



THE TAIWANESE BUSINESSMEN ASSESS THE INVESTMENT ENVIRONMENT OF CHINA – CONSTRUCTION AND APPLICATION OF PR AHP PROGRAM

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ABSTRACT

The economy of China has been rapidly growing in recent years. One of the important reasons is that there are a large number of foreign capital investments made in China. Creating a good investment environment in order to continuously attract foreign capitals is therefore an important topic for discussion. Taiwanese businessmen play an important role in the investments made in China, so this study investigates which aspects of China's investment environment concerns Taiwanese businessmen more. Whether in the engineering or management field, AHP is a popular method on multi-criteria decision-making issues. However, with AHP, one must consider the problem of inconsistency. Later on, the Consistent Fuzzy Preference Relation method was developed. However, since this method does not have the easy-to-use software, this study is to construct and introduce the software using this method. From the results, the following items top the list: number of specialized manpower, quality and quantity of skilled manpower, electronic capabilities, electronic service, administrative efficiency, efficiency of finance and steady financial policies.

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Keywords: Investment environment, AHP, PR AHP, MCDM, Consistent fuzzy preference relation, Taiwanese businessman.

Contribution/ Originality

The paper's primary contribution is investigating what are the key investment environment items that Taiwanese businessmen consider when investing into China. And the second contribution is constructing a PR AHP program.

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1. INTRODUCTION

The economy of China has been rapidly growing in recent years. It maintains a GDP that is higher by 9% in 2008~2011 (The World Bank, 2013). The main reasons for the said growth include a large number of foreign capitals being invested into China (Yang, 2003). The amount of investment made by Taiwanese businessmen is quite huge. According to the statistics of Taiwan's investment commission, it has reached up to US\$10,924 million in 2012 (MOEA, 2013). The investment of Taiwanese businessmen in China is made even more significant by the fact that they belong to the same region and have the same culture. China's method for constructing a fine investment environment that lures Taiwanese businessmen is an important topic.

AHP (Analytic Hierarchy Process) was proposed by Saaty which has been widely applied in many fields afterwards (Ju and Wang, 2012; Abdi *et al.*, 2013). Its advantage is to provide a structural and simple solution to the decision-making issue (Skibniewski and Chao, 1992). But AHP also has some weaknesses. For example, with the increase of items, the efficiency may be decreased (Millet and Harker, 1990). When there are n items, the traditional AHP method must conduct $n(n-1)/2$ pair-wise comparisons, which may cause the problem of inconsistency (Wang and Chen, 2008). Then Herrera-Viedma *et al.* (2004) propose the CFPR (Consistent Fuzzy Preference Relation) method. This method just needs to conduct the $(n-1)$ pair-wise comparisons. It greatly reduces the number of pair-wise comparisons.

Although the CFPR method can reduce the number of pair-wise comparisons, there is no software that can be used directly for this method. The main purpose of this study is to develop and introduce the easy-to-use software for this method.

This topic can be regarded as a multiple criteria decision making (MCDM) problem, therefore, using the CFPR (Consistent Fuzzy Preference Relation) method is quite suitable.

As described above, the main purposes of this study include investigating what are the key invest environment items that Taiwanese businessmen consider when investing into China, and introducing the CFPR software.

2. LITERATURE REVIEW

This section will discuss the related studies on Taiwanese businessmen's assessment of China's investment environment and introduce AHP and CFPR method.

2.1. Investment Environment

A country with a good investment environment will become a treasured place that can establish its rich economic resources and attract the most excellent enterprises. On the contrary, a country with a bad investment environment just becomes a forgotten corner in the international market. If the investment environment is considered good, it means that the system is also good. A good system means the country has the ability to satisfy foreign investors. This depends on the country's market space, economic system, government policies, quality of the population,

infrastructure, social environment, cultural atmosphere, etc. To sum it up in one line, a sound investment environment has the power to attract global enterprises (Han, 2000).

Yu (1982) thinks the investment environment refers to the primary condition that can lure investors into investing. Lu (1997) gave the investment environment a direct and simple definition. He thinks that if one decides to operate a business in a particular area, if it can make a lot of money, then that place is considered to have a good investment environment. Therefore, improving the investment environment is related to working on the factors why enterprises cannot make a lot of money. Jorgenson (1963) proposed a neoclassical investment theory to explain a manufacturer's investment decision. According to this theory, the principle of investment is that the marginal benefit is compared with the user cost. If the marginal benefit is bigger than the user cost, it shows that there are profits. Hence, if the investment environment cost is still at a low level, we should increase the amount of investment. If on the contrary, we should reduce the amount of investment.

When one successful entrepreneur carries on an investment plan, he should assess the investment environment's quality of the locality in detail. It is very important to understand that in depth, especially the political economic factors. Investments have some or totally irreversible nature. That is to say, once one decides to invest now, even if there are some unfavorable conditions in the future, that investor can't totally disinvest either. The initial investment expenditure should be considered as sunk cost. The investment environment is uncertain. It is possible that the profit of the next stage will rise up or drop down. In this light, the investment plan execution can be delayed, meaning, companies are willing to wait for more information, before deciding whether to invest or not (Pindyck, 1991; Hubbard, 1994; Chirinko Robet, 1996).

According to Yuan (2000) study of the Taiwanese investment in China, there are 87% of investors who gather information in advance before they make a decision, the majority of which (68%), involves the boss making the research personally. However, the investments made by Taiwanese in China have a common problem and that is a poor choice of investment location. This easily leads to investment failure. Therefore, the investors, no matter where they invest, should understand the local investment environment. Being cautious is one of the most important factors (Fang, 2002).

2.2. China's Investment Environment

TEEMA (2004) assesses the investment environments and risks of the major cities in China. The evaluation criteria included in the eight dimensions is divided into (A) Natural environment, (B) Basic condition, (C) Communal facilities, (D) Social environment, (E) Legal system environment, (F) Economic environment, (G) Operations environment and (H) Knowledge economy environment. Then, it is further subdivided into 39 evaluation items. Lin (2004) analyzed TEEMA's report and mentioned that among the 129 major cities in China, the top ten cities in terms of competitiveness were Guangzhou, Shenzhen, Shanghai, Beijing, Dalian, Qingdao, Shenyang, Tianjin, Chengdu and Wuxi. The survey results show that the overall investment environment in China is improving year by year. In addition, the item that tops the list in terms of satisfaction

rating every year is always the natural environment and conditions, while the legal environment is the lowest.

TEEMA (2009) marshaled the assessment of major cities in China since 2000 and found the following trends: (1) the Taiwanese investors pay attention to three economic zones, the western coast economic zone of the Taiwan Straits, West Triangle (Chongqing, Chengdu, Xian), Pan-Beibu Bay economic area, (2) return to the 'invest environment force' up and 'investment risk degree' downward trend, (3) Vietnam is in the top ten areas for future mapping by the Taiwanese businessmen, (4) Taiwanese businessmen's structuring of the China market ranges from the 'single market' to the 'regional market', (5) Taiwanese businessmen's mapping of the China market reversed from the 'trade market' to the 'domestic market', (6) Taiwanese businessmen's mapping of the China market reversed from OEM to OBM, (7) 'Yangtze River Delta' still tops the economic area better than the 'Bohai Sea' and 'Pearl River Delta', (8) Selection for the investment zone is still on the 'high-tech development zones' and the 'economic zones' (9) Taiwanese businessmen are still not concerned about 'western development', 'the revitalization of the northeast' and 'central China', (10) the number of cases of cross-strait economic and trade disputes still show a high trend.

2.3. The AHP Method

The AHP method was developed by Saaty in 1977, which is used to deal with Multiple Criteria Decision Making (MCDM) issues in uncertain situations. So far, the application of the AHP method has been quite popular (Wu *et al.*, 2012; Chen, 2014).

When there are n criteria, the traditional AHP method must conduct $n(n-1)/2$ pair-wise comparisons, too many questions may cause the confusion of the experts who answer the questionnaire. Consequently, the questionnaires will fail to meet the requirement of consistency, which will thus turn out to be invalid (Wang and Chen, 2008). Therefore, to improve these problems of inconsistency, many scholars propose some methods for improving the AHP consistency problem (Zheng *et al.*, 2012).

2.4. PR AHP

Among a lot of improvement methods about the AHP, (Herrera-Viedma *et al.*, 2004) proposed the Consistent Fuzzy Preference Relation (CFPR) method. This method skips the consistency verification during the decision-making process. In an $n \times n$ evaluation matrix, $n(n-1)/2$ pair-wise comparisons needs to be conducted when using the AHP method. If it is established, the Consistent Fuzzy Preference Relation method just needs $(n-1)$ pair-wise comparisons. Therefore, the CFPR method reduces the number of pair-wise comparisons. In addition, for the consistent fuzzy preference relation, the pair-wise comparison between the attributes is more transitive. For example, if A is more optimal than B, and B is more optimal than C, then A is definitely more optimal than C.

There is another advantage of the CFPR method. It doesn't have the problem of inconsistency but this method never mentions about the fuzzy concept (Wang *et al.*, 2008). Thus, in this study, the Consistent Fuzzy Preference Relation method is named as the PR AHP (Preference Relation Analytic Hierarchy Process). Some previous studies (Wang and Chen, 2005) mentioned that the results obtained by AHP and PR AHP methods are similar. The next section will introduce the detail of the PR AHP calculation process.

The traditional AHP method is developed for a long time, and it is supported by some application software. For example, there are some software such as Expert Choice and Super Decisions (ExpertChoice, 2002; ANP Team, 2012) which are so convenient for the users. Although the PR AHP is a good method for improving the traditional AHP, there is no easy-to-use software for the PR AHP. This study will construct the easy-to-use software for the PR AHP to allow researchers to easily use the PR AHP method.

The aim of this study is to investigate the elements of China's investment environment which the Taiwanese businessmen are more concerned about. In the literature, (TEEMA, 2004) structure is the most suitable for this study. Therefore, this study will take the structure as study framework in order to explore more results. On the research methodology, the next section will further illustrate that. And the PR AHP software that this study adopted will illustrate the operation process in the results section.

3. METHOD

This study's case is to find out the key factors of China's investment environment which the Taiwanese businessmen are more concerned about. The method of this study is illustrated as below.

3.1. Study Framework

This study lists the following items from TEEMA (2004) as the study framework, which is composed of 34 items and classified into 8 categories. The hierarchy structure of this study includes eight groups, (A) Natural environment, (B) Basic condition, (C) Communal facilities, (D) Social environment, (E) Legal system environment, (F) Economic environment, (G) Operations environment and (H) Knowledge economy environment. These are further subdivided into 34 items. Then this study constructed the evaluation framework of the key factors in China's investment environment. The study framework is shown as Table 3.

3.2. PR AHP Method

3.2.1. Content of Questionnaire

The PR AHP method conducts a survey among experts to collect their opinion. The questionnaire content includes (1) the definition of the scale, (2) sample answers and (3) pair-wise comparison question items.

The scale is defined as '1: Equal', '3: Moderate importance', '5: Strong importance', '7:Very strong importance', '9: Extreme importance' and '2,4,6,8 :Intermediate'.

Then the sample answer is shown in Table 1.

Table-1. Sample answer

Scale																		Scale
Items	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Items
A																	✓	B
B					✓													C

In the comparison of importance of the items, 9 was selected on the right-side in comparison of 'A' and 'B' in the pair-wise comparison, which indicates that 'B' is of extreme importance as compared to 'A'. As for the comparison between 'B' and 'C', 5 selected on the left-side, which indicates that 'B' is of strong importance as compared to 'C'.

3.3. PR AHP Calculation Steps

At first, we combine the questionnaire results of all the experts using the geometric mean method (Chen, 2014).

A preference relation P on a set of alternatives A is a set on the product set $A \times A$ with membership function $\mu_p: A \times A \rightarrow [0, 1]$. The preference relation is represented by the $n \times n$ matrix $P=(p_{ij})$, where $p_{ij}=\mu_p(a_i, a_j)$ for every $i, j \in \{1, \dots, n\}$. Herein, p_{ij} is the preference ratio of alternative a_i to a_j : $p_{ij}=1/2$ means that no difference exists between a_i and a_j , $p_{ij}=1$ indicates that a_i is absolutely better than a_j , and $p_{ij} > 1/2$ indicates that a_i is better than a_j . In this case, the preference matrix P is generally assumed to be an additive reciprocal, $p_{ij} + p_{ji} = 1$ for every $i, j = 1, \dots, n$. (Chen, 2008).

Proposition 1. Consider a set of alternatives, $A = \{a_1, \dots, a_n\}$, associated with a reciprocal multiplicative preference relation $A = (a_{ij})$ for $a_{ij} \in [1/9, 9]$. Then, the corresponding reciprocal preference relation, $P= (p_{ij})$ with $p_{ij} \in [0, 1]$ associated with A is given as $p_{ij}=g(a_{ij})=(1/2)(1+\log_9 a_{ij})$.

Proposition 2. For a reciprocal preference relation $P=(p_{ij})$, the following statements are equivalent:

$$p_{ij}+p_{jk}+p_{ki}=(3/2), \text{ for every } i,j,k. \quad p_{ij}+p_{jk}+p_{ki}=(3/2), \text{ for every } i<j<k.$$

Proposition 3. For a reciprocal preference relation $P=(p_{ij})$, the following statements are equivalent:

$$p_{ij}+p_{jk}+p_{ki}=(3/2), \text{ for every } i<j<k. \quad p_{i(i+1)}+p_{(i+1)(i+2)}+\dots+p_{(j-1)j}+p_{ji}=(j-i+1)/2, \text{ for every } i<j$$

Proposition 4. If a decision matrix with entries that are not in the interval $[0, 1]$, but in an interval $[-k, 1+ k]$, $k > 0$ can be obtained by transforming the obtained values using a transformation function that preserves reciprocity and additive consistency. It is given by the function. Now we can get the new preference relation P' is obtained as $P'=F(P)$, The function $f :[-k, 1+ k]$, $k>0 \rightarrow [0, 1]$, $f(x)=(x+k)/(1+2k)$.

Proposition 5. The preference relation A' is obtained as $A' = f(P')$ such that $A'=(a'_{ij})$, $a'_{ij} =9^{(2p'_{ij}-1)}$.

Weight

We get the sum of every row in matrix A' using $r_i=\sum_{j=1}^n(a'_{ij})$. Then we can get the weight of each item by $W_i= r_i/\sum_{i=1}^n (r_i)$.

3.4. Study Subjects

According to Teng (2002) 5-15 experts will be appropriate for group decision making. This study adopts the expert questionnaire. However, this study expects to obtain more accurate study results. Therefore, it adopts a greater volume of questionnaires, being 21 in total. The selected experts must be in a managerial level at least, with a working experience in China of more than 5 years and their companies must have invested in China. The experts were asked through a series of pair-wise comparisons. This study adopts the geometric mean of the whole decision making group to integrate experts' preferences because of its simplicity of calculation and judgment (Chen *et al.*, 2012).

3.5. PR AHP Software

The calculation of the PR AHP method involves a lot of matrix calculation, so it generally uses the Matlab program to calculate, which requires coding. For the researchers of the commerce department and management department, most of them are not good at coding.

That makes it inconvenient for a lot of researchers of social sciences who want to use the PR AHP method. Therefore, taking into account an easy-to-use feature for the user, this study develops the PR AHP software based on Microsoft EXCEL with which most researchers are familiar. The software was named PR AHP ver.1.3 that takes advantage of the excel database, functions and macro features. This software will be discussed further in the next section.

4. RESULTS

This study collected 21 questionnaires in total, and the analysis results will be shown in detail in this section. In the meantime, this study will introduce the operational instructions for the PR AHP ver1.3.

4.1. Structure of PR AHP

The basic structure of the PR AHP ver1.3 adopts the hierarchical structure commonly used by researchers. It is composed of 3 hierarchies, Goal, Criteria and Sub-criteria. According to the study of Saaty, when there are more than 7 criteria, it may make judgment more difficult for the respondents (Teng, 2002). Therefore, this study designed 8 criteria at most, each of which contains 8 sub-items respectively.

The PR AHP ver1.3 software was designed from MS EXCEL. There are 4 sheets, including 1.Introduction, 2.Setup, 3.Input and 4.Results. The user just needs to setup and input all of the data. Then he can obtain the calculation results. First is 1.Introduction sheet, which are the operational instructions provided for the user to learn how to use this software quickly. The next is 2.Setup sheet, which sets the number and names of criteria and sub-criteria.

4.2. Input the Questionnaire Data

The PR AHP is an MCDM method, which generally adopts the expert questionnaire. Thus, the questionnaires used are not in a large quantity. In this study, the PR AHP sets the maximum limit to 100 questionnaires. Now we come to 3.Input sheet, which is provided to input the questionnaire data. Assign a number for each returned questionnaire, and follow the number to input the data into the ellipse shown in Fig 2. Keep the cell blank if it has no data. For example, if the questionnaire results are as shown in Fig 1, input 1/3, 1/5, 7, 1/7, 5, 1/5, 1 (Fig 2) in each cell of the matrix respectively. For the cells of the matrix in dark color, the value is 1, which will be generated by the software automatically.

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A											✓							B
B													✓					C
C			✓															D
D															✓			E
E				✓														F
F									✓				✓					G
G										✓								H

Fig-1. Example - The results of the questionnaire

	A	B	C	D	E	F	G	H
A	1	1/3						
B		1	1/5					
C			1	7				
D				1	1/7			
E					1	5		
F						1	1/5	
G							1	1
H								1

Fig-2. Input data matrix

The original questionnaire data of the study are too many to present all, so the algorithm only takes the classification part of the study structure as an example. The above example only inputs the classification matrix of the first questionnaire, which also needs to input the matrix of its sub-criteria later. After that, we will follow the same way to input the data of each questionnaire

4.3. Result Output Example

4.3.1. Integration of Questionnaire Data

After inputting all the questionnaire data, we must integrate them by using the geometric mean method, which is a common method as stated in Section 3.3. Take the classification matrix result of the study as an example. PR AHP v1.3 will calculate the geometric mean values of the 21 questionnaire data, as shown in Fig 3.

	A	B	C	D	E	F	G	H
A	1	0.6168						
B		1	0.9010					
C			1	1.0083				
D				1	0.5307			
E					1	0.8308		
F						1	0.5507	
G							1	0.6542
H								1

Fig-3. Integrated input data matrix using the geometric mean

4.3.2. Original PR AHP Matrix

From $p_{ij}=g(a_{ij})=(1/2)(1+\log_9 a_{ij})$, we can get $P_{11}=(1/2)(1+\log_9 a_{11})= (1/2)(1+\log_9 1)=0.5$. Similarly, we can work out that $P_{22}, P_{33}, P_{44}, P_{55}, P_{66}, P_{77}$ and P_{88} are all 0.5.

$$P_{12}=(1/2)(1+\log_9 a_{12})= (1/2)(1+\log_9 0.6168)=0.3900$$

$$P_{23}=(1/2)(1+\log_9 a_{23})= (1/2)(1+\log_9 0.9010)=0.4763$$

Based on above method, we can get the values of $P_{34}=0.5019, P_{45}=0.3558, P_{56}=0.4578, P_{67}=0.3643$ and $P_{78}=0.4034$.

According to function $p_{ij}+p_{ji}=1$, we can get $p_{12}+p_{21}=1$, so $p_{21}=1-p_{12}=1-0.3900=0.6100$. Based on this method, we can get the values of $p_{32}, p_{43}, p_{54}, p_{65}, p_{76}$ and p_{87} .

According to function $p_{ij}+p_{jk}+p_{ki}=(3/2)$, for every $i < j < k$, we can get $p_{12}+p_{23}+p_{31}=(3/2)$, $0.390+0.4763+ p_{31}=(3/2)$, so $p_{31}=0.6337$. Similarly, according to function $p_{23}+p_{34}+p_{42}=(3/2)$, $0.4763+0.5019+ p_{42}=(3/2)$, we can get $p_{42}=0.5218$. Based on this method, we can calculate the values of $p_{53}=0.6423, p_{64}=0.6863, p_{75}=0.6779$ and $p_{86}=0.7323$.

According to the function $p_{i(i+1)}+p_{(i+1)(i+2)}+\dots+p_{(j-1)j}+p_{ji}=(j-i+1)/2$, for every $i < j$. The $p_{12}+p_{23}+p_{34}+p_{41}=(4-1+1)/2=2$, $p_{41}=2-p_{12}-p_{23}-p_{34}$, then we can get $p_{41}=2-0.3900-0.4763-0.5019=0.6318$. As the same, we can get the value of $p_{41}=0.6318, p_{52}=0.6660, p_{63}=0.6845, p_{74}=0.8221$ and $p_{85}=0.7745$.

Using the same function, $p_{12}+p_{23}+p_{34}+p_{45}+p_{51}=(5-1+1)/2=2.5$, $p_{51}=2.5-p_{12}-p_{23}-p_{34}-p_{45}$, then we can get $p_{51}=2.5-0.3900-0.4763-0.5019-0.3558=0.7760$. As the same, we can get the value of $p_{62}=0.7082, p_{73}=0.8202$ and $p_{84}=0.9186$. Following this method, we can get all value of bottom-right part in matrix.

We made computations according to $p_{ij}+p_{ji}=1$ as stated in Section 3.3, $p_{13}+p_{31}=1$, so we can get $p_{13}=1-p_{31}=1-0.6337=0.3663$. Based on this method, we can calculate all values on the upper right of the matrix, and finally get matrix P as shown in Fig 4.

$$P = \begin{bmatrix} 0.5000 & 0.3900 & 0.3663 & 0.3682 & 0.2240 & 0.1819 & 0.0461 & -0.0504 \\ 0.6100 & 0.5000 & 0.4763 & 0.4782 & 0.3340 & 0.2918 & 0.1561 & 0.0595 \\ 0.6337 & 0.5237 & 0.5000 & 0.5019 & 0.3577 & 0.3155 & 0.1798 & 0.0832 \\ 0.6318 & 0.5218 & 0.4981 & 0.5000 & 0.3558 & 0.3137 & 0.1779 & 0.0814 \\ 0.7760 & 0.6660 & 0.6423 & 0.6442 & 0.5000 & 0.4578 & 0.3221 & 0.2255 \\ 0.8181 & 0.7082 & 0.6845 & 0.6863 & 0.5422 & 0.5000 & 0.3643 & 0.2677 \\ 0.9539 & 0.8439 & 0.8202 & 0.8221 & 0.6779 & 0.6357 & 0.5000 & 0.4034 \\ 1.0504 & 0.9405 & 0.9168 & 0.9186 & 0.7745 & 0.7323 & 0.5966 & 0.5000 \end{bmatrix}$$

Fig-4. Matrix P

4.3.3. Transformed PR AHP matrix

Proposition 4 in Section 3.3 mentions that all values are required to be in the range of [0,1]. If we review the values in Fig 4, we find $p_{81}=1.0504$ and $p_{18}=-0.504$, which are beyond the range. So the matrix must be transformed by the function $f : [-k, 1 + k] \rightarrow [0, 1]$, $f(x)=(x+k)/(1+2k)$, wherein $k=0.0504$. Take $p_{17}=0.0461$ as an example, the transformed values are $f(p_{17})=(0.0461+0.0504)/(1+2*0.0504)=0.0877$. All other values are also transformed by the same way. The program calculated the transformed matrix P' (Fig 5). If the result calculated by the reader is different from the data in Fig 5, it is because PR AHP v1.3 calculates based on the original data, while the figures in the table above are the rounded results, which might produce some difference. The figures in Fig. 5 are the results calculated by PR AHP v1.3, which are relatively accurate.

$$P' = \begin{bmatrix} 0.5000 & 0.4001 & 0.3786 & 0.3803 & 0.2493 & 0.2110 & 0.0877 & 0.0000 \\ 0.5999 & 0.5000 & 0.4785 & 0.4802 & 0.3492 & 0.3109 & 0.1876 & 0.0999 \\ 0.6214 & 0.5215 & 0.5000 & 0.5017 & 0.3708 & 0.3324 & 0.2091 & 0.1214 \\ 0.6197 & 0.5198 & 0.4983 & 0.5000 & 0.3690 & 0.3307 & 0.2074 & 0.1197 \\ 0.7507 & 0.6508 & 0.6292 & 0.6310 & 0.5000 & 0.4617 & 0.3384 & 0.2507 \\ 0.7890 & 0.6891 & 0.6676 & 0.6693 & 0.5383 & 0.5000 & 0.3767 & 0.2890 \\ 0.9123 & 0.8124 & 0.7909 & 0.7926 & 0.6616 & 0.6233 & 0.5000 & 0.4123 \\ 1.0000 & 0.9001 & 0.8786 & 0.8803 & 0.7493 & 0.7110 & 0.5877 & 0.5000 \end{bmatrix}$$

Fig-5. Matrix P'

According to Proposition 4 in Section 3.3, then we get matrix A' (Fig 6) from matrix P' (Fig 5).

$$A' = \begin{bmatrix} 1.0000 & 0.6447 & 0.5865 & 0.5909 & 0.3323 & 0.2808 & 0.1634 & 0.1111 \\ 1.5510 & 1.0000 & 0.9096 & 0.9165 & 0.5155 & 0.4356 & 0.2534 & 0.1723 \\ 1.7051 & 1.0993 & 1.0000 & 1.0076 & 0.5667 & 0.4789 & 0.2785 & 0.1895 \\ 1.6923 & 1.0911 & 0.9925 & 1.0000 & 0.5624 & 0.4753 & 0.2765 & 0.1880 \\ 3.0090 & 1.9400 & 1.7647 & 1.7781 & 1.0000 & 0.8451 & 0.4915 & 0.3343 \\ 3.5606 & 2.2957 & 2.0882 & 2.1041 & 1.1833 & 1.0000 & 0.5817 & 0.3956 \\ 6.1214 & 3.9467 & 3.5901 & 3.6173 & 2.0344 & 1.7192 & 1.0000 & 0.6802 \\ 9.0000 & 5.8026 & 5.2783 & 5.3183 & 2.9911 & 2.5276 & 1.4702 & 1.0000 \end{bmatrix}$$

Fig-6. Matrix A'

4.3.4. Weight

We calculate the sum of each row, $r_i = \sum_{j=1}^n (a'_{ij})$, such as $r_1 = a_{11} + a_{12} + a_{13} + a_{14} + a_{15} + a_{16} + a_{17} + a_{18} = 3.7098$; and then calculate the values of $r_2, r_3, r_4, r_5, r_6, r_7$ and r_8 . After that, we sum up these values of r_i to get $\sum_{i=1}^n (r_i) = 102.5366$. Afterwards, we calculate the weight of each item. For example, the weight of item A is $W_1 = r_1 / \sum_{i=1}^n (r_i) = 3.7098 / 102.5366 = 0.0362$. Next, we calculate and rank the weights of other items, the results of which are shown in Table 2.

Table-2. The weight and ranking of classifications

	A	B	C	D	E	F	G	H	Total	Weight	Ranking
A	1.0000	0.6447	0.5865	0.5909	0.3323	0.2808	0.1634	0.1111	3.7098	0.0362	8
B	1.5510	1.0000	0.9096	0.9165	0.5155	0.4356	0.2534	0.1723	5.7540	0.0561	7
C	1.7051	1.0993	1.0000	1.0076	0.5667	0.4789	0.2785	0.1895	6.3255	0.0617	5
D	1.6923	1.0911	0.9925	1.0000	0.5624	0.4753	0.2765	0.1880	6.2780	0.0612	6
E	3.0090	1.9400	1.7647	1.7781	1.0000	0.8451	0.4915	0.3343	11.1626	0.1089	4
F	3.5606	2.2957	2.0882	2.1041	1.1833	1.0000	0.5817	0.3956	13.2092	0.1288	3
G	6.1214	3.9467	3.5901	3.6173	2.0344	1.7192	1.0000	0.6802	22.7093	0.2215	2
H	9.0000	5.8026	5.2783	5.3183	2.9911	2.5276	1.4702	1.0000	33.3882	0.3256	1
								Total	102.5366	1	

4.4. All of Result Outputs

After inputting the data of all the questionnaires, we can get the results worksheet, which shows the final results, including the weight and ranking of each activity. This study is mainly to find out the key items of China's investment environment that Taiwanese businessmen are more concerned about. According to the results of PR AHP v1.3 calculation, the weights and rankings of all activities are sorted as below (Table 3).

Table-3. The weight and ranking of every item

Classification / Items of the Investment Environment	Weight	Ranking
A. Natural environment	0.0362	8
a1. Superior local geographical position and condition	0.0135	22
a2. Fine local weather and climate	0.0042	34
a3. Abundant local usable land resource, low land price	0.0117	26
a4. Abundant local water resource and mineral resources	0.0068	32
B. Basic condition	0.0561	7
b1. Convenient sea-air-land transportation	0.0119	25
b2. Complete communication apparatus	0.0088	29
b3. Complete material and energy supplies	0.0079	31
b4. Complete development, construction plan in the future	0.0132	24
b5. Complete computer networking	0.0143	20
C. Communal facilities	0.0617	5
c1. Good diet and living environment	0.0133	23
c2. High internationalized intensity of the urban construction	0.0102	27
c3. Complete amusement and recreation equipment	0.0040	35
c4. Complete educational institution	0.0101	28
		<i>Continue</i>

c5. Good medical sanitary condition	0.0241	12
D. Social environment	0.0612	6
d1. Good social security	0.0171	19
d2. Pure servant and enlighten local trait	0.0065	33
d3. Competent life and culture quality	0.0192	17
d4. Excellent international perspective	0.0185	18
E. Legal system environment	0.1089	4
e1. Comprehensive policies for favorable conditions	0.0219	15
e2. High efficiency of the organ's administration of industrial and commercial factors	0.0504	5
e3. Suitable rules and regulations for environmental protection	0.0365	9
F. Economic environment	0.1288	3
f1. Rapidly growing economy	0.0080	30
f2. Government actively improving the investment environment	0.0230	13
f3. Extensive industrial property type	0.0137	21
f4. Stable financial measures and effective financial organs	0.0432	6
f5. High average income of the people	0.0410	8
G. Operational environment	0.2215	2
g1. Abundant basic level manpower	0.0193	16
g2. High potential to exploit the market	0.0263	11
g3. Low cost of factory buildings and relevant facilities	0.0224	14
g4. Easy to obtain materials or semi-manufactured goods	0.0412	7
g5. Sufficient specialized human resources	0.1123	1
H. Knowledge economy environment	0.3256	1
h1. Sufficient universities, colleges and research institutes	0.0305	10
h2. High quantity and quality of scientific and technical human resources	0.1077	2
h3. High electronic capabilities	0.0988	3
h4. Efficient bank electronic service	0.0886	4
Sum	1 1	

Note: Bold means the weight and ranking of classification

According to the rankings of the weights as shown above, the key items of China's investment environment that Taiwanese businessmen are more concerned about are g5, h2, h3, h4, e2 and f4.

5. DISCUSSION

This study focuses on those aspects of the investment environment in China which Taiwanese businessmen are most concerned about. Table 2 shows the items with top weight rankings including (g5) High quantity and quality of scientific and technical resources, (h2) High quantity and quality of scientific and technical human resources, (h3) High electronic capabilities, (h4) Efficiency of bank electronic service, and (e2) High efficiency of the organ's administration of industrial and commercial factors.

Based on the opinions of the experts and the results, it was found that Taiwanese businessmen are most concerned about the high quality and quantity of all kinds of professional and technological talents, convenient electronic payment services and efficient business administration organizations. This shows that the Chinese industrial structure is rapidly changing, with the industry level gradually improving. In the past, foreign investors were relatively concerned about

low labor and raw material costs. And they hope China's vast domestic demand can bring huge profits. But in recent years, China has been rapidly on the rise in terms of economy and globalization. Therefore, the emphasis on the investment environment by Taiwanese businessmen was also upgraded to a higher level. In terms of human resources, they require a lot of high-quality scientific and technological personnel. In the overall environment, they need a higher electronic environment that can facilitate the flow of information and cash. In addition, the stable financial measures and high efficiency of financial institutions can enhance the effective use of funds. The legal environment, which is always the least item in terms of satisfaction rating in the investment environment as assessed by Taiwanese businessmen, is highly emphasized by Taiwanese businessmen in this study. Taiwanese businessmen also prefer for Chinese administration institutions to provide excellent administrative efficiency. All the above measures can enhance business efficiency. We expect that follow-up researches can work out better methods and make a more comprehensive study in this field.

As for the study methods, the structure of this study has 8 dimensions in total, each of which has 4, 5, 5, 4, 3, 5, 4, 4 items respectively. If we use the traditional AHP method, it requires 85 pairs of comparison, namely, $(8(8-1)/2) + (4(4-1)/2) + (5(5-1)/2) + (5(5-1)/2) + (4(4-1)/2) + (3(3-1)/2) + (5(5-1)/2) + (4(4-1)/2) + (4(4-1)/2) = 85$. After the PR AHP is used, 32 pairs of comparison are needed, namely, $(8-1) + (4-1) + (5-1) + (5-1) + (4-1) + (3-1) + (5-1) + (4-1) + (4-1) = 32$. With a reduction of $(85-32) = 53$ pairs, it greatly decreases the items in the questionnaire, but it doesn't affect the accuracy of the study results. The study of [Chen \(2014\)](#) proves that the results of the traditional AHP and PR AHP are consistent. PR AHP can greatly relieve the burden of the respondents, and increase their willingness to fill in the questionnaire. It is also helpful to the researcher in collecting the opinions of the experts.

The PR AHP v1.3 software is designed based on MS Excel, which is a popular office software. Thus, the PR AHP v1.3 has a friendly and easy-to-use interface and operating system.

6. CONCLUSIONS

With regard to Taiwanese businessmen's evaluation of the investment environment in China, the more important constructs are: (H) Knowledge economy environment and (G) Operations environment. According to the ranking of all the items, the more important items are: (g5) High quantity and quality of scientific and technical resources, (h2) High quantity and quality of scientific and technical human resources, (h3) High electronic capabilities, (h4) Efficiency of bank electronic service, and (e2) High efficiency of the organ's administration of the industrial and commercial aspects. Although this study that was meant to assess the investment environment in China was taken only from the Taiwanese businessmen's perspective, the results can also serve as a reference for the other countries that want to establish a good environment to attract foreign investments. If any government wants to establish a sound investment environment, they can start first from the aspects described above.

This study probes into the key investment environment items in China focusing only on the Taiwanese businessmen's perspective. We suggest for the follow up researches to focus on the important investment environment items and do a more detailed discussion on those. The researchers can study how a government can improve the conditions for a sound investment environment. That can make this study more complete, and have more practical value.

On the research approach, the PR AHP has really solved the problem of inconsistency relative to the traditional AHP. The more important thing is, the PR AHP method reduces a large number of pair-wise comparisons. This can reduce the load on the experts when they fill in the questionnaire. This study developed the PR AHP v1.3 software which really offered a friendly and easy-to-use interface, reducing the problems of a researcher.

The major contributions of this study can be summarized into two points: (1) it finds out the key items of China's investment environment that the Taiwanese businessmen are more concerned about. The study result can serve as a reference for other countries when they intend to develop a sound investment environment, (2) this study develops the PR AHP software, which is a friendly and easy-to-use tool for the researchers.

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