Feasibility analysis of a Global Logistics Hub in Panama

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Abstract: The objective of this essay is to identify the more relevant criteria for a Global Logistic Hub (GLH) development in Panama, which main obstacle is the multi-criteria evaluation and decision environment it is immersed in. The Analytic Hierarchy Process (AHP) was chosen because of its capacity to deal with such complex decision environment. After identification of Panama's logistic potential, the next step was surveying the development criteria within a widely group of specialists and applying the AHP technical aspects. The results reveal global strategic position, Vorland development and proximity to import/export areas as the more relevant criteria to assure a GLH development.

Keywords: AHP, analytic hierarchy process; GLH, global logistic hub; Panama; development criteria; multi-criteria.

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1 Introduction

Logistics is one of the key pillars of Panama's economy. The country enjoys a very sound international reputation because of two obvious reasons: the strategic geographic position and the top internal situation in infrastructure and logistics technology, much because of its unique link between the Atlantic and the Pacific Oceans, the Canal.

The Panamanian government and other national development agencies are aware of this situation and are working on ways to extract all the best commercial and logistic competitive advantages offered by the Canal. The idea is to turn Panama into a world economic reference, trough the development of a Global Logistics Hub (GLH). The fact is that Panamá was never before ready to play such an important role in world economy. Now, a whole conjecture points this possibility. As an example, a good definition that summarises Panama's situation today is made by Lech (2008): "One country, two oceans and a wealth of opportunity".

Panama's logistics potential is subject of numerous works and researches, aiming at indentifying and enhancing this huge business opportunity, such as the work of Muños and Rivera (2010) – that place Panama GLH inside the Latin America development context, Denver et al. (2009) and Mitchell (2011) – that evaluates the effects the expansion of the Panama Canal over U.S. market, Sebastian and Richards (2009) that evaluate if, in Panama GLH, the dilemma between the reductions in holding costs (caused by the GLH inventory centralisation) outweighs the increases in transportation and handling costs and Gelareh and Nickel (2011) and Gelareh and Pisinger (2011), that consider Panama GLH potential when developing hub locations mathematical formulations. Also, Alvarez et al. (2009) develop a deep study over the Canal Expansion Project and attempt to explain the decision-making processes for complex systems and develop a system dynamic model that will help with the political, social and economic decision-making processes that are involved in this very large project.

The main objective of this essay is to develop a methodology to establish the more relevant development criteria for GLH. To serve this purpose, the Analytic Hierarchy Process (AHP) and variations are going to be the basic analysis and evaluation methodology. The AHP is a structured technique for dealing with multiple criteria decision problems, such as the GLH development. In the GLH development process, there are several variables to be considered including infrastructure evaluation, geographic positioning, transportation lead times, labour, transportation and warehousing costs analysis, tax benefits, political and economic planning investigation, among many others. Each of those variables plays a role and has relevance level, creating a situation that should be incorporated to the evaluation and analysis model.

By first identifying Panama's logistics potential, we can justify the logistics hub implementation proposal. After that, it is necessary to create and implement an evaluation methodology to substantiate Panamá's GLH. Aiming at a bigger contribution, this project focus is to develop a methodology not only to evaluate Panamá's GLH feasibility but also any other similar business clusters.

2 The Panama

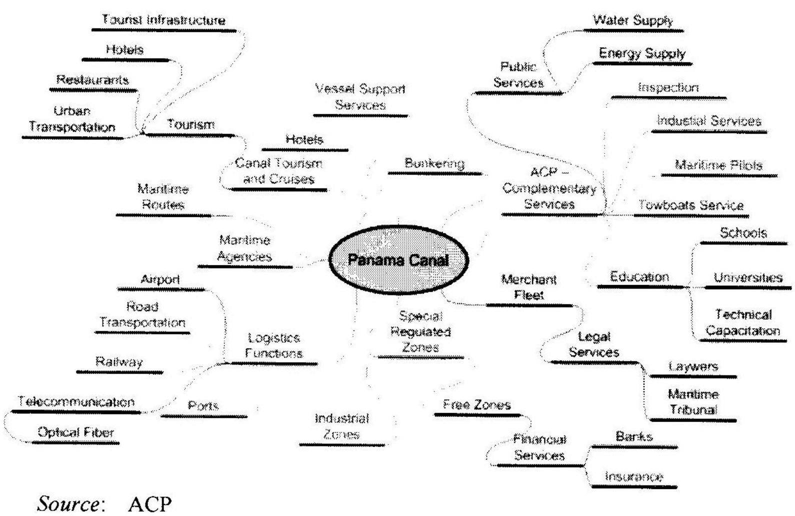
Initially developed for military purposes, the Canal became an essential passage for transporting goods between world economies. Since opening, the Canal has been an enormous success, and today it still is a key conduit for international maritime trade – circa 5 percent of global trade passes through this trade artery, even though world shipping has changed markedly in the last century.

According to the Canal administrator, the ACP, traffic in 2008 reached the 310 million tonnes level. Nevertheless, it faces a number of potential problems. The canal is approaching its maximum capacity and its locks aren't large enough to fit the new word shipping fleet – vessels with more than 300 meters length. By 2012, it is expected that 38% of the world's container ships fleet will be too large for the present canal dimensions (ACP). Also according to Plan Maestro del Canal de Panama (2006), the maximum traffic capacity of the canal is estimated at 340 million tonnes per year. That means that the canal operates today at 90% of its maximum capacity and projections indicate that the maximum capacity will be reached between 2011 and 2012 (ACP).

In order to retain a significant market share on international trade, operational and structural changes are necessary. The Panamanian authority is absolutely conscious about the challenges faced and the project of a third set of locks is already under construction.

But hopefully, as stated by Leach (2008), Panama is not pinning its plans for growth exclusively on the fact that the third set of locks will be able to accommodate the new 13,500 TEU container ships generation. The ACP and the Panamanian government have developed a very deep and conscientious analysis about the Canal and its direct and indirect impacts over the economics and logistics systems. The obvious economic advantages provided by the Canal promoted the development of varied economic activities related to the traffic business. A conglomerate of economics activities related to the Canal is illustrated in Figure 1.

Figure 1 Diagram of the Canal's conglomerate direct (blue) and indirect (red) activities (see online version for colours)



Source: ACP

This conglomerate corresponds to a group of physically close, complementary and synergic activities capable of generating benefits to Panama. The continuous development of this conglomerate is considered by the ACP, in the Master Plan of the Panama Canal, as an essential element to turn Panamá into a world economic reference. As the Canal is located at diagram centre, ACP concludes that the Canal is the keystone over which the Panamá development and progress lean on.

Therefore, the Panamanian government and ACP have already realised that there are several other factors in the growth equation besides the physical Canal Expansion Plan. The institution's main idea is to develop all the Canal related conglomerate activities, turning Panama into a major logistic hub.

3 Definition of Global Logistics Hub

A broad definition of a logistic hub is an integrated centre for transshipment, storage, collection, production and distribution of goods' (Jorgensen, 2007). We can define then that a logistic hub main function is to promote the integration between the various logistics activities, becoming a centre of a broad network of trade entities, adding up value to the activities and offering a complete solution to the costumer.

Jin and Li (2007) concept of global logistics centre offers a broader view. Global logistics centre "integrates logistics, trade, industry, distribution and living functions, facilitates logistics services and value-added services through linkage between various destinations, playing a major role in national economic development".

4 Implementing a GLH in Panama

Traditionally, Panama has been compared to Singapore because of their similar open economy and service-oriented characteristic. The question is why Panama does not have the same economic importance level to its region as Singapore does. In 2002, Panama represented 2.1% of Latin America trade, while Singapore represented 8% of Asia trade. The fact is that Panama was never before ready to play such an important role. Now, a whole social, economic, logistic, cultural and political conjecture points this possibility. Doing business overseas in Panama has never been more advantageous.

The decision on concentrating logistics functions in a particular GLH has critical importance (Lee et al., 2007). Then, in order to develop a successful GLH, the administrator is required to design and implement proper strategies regarding numerous aspects for attraction of international firms (Tao and Park, 2004). This ambitious project realisation requires substantial planning and working, is subject to risks and uncertainties and embraces pros and contras aspects.

The question proposed in this essay is: "Is Panama GLH really possible to operate? Will it operate the way it is expected to? What are the main relevant criteria to grant this GLH development? "

As stated before, this essay aims at employing and adapting a methodology to answer those questions while taking into consideration and evaluating all variables considered in implementing a logistics hub, such as location, infrastructure availability, transportation cost, intermodality development, warehousing and labour costs, tax benefits, workforce qualification and many others.

5 Methodology

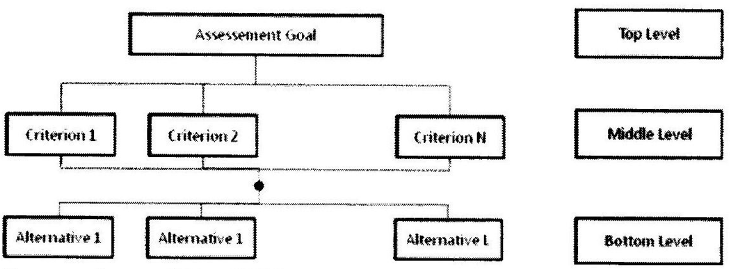
Developing a successful GLH requires designing and implementing adequate strategies (Tao and Park, 2004) regarding numerous aspects for attraction of international firms. The evaluation of the positioning and implementation of a GLH is a Multiple Criteria Decision-Making (MCDM), as stated by Lee et al (2007). Therefore, it is necessary to apply a proper and sufficiently powerful methodology, able to deal with all the facets of this challenge. The proposed methodology to deal with such a particular situation is the AHP.

5.1 Analytic Hierarchy Process – AHP

The AHP is a structured technique for dealing with multiple criteria decision problems, initially presented by Saaty (1980). 'The AHP provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions' (Saaty, 1980).

The AHP methodology is a powerful and flexible multi-criteria decision-tool that can be applied to any hierarchy of performance measures (Rangone, 1996). Basically, the AHP methodology first decomposes the decision problem into a hierarchy of more easily comprehended sub-problems – with goal at the top of the hierarchy, criteria and sub-criteria at levels and sublevels and decision alternatives at the bottom of the hierarchy, as shown in Figure 2. The evaluation of the elements of the hierarchy is made in pairs, by comparison, either through concrete data or human judgement, to assess their relative preference. Following, there is the conversion of the preference evaluation into numerical values that, combined with numerical weights determined to each of the elements of the hierarchy, allows the comparison of the hall of proposed solutions.

Figure 2 Conceptual framework of a decision problem decomposition



Source: Song and Yeo (2004)

Zahedi (1986) describes the AHP methodology in four steps:

1 Structuring the decision hierarchy by breaking down the decision problem into a hierarchy of interrelated decision elements (criteria, decision, alternatives)

2 Collecting input data, depicted by matrices of pairwise comparisons, of decision elements

3 Using a pre-established method to estimate the relative weights of the decision elements

4 Aggregating the relative weights of decision elements to arrive at a set of ratings for decision alternatives.

Rather than prescribing a 'correct' decision, the AHP helps the decision makers find the one that best suits their needs and their understanding of the problem.

Many authors have reviewed the usage of AHP as decision support tool, in different working fields – Vaidya and Kumar (2006) found about 150 papers investigating the AHP with a wide range of applications (education, engineering, government, industry, management, manufacturing, personal, political, social and sports), while Steuer and Na (2003) reviewed 18 papers studying the AHP combined with finance.

Saaty (2001) lists 10 advantages of the AHP as a decision-making tool: "unity, complexity, interdependence, hierarchy structure, measurement, consistency, synthesis, tradeoffs, judgement, and consensus". Saaty (1980) also confirmed the AHP 'as a successful track record regarding applications in the wider transport area following its introduction as a MCDM methodology'.

The success of AHP deployment in numerous areas, from the simple everyday problems to complex problems of designing alternative future outcomes of a developing country, but especially in helping solving logistics and transportation issues – structuring complex logistics problems in form of simple hierarchies and evaluate a large number of quantitative and qualitative factors under a multiple criteria environment, makes the method very attractive. Ho (2008), presents a summary of AHP applications by working field (see Table 1), where it is possible to conclude that the AHP logistic field application is dominant over all others.

Table 1 Main assessment criteria to GLH development

Applications	*Number of articles*
Logistics	21
Manufacturing	18
Government	4
Higher education	4
Business	3
Environment	3
Military	3
Agriculture	2
Health-Care	2
Marketing	2
Industry	1
Service	1
Sports	1
Tourism	1

5.2 Fuzzy Analytic Hierarchy Process – FAHP

The Fuzzy AHP (FAHP) is an extension of the classical AHP method. The main contribution of the extension is the consideration of the fuzziness of the decision maker.

As defined before, the AHP methodology is one of the best ways for deciding among the complex criteria structure in different levels. However, the final considered relatives values are usually based on incomplete or imprecise information and criteria, or on analysis that are subjective or endowed by the linguistic, creating a fuzzy environment (Yang, 2009). The utilisation of the FAHP, with employment of the fuzzy numbers theory, might be more suitable in situations like that.

Actually, at most of the real world decision situations, some of the preference judgements cannot be precisely assessed and should, preferentially, be evaluated under FAHP methodology. Leung and Chao (2000) affirm that this uncertainty in the preference judgement gives rise to difficulty in establishing preference's consistency. There is an extensive literature that address to FAHP methodology, applied in numerous research areas such as evaluating naval tactical missile systems (Ching-Hsue, 1997) or developing a decision support system for locating a new convenience store (Kuo and Chen, 2002), with different perspectives and applying methodologies, proving it's flexibility and power.

Two authors – Xu (1998) and Ding (2006), work on developing and presenting guides for evaluating weights using FAHP, summarised on Chapter 3.3. Basically, based on Xu (1998) and Ding (2006), there are eight systematic steps to be taken for evaluating relative weights using FAHP:

- Step 1: Decompose the problem and re-build it as a hierarchical structure
- Step 2: Collect pairwise comparison and build matrices of decision attributes
- Step 3: Application of the fuzzy number theory
- Step 4: Build fuzzy positive reciprocal matrices
- Step 5: Calculate the fuzzy weights
- Step 6: Defuzzify the fuzzy weights (turned into crisp weights)
- Step 7: Normalise the crisp weights
- Step 8: Calculate the integrated weights for each level and element.

5.3 Technical Aspects of FAHP Methodology

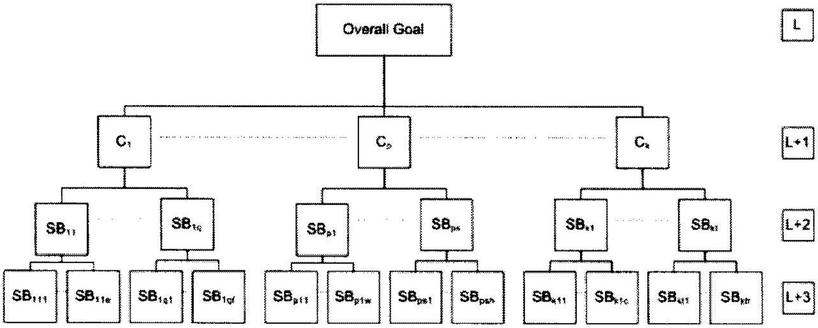
The eight systematic steps to be taken for evaluating relative weights using FAHP are based on Xu (1998), Ding (2006) and Yang (2009).

- Step 1: Decompose the problem and re-build it as a hierarchical structure

The essence of the FAHP methodology is the decomposition of a complex problem into a hierarchy structure into humanly manageable sub-problems. The FAHP structure comprises: overall goal at the top level; criteria and sub-criteria (evaluation parameters) are at levels and sub-levels of the hierarchy.

An example of a hierarchical structure is shown in Figure 3.

Figure 3 Hierarchical structure of FAHP



Source: Yang (2009)

Figure 3 represents a hierarchical structure with k criteria on 1st level, $q + \ldots + s + \ldots + t$ sub-criteria on 2nd level, and $e + \ldots f + \ldots + w + \ldots + h + \ldots + c + \ldots + r$ sub-criteria on 3rd level.

- Step 2: Collect pairwise comparison and build matrices of decision attributes

The collection of pairwise comparison matrices of decision attributes is done, firstly, by properly selecting the judging source.

The pairwise comparison final objective is to basically assign a relative weight to each criterion. Pairwise comparisons are to be made for the detailed elements of each level (Saaty, 1980b), to assess their relative preference with respect to each of the elements at the next higher level.

A ratio scale is used to guide the pairwise comparison. The scale ratio proposed by Saaty (1980b) will be applied in this work: [1/9, 1/8, ..., 1/2, 1, 2, ..., 8, 9]. The scale translation is quite simple: the values represent how much more important is criteria A compared to criterion B. The reciprocal evaluation is valid as well: if criterion A relative importance to criterion B is 1/2, then criterion B relative importance to criterion A is 2. So, if n is the number of same level comparative elements, the decision maker will have to make as much pair-comparisons as $n^*(n-1)/2$.

To each selected judging source, it is necessary to build a comparison matrix of decision attributes, which represents the relative importance of each pairwise: (based on Yang, 2009 and on Figure 3)

- (1) $a_{i.j}^{h}$ is the relative importance given to element i to element j on the 1st level and h is the hth decision-maker judgement, $\forall i, j = 1, 2, \ldots, k \setminus i \neq j$. The pairwise comparison matrix is defined as $[a_{i.j}^{h}]_{kxk}$.
- (2) $a_{u.v}^{h}$ is the relative importance given to element u to element v on the 2nd level and h is the hth decision-maker judgement, $\forall u, v = 1, 2, \ldots, q \setminus u \neq v, \ldots, \forall u, v = 1, 2, \ldots, s \setminus u \neq v, \ldots, \forall u, v = 1, 2, \ldots, t \setminus u \neq v$.
  The pairwise comparison matrix, to each criteria element ($C1, \ldots, C_p, \ldots, C_k$) is defined as $[a_{u.v}^{h}]_{qxq}, \ldots, [a_{u.v}^{h}]_{sxs}, \ldots, [a_{u.v}^{h}]_{txt}$.

- (3) $a^h_{y.z}$ is the relative importance given to element y to element z on the 3rd level and h is the hth decision-maker judgement,
  $\forall y,z = 1,2,\ldots,e \setminus y \neq z,\ldots, \forall y,z = 1,2,\ldots,f \setminus y \neq z,\ldots, \forall y,z = 1,2,\ldots,w \setminus y \neq z,\ldots,$
  $\forall y,z = 1,2,\ldots,h \setminus y \neq z,\ldots, \forall y,z = 1,2,\ldots,c \setminus y \neq z,\ldots, \forall y,z = 1,2,\ldots,r \setminus y \neq z.$

The pairwise comparison matrix, to each criteria element, ($SB_{11},\ldots,SB_{1q},\ldots,SB_{p1},\ldots,$ $SB_{ps},\ldots,SB_{k1},\ldots,SB_{kt}$) is defined as $[a^h_{y.z}]_{exe},\ldots,[a^h_{y.z}]_{fxf},\ldots,$ $[a^h_{y.z}]_{wxw},\ldots,[a^h_{y.z}]_{hxh},\ldots,$ $[a^h_{y.z}]_{cxc},\ldots,[a^h_{y.z}]_{rxr}.$

- Step 3: Application of the fuzzy number theory

To represent multiple decision-makers' consensus opinions, the geometric mean is more effective than any other mean (Saaty, 1980b). However, to aggregate and to represent the opinion of all judgements sources, this essay is going to use triangular fuzzy numbers characterised by using the minimum, maximum and geometric mean. After integrating all multiple decision-makers, the triangular fuzzy number defined is:

$$T_{i.j} = (l_{ij}, g_{ij}, h_{ij}),$$

where:

$$l_{ij} = \min\{a^1_{ij}, a^2_{ij},\ldots,a^n_{ij}\},$$

$$g_{ij} = \left[\prod_{h=1}^{n} a^h_{ij}\right]^{1/n}$$

$h_{ij} = \max\left\{a^1_{ij}, a^2_{ij},\ldots,a^n_{ij}\right\}$, where n is the nth decision maker.

T_{ij} represents the triangular fuzzy number of the 1st level of the problem hierarchy. This model is going to be used to define triangular fuzzy number in all possible levels of analysis.

- Step 4: Build fuzzy reciprocal matrices

For each level, it is necessary to build a fuzzy number reciprocal matrix, using the triangular fuzzy number defined as $T_{ij} = (l_{ij}, g_{ij}, h_{ij})$. As an example, the 1st level matrix is presented below:

$$T = \left[T^1_{ij}\right] = \begin{bmatrix} 1 & T^1_{1.2} & \cdots & T^1_{1.k} \\ \dfrac{1}{T^1_{1.2}} & 1 & \cdots & T^1_{2.k} \\ \vdots & \vdots & \ddots & \vdots \\ \dfrac{1}{T^1_{1.k}} & \dfrac{1}{T^1_{2.k}} & \cdots & 1 \end{bmatrix}$$

The analogue equations of the fuzzy reciprocal matrices for 2nd and 3rd levels are omitted.

- Step 5: Calculate the fuzzy weights

The geometric mean of the triangular fuzzy number of the ith element on the 1st level is:

$$Z_i^1 = \left[\prod_{j=1}^{k} T_{ij}^1 \right]^{1/k}, \quad \forall i = 1, 2, \ldots, k.$$

The calculation of the fuzzy weight of the ith element in 1st level is designated by:

$$W_i^1 = \frac{Z_i^1}{Z_1^1 + Z_2^1 + \ldots + Z_k^1}, \quad \forall i = 1, 2, \ldots, k$$

The triangular fuzzy weight is defined as $W_i^1 = (w_{i.l}, w_{i.g}, w_{i.h})$.

- Step 6: Defuzzify the fuzzy weights (turned into crisp weights)

The most usual method of defuzzification is the method proposed by Chen and Hsieh (2000) where the crisp weight of a triangular fuzzy weight is denoted by:

$$\mathrm{CW}_i^1 = \frac{w_{i.l} + 4 * w_{i.g} + w_{i.h}}{6}, \quad \forall i = 1, 2, \ldots, k$$

- Step 7: Normalise the crisp weights

The normalisation of the crisp weights makes possible the comparison of the relative importance between each level. The normalised weight of element i in the 1st level is represented as:

$$\mathrm{NW}_i^1 = \frac{\mathrm{CW}_i^1}{\mathrm{CW}_1^1 + \mathrm{CW}_2^1 + \ldots + \mathrm{CW}_k^1}, \quad \forall i = 1, 2, \ldots, k$$

- Step 8: Calculate the integrated weights for each level and element

The last step is to calculate the integrated weight for each element of each level. Only after that the method is applicable. $\mathrm{NW}_i^1, \mathrm{NW}_j^2, \mathrm{NW}_y^3$ are the normalised crisp weights of the 1st, 2nd and 3rd levels respectively, and the integrated weights for each element at each level are (Yang, 2009):

- 1st Level:

$$\mathrm{IW}_i^1 = \mathrm{NW}_i^1, \quad \forall i = 1, 2, \ldots, k$$

- 2nd Level:

$$\mathrm{IW}_j^2 = \mathrm{NW}_i^1 * \mathrm{NW}_j^2,$$

$$\forall i = 1, 2, \ldots, k \text{ and } [\forall j = 1, 2, \ldots, q \quad \text{or } \forall j = 1, 2, \ldots, s \quad \text{or } \forall j = 1, 2, \ldots, t\,]$$

- 3rd Level:

$$IW_y^3 = NW_i^1 * NW_j^2 * NW_y^3,$$

$$\forall i = 1, 2, \ldots, k \text{ and } \begin{cases} (\forall j = 1, 2, \ldots, q\, e(\forall y = 1, 2, \ldots, e\, ou\, \forall y = 1, 2, \ldots, f)) \\ \text{or} (\forall j = 1, 2, \ldots, s\, e(\forall y = 1, 2, \ldots, w\, ou\, \forall y = 1, 2, \ldots, h)) \\ \text{or} (\forall j = 1, 2, \ldots, t\, e(\forall y = 1, 2, \ldots, c\, ou\, \forall y = 1, 2, \ldots, r)) \end{cases}$$

6 Selecting GLH's development criteria

The literature about GLH development is very limited. However, there are several works regarding port development and selection, focusing on identifying and understanding the most important factors for those processes (Song and Yeo (2004)) identify competitiveness aspects of container ports in China from the outsiders' perspective; Ugboma et al. (2006) studies the findings of a survey to determine important service characteristics to port selection; Guy's and Urli (2006) goal is to assess how port choice is affected by changes in criteria preferences; Lirn (2004) analyses transshipment port selection, revealing the most important attributes influencing global carriers' choices).

Regarding Panama, the maritime logistics potential is a major aspect to consider. The development of GLH in Panama has, of course, a very strong link with maritime terminals, ports and the Canal operations. The recurrent literature about AHP application on port development and selection will then serve as an excellent basis for definition of the initial pool of criteria for a GLH development. A common characteristic of the researched papers is the application of the AHP framework, aiming at managerial and strategic implications.

Also, a GLH presents much of the same aspects of a free trade zone, element scrutinised by Yang (2009). In fact, the *Taiwanese Act for the Establishment and Management of Free Trade Zone* (2004), in its first article, states that the main goal of Taiwan's Port Free Trade Zones is to develop an operating model for global logistics and management systems, enhancing competitiveness and trade/logistics liberalisation mechanism.

Table 2 presents the initial pool of criteria to allow a GLH development, collect from literature review, some expert and logistic hub players (logistic operators, shippers and government institutions) interviews. Because the criteria selection stage in FAHP context is very important, this selection still always open to further discussions and new discoveries.

An important consideration at this stage is that too much information may lead to confusion or meaningless choice, degrading the clarity of the questionnaire and the consistency of answers. So a certain number of information (in this case, a limitation on the criteria and sub-criteria amount) is desirable (Song and Yeo, 2004). A benchmarking analysis concluded that a number between 10 and 20 sub-criteria, depending on the size of the analysis, is enough to provide a deep investigation tool, keeping the clarity, consistency and linearity of the analysis. Afterward, the initial number of selected sub-criteria considered previously in this essay (18), was considered reasonable.

Based on the work of Lirn (2004), we can represent the selected assessment criteria of GLH development with the conceptual framework of FAHP application methodology in Figure 4.

Table 2 Main assessment criteria to GLH development

Category 1	*Category 2*	#
Physical and technical infrastructure	Intermodal network development; Efficiency of modal integration	[1]
	General GLH accessibility adequacy infrastructure facilities	[2] [3]
	Hinterland size, development and potential	[4]
Costs environment	Freight and transhipment costs	[5]
	Land availability and cost	[6]
	Cost of labour force (training, education, R&D)	[7]
	Industrialisation cost (fabrication and Processing)	[8]
Political/administrative perspective	Political stability	[9]
	International trade soundness	[10]
	Administrative efficiency	[11]
	Customs regulation	[12]
	Business tradition/potential	[13]
	Taxes/subsidy to business activities	[14]
	Soundness of investment system	[15]
Geographical location	Proximity to import/export areas	[16]
	Vorland development (attractiviness to main commercial routes)	[17]
	Global Strategic position	[18]

6.1 *Surveying GLH's development criteria through FAHP*

The next step of the methodology consists in collecting the pairwise comparisons – made by a selected pool of decision makers (players), between the elements in the same level of the framework in Figure 4.

Collecting data to FAHP methodology application requires commitment, persuasion and perseverance. It is necessary to first identify all possible players, either direct and/or indirect. A list of the major players was built and is briefly divided in the major groups below:

Direct players	*Indirect (influential) players*
Global container carriers	Local research labs at unis
Container port authorities	Global logistics specialists
Local commerce chamber	World-Top academic researches
Free trade zone authorities	
Governmental institutions	

The following step was to design a questionnaire to assess all players' considerations and opinions about the selected main assessment criteria to GLH development. The questionnaire design includes an introductory page with an explanation and definition of each of the criteria and sub-criteria and a clear example of how to answer the questionnaire. This is important to familiarise the recipients with the pairwise comparison technique of FAHP survey to minimise inconsistent answers. A total of about 85 questionnaires were sent to selected players, either in Brazil and Panama.

The pairwise comparison is done with a relative importance scale support (see Figure 5). The scale translation is quite simple: the values represent how much important is criteria A compared to criteria B.

Figure 4 Selected assessment criteria of GLH development with the conceptual framework of FAHP application methodology

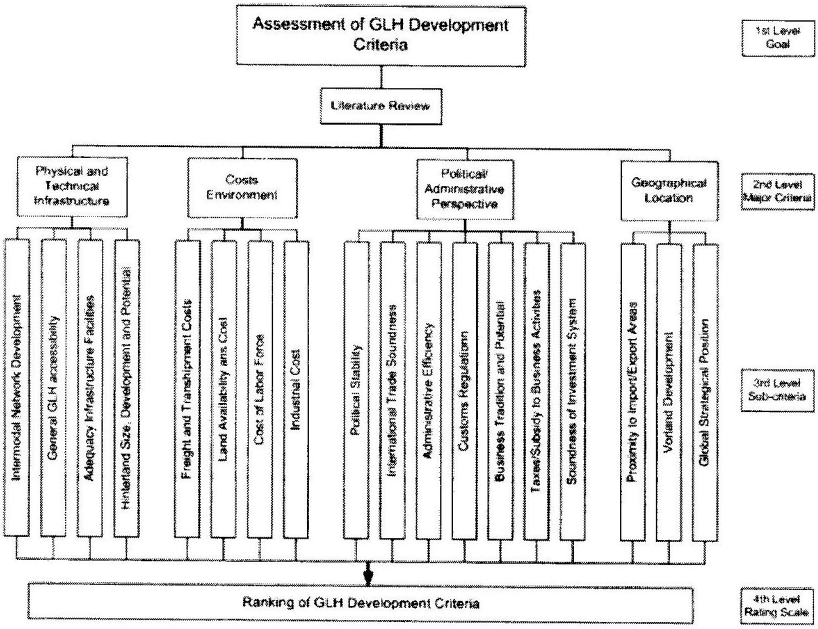


Figure 5 Relative importance scale to compare Criterion A and Criterion B (see online version for colours)

Criterion A	Intensity of Relative Importance																	Criterion B
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

7 Empirical study

A total of 48 valid questionnaires were collected, which represents a return mail ratio of about 56%. Literature investigation proved this number to be considered reasonable. A return ratio between 40% and 70% is considered satisfactory by all FAHP and AHP authors. All valid questionnaires were considered when applying the FAHP methodology described in Chapter 3.3. Table 3 resumes the calculated integrated weight for each of the 18 sub-criteria and the four major criteria. Table 3 also ranks all sub-criteria in a general rank and in a category rank.

A GLH development depends, of course, on all the four major selected criteria improvement. However, FAHP methodology allows to rate importance of each of the major criteria (see Table 4), creating an easy-to-understand picture of what, in accordance of player's judgements, is more important to reach success.

Table 3 Integrated weight value of GLH development criteria

Category 1	*Norm. crisp weight (a)*	*Category 2*	*#*	*Norm. crisp weight (b)*	*Integrated weight (a x b)*	*General rank*	*Category rank*
		Intermodal network development	[1]	0.2510	0.070	6	3
(A) Physical and technical infrastructure	0281	General GLH accessibility adequacy	[2]	0.2629	0.074		
		infrastructure facilities	[3]	0.2200	0.062	3 10	2 4
		Hinterland size, development and potential	[4]	0.2662	0.075	2	1
		Freight and transhipment costs	[5]	0.2691	0.067	7	1
		Land availability and cost	[6]	0.2518	0.062	9	3
(B) Costs environment	0247	Cost of labour force (training, education, R&D)	[7]	0.2100	0.052	11	4
		Industrialisation cost	[8]	0.2691	0.067	8	2
		Political stability	[9]	0.1301	0.033	15	4
		International trade soundness	[10]	0.1196	0.030	17	6
(Q) Political/ administrative perspective	0251	Administrative efficiency customs	[11]	0.1700	0.043		
		regulation	[12]	0.1577	0.040	13 14	2 3
		Business tradition/potential	[13]	0.1169	0.029	18	7
		Taxes/subsidy to business activities	[14]	0.1831	0.046	12	1
		Soundness of investment system	[15]	0.1226	0.031	16	5
		Proximity to import/export areas	[16]	0.3212	0.071	5	3
(D) Geographical location	0221	Vorland development	[17]	0.3302	0.073	4 1	2 1
		global strategic position	[18]	0.3487	0.077		

Table 4 Weight value of GLH development major criteria

	Major Criteria	*Weight*
[A]	Physical and technical infrastructure	0.281
[B]	Costs environment	0.247
[C]	Political/administrative perspective	0.251
[D]	Geographical location	0.221

In the case, all major criteria reached a very close level of importance. Mathematically, it is possible to say that that Physical and Technical Infrastructure is the most important criteria to be considered when developing a GLH, with Political/Administrative Perspective and Cost Environment playing the second and third most important role respectively. However, all major criteria weights are relatively very close, demonstrating a generally similar level of importance.

When evaluating the 18 selected sub-criteria that compose the 4 major criteria mentioned, the top ones to be considered when developing a GLH are:

The FAHP applied methodology allows the conclusion that the Top 10 Ranked Sub-criteria present in Table 5 are the most important ones when planning a GLH implementation. But, bearing in mind prior conclusion of importance level similarity of the four major selected criteria (Physical and Technical Infrastructure, Political/ Administrative Perspective, Cost Environment and Geographic Location), a major criteria individual sub-criteria ranking classification was considered convenient. This promotes a more focused view regarding the particular components of each major criterion, allowing a more understandable and conscious 'action plan' to be built in order to promote the development of each individual criterion.

Table 5 Top ranked sub-criteria

Ranking	*General rank*	*Integrated weight*
1	Global strategic position	0.3487
2	Hinterland size, development and potential	0.2662
3	General GLH accessibility	0.2629
4	Vorland development	0.3302
5	Proximity to import/export areas	0.3212
6	Intermodal network development	0.2510
7	Freight and transhipment costs	0.2691
8	Industrialisation cost	0.2691
9	Land availability and cost	0.2518
10	Adequacy infrastructure facilities	0.2200

Table 6 allows us to conclude that, regarding the Physical and Technical Infrastructure Criteria, the GLH's Hinterland Development is the most critical factor. The hinterland definition is usually unclear. Literally, hinterland is the area behind the economic/logistic conglomerate. In fact, the hinterland is the area served by the conglomerate, where it sells its services and interacts with clients. It does not mean necessarily that the hinterland is a contiguous area to the conglomerate. Then, the hinterland is defined not only by geographic proximity but by the capacity of the conglomerate to promote/control the types of business which operates there and the logistics integration aspects of the hinterland-conglomerate. Each individual region presents its particular economy and social characteristics, and then conducting a proper strategy to make the conglomerate attractive to its hinterland and vice-versa is essential in order to the business to-support itself.

Table 6 Political and technical infrastructure sub-criteria rank

Ranking	*Physical and technical infrastructure*	*Integrated weight*
1	Hinterland size, development and potential	0.0747
2	General GLH accessibility	0.0738
3	Intermodal Network development	0.0705
4	Adequacy infrastructure facilities	0.0618

Table 7 reveals that Freight and Transshipment Costs is the most relevant sub-criteria in the GLH Costs Environment. Actually, Industrial Costs (fabrication and processing costs) have also the same level of importance as the environment, but a quick analysis will be done over the first one only.

Table 7 Costs environment sub-criteria rank

Ranking	*Costs environment*	*Integrated weight*
1	Freight and transhipment costs	0.0665
2	Industrialisation cost	0.0665
3	Land availability and cost	0.0622
4	Cost of labour force (training, education, R&D)	0.0519

The development of a GLH implies in the constitution of a major crossroads for international trade. Associated with this, the increasing use of mega containerships in transoceanic trades leads to the necessity of highly developed transshipment services. According to Frankel (2002), the objectives of transshipment are "not only to reduce the total cost of collecting and/or distributing the containers carried by a mega-mainline container vessel from and to numerous origin and destination ports, each of which only contributes a part of the mainline vessel cargo, but also to improve just-in-time delivery of cargo, reduce in transit inventory, and make the total origin-to-destination movement of containerised cargo more seamless". This means turning the whole supply-chain more efficient and more responsive.

The transshipment activity must then be seen not only as a 'logistic convenience' but as a possibility to perform an adding-value activity the supply-chain. Intrinsic transshipment activities such as cargo consolidation, deconsolidation, subassembly, customisation, postponement, etc. are some of the adding-value activities performed in a transshipment hub.

Table 8 Political/Administrative perspective sub-criteria rank

Ranking	*Political/Administrative perspective*	*Integrated weight*
1	Taxes/subsidy to business activities	0.0460
2	Administrative efficiency	0.0427
3	Customs regulation	0.0396
4	Political stability	0.0327
5	Soundness of investment system	0.0308
6	International trade soundness	0.0301
7	Business tradition/potential	0.0294

Tax Subsidies, by far the most important sub-criteria regarding the Political/ Administrative Perspective in GLH Development (Table 8), are the result of selective tax legislation that benefits particular groups of people or industries in the economy. In effect, they share the costs of certain actions between the private sector and the government and impact investment decisions by increasing the expected returns associated with a particular pattern of economic activity.

The stated goal of tax subsidies, according to the US General Accounting Office, is to promote some policy objective such as "economic growth or a desirable expenditure pattern by taxpayers." However, there is a great deal of disagreement over whether particular tax benefits typically encourage socially desirable" economic behaviour. This is, however, topic of numerous other studies and academic researches.

Table 9 highlights the big importance of a global strategic position in order to success in deploying a GLH. 'Whosoever commands the sea commands trade; whosoever commands the trade of the world commands the riches of the world, and consequently the world itself.' (Anon., 1610). Historically, the importance of a global strategic position has already been attested, driving many conflicts to gain control over trade routes, to gain control over mineral or energy deposits, to gain colonial control over untapped regions, or to set trade routes via existing ocean ports and others.

Table 9 Geographical location sub-criteria rank

Ranking	*Geographical location*	*Integrated weight*
1	Global strategic position	0.0770
2	Vorland development	0.0729
3	Proximity to import/export areas	0.0709

Besides, maritime transportation is the dominant purveyor of international freight distribution and evolves over a global maritime space. This space has its own constrains such as the profile of continental masses and the imperatives it creates. International maritime routes are thus forced to pass through specific locations corresponding to passages, capes and straits, such as the Panama Canal, which tend to be shallow and narrow, impairing navigation. Once a huge international development projects (such as a GLH), strongly linked with international trade, are severally constrained by geographic location aspects.

7 Conclusions and recommendations

The AHP methodology was able to indicate what are the more relevant aspects (criteria) for a Global Logistic Hub (GLH) development in Panama. Dealing with a multi-criteria environment and decision (such a GLH implementation) is critical for decision-makers once it turns the comprehension into a much more difficult task. Once again, AHP methodology proved to be powerful enough to help into the process of decomposing the big problem into small and comprehensive problems, clarifying the big picture of the problem.

In Panama's specific case, this study proposes that "Global Strategic Position", "Hinterland Size, Development and Potential", "General GLH Accessibility", "Vorland Development" and "Proximity to Import/Export Areas" are the five most important aspects in developing a GLH. A deeper analysis and further investigation over Panama's current situation regarding each of the top-important identified criteria might help to promote a more focused view over Panama's developing demands, allowing a more understandable and conscious "action plan" to be build in order to promote a GLH successful development, is suggests as the natural next step of the project.

It is emphasised that the same methodology applied in this study may be applied to others similar clusters and hub evaluation. Highlighting the more relevant aspects to such complex logistic venture might be extremely helpful in determining politics and planning actions to ensure its success.

However, it is important to emphasise that the whole AHP application process is a very sensitive process, dependant of personal decisions and choice of the AHP applicant criteria selection and interviewee evaluation of criteria. So, a sensitivity analysis of the decision criteria comparison values and final weight is suggested as a next step.

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