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Prioritizing the Key Problems Affecting the Cold Chain Logistics in the Trading of Fruits and Vegetables from Xinjiang to Other Central Asian Countries: an IAHP Approach

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Abstract: This paper analyzed the key problems that affected the cold chain logistics in the trading of fruits and vegetables from Xinjiang to other Central Asian Countries. The study used a combination of two traditional techniques; macro-environmental components (PEST analysis) and Analytical Hierarchy Process (AHP) to create the IAHP (Improved Analytic Hierarchy Process). This hybrid method was adopted to prioritize these key problems statistically in order of their importance to best address them. Cold chain technology had been in use in this region for a number of years in order to improve the quality of agricultural products in transit. According to the findings, overall planning and integration were the major challenges in cold chain logistics development. These findings were based on the researchers' own simulated experiments and judgments, and should not be generalized beyond this region. Moreover, these could add some practical value and be beneficial in policy development and in managerial decision-making when addressing issues associated with uncertainties or risks in the supply chain, and contribute to the body of existing knowledge.

Keywords: Prioritizing, Key Problems, Improved Analytical Hierarchy Process (IAHP), Modern Cold Chain Logistics, Export Trading, Fruits & Vegetables, Xinjiang

I. Introduction

In Xinjiang, as well as other Asian Central Countries, fruits and vegetables are seasonal agricultural goods that are in highon demand for their different dietary and nutritional values. However, their scarcity in termsof availability due to countries' battles with undisputed climatic as well as geographical conditions and discrepancies in stockpiles of these products, forces them to outsource the supplies from their counterparts in order to meet domestic needs. These products are known to be exceptionally perishable on the basis of their distinctiveness in characteristics, which requires proper storage with regard to temperature moderation for maintaining their freshness and quality. This will also help them in further preserving their longevity pertaining to their shelf-life in case these fruits and vegetables will be traded within or out side these countries. Hence the idea of examining or enhancing the cold chain logistics facilities for these products. However, recent studies have indicated that companies such as the Shenzhen Yuanxing Fruit Products Co. Ltd, has

found ways of tackling these challenges in order to bring top-quality delicious fruits to the consumer's table in China and abroad, by carrying out a very strict product quality control across the board (Fresh Plaza, 2019).

In this study, cold chain refers to a temperature-managed type of supply chain storage and logistics which is designed specifically to control and reduce contamination as well as to improve the quality improvement of agricultural products in transit. Cold chain logistics is mostly used to effectively maintain the freshness of fruits and vegetables in Xinjiang. Yu, Tianshan and Sharif (2019), indicate that cold chain is just a fraction of the supply chain, which can also be used to deep-freeze or chill foods, medical supplies and delicate products such as fruits and vegetables, meat, medication, ice cream, fish, and so forth. By being the biggest legislative division and the eighth biggest country sub-division in the world, Xinjiang has shown good momentum in development, regardless of its investment challenges which not only affected its well-being in respect of wasted resources and efforts, but also the lack of feasible investment structures to boost its economy (Dede, 2008).According to Yan (2015), China's cold chain logistics development is in the infancy stage of its industry life cycle, which makes it vulnerable to challenges and impairment in the trading of fruits and vegetables. Despite the asset advancement and slight improvement in how the system operated, the cold chain logistics system has never been created, considering some indisputable difficulties relative to infrastructural development. This matter has been one of the significant global food supply chain's threats over the years when addressing the underlying issues of distance, tonnage of food cargo and risks involved. Having said that, current reviews suggest that cold chain in expanding swiftly in China, outdoing $23 billion in 2015, and being anticipated to hit $56 billion in 2020 (Dong, Xu and Miller, 2020). Furthermore, other concerns in Xinjiang relate to food safety, traceability and technology which can ensure the proper control and administration of this system to deliver value to the ultimate consumers eventually.

In this framework, the main aim of this study is to identify and prioritize the key problems affecting the cold chain logistics in the trading of fruits and vegetables from Xinjiang to other Central Asian Countries. This will assist stakeholders to derive some clear directions for significant advancement, development and in-depth understanding ofhow the current cold chain logistic industry can reach global standards. Inspiration is drawn from an American researcher from Pittsburgh University, Professor Saaty, who developed the Analytical Hierarchical Process (AHP) in the early 1970s as a prescription to help decision-makers to solve complex challenges. In addition, the study adopts Long et al's (2009) idea of combining these two traditional methods (PEST analysis together with AHP) on the basis of their coherence in order to advocate forward an improved version of namely AHP "IAHP", which will be discussed accordingly under the Materials and Methods section. This study was not only inspired by these experts but also adopted their strategic characteristics, principles and policies in order to forge this hybrid. In addition, technical approaches, ideology and concepts were drawn from other experts such as Sun, Wang, and Hao (2017), who have prolific works in the field regarding this subject matter. This approach is deemed appropriate in defining the study's intention of addressing its key problems, by designing and presenting a suitable modern cold chain logistical model for the fruits and vegetables situation in Xinjiang. Moreover, care should be taken that the issue of the supply chain in this paper simply painted a situational analysis of what takes place in Xinjiang, and does not derail the study from the value of the improved methodology under taken. The conception of IAHP will contribute to the body of the existing knowledge and add some practical use in research as well as various industries.

Theoretical Background of Export Trade in Fruits & Vegetables (Xinjiang)

This study took a desk-research approach, whereby its conduct dwelled up on previous studies of other experts related to the topic undertaken, in order to develop this particular literature review. The intention was to read and organize available literature, combine research data collected and to sort out the relevant factors regarding the subject matter in Xinjiang and abroad accordingly. Emphasis was placed on selected keywords of the study (Export Trade; Fruits and Vegetables; Cold Chain Logistics; and Analytical Hierarchy Process), formulating the basis for which the theoretical background of key problems affecting cold chain logistics in the trading of fruits and vegetables were identified and analyzed. Therefore, literature has been sectioned into selected subject matters (keywords) in order to pinpoint problems in the cold chain supply of fruits and vegetables in Xinjiang (China),as follows:

Export trade of fruits and vegetables

According to Dede (2008), China's retail food markets are dominated by fruits and vegetables, making it a substantial producer with almost half of the world's production in terms of these kinds of commodities. Even though processed products are gradually gaining recognition, the majority of consumers in China still favor fresh produce above all others. Ma (2021) emphasized that, when it came to the distribution of grocery retail market in China, the conventional contemporary retailers, particularly hypermarkets as well as supermarkets accounted approximately 64 percent of this market. Furthermore, the fruit production section is splintered down and comprisessm all holders who specialize in varieties of apples, pears, peach, citrus, bananas and grapes, and who are mostly situated in the North-eastern and North-western parts of the country where Xinjiang is located. The vegetable producers are mostly found in the central and eastern parts, where favorable weather conditions together with arable terrain are found, not to mention the available advancements in production facilities and business opportunities for interested entities in terms of investment possibilities. On the other hand, nowadays China's horticulture imports and exports stood up to the ramifications of Covid-19 to elevate to new heights despite the fact that it was amongst the top five markets that import their produce from New Zealand. Kiwifruit, apples and avocadoes are amongst fruits import from New Zealand (Fresh Plaza, 2020).

Nevertheless, Xinjiang has become a center for international trade and economic activities since it is directly connected to the neighboring countries and is a gateway for the exchange of resources (HKTDC Research, 2016). This country is the biggest legislative and eighth sub-divided region in the world. It also provides a corridor to other countries along the Belt and Road (Silk Road Economic Belt and Maritime Silk Road), which is a strategic initiative designed to integrate markets amongst all stakeholders, benefiting the country economically and infrastructurally. In addition, with its distinctive topographical location Xinjiang has a core orientation in the Silk Road Economic Belt, making it to have an overall industrial and economical advantage (Xiao, Na and Rang, 2021). Therefore, the rapid growth of the fruits and vegetables industry puts more pressure on governments' to improve and source for help thereof, which applies to the rest of China as well. According to Dede (2008), China is the largest producer of fruits and vegetables, contributing to over one third of the world's population. The government is striving to develop the rural economy, developing the current industry and even educating farmers of organic production, focusing on food safety and quality which are important in the import and export trade of these agri-products.

Central Asian Countries (Kazakhstan, Tajikistan, Kyrgyzstan and Turkmenistan) have direct significance for Xinjiang in respect of their rapid economic growth, which can be seen in the changing patterns of their living standards (social and

purchasing power), import demand and market consumption structure upgrades. However, there is a dispute when it comes to the distribution of commercial and agricultural products as their logistical infrastructure is very poor in such way that it affects how operations, governance and perhaps how co-ordination takes place, resulting mostly in a shortage of agricultural product availability. Despite all these irregularities, Xinjiang still has sufficient produce of fresh agricultural products such as fruits and vegetables, which are continuously exported to the Central Asian countries to meet their domestic demand, taking advantage of the current situation. On the contrary, this exportation trade has resulted and caused some challenges for trade co-operation, which has further affected both domestic and international trading decisions. In recent studies, China had been counted amongst the emerging powers that have illustrated themselves as movers and shakers, striving to make the trading systems equitable for third world countries (Hopewell, 2021).

Cold chain logistics models in China

The marketing mix (4Ps) is a fundamental holy grail of marketing strategy, comprising of product, price, place and promotion (Galli, 2021). This is the gist and existence of any business. As part of the 4Ps, when it comes to the Product Life Cycle (PLC), all four major stages of Introduction, Growth, Maturity and Decline are essential for the longevity of any firm and the product itself (Canavari et al, 2017). Therefore, constant analysis should be conducted to identify their fluctuations in order to vividly forecast future business opportunities, as well as trends. Ideally, the cycle runs from the development phase down to the distribution stage where it can either face its ultimate consumption or be re-used to produce other products. Although this provides a synoptically background to the PLC, the whole process is generally prone to a number of challenges and losses in its totality or entirety. Some of these challenges range from post-harvest losses to others which are estimated to cost farmers of agricultural food stuff over billions of dollars worldwide due to inadequate and ineffective post-harvest management processes (Goedhals-Gerber et al, 2015). Central to this mis-management is the aspect of cold chain that is seen to be a vital and potential resolution in these unnecessary losses since it decreases wastage significantly, putting more money into farmers' pockets, which can further create employment opportunities not ignoring improvements in living standards, and developing economies (Negi and Anand, 2015).

When justifying this matter as slightly hinted in this context as earlier regarding the cold storage of perishable foods and medicine, WHO (2021), outlined that the COVID-19 epidemic has caused unparalleled social and economic costs in all nations and citizens throughout the world. As a result controlled temperature chain (CTC) facilities and systems would be vital in the quest to save lives and combating this pandemic. Therefore, cold chain is generally important.

In this framework,temperature control pays the cheque as a central aspect. This not only influences but helps in terms of packaging, storage and transportation of goods, prolonging their shelf life and their longevity while in transit (Yu, Tianshan and Sharif, 2019). However, proper procedures need to be followed in the running and controlling of these cold chain facilities in order to maintain the quality and freshness of these commodities to their outmost levels until they reach their destinations. More than anything, adequate airflow and temperature monitoring are very important factors to keep account of (Dede, 2008). In addition, new developments in technological innovations and advancements have changed the face of conventional storage and logistics in the agri-food stuff industry since 2010 whereby containerized

refrigeration reefer ships and refrigerated road transport have slowly been adapted (Goedhals-Gerber et al, 2015). As alarming as it may sound, the cold chain logistics in Xingjian is in serious need of cost-effective and technologically advanced facilities to benefit the local and international stakeholders, not to forget charges in prices of the trading of fruits and vegetables, which need to be regulated and standardized (Fresh Plaza, 2019). According to Wang, Sun and Zhu(2017), various measures in the distribution of agri-food products need to be taken into account. These include the need for additional facilities; average-temperature controlled technology that requiresupgrades; contingency measures should be strengthened to avoid power cuts; and developing the whole supply chain governance in an adequate manner, together with the flow and management of information. This issue was outlined and emphasized by Ma (2021) earlier in this study in this regard.

Furthermore, Dede (2008) indicates that cold chain contributes massively to the local economy. Dong, Xu and Miller (2020) agree that cold chain development has a potential to growth the economy, promote changes in terms of food demand, and the amendment of chain laws in China. Consequently, more knowledge, understanding and awareness needs to be created to increase growth in this industry and to benefit all the stakeholders involved. Additionally, the Chinese agricultural sector loses more commodities due to poor logistical processes, which puts more pressure on the country's current logistics and distribution structures. Furthermore, warehousing and storage facilities are under-developed and are not on par with the developments of the fruits and vegetables industry. Other factors include regulatory barriers such as license requirements; fees and inspection; and low-quality equipment, together with unskilled labour and despite other geographical factors (Dede, 2008).

II. Material and Methods

This study forged and used the IAHP, a hybrid method that came from the merger of PEST and AHP, which isused to prioritize key problems statistically in order of their importance to best address them. Technically, this hybrid is a mixed-methods (quantitative and qualitative multi-criteria decision analysis) research approach that draws or sources its soul or information from the study's literature review, which informed the questionnaire used. The significance of merging multiple methods is to address complex research issues (Maree, 2021).The encouragement was drawn from Professor Saaty principles and ideas, the developer of the AHP and adopted Long et al's (2009) idea of combining these two traditional methods (PEST analysis and AHP) to create IAHP, which will form a proposed methodology used in/for this paper. Ultimately, the analysis and interpretation of data will follow scientific approach.

Analytical Hierarchy Process (AHP) is a principles-based criterion amongst other decision-making techniques that use diverse approaches to attain relationship measures through joined contrast and which can be utilized to find an answer to complicated decision problems. This was designed and developed by Professor Thomas Saaty in the 1970s (Triantaphyllon and Mann, 1995) as indicated above. AHP enables minor irregularity when it comes to decisions since people are prone to making mistakes. Data can be acquired from real calculations such as pleasure and affection, as well as desire (Turcksin, Bernardini and Macharis, 2011). Dweiri et al (2016) highlight two different situations in particular where these kinds of calculations or the pairwise comparison of the criteria value in relation to the goal are used. The first instance can be in a situation where quantitative data is available, which can ease the comparison on the basis of a

defined scale or ratio causing judgment to amount to zero and implying a perfect judgment. The second instance, can be in a situation where quantitative data is not available. In this case qualitative judgments can be applicable for a pairwise comparison and therefore this follows the importance scale recommended by Saaty.

According to Yao, Gong and Wang (2012), AHP solves issues in an orderly hierarchical structure through people's judgment onthe decision schemes sorting. Moreover, this method can also be characterized by its practicality andsystematisms, as well as its simplicity. However, AHP completely relies on subjective evaluation ranking schemes which are suitable for difficult situations in quantifying the measurement of complex problems and qualitative judgments. This ultimately contributes positively and directly to decisions. According to Macharis et al (2004), the AHP method relies on three principles, namely building hierarchy; priority setting, as well as logical consistency. These principles add a valuable advantage to its proficiency in breaking down an intricate situation in a reasonable and simplified manner. However, AHP is known to have a significant shortcoming in its potential to lose important information in its criteria. Furthermore, the amount of pair wise comparisons for the assessment of other options in relation to the role they play to the criteria can become essentially high (Turcksin et al, 2011).

A literature review in the form of desk-research informed this proposed hybrid method (PEST analysis and AHP, IAHP). Firstly, the study used the PEST analysis method (Political-B1, Economic-B2, Social-B3 and Technological-B4) to identify the key problems that affected the cold chain logistics in the trading of fruits and vegetables from Xinjiang to other Central Asian Countries. Care was taken that its variables were coded in order to clearly define the hierarchical structure or model as indicated in **Table 1** (Chen and Li, 2014). Based on the study's nature, the PEST analysis was defined as a framework of external uncontrollable factors that provided an insightful overview of the macro-environment, which farmers needed to take into consideration in their decision-making processes since it outlines the enterprises' situation objectives accurately. PEST analysis was further considered as a valuable and critical device for taking into account the market growth or decline, business potential and direction for operations, which made this method fit within the scope of this study.

In addition, the study further intended to prioritize key problems (political, economic, social and technological) affecting the cold chain logistics in the trading of fruits and vegetables from Xinjiang to other Central Asian Countries using an adopted version of the AHP method called the Improved Analytic Hierarchy Process, which incorporated the use of quantitative and qualitative information for complex decision-making (Yao, Gong and Wang, 2012). Similar to AHP, IAHP could be used for solving complex problems in an orderly hierarchical manner, based on people's judgment on the decision schemes sorting and influence of a factor's weight calculations. This method completely relied on a subjective evaluation ranking scheme (in this case, data came from the researchers' own evaluations that however inspiration and assistance came from Professor Saaty's, 1984, principles and ideas, together with Long et al's, 2009, notions).This was suitable for difficult situations in quantifying the measurement of complex problems and qualitative judgments, which will ultimately play an important direct role on decisions or results. An array of studies covered in this study suggested that IAHP may possess potential qualities that could improve the traditional AHP's shortcoming by enhancing its validity and ability in helping managers to split complicated decision-making issues into an easier order. Lastly, Sun, Wang and Hao (2017), who have contributed enormously through their works in pushing the idea of improving AHP, were considered in this study.

This new AHP (IAHP) will have the following advantages:

- When using the three scale (0, 1, 2 values) to determine the important relations of various elements on the same level, the difficulty of judgment will be reduced;
- It will also reduce the ambiguity degree of judgment as far as possible in order to reduce the subjectivity of the judgment matrix;
- It will improve the consistency of the judgement matrix, which is related to contradiction and confusion phenomena in the case of comparison judgment; and
- Finally, it will enable the flexibility of options in a situation whereby a number of options adjusts the sorting of other options and remains constant.

Therefore, the intention was to read and organize available literature, combined research data collected and to sort out the relevant factors regarding the subject matter in Xinjiang and abroad. This was to devise a means of constructing a hierarchical structure or model that could appeal more and create interest more in addressing the underlining issue, as demonstrated in **Table 1** in terms of criterion layers and more. The study was experimental whereby the questionnaire was filled by one of the researchers (who was an expert on the specific issue under investigation) to simulate and formulate quantitative data. This questionnaire was derived from the literature review, which could be justifiable in **Table 1** and also as results codes for various variables were created as indicated. Additionally, there was expert consultation as interviewing relevant stakeholders in the fruits and vegetables industry in Xinjiang using a questionnaire and combining the actual situation with influential factors of the cold chain logistics development of farm products using the Analytic Hierarchy Process. Putting the cold chain logistics development of farm products as the goal layer, the influence factors of the same issue for fruits and vegetables as the middle layer and rule layer did this. Consequently, this made it easier to get the hierarchy structure or model of factors affected as shown in **Table 1**.

Table 1. The hierarchical structure or model of influencing factors for fruit and vegetable cold chain logistics

The destination Layer	The intermediate layer	The criterion layer
Fresh agricultural products cold chain logistics A	Policy factors B1	The relevant laws and regulations system was not suitable C11;
		The lack of industry standards and the regulatoryimplementation of standards C12;
		Cold chain logistics system had not yet formed C13;
		The lack of cold chain overall planning and integration of upstream and downstream C14;
	Economic factors B2	The degree of marketization of cold chain logistics was lower C21;
		Cold chain cost and loss of goods with high C22;
		The low price competition resulting in industry level was low C23;
		The trading market of agricultural products circulation form level was low C24;

	Fresh agricultural products cold chain logistics consciousness waslight C31;
Social cultural factors B3	The conservative living habits and consumption concept C32;
	The lack of cold chain logistics professional personnel C33;
	The infrastructure of the cold chain logistics behind C41;
	The application of information technology was of a low level C42;
Technical factors B4	Processing capacity of fresh agricultural products C43; and
	Agricultural postpartum full low temperature storage of low degree C44.

Inspired by Zuo's (1988) works, this paper applied the IAHP matrix judgment method indirectly in order to avoid the subjective factors of the traditional comprehensive evaluation in order to make the process and results more objective, as well as accurate.

The main idea of this method was to use these three point-scale values (0, 1, 2) for decision-makers to determine the important relationship between each element on the same level. As an example (depicted from **Table 1**), two (2) decision-makers indicated that **A** elements were more important than **B** elements; while on the other hand one (1) decision-maker indicated that **A** and **B** elements were equally important; and zero (0) or no decision-maker indicated **A** elements to be important nor **B** elements to be important at all. Therefore, by using the three scales matrix and formula (1) the study calculated the ranking index of each element which represented the degree of importance; the maximum ranking index represented by r_{max}; and the lowest ranking index by r_{min}. Furthermore, the largest element ordering index was represented by A_{max}, while the smallest element ordering index was shown by A_{min}. These two elements were used to make comparative basis elements by a 1 - 9 basis points scale, given the relative importance of b_m (> 1).Through formula (2), the relative importance of each element could be obtained. In addition, it can be seen that as bm changed, Pij also changed accordingly. If the consistency requirements were not met, then the EXCEL application would readjust the b_m assignment, whereby each weight index would change accordingly in order to achieve it in a more convenient manner and to also find the relative importance index value variation easily, thereby saving time, effort and cost. Therefore, it would be important to obtain accurate and reliable conclusions, conveniently（Li, Ceng and Zhou, 2009).

III. Results

This section outlines an overview of the results of the study, calculations and technicalities involved as follows:

$$r_i = \sum_{j=1}^{n} c_{ij} \quad (i=1,\ 2,\ 3,\ \ldots n) \quad (1)$$

$$P_{ij} = \begin{cases} \dfrac{r_j - r_i}{r_{max} - r_{min}} (b_m - 1) + 1 & r_i - r_j \geq 0 \\ 1 \Big/ \left[\dfrac{r_j - r_i}{r_{max} - r_{min}} (b_m - 1) + 1 \right] & r_i - r_j < 0 \end{cases} \quad (2)$$

Table 2 represented the results of the group pairwise comparison for theinfluential factors of cold chain logistics foragricultural products (fruits and vegetables), namely economic factors B1;political (policy) factors B2; social (cultural) factors B3; and technical factors B4, which weretabulated as follows.**N.B**. In **Table 2**, the study uses three scales (0, 1, 2) to determine the vital relationships of the elements at the same level.

Table 2.Group pairwise comparison matrix

P1	P2	P3	P4	Geometric average	Weight coefficient	Weighted sum	Approximate λ
1.000	2.000	1.000	2.000	1.4142	**0.3431**	1.4142	4.1213
0.500	1.000	2.000	1.000	1.0000	**0.2426**	1.0711	4.4142
1.000	0.500	1.000	2.000	1.0000	**0.2426**	1.0503	4.3284
0.500	1.000	0.500	1.000	0.7071	**0.1716**	0.7071	4.1213

The feature vector for the weights (w)= (0.3431, 0.2426, 0.2426, 0.1716) ^{T} to check the consistency of the matrix, the largest eigenvalue λmax= (4.1213+4.4142+4.3284+4.1213) /4=4.2463 was close to 4; consistency index CI=(λmax-n) / (n-1) =0.0821; and the value of the mean random consistency index RI were shown in **Table 3**. Saaty (1984) proposed a method to calculate or check the consistency of the judgment matrix, which will take the relative error between the maximum characteristic value λ max and the theoretical value n of the judgment matrix as the consistency index of the judgment matrix. CI= (λ max-n)/(n-1). Consistency should also be calculated by eigen values λ, not by weights.

The consistency check formula, CI= (λ max-n)/ (n-1), requires the λ max value. In practice, the approximate value of the maximum characteristic lambda max (P) is calculated by the following method: Lambda max can be approximately regarded as pair matrices P = (P ij) corresponding to the maximum eigen value.

$$\lambda = \frac{1}{n}\sum_{i=1}^{n}\frac{(AU)_i}{u_i} = \frac{1}{n}\sum_{i=1}^{n}\frac{\sum_{i=1}^{n}}{\frac{\sum_{j=1}^{n} a_{ij}\,u_j}{u_i}}$$

Table 3.The value of the mean random consistency index

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.52	1.54	1.56	1.58	1.59

This could be,a drawn random consistency index RI=0.9000 so that the comparison matrix, the consistency ratio CR=CI/RI=0.0821/0.9000=0.0912<0.10; namely the comparison matrix and consistency matrix was very close and, could be used to sort the feature vector.

Factors affecting the political (policy) environment for C1—B; the legal laws and regulations construction of C11; implementation of industry standards and the supervision industry standard C12; cold chain logistics system for C13; the cold chain of overall planning and integration of C14between pair wise comparison, the importance of the assignment got the relationship between each other as in **Table 4**.**Tables 4 – 7** calculate P = (Pij) without using another scale.However, they use formula **(2)**.

Table 4.Political (policy) factors pair wise comparison matrix

P1	P2	P3	P4	Geometric average	Weight coefficient	Weighted sum	Approximate λ
1.000	5.000	3.400	1.000	2.0305	**0.3980**	1.6001	4.0203
0.200	1.000	0.385	0.200	0.3522	**0.0690**	0.2801	4.0583
0.294	2.600	1.000	0.294	0.6887	**0.1350**	0.5486	4.0641
1.000	5.000	3.400	1.000	2.0305	**0.3980**	1.6001	4.0203

The feature vector for the w= (0.3980, 0.0690, 0.1350, 0.3980) ^{T}checks the consistency of the matrix with the largest eigen value λ max=4.0408, close to 4 and with a consistency index CI= (λmax-n) / (n-1) =0.0136. Could be obtained, the comparison matrix of random consistency index RI=0.9000.Therefore, the consistency ratio CR=CI/RI=0.0151<0.10, namely the comparison matrix and matrix consistency which were very close, could be used to sort the feature vector. The reason why there are three different rankings with geometric average, weight coefficient and weighted sum in **Table 4** is that the judgment matrix weighting coefficient calculated by the geometric average method reflects the relative importance weights of each element of the hierarchy order. These calculate the synthetic weight values of each layer element to the system target and make the total order determine the importance of the underlying elements in the overall target.

The variables influencing the economic factors of C2—B, the degree of marketization of cold chain logistics for the C21, cold chain cost and the goods loss with high C22, the low price competition resulting in industry level was lowC23, the degree of market transactions of agricultural products circulation C24and pairwise comparison showed the relationship between each other as in **Table 5**.

Table 5.Economic factors pairwise comparison matrix

P1	P2	P3	P4	Geometric average	Weight coefficient	Weighted sum	Approximate λ
1.000	1.800	0.833	1.200	1.1583	**0.2823**	1.1880	4.2086
0.556	1.000	0.500	0.625	0.6455	**0.1573**	0.6618	4.2073
1.200	2.000	1.000	1.400	1.3539	**0.3299**	1.3799	4.1822
0.833	1.600	0.600	1.000	0.9457	**0.2305**	0.9913	4.3013

The feature vector for the w= (0.2823, 0.1573, 0.3299, 0.2305) ^{T}checks the consistency of the matrix with the largest eigenvalueλmax=4.1702, close to 4 and with a consistency index CI= (λmax-n) / (n-1) =0.0567. Could be obtained, the comparison matrix of random consistency index RI=0.9000.Therefore, the consistency ratio CR= CI/RI= 0.0630<0.10, namely the comparison matrix and matrix consistency, was very close, and could be used to sort the feature vector.

The variables influencing the social (cultural) factors of C3—B, fresh agricultural products cold chain logistics consciousness for C31, habits and consumption concept for C32, cold logistics professional personnel for C33, pairwise comparison, showed the relationship between each other as in **Table 6**.

Table 6.Social (cultural) factors pair wise comparison matrix

P1	P2	P3	Geometric average	Weight coefficient	Weighted sum	Approximate λ
1.000	4.000	2.500	2.1544	**0.5954**	1.7993	3.0222
0.250	1.000	0.400	0.4642	**0.1283**	0.3877	3.0222
0.400	2.500	1.000	1.0000	**0.2764**	0.8352	3.0222

The feature vector for the w= (0.5954, 0.1283, 0.2764) ^{T}checks the consistency of the matrix with the largest eigenvalueλmax=3.0054, close to 3 and with a consistency index CI= (λmax-n) / (n-1) =0.0027. Could be obtained, the comparison matrix of random consistency index RI=0.58.Therefore, the consistency ratio CR=CI/RI=0.0047<0.10, namely the comparison matrix and matrix consistency was very close and could be used to sort the feature vector.

The variables influencing technology (technical) factors of C4—B, cold chain logistics infrastructure for the C41, the application of information technology for C42, the processing capacity of fresh agricultural products C43, agricultural postpartum whole degree of temperature storage low C44 pairwise comparison, got the weights in **Table 7**.

Table 7.Technological (technical) factors pairwise comparison matrix

P1	P2	P3	P4	Geometric average	Weight coefficient	Weighted sum	Approximate λ
1.000	1.000	0.667	0.769	0.8462	**0.2082**	0.8795	4.2236

1.000	1.000	0.667	0.769	0.8462	**0.2082**	0.8795	4.2236
1.500	1.500	1.000	1.200	1.2819	**0.3154**	1.3272	4.2075
1.300	1.300	0.833	1.000	1.0894	**0.2681**	1.1353	4.2350

To get the feature vector for the w= (0.2082, 0.2082, 0.3154, 0.2681) ^{T}checks the consistency of the matrix with the largest eigen valueλmax=4.2224, close to 4 and with a consistency index CI= ($l\lambda max$-n) / (n-1) =0.0741. Could be obtained, the comparison matrix of random consistency index RI=0.9000.Therefore, the consistency ratio CR= CI/RI= 0.0824<0.10, namely the comparison matrix and matrix consistency, was very close and could be used to sort the feature vector.

Hierarchical single arrangements. On the basis of single level sorting, the hierarchical arrangement is organized from top to bottom and the importance weight value of all factors relative to the target layer A is calculated.

This sorted according to the feature vector matrix and obtained the weight vector of judgment matrix as follows:

W_{A-B}=(0.3431, 0.2426, 0.2426, 0.1716) ^{T}

W_{B1-C1} = (0.3980, 0.0690, 0.1350, 0.3980) ^{T}

W_{B2-C2} = (0.2823, 0.1573, 0.3299, 0.2305) ^{T}

W_{B3-C3} = (0.5954, 0.1283, 0.2764) ^{T}

W_{B4-C4} = (0.2082, 0.2082, 0.3154, 0.2681) ^{T}

The level of total order.

Thus, the sort of factors influencing the cold chain logistics development of fresh agricultural products in Xinjiang, is shown in **Table 8**.

Table 8.Thelevel of total order influence factors of cold chain logistics development of FAP

Factor	Weight coefficient	Sort	Factor	Weight coefficient	Sort
C11	0.3980	2	C31	0.5954	1
C12	0.0690	15	C32	0.1283	14
C13	0.1350	13	C33	0.2764	7
C14	0.3980	3	C41	0.2082	11
C21	0.2823	6	C42	0.2082	10
C23	0.1573	12	C43	0.3154	5
C22	0.3299	4	C44	0.2681	8
C24	0.2305	9			

The sort of values influencing the cold chain logistics is in**Table 8**, whereby weight value of the top 6 was respectively indicated. Fresh agricultural products and cold chain logistics consciousness were inadequate C31. While the relevant

legal systems were imperfect C11, there was a lack of cold chain overall planning and integration C14, whereby cold chain costs and losses of goods were high C22. There were also fresh agricultural products which had low processing capacity C43, together with cold chain logistics that had a low degree of marketization C21. Therefore, these six (C31, C11, C22, C14, C43 and C21) obstacle factors were the most important and effective factors in the cold chain logistics development of fresh agricultural products. Whether government departments or cold chain logistics enterprises should focus on them in order to increase investment and giving priority to solve them remain subjective matters.

IV. Discussion and conclusions

This paper determined to analyze the key impact factors of fruits and vegetables in cold chain logistics development, particularly in Xinjiang, using IAHP. The idea was to identify and prioritize these key factors in the trading of fruits and vegetables where cold chain logistics were utilized. The aim was to devise suggestions for decision-makers on how to approach and solve the following problems (**Table 8**) accordingly: 1. Fresh agricultural products and cold chain logistics consciousness were poor or inadequate;2. the relevant laws and regulation systems were imperfect; and3. the lack of cold chain overall planning and integration were the most important factors out of the three factors' effectiveness on the cold chain logistics development for fresh agricultural products.

Therefore, whether the relevant government departments or cold chain logistics enterprises should be focused on taking constructive measures to solve these three problem sremain a subjective matter. However, it may be concluded that the immediate construction or development of modern cold chain logistics systems in Xinjiang could play some important roles in the trading of fruits and vegetables (whether locally or internationally) in this region.

Regarding the issues of limitations, the evaluation was only based on the researchers' own experiments, and simulations, as well as judgments based on other experts' works, mastery, principles, policies and ideas in relation to this specific topic under investigation. Therefore, the study recommends the use of more comprehensive data and expertise in order to outline and strengthen how reliable this hybrid method (IAHP)and how useful it could beas compared to the traditional one (AHP). More studies of this nature should be conducted. This hybrid method improved and contributed towards this known AHP's shortcomings by improving its validity (loss of important information in its criteria, plus the amount of pair wise comparisons for the assessment of other alternatives in relation to the role they played in the criteria, which become essentially high), not to detract from its potential in helping managers to split complicated decision-making issues into easier ones. Moreover, the improved model also showed an ability to function well in tackling vague input data. The results of the study suggested that IAHP could be useful adding some practical valuein terms of the development of policiesand in managerial decisions in order to determine ways to deal with uncertainties or risks in the supply chain and any other complex situations, which the traditional AHP could not fully address. Finally, this improved AHP will contribute to the body of existing knowledge.

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