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Application of Fuzzy AHP and ELECTRE to China Dry Port Location Selection

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Abstract

The selection of optimal dry ports construction projects is a process of multi-objective decision making. This paper lists 6 important factors that have influence on dry ports location selection in China according to references: transportation, economic level, infrastructure facilities, trade level, political environmen, cost. And based on these, the paper combines two optimal selection model of dry ports construction projects--Fuzzy-AHP and ELECTRE (Elimination Et Choice Translating Reality) in the New Eurasia Continental Bridges (NECB) of China region. Compared with simple quantitative or qualitative decision- making model of site selection, this model takes the fuzziness and preference of the factors affecting site selection proposals into account , which is much more suitable for decision makers making decisions to the real situation. It provides scientific reference on the reasonable distribution of dry ports, saving cost of logistics and ports construction, avoiding reduplicate port construction, and scientific site selection.

Key words : Dry Ports, Eurasia Continental Bridges, Fuzzy AHP, ELECTRE

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I. Introduction

Currently the NECB has had great impact on the inland transportation in European-Asia areas, and is conductive to the regional economic development. Meanwhile, two-way communication between Asia-Pacific and European areas becomes more and more obvious through land bridge link. But there are also many problems of the NECB. For example, the logistics facilities are undergrown;information fails to be feedbacked in time; the logistics between the east and the west is unbalance. Moreover, the biggest bottleneck is the low speed of customs clearance. However,in recent years, the rapid development of dry ports can solve thoes problems. If dry ports are established along the NECB, the transport line can be fully optimized.

In this paper, the basic concept of dry port is summarized as follows: "dry port" refers to a logistics center established in inland area which has service function of customs declaration, inspection declaration and issurance on bills of lading. Supervisory authorities, including Customs, Animal and Plant Quarantine Bureau, Commodity Inspection Bureau and Health Inspection Authorities, are set up in dry ports to provide services for customs clearance. In other words, it possesses all port functions except loading vessel. [1)]

When we are selecting sites for dry ports, a variety of factors should be taken into consideration. In the process of site selection, we should fully consider the characteristics of dry ports combining quantitative and qualitative decision-making methods. So far, the methodologies for dry port location are DEA[2)], ANP[3)], Fuzzy C-clustering[4)], freight volume based on curve impedance function[5)], genetic fuzzy clustering[6)] etc.

Different from the previous research, after referring to all kinds of research materials, and considering the language fuzziness as well as the preference

1) Dry port definition by United Nations text in 1982: An inland terminal to which shipping companies issue their own import bills of lading for import cargoes assuming full responsibility of costs and conditions and from which shipping companies issue their own bills of lading for export cargoes.
Leveque and Roso(2002): A dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport. From the perspective of definition, this definition is not elaborate the essence significance of a international dry port, in fact, dry port can also function as a logistics center with integrated functions.

2) Rui YANG(2006).

3) Chun-hui WANG(2008).

4) Zhao-min ZHANG(2008).

5) Qin FANG(2008).

6) Wei-hong ZOU(2009).

incomparability of qualitative methods, the author prefers Fuzzy-AHP and ELECTRE combined with multi-objective decision-making method. This method avoids the defect of traditional single method in site selection. Additionally, other more comprehensive factors are also taken into account to make the decision more scientific and reasonable.

The main purpose of the article is to list all the factors affecting site selection of dry port along the NECB in Chinese region. And adopting site selection model combined of quantitative and qualitative method not only provides scientific and theoretical reference for dry port construction along NECB area, but also for the other areas.

In the first half of this paper, the author focuses on the nature and current situation of dry ports in China, and points out that the current problem lies in no systematical and scientific site selection. In the second half, the author indicates that dry port construction along with the bridge can solve the problems in NECB's transportation links, and gives the scientific location model of dry ports with the combination of quantitative and qualitative methods. Besides, Lianyungang port is selected as an actual calculation example, so as to obtain scientific and reasonable sequencing results of port location.

II. Current Situation of Dry Ports in China

At present, Europe and North America already have very perfect inland container transport networks with dry ports as their solid foundation. China started to build dry ports later, but as long as the rapid development, it will bring great benefits to the society and have a far-reaching impact on China's sea-land transportation.

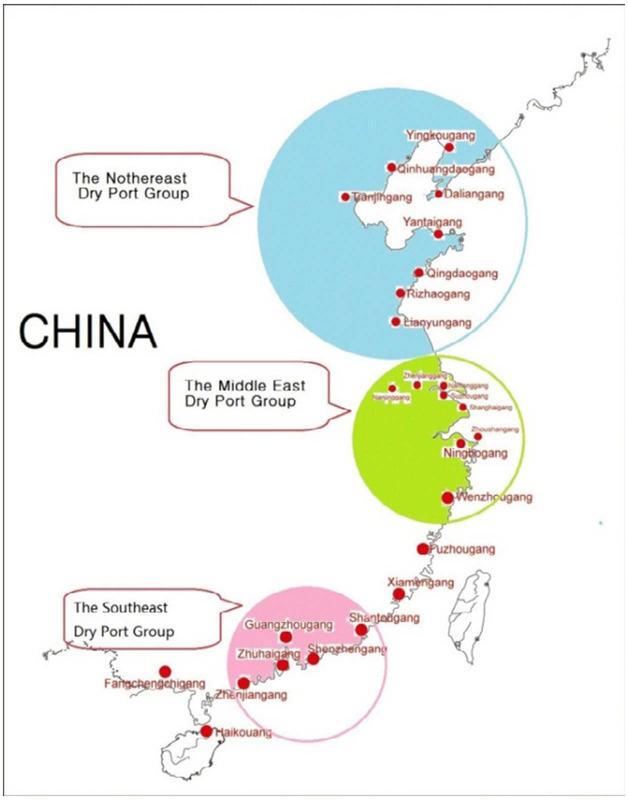
In October 2002, Beijing, cooperating with Tianjing, started to build Chaoyang Inland Port which was in the nature of dry port. Since then, dry port construction in China has entered the hottest stage.[7)]

By 2010, 4 large dry port groups have formed, namely Northeast dry port

7) http://info.jctrans.com/zhuanti/zt3/xw1/2008416624024.shtml

group led by Dalian, Middle East dry port group formed by 12 provinces and municipalities led by Tianjin, dry port group along coastal areas of Jiangsu and Zhejiang Province with communication to south and southwest of China, and Pearl River Delta dry port group led by Guangzhou.[8)] It shows in figure 1:

<Figure 1> Distribution of the major dry port groups



Through research, dry ports development in China can be mainly divided into the following three conditions.

1. Dry Ports Built by Port Cities and Inland Regions

It has become a main trend to build dry ports through strategic alliance. The dry ports cooperation plan between Tianjin Port and Shijiazhuang is based on mutual benefit. Shijiazhuang dry port, with total investment of 268 million yuan, covering an area of 326 acres, is the largest international logistics park in North China. In the past, the containers transported from Tianjin Port to

8) ZHANG (2010).

Shijiazhuang were unloaded on return with an actual loading rate of only 50%. Since the establishment of dry port, the actual loading rate has increased to 100%, which saved 10% to 15% land transport costs. Shijiangzhuang Dry Port also planned to run intercity trains between Shijiangzhuang and Tianjin, trying to cut land transport costs by 30% to 40%. Since Shijiangzhuang Dry Port was put into operation, the average monthly throughput has been 1000TEUs. Meanwhile, Tianjin Port also built dry ports in Urumqi and Zhengzhou successively, expanding its original land area from 37 km^2 to 4.5million km^2. Tianjin-Shijiazhuang Dry Port becomes one of the win-win examples of China's dry ports.

In addition, Dalian also cooperates with national railway authorities, municipal governments and companies in Northeast to accelerate construction of dry ports. In 2005, the proposal to build inland port in Changchun, Harbin and Shenyang with Dalian as the portal was officially confirmed.

Table 1 sums up all the sea ports that cooperate with inland cities initiatively by signing agreements , and those inland cities by 2009:

<Table 1> Docking Status between Port and Inland Cities (Include signing agreements)

No.	Port cities	Inland cities
1	Dalian	Shenyang, Changchun, Herbing, Jilin, Mudanjiang, Qiqihar
2	Tianjin	Baotou, Urumqi, Hohhot, Manchuria, Zhengzhou, Shijiazhuang, Taiyuan, Beijing, Hebei, Inner Mongolia, Bayannao'er
3	Yingkou	Shenyang, Changchun, Herbing, Liaotong
4	Yantai	Weifang
5	Qingdao	Xi'an, Urumqi, Chengdu, Binzhou, Zibo, Dongying, Jinan, Dezhou, Liaocheng
6	Rizhao	Linyi、Xinjiang
7	Lianyungang	Ningxia, Zhengzhou, Luoyang, Qinghai, Yinchuan, Shanxi, Lanzhou
8	Shanghai	Jiujiang, Fuyang
9	Ningbo	Shangrao, Yintan, Jinhua, Yiwu, Shaoxing, Yuyao, Quzhou
10	Taicang	Suzhou
12	Guangzhou	Kunming
13	Shenzhen	Ji'an
14	Huizhou	Dingnan

Source: Compiled in accordance with relevant data of each port authority(2009)

2. Port cities take the initiative to build dry ports

In order to strive for hinterland resources and improve competitiveness against surrounding ports, many domestic ports have started to or are planning to build dry ports in hinterland, for example Lianyungang Port and Rizhao Port. Both of them have overlaps in hinterland and similar strategic location. To improve competitiveness, Lianyungang Port began to build western dry port in 2008. Yinchuan-Lianyungang container trains were officially put into operation in 2009. With the support from central and western dry ports, goods from central and western regions accounted for over 60% of the throughput of Lianyungang Port.[9)]

Ningbo Port built mid-range and close dry ports in Jinhua, Yiwu, Shaoxing, Yuyao and Quzhou. In 2009, the container throughput of Ningbo Port broke through 10million TEUs and its external radiation was increasing. According to the latest statistics from Ningbo Customs, external enterprises have taken more than 60% of the gross value of import and export of Ningbo Port.

Yingkou Port in Northeast is a typical port benefiting from dry ports. As early as the end of 2005, the Yingkou port authority built a dry port in Hunnan New District in Shenyang Province with land coverage of over 40000 m^2. The international container trains which connected Manzhouli with Europe was put into operation, making sea-rail transport the new growth point for Yingkou Port.

Among the global top 100 container ports in 2008[10)], only 29 ports were recorded to acomplish a double digit growth. China's Lianyungang Port and Yingkou Port ranked top two with a growth rate of 50% and 49% respectively. A large proportion of them were contributed by hinterland goods supply provided by dry ports.

3. Dry Ports Construction in Inland Regions

Table 2 sums up by 2009 all the inland cities that initiatively to built dry ports, and the port cities they cooperate with.

9) http://www.xwxq.gov.cn/list.aspx?folderid=017001
10) Container throughput of Cargo Systems(2008)

<Table 2> Current Status of Dry Port Construction in Inland Cities

No.	Inland cities	Port cities
1	Jinjiang	Quanzhou, Zhujiang, Zhanjiang
2	Gaizhou	Xiamen
	Longyan	
3	Zhengzhou	Shanghai, Tianjin, Qingdao, Lianyungang
4	Wuyishan	Construction by Inland Region
5	Xi’an	
6	Nanchang	
7	Nanning	

Source: Compiled in accordance with relevant data of each port authority(2009)

In order to develop export-intensive economy, inland areas built dry ports to attract cooperation with sea port. As early as 2006, Zhengzhou established the first inland dry port in China. At present, 40% import and export goods of Henan Province are handled by Tianjin Port. Henan Province has become one of the most important customers of Tianjin Port.

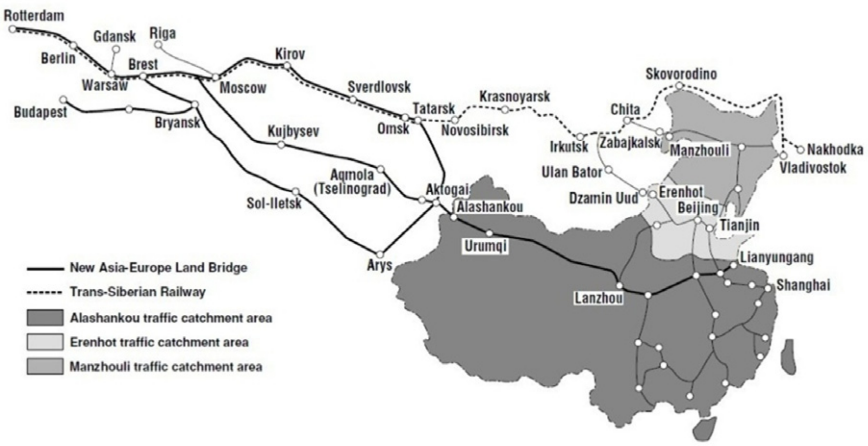
Xi’an is an important city located in the middle of the NECB, who effectively connects the sea, land and air transport network, and in there construction of dry port can realize goods transportation and commodity distribution between western areas and the ports. In 2004, the local government officially approved the plan to build Xi’an International Port Zone. The plan project covered an area of 8.2 square kilometers and has total investment of 9.8 billion yuan. Xi’an International Port Zone, combines the function of international hinge inland port and modern integrated logistics park in the west, effectively solving bottleneck of export-intensive transport in inland areas.

Development of container terminals and logistic parks provides foundation for obtaining goods supply in hinterland. However, they are merely limited to basic transport system like optimization of logistics network and centralization of resource allocation, and has not got rid of traditional land and sea transport modes, thus they are unable to fully play the inland functions. With the emergence of dry ports, inland areas without water and boats also enjoy the convenience of rapid transportation.

III. Research on dry ports location of the NECB in China region

The comparison between using NECB and using shipping transportation from China to Northern and Western Europe shows that through Eurasia Continental bridge transportation, customers can save time and get foreign exchange in time, and that turnover of freight transport will be increased.

<Figure 2> Route of New European continental bridge and Trans-Siberian Railway



Soucre: Shu XU, The New Eurasia Continental Bridge—Current Situation and Future Prospects[J]. Japan Railway & Transport Review, Decemeber 1997:30

However, customs declaration is inconvenient in the countries and cities along the NECB, which is the biggest constraint to the development of the NECB transportation. According to the statistics, the average cargo retention time in the port accounted for 30% of the entire transport time, among which the time for handling document, customs inspection and other reasons accounted for 60%, and the time limited by transportation capacity and other accounted for 40%. Aiming at solving the “Not very smooth” problem existing in the NECB in recent years, building dry port in the cities along bridge can help improve the overall quality of the logistics park in the region along the NECB and solve problems such as insufficient feedback of transportation information, shipper formalities inconvenience and so on. It can also speed up the development of the economic region along bridge.

Dry port provides import and export enterprises the overall international port service such as storage, transportation, customs declaration, inspection declaration, handling documents, settlement of exchange and so on, and achieves the direct acquirement of inland port and international maritime markets.

Besides, dry port construction is conducive to the development of the growth pole along the NECB and logistics cooperation. Dry port is not only a logistics center, but also a talents, funds and information center.

Thus, although building dry port along the bridge can't solve all the problems existing on the NECB now, aiming at optimizing transportation over long distances, service efficiency and quality, the amount of logistics information and so on, and the construction of dry port is very significant.

1. The comparative analysis of several site selection methods

Site selection is actually a complicated multi-objective decision making problem. Dealing with multi-objective decision making problem is generally divided into Multi-Criteria Decision Making (MCDM) and Multi Attribute Decision Making (MADM). [11)]

But the qualitative decision-making methods above just take those single aspects such as the cost and distance of transportation into account. In the process of dry ports' site selection, especially in China, objective factors such as political factors, human factors and environmental factors are also of much importance. Hence, in this paper, the author adopts the model with combination of qualitative methods and quantitative methods to select sites for dry ports.

Fuzzy AHP, a MADM method, is initially applied to determining the weight of certain Quality of Service indicators that act as the criteria that have impact on the decision making process. The fuzzy extension of the method, and consequently the use of fuzzy numbers, are adopted in order to incorporate the existence of fuzziness as a result of subjective evaluations. Afterwards, ELECTRE, a ranking MADM method, is applied to rank the alternatives.[12)]

11) Chao-yuan YUE(2003). pp.247.
12) Dimitris E. Charilas(2009).

Combined with Fuzzy-AHP method and ELECTRE method mentioned in this paper, here it gives a comparison sheet of several methodologies. In table 3, Delphi, AHP and other simple qualitative approaches are too subjective. Quantitative methods such as Gravity, MCLP, 0-1 Integer do not consider the subjective factors in reality. Using vague comparisons, FAHP is applied to providing a fuzzy weight for each criterion in the selection process, but it's not enough. The sites selection for dry ports belongs to multiple target decision-making, therefore, using a good decision-making method can solve the problem effectively. ELECTRE method is a kind of analytical method to solve multiple decision-making problems in limited programs. It has simple and clear logical relation and good interaction which contribute to the fully using of information in decision matrix. Based on the study on domestic and abroad research, the author integrates the advantages of multi-objective decision making methods and obtains more scientific and reasonable methods for site selection.

<Table 3> The comparative of several site selection methods

	Delphi	AHP	Gravity	MCLP	0-1 integer	Fuzzy AHP	ELECTER	Fuzzy AHP and ELECTRE
Qualitative	O	O				O		O
Quantitative			O	O	O		O	O
Sequence	O	O				O	O	O
Fuzzy						O	O	O
Preferences							O	O
MADM (Discrete)		O				O	O	O

2. Fuzzy-AHP and ELECTRE Method

Fuzzy-AHP introduces the concept of interaction based on AHP and make a careful analysis and evaluation to evaluation object by using the weight of each element.

First, use AHP method to construct hierarchical structure: the top structure is the objective of decision making, middle the criteria layer and the bottom strategic layer. Judgment matrixes are not all consistent. To check the consistency of judgment matrix, C.R. (Consistency Ration) must be introduced:

$$C.R. = \frac{C.I.}{R.I.} = \frac{\lambda_{max} - n}{n-1} \cdot \frac{1}{R.I} \quad (1)$$

Consistency index C.I.=0 when $\lambda_{max}= n$, here judgment matrix is completely consistent. Consistency ratio (CR) can be used to determine the consistency of matrix A can be accepted. If CR≥0.1, it means that the estimated consistency of the elements in A is too bad and appropriate adjustment should be made to judgment matrix.

Second, Fuzzy scale expanded in accordance with linear scale is defined as below:[13)] X in P(X) is called deep set. When set function g:P(X)→[0,1]on P(X) meets relativity and monotonicity, g is called fuzzy scale. In addition, λ-fuzzy scale (g_λ) introduces parameter λ exactly the same as below formula. But λ-fuzzy scale (g_λ) here is monotonic (Monotonicity).

$$g(A \cup B) = g(A) + g(B) + \lambda\, g(A)g(B)$$
$$\text{and, } A, B \in X, A \cap B = \emptyset, -1 < \lambda < \infty \quad (2)$$

Deformation formula as below:

$$g(X) = \frac{1}{\lambda}\left(\prod_{k=1}^{n}(1 + \lambda \cdot g_k) - 1\right) \quad (3)$$

$$\text{and,} \quad X = \bigcup_{i=1}^{n} A_i \,, g_i = g_\lambda(A_i)$$

In addition, other forms of l-Fuzzy scale are as follows

$$f_\lambda(\mu) = \begin{cases} ((1+\lambda)^\mu - 1))/\lambda & \text{if } \lambda \neq 0 \\ \mu & \text{if } \lambda = 0 \end{cases} \quad (4)$$

ELECTRE II[14)] Method is applied in this paper for sorting of dry ports candidates. ELECTRE II offers two levels of outranking relation (strong outranking relation S^F and weak outranking relation S^F) and introduces two groups of thresholds for two preference relations. C*,D* is strong

13) Sung-Tae KIM (2009), pp.45-46.

14) ELECTRE Method was first proposed by the French scholar Roy (1971). Divided into ELECTRE I, IS, II, III, IV and ELECTRE TRI . This paper use ElECTRE II, to sort the schemes partially or completely.

relation threshold and, C^-,D^- is weak relation threshold. Compared with weak outranking relation, strong outranking relation has a higher consistent threshold and lower inconsistent threshold, that is $C^* > C^-$, and $D^* < D^-$. And on this basis, restriction $c(a,b) \geq c(b,a)$ is introduced to avoid the outranking relation between the two schemes.[15)] Analysis steps of ELECTRE II Method are explained as following:

Step 1: To establish standard matrix on the basis of Fuzzy-AHP weight and determine consistent and inconsistent index.

For any pair of program "a" and "b", attribute set is divided into consistent set and inconsistent set $D_{ab}=[\ j \mid x_{aj} < x_{bj}\ ]=J-C_{ab}$ two subsets.

$$c(a,b) = \sum_{j \in C_{ab}} w_j \tag{5}$$

For pair wise comparison of all programs, the consistent/advantage index forms consistent matrix "C". By calculating disadvantage index, inconsistent matrix "D" can be determined. The formula for calculating disadvantage index d is as below:

$$d(a,b) = \frac{\max_{j \in D_{ab}} |v_{aj} - v_{bj}|}{\max_{j \in J, s, t \in I} |v_{sj} - v_{tj}|} \tag{6}$$

Inconsistent matrix called "D" .

Step 2: To establish preference relation matrix between the schemes (strong outranking relation S^F and weak outranking relation S^f).

First of all, determine the threshold of two ordering relations, $C^* > C^-$, and $D^* < D^-$. Strong outranking relation $S^F b$: scheme "a" is not inferior to scheme "b" and the following three conditions need to be met at the same time:

$$\begin{cases} c(a,b) \geq C^* \\ d(a,b) \leq D^* \\ c(a,b) \geq d(a,b) \end{cases}$$

15) Bao-an YANG(2008), pp.79.

Step 3: Weak outranking relation $aS^{f}b$ or $aS^{F}b$, the decision maker may sort the scheme in descending order in accordance with the four steps below:

a) Starting from set "A", define "A" as the set formed by all schemes
b) Define set "F", including all options not inferior to other schemes
c) Define set , namely scheme set not inferior to other schemes in "F".
d) F* is selected out. Delete from "A". Repeat step 1 for the remaining scheme in "A" until all schemes is sorted out to form a descending order.

Step 4: scheme-based preference relation $aS^{f}b$ or $aS^{F}b$, the decision maker may follow the four steps below for ascending order of the schemes:

a) Starting from set "A", define "A" as the set formed by all schemes
b) Define set "G", formed by all options not inferior to other schemes
c) Define set, formed by schemes is not slightly better than other schemes in set "G".
d) Delete from "A", repeat step 1 for the remaining scheme in A until all schemes are sorted out to form an ascending order.

Step 5: Comprehensive ordering based on descending and ascending orders. Cross-synthesis method can be used to construct the final order.

3.Empirical Research

Since 75% of the total cargo traffic in the NECB is through Lianyungang port, so in this paper, Lianyungang port is selected to do empirical research, and 7 cities in its hinterland will be sequenced.[16)]

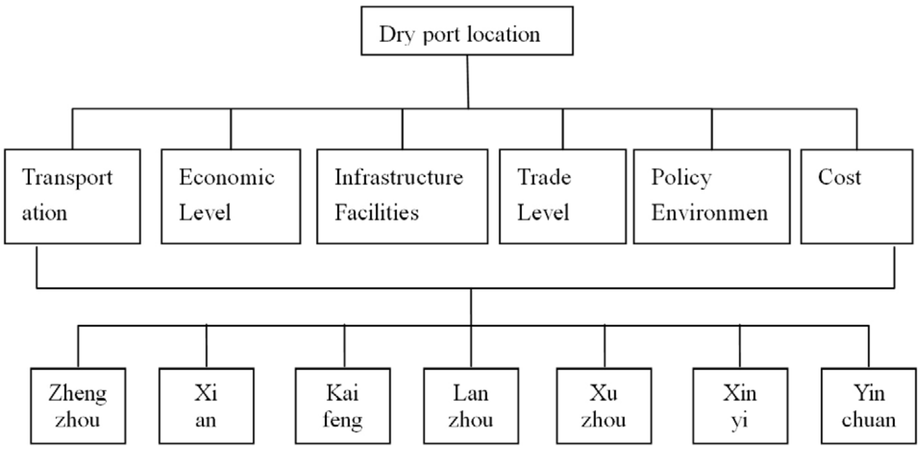
To build dry port location model as Fuzzy-AHP, hierarchical chart needs to be created in accordance with relevant factors of dry port location principle.

16) The 7cities (Zheng zhou, Xi'an, Kai feng, Lan zhou, Xu zhou, Xin yi, Yin chuan) was resulted from the Delphi Method .

<Table 4>The determining factors and the details[17)]

Step 1	Step 2	Details
Transportation	Transport distance	The distance between central and road
	Region scale of freight volume	Region freight volume in 2009
Economic Level	GDP	Each years' GDP growth speed from 2005 to 2009
	Commercial and industrial output value	Ratio of planned finished relative index of actual production rate and planned production rate in 2009
Infrastructure Facilities	Security of infrastructure facilities	Whether city's floor control facility, quake proof facility and fire control facility are complete.
	Logistics center	Whether there are logistics centers in the area or nearby area.
Trade level	Mutual complimentary of Resource	Along the bridge, countries have high trade dependence and mutual complimentary of resource
	Import and export trade	Total annual import and export trade volume of the bridge countries along (2002-2009)
Policy environment	Policy-oriented	Policy support to the countries along the Continental bridge
	Regional cooperation environment	Economic, political and cultural cooperation in Continental bridge region
Cost	Transportation cost	Freight from goods supplying place to inland port+ freight from inland port to port
	Land cost	Local area's average land price in 2009

<Figure 3> The determining factors for dry port location



17) All factors and content were obtained according to literature review, experts' opinion and the real situation of dry port's site selection.

Through the expert survey,[18] 50 questionnaires were collected, with 8 questionnaires not meeting the consistency. And 42 questionnaires were finally qualified to calculate matrix elements and the weight compared in Table 4, and consistency scale=0.0008. Consistency is good.[19] AHP weight matrix as follows:

$$A(w_i) = \begin{bmatrix} 1.0000 & 0.5453 & 0.4824 & 0.6703 & 0.6532 & 0.4793 & \left|0.0993\right| \\ 1.8339 & 1.0000 & 0.8347 & 1.3807 & 1.2057 & 0.7725 & \left|0.1801\right| \\ 2.0731 & 1.1980 & 1.0000 & 1.5308 & 1.4727 & 0.9019 & \left|0.2107\right| \\ 1.4918 & 0.7243 & 0.6532 & 1.0000 & 0.9872 & 0.6790 & \left|0.1420\right| \\ 1.5308 & 0.8294 & 0.6790 & 1.1030 & 1.0000 & 0.6366 & \left|0.1459\right| \\ 2.0865 & 1.2994 & 1.1087 & 1.4727 & 1.5708 & 1.0000 & \left|0.2221\right| \end{bmatrix}$$

Eight experts were selected from 50 experts. They made pairwise comparison on reproducibility of various factors and used formula (3) to obtain the interaction parameter between the various elements. Calculate interaction parameter λ of each factor, see table 5:

<Table 5> Interaction parameter λ

Factors	Transportation	Infrastructure Facilities	Economic Level	Trade Level	Policy Environment	Cost Factor	Average (λ)
Interaction parameter	-0.280	-0.152	-0.246	-0.200	-0.23	-0.216	-0.221

When average interaction parameter l=0.221, use fuzzy integral approach to get the final weight and fuzzy scale of evaluation factors as shown in table 6:

<Table 6>The final weight and fuzzy scale of evaluation factors

Evaluation criteria	Transportation	Common Facilities	Economic Level	Trade Level	Policy Advantages	Cost Factor	Total
Weight w(·)	0.2221	0.0993	0.1420	0.2107	0.1459	0.1801	1.0
Fuzzy scale g(·)	0.200	0.093	0.129	0.196	0.133	0.166	0.917

18) The questionnaires are the experts from China Lianyungang port Authority, management committee in Lianyuan port development zone, and Continental bridge group. Among them are 8 experts with over 20 years working experience, 23 experts with 10 to 20 years working experience. The rest are experts with over 5 years working experience.

19) The software package that is used to perform the analysis(EXPERT CHOICE) supports this transparency, because excellent visualization is made possible.

As Table 6 shows, transportation occupies the largest proportion, followed by trade level, land prices, salaries and other costs that may have a great impact on site selection. In the process of dry port location, each candidate is scored according to the above weights. Places with higher scores will be selected for dry port construction. However, there are some shortcomings for this approach, which cannot be classified but sequenced. These problems can be solved by using factor weight calculated by Fuzzy-AHP of the ELECTRE method below.

Table 7 presents the attribute values of all candidates, as well as the reference values used for normalization. Tables 8 and 9 depicts the normalized and weighted values respectively.[20]

<Table 7> Attribute values

	Transportation	Common Facilities	Cost Factor	Economic Level	Trade Level	Policy Advantages
Xinyi	11	12	10	7	8	6
Xuzhou	8	7	7	9	6	5
Zhengzhou	5	17	7	8	9	8
Yinchuan	17	4	5	5	7	9
Kaifeng	22	3	4	4	6	4
Xi'an	20	3	10	5	7	9
Lanzhou	13	17	7	5	6	10

<Table 8> Normalized values

	Xinyi	Xuzhou	Zhengzhou	Yinchuan	Kaifeng	Xi'an	Lanzhou
Xinyi	1	0.78	0.37	0.83	0.92	0.76	0.74
Xuzhou	0.45	1	0.68	0.58	0.92	0.53	0.43
Zhengzhou	0.88	0.52	1	0.83	0.92	0.76	0.76
Yinchuan	0.37	0.63	0.39	1	0.92	0.51	0.86
Kaifeng	0.25	0.21	0.21	0.21	1	0.35	0.21
Xi'an	0.76	0.72	0.46	0.99	0.92	1	0.91
Lanzhou	0.48	0.78	0.55	0.67	0.92	0.21	1

20) Using vector normalization to pretreat those datum can normalize their attribute value. Whatever it belongs to cost type attribute or efficiency attribute, formula like $z_{ij}=y_j/\sqrt{\sum_{i=1}^{m} y}$ can also be available in vector normalization. And such kind of switch is linear, but we can not distinguish the advantages and disadvantages of the attribute value judging from the sizes of after-switching attribute value.

Combination of fuzzy scale and normalized values (Table 6&8), normalized and weighted values as following:

<Table 9> Normalized and weighted values

	Xinyi	Xuzhou	Zhengzhou	Yinchuan	Kaifeng	Xi'an	Lanzhou
Xinyi	-	0.55	0.33	0.42	0.74	0.62	0.35
Xuzhou	0.42	-	0.57	0.67	0.97	0.86	0.54
Zhengzhou	0.49	0.33	-	0.72	1.00	0.97	0.62
Yinchuan	0.44	0.87	0.66	-	0.42	0.39	0.63
Kaifeng	0.55	0.98	0.77	0.43	-	0.44	0.67
Xi'an	0.45	0.77	0.67	0.15	0.24	-	0.67
Lanzhou	0.44	0.87	0.66	0.21	0.62	0.49	-

Using the matrix in Table 9, combining with formula (5) and (6), strong and weak preference relation can be determined as Table 10:

<Table 10> Threshold of strong and weak preference relation

C^*	D^*	C^-	D^-
0.7	0.6	0.5	0.8

By step 2, we obtained strong outranking relation S^F and weak outranking relation S^f, as shown in Table 11:

<Table 11>Strong and Weak Preference Matrix

	Xinyi	Xuzhou	Zhengzhou	Yinchuan	Kaifeng	Xi'an	Lanzhou
Xinyi		S^F	-	S^F	S^f	-	S^F
Qinghai	-		S^f	-	-	-	-
Zhengzhou	S^f	-		S^f	-	-	S^F
Yinchuan	-	-	-		S^F	-	S^f
Kaifeng	-	-	-	-		-	-
Xi'an	S^f	S^f	-	S^F	S^F		S^f
Lanzhou	-	-	-	-	S^F	-	

1) Descending Order

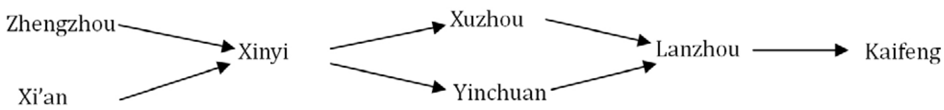
Define set F which is formed by schemes not inferior to other schemes. Table 12 does not include scheme S^F, for example, Xinyi, Zhengzhou and Xi'an form set "F".

<Table 12> Scheme of set F*

	Xinyi	Zhengzhou	Xi'an
Xinyi		-	-
Zhengzhou	S^f		-
Xi'an	S^f	-	

Delete F* from 7 candidate cities, and repeat step 3 for the 7 cities until all cities have been sorted out to form a descending order (Table 13). A descending order (Fig 3) is formed as per by double-distilled, in which Zhengzhou and Xi'an are the best schemes, followed by Xinyi the second, Xuzhou and Yinchuan the third, Lanzhou the fourth and Kaifeng the worst scheme.

<Figure 3> Descending Order of the 7 Cities



2) Ascending Order

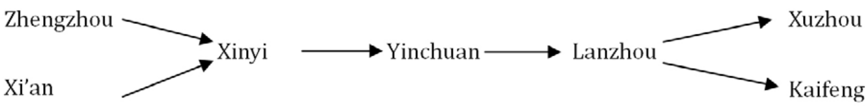
Based on weak and strong preference relation matrix, define Set "G" which is formed by other less good schemes. In Table 14, schemes excluding S^F like Xuzhou and Kaifeng form Scheme "G"(Table 15). Define set G*, formed by schemes not worse than other schemes in Set "G". G* includes Xuzhou and Kaifeng. Both schemes are not comparable. Delete G* from the 7 cities and repeat step 4 above for remaining schemes (Xinyi, Zhengzhou, Yinchuan, Xi'an and Lanzhou) until forming an ascending order.

<Table 15> Schemes excluding S^F

	Xuzhou	Kaifeng
Xuzhou		-
Kaifeng	-	

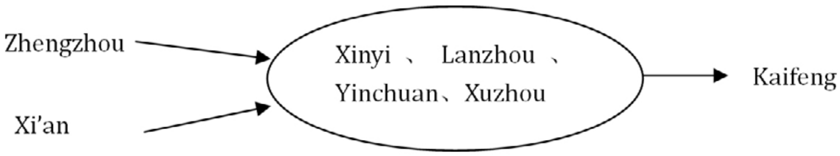
A ascending order (Fig 4) is formed as per through three distillation, in which Zhengzhou and Xi'an are the best schemes, followed by Xinyi, Yinchuan and lanzhou are the second, Xuzhou and Kaifeng are the worst scheme.

<Figure 4> Ascending Order of the 7 cities



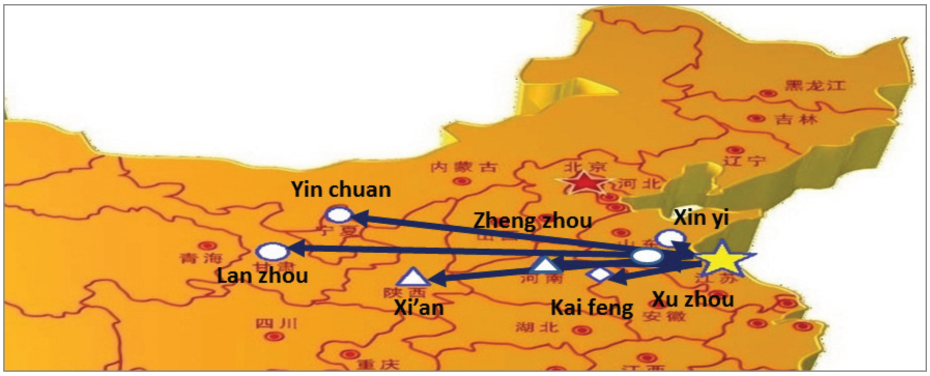
Comprehensive ordering based on descending and ascending orders(Figure 3&4), comprehensive order of the 7 cities is showing in Figure 5:

<Figure 5> Comprehensive order of the 7 cities



The final sequence results of the 7 cities have obtained in accordance with descending order and ascending order (Figure 5&6). That is, Zhengzhou and Xi'an are the best candidates, followed by Xinyi, Lanzhou, Yinchuan and Xuzhou, and Kaifeng is the worst.

<Figure 6> The map of comprehensive order of the 7 cities



The final sequence results of the 7 cities have reached in accordance with descending order and ascending order (Figure 6). That is, Zhengzhou and Xi'an are the best candidates, followed by Xinyi, Lanzhou, Yinchuan and Xuzhou, and Kaifeng is the worst.

According to the information of Lianyungang Port Authority and Development Zone, it shows that: Zhengzhou and Lianyungang in 2008 signed an aggrement on extending the customs function to the mainland, and reducing the logistics costs. Xi'an in late 2008 signed a cooperation agreement with Lianyungang on building and sharing Lianyungang Port together. Yinchuan and Lanzhou in September 2009 and May 2010 respectively signed a bridge logistics alliance agreement with Lianyungang in order to build the most convenient sea port in mid-west. Besides, recently Lianyungang Port Authority is planning to build close dry ports in Xinyi, Xuzhou. After combining the actual information and consulting with the experts, the sorting results in this paper are basically consistent with the actual situation, and they can determine that it is scientific and feasible to judge the location of dry port in combination of Fuzzy-AHP and ELECTRE.

IV. Conclusions

In recent years, the dry ports construction in China developed rapidly, although it started late. But it focused on the discussion of the domestic dry port construction so far, and involved constructing transnational dry port projects. This paper presents some problems of the NECB, and argues that if the regions along the bridge can scientifically and reasonably plan to build dry ports. It will produce a profound impact on the development of the NECB and the future trade between Asia and Europe.

Many papers propose to build dry ports relying on railway container logistics centers or the existing logistics parks. But more factors are still needed to consider when selecting site for dry ports. This paper gives the scientific location model of dry ports combining Fuzzy-AHP and ELECTRE methods. This method has built up a evaluation index system of dry ports site selection through the analysis on the qualitative influencing factors of the dry ports site selection. And then, it acquired the weight matrix by using the Fuzzy-AHP method to ensure the weight of each factors. This weight matrix was integrated with the actual data of those candidates to normalize the matrix. ELECTER was used to have the distillated order on the matrix in order to obtain the lift sort. And ultimately, it has got the final order after another distillated order. Compared with former methords, this new method is more appropriate for dry pots site selection.

The proposed methodology was finally testified through the case of Lianyungang port. Sequencing results are basically consistent with the actual situation and are proved to be scientific and feasible to judge the location of dry port in combination of Fuzzy-AHP and ELECTRE. It provides scientific theoretical basis for building dry ports considering the overall situation.

But there are some deficiencies in this paper, for example, the problems of representativeness in selecting samples. The results should be further testified, and it will be improved in further studies.*

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