscomb et al., 2010; Lee, 2007; Lu and Yang, 2006; Kayikci, 2010; Long et al., 2012). It means that for each region, we will assess the attractivity of the country to which this region belongs using national criteria (§3.1) and the potential of this region based on subnational criteria (§3.2) simultaneously. The main difficulty and ambiguity of this method lies on the relevance of merging common criteria. Indeed, we may take into account some criteria on both level, as their measure are complementary (quality of infrastructure, for example) or we may consider them only on one level (workforce attractivity, for example). Indeed, we will consider quality of infrastructure criteria on both levels as we have to evaluate not only the quality of infrastructure within a specific region/city but also the availability and quality of ports/airports, railway line highways which serve the entire territory. However, we may assess workforce attractivity only on subnational level as it would be redundant to evaluate it at both levels. This strategy leads to a pertinent analysis since regions from different countries compete against each other. However, it might be heavy to implement it especially if we have a high number of alternatives and criteria.

3.4 Sequential assessment criteria

A sequential choice is a hierarchical choice process in which location alternatives are eliminated in phases based on different attributes (Mataloni, 2011). In our context, it consists in comparing first countries based on national level criteria (§3.1) then cities/regions belonging to the same selected country according to subnational level criteria (§ 3.2). As the final objective of both sequence of decision is the selection of a set of regions/cities where logistic hub will be set up, a key advantage of this sequence of decisions is that it reduces the number of cities/regions and criteria compared to simultaneous approach. However, this strategy has a notable limit as regions of different countries would not be in competition.

3.5 Criteria assessment

There are several ways to assess criteria depending on the availability of either qualitative or quantitative data, qualitative data being usually assessed by expert's judgement. Moreover, data might be precise (specific value), or imprecise (interval value). Imprecise data based on expert knowledge is often modelled using fuzzy logic (Chu, 2002).

4. CONCLUSIONS AND PERSPECTIVES

In this communication, we propose a generic structuration of criteria used for the choice of hub location by geographical level (national, subnational) and by category. This structuration can be adapted according to specific applications and allows to conduct a complete evaluation of the location decision either in a sequential or simultaneous way, which is seldom done in literature.

This study represents a first step toward a multicriteria decision analysis of hub location selection aiming to determine a subset of qualified countries and cities to host logistics hubs.

In the future research, we will finalise the assessment of criteria introduced in this communication and will compare Multiple Criteria Decision Methods (MCDM) such as AHP, TOPSIS, ELECTRE or PROMETHEE in order to choose one of them (or a combination of them) and proceed in the evaluation of logistic location.

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