Supply Chain Key Success Factors for Organic Agricultural Products: Case Study in Taiwan

Ching-Chiao Yang[1], Po-Lin Lai[2], Ying Li[2], Yin-Yu Hsu[1],

[1]Department of Shipping and Transportation Management,

National Kaohsiung Marine University,
No. 142, Haijhuan Rd., Nanzih District, Kaohsiung City, Taiwan 811,
yangcc@webmail.nkmu.edu.tw

[2] *Department of International logistics, Chung-Ang University,*
84 Heuksuk-Ro, Dongjak-Ku, Seoul 06974, Republic of Korea
Polin@cau.ac.kr (corresponding author)

***Abstract*— The Analytic Hierarchy Process (AHP) method is employed to evaluate the significance of various criteria influencing development of the organic agricultural products supply chain in Taiwan. A three-level hierarchical structure with four dimensions and 19 criteria was proposed based on literature review and personal interviews. Sourcing results from an AHP survey indicates that "policies and laws" are perceived as the most crucial factors influencing development of the organic agricultural products supply chain in Taiwan, followed by "manufacturing capability", "marketing capability", and "logistics capability". Overall, results indicate that the five most critical criteria influencing development of the organic agricultural products supply chain in Taiwan are "organic agricultural products approval and certification", "capital acquiring", "improving cultivated skills", "establish stable system of distribution", and "transparent and reasonable pricing". It is important to note that government and related authorities also put more effort in "temperature control" and "post-harvest handling". The result reveals that logistics capability is a critical factor influencing development of the organic agricultural products supply chain in Taiwan whereas few previous studies have discussed this issue. From this study can provide some suggestions for the policy makers to determine the main factors for the organic product supply chain.**

***Keywords*—** Organic product; Supply chain; Analytic hierarchy process (AHP).

1. Introduction

The agriculture industry played a key role in accelerating economic development in Taiwan since 1960s. The value of agricultural exports and imports reached $20.86 billion (USD) in 2016 and accounted for 3.7% of the total value of trade in Taiwan [1]. Since entering the World Trade Organization (WTO), trade liberalization has forced Taiwan's agriculture industry to face fierce competition in domestic and foreign markets that have severely affected agricultural system and resulted in a decline in farmers' income and farm labour in Taiwan [2]. Global and regional economic integration has forced each country to sign the Free Trade Agreement (FTA) for facilitating the international trade by customs tariff reduction. The FTA was signed by major countries, therefore Taiwan's agricultural export has faced competition and been replaced by other countries agricultural exports. The value of agricultural exports[1] accounted for only 1.78% in 2016 and trade deficit dramatically increased from $ 4.3 billion (USD) in 2000 to $10.3 billion (USD) in 2016 [1].

The agriculture industry in Taiwan has features of small-scaled operations, elder farmer, shortage of labour, high harvesting cost and instability of quality and stock [2]. In contrast, some well-known multi-national grocers, such as Dole (Dole Food Company, Inc.), pursued the economies of scale by investing large funds in production and marketing. By integrating and cooperating with farmers, Dole can adopt standardized operation process from harvesting to delivery along the entire supply chain. Accordingly, the economy of scale has led Dole to have a high market share on agricultural products [3]. Given this competitive marketplace, agricultural industry has lost its vital role in the export market. Therefore, it is imperative for farmers or government authorities to increase industrial competitiveness in Taiwan.

To meet the challenge of trade liberalization, government and related authorities have proposed subsidizing policies for developing modern agriculture to increase competitiveness in the agriculture industry. Public awareness of health and food safety has also forced rapid development of organic agriculture in Taiwan. The transformation of

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

traditional agriculture into organic agriculture is seen as one of the best strategies to increase farmers' competitiveness and profitability. Organic agriculture is the most environmentally-friendly methods to produce agricultural products. It must comply with the principle of sustainable use of natural resources with no use of synthetic chemicals, and stresses ecological balance of the soil and water to achieve the goal of producing safe and natural products [1]. After introducing the "*Agricultural Production and Certification Act*" in 2007, the government initiated several regulations such as "*Organic Agricultural Product and Organic Agricultural Processed Product Certification Management Regulations*" and "*Imported Organic Agricultural Product and Organic Agricultural Processed Product Management Regulations*" to manage organic agricultural products.

According to [4] revealed that 170 countries participating in organic agriculture and farming organic agricultural land had produced 43.1 million hectares. The organic market size had increased from $15.2 billion (USD) in 1999 to $72 billion (USD) with five times growth in 2013 in the world. Conversely, organic agricultural land produced 6,071 hectares in Taiwan and the value of organic agricultural products only increased from $0.08 billion (USD) in 2010 to $0.12 billion (USD) in 2014 [1]. Although the government has proposed the "Youth Project" and the "Young Farmers' Training Program" to encourage young talent to participate in the agricultural industry the development of organic agriculture in Taiwan is still in its infancy compared to other countries. The main reasons for this are high production costs, distribution channels, and difficulty in acquiring organic agricultural land.

Many advanced countries have actively engaged in the development of organic agricultural. To ensure the quality and safety of organic agricultural products and increasing farmers' competitiveness, it is imperative to recognize the critical factors influencing development of the organic agricultural industry. Although several studies have addressed this issue, to the best of our knowledge these studies were conducted independently from views on policy and regulation, production technology, and marketing and promotion from the entire supply chain. Therefore, this empirical study explores key success factors influencing the development of organic agricultural products supply chain in Taiwan.

This study has five sections. Section 1 introduces the motivation, background and purpose of the study. Section 2 discusses the literature review of the status of the organic agricultural supply chain. Section 3 describes the AHP analysis used here. Section 4 presents the results of this analysis. Our conclusion and this study's implications are discussed in the final section.

2. Literature review

2.1 Organic agricultural supply chain

Supply chain is a business process from the procurement of raw materials and products required to end customers through cash, logistics and information flow [5]. The organic agricultural supply chain refers to the initial breeding development, cultivating, ripening, harvesting and producing validation or quarantine through grading, sorting, packaging, transporting, processing, storing, wholesale, retailing, promoting and sending and receiving market information, following into the market to sell until delivered to the final customer [6]. Agricultural logistics is a process in which agricultural products are delivered from original markets, wholesalers, retailers, and finally to consumers, via a set of logistical value-added activities including collecting, grading, packaging, transporting, processing, storing, promoting, and information collecting [7]. Typically, there are four kinds of agricultural marketing; traditional marketing, joint marketing, contact marketing, and direct marketing [8].

Traditional marketing refers to a producer delivering products to a wholesale market by traffickers after gathering, and reselling to consumers via retailers in traditional markets [2]. Joint marketing is integrating products into a distribution unit, and delivering to markets for sale with the power of the farmers' group. [8] defined joint marketing as farmers shipping their products to a collection yard that on sorts, grades, packages their products, etc. after acquiring the code and account number from the farmers' association, cooperative farms or other farming communities. Then, the farmers' association or cooperative association will transport the products to wholesale markets and sell the products to consumers through retailers.

Contract marketing is set by buyers and sellers to form a fixed partnership. The content states quantity of transaction, price, quality, maturity and delivery method, until expiration date to complete the transaction. According to features of the contract, the seller has the advantage in selecting buyers to sustain a stable income and promote trade efficiency. For the purchaser, contract marketing enables control of production input and diversity of decision-making [9]. [10] characterized Taiwan agricultural products as belonging to a spot market, meaning farmers urgently seek buyers when harvesting is nearing. Consequently, the reason why farmers choose is because of lower risks and stable income. The popularity of the internet and e-commerce development, has spawned the direct marketing mode to meet the new consumer pattern. [11] noted that most consumers prefer conduct business online or via telephone to purchase goods because of convenience. Consumers choose the method of payment according to needs and designate delivery the location or pickup mode. Then, the order

is transmitted to producers. After receiving orders, producers will package their product (or products) or authorize the packaging center to sort, grade and package, etc. the product or products, for distribution to customers via logistical means; or collect, pre-cool, grade, package, refrigerate, distribute and make collections via agricultural logistics centers.

2.2 Key success factors for organic agricultural products supply chain in Taiwan

To ensure quality and safety of organic agricultural products from farm to table, it is imperative to understand key success factors of organic agriculture from the entire supply chain. Based on [12] studies on organic agriculture, four major factors were identified; production capability, policy and regulation, marketing capability, and logistics capability, and are described as follows.

2.2.1 Production capability

Products move into market at the same time during the peak period, resulting in supply considerably greater than demand, leading to fierce competition and lower prices. Therefore, farmers should make use of market segments, such as implementation of quality grading standards [13, 14], and acquisition of verification of organic agricultural products [15]. It could create differentiation of agricultural products.

2.2.2 Policy and regulations

Taiwan introduced the "Agricultural Production and Certification Act" in 2007, which stipulates that agricultural products must be approved by competent authorities for sale as organic agricultural good [15]. According to "agricultural production and organic processed agricultural products method and verification management", if applying to a certificate, a certification institution will assign auditors to inspect the production environment, water quality, soil and pest management as well as harvesting, storing, and packaging after signing the contract with an applicant [15].

Compared to traditional agriculture, organic agriculture products and approval of such products must have relevant policies, regulations and construction norms to foster. The threshold of investment is higher. For inspiring farmers to engage in organic agriculture, the government should set relevant counseling or subsidies to reduce production costs.

2.2.3 Marketing capability

Organic agricultural products must be in smooth marketing channels because of intolerant storage characteristics. Since market access has been one of the challenges of selling organic agricultural products farmers need consider whether there is a channel of distribution and invest in the operation after evaluation [7]. To address lagging sales lacking a robust sales pipeline, government should integrate production, supply path and group meals, and set up organic produce counters at supermarkets and stores with a lease agreement and establish an organic farmers market to improve cooperation and stability in the supply chain.

2.2.4 Logistics capability

The process of fresh organic agricultural products from harvest to consumers relies on the temperature control technique to extend the life cycle and maintain freshness and quality. Time, distance and temperature change may cause changes and compromise product quality [16, 17]. If the storage environment cannot maintain the proper temperature, it will lead to growth of bacteria and microorganisms, shorten shelf quality and accelerate a recession from loss of income.

According to relevant literature and interviews, this study summarizes four dimensions for critical success factors for organic agricultural products supply chain; policies and regulations, production capability, marketing capability and logistical capability. The key success factors which are collected from relevant literatures and developed a hierarchy of key success factors for organic agricultural products in Taiwan are divided into four dimensions (as shown in Figure 1).

3. Methodology

3.1 Structure and definition

Data were collected through AHP questionnaire survey and semi-structured interview. Four dimensions, along with 19 criteria, presented in Figure 1, were identified from previous studies and interviews and used in the questionnaire.

3.2 Questionnaire design and sampling technique

Questionnaire design is based on analytic hierarchy process to establish a hierarchical structure, an investigation of the "key success factors for organic agricultural products supply chain in Taiwan". As recommended by [18], a range scale of relative significance from 1 to 9 was used for this questionnaire (See Table 1). After collecting the questionnaires, make comparative judgments to filter out the CR values less than 0.1 and obtain weights in different hierarchies by re-use of Expert Choice. This study examined Taiwan's organic agricultural supply chain key success factors through expert surveys. Therefore, 50 surveys were interviewed, 15 for government (academia, government departments, civil society); 15 for producers; 20 for logistical facilitators (distributors, organic monopoly stores,

supermarkets, discount stores and agricultural products logistics centers).

The AHP, proposed by [19], is a multiple criteria decision-making (MCDM) method that has been widely used to formulate and analyze decisions. When constructing an evaluation model and assigning relative criterion weight, it could be divided into the following steps [20]:

1. Describe the problem.

First, determine the desired target of which the function should be considered generally while establishing an expert team. Clarify the causal relationship of complex issues between the front and rear.

2. Construct a hierarchy.

Members brainstorm to identify the methods of scheme and determine required changes in the project. Then, group similar elements not more than seven in total on the same level.

3. Design the questionnaire and survey.

Each level based on upper level should be compared with each other by a nine range scale. Consequently, the questionnaire should be designed for the planning group to fill in to determine relative significance.

4. Develop a comparison matrix.

Elements in each level are compared in pairs with respect to their importance to an element in the next level. The first of the pair comparisons are made at the top of the hierarchy, working down, and may be reduced to a number of square matrices $A=\lfloor a_{ij} \rfloor_{n\times n}$ as in the following matrix:

$$A=\lfloor a_{ij} \rfloor=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}_{n\times n} \quad (1)$$

5. Compute the relative weights.

Evaluate the weights of elements in each level according to the comparison matrix.

6. Calculate the consistency of judgment.

Check the entire hierarchy with consistency due to the differences of importance in each level. Saaty (1980) suggested CR value should be approximately 0.1, to yield consistency. The CR may be calculated using Equation (2) & (3) as follows:

$$CR=\frac{CI}{RI} \quad (2)$$

$$CI=\frac{1}{n-1}(\lambda_{\max}-n) \quad (3)$$

Among them, CR is consistency ratio; CI is consistency index; RI is random consistency index shown in Table 2.

4. Results of the AHP survey

4.1 Basic descriptive statistics analysis

This study used AHP to investigate critical factors for the organic agricultural products supply chain in Taiwan. The 50 questionnaires were sent to (1) government (2) producers (3) logistical dealers, as executives for industry operators or working in the field for more than five years. A total of 33 questionnaires were collected with 15 usable responses, and the response rate was 30%. In terms of years of service, 6-10 years and 5 years were in the majority for 33.3% and 26.7%; in terms of work title, all respondents were managers and executives; in terms of industry, 53.3% of respondents were in charge as operators responsible for profit and loss. Therefore, their perception of affecting the supply chain has credibility. Regarding government titles, there were chairman, general manager, professor, chief, clerk and professor with agricultural Ph.D. background, mostly working for 14-24 years (See Table 3).

Table 1. The fundamental scale

Intensity of importance on an absolute scale	Definition
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

Source: [19]

Table 2. Random consistency indices (RIs)

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Source: [20].

4.2 The analysis of weight influencing the key factors for the organic agricultural products supply chain in Taiwan.

This section involves making comparative judgments in light of 15 responses and obtaining the weights in different hierarchies respectively for the government,

producers and logistical dealers. Differences of viewpoint between each other, are explained as follows:

4.2.1 The first level local weight analysis

Results are shown in Table 4. The government perceives production capability (0.312) as the most critical factor influencing the organic agricultural products supply chain, followed by policy and regulations (0.275), marketing capability (0.208) and logistical capability (0.205); Producers indicate that their order of factors are policy and regulations (0.409), production capability (0.282), marketing capability (0.192) and logistical capability (0.117); as to logistical dealers, marketing capability (0.304) is the most crucial factor, followed by policy and regulations (0.277), production capability (0.271) and logistical capability (0.147). To summarize, all respondents perceive policy and regulations (0.320) as the most influential factor, followed by production capability (0.293), marketing capability (0.232) and logistical capability (0.155).

Table 3. Profile of respondents

Items		Object	Number of people	Percent (%)
Category		Government	5	33.3
		Producer	5	33.3
		Logistics dealer	5	33.3
Seniority		Below 5 years	4	26.7
		6 to 10 years	5	33.3
		11 to 15 years	3	20.0
		Over 21 years	3	20.0
Title	Government	Chairman	1	6.7
		General manager	1	6.7
		Chief/clerk	2	13.3
		Professor	1	6.7
	Producer	Executive	5	33.3
	Logistics dealer	Executive	3	20.0
		Manager	2	13.3
In total:15				100

4.2.2 The second level local weight analysis

The second level local weights of each attribute are shown in Table 5. In terms of policy and regulations, all experts perceive agricultural product verification (0.338) (0.405) (0.418) (0.390) as the most significant attribute influencing the supply chain. As for production capability, the government points out that the cultivation technique (0.329) is the most crucial attribute while all producers, logistical dealers and other experts consider acquisition of funds (0.386) (0.260) (0.285) as more significant. In terms of marketing capability, promotion of agricultural products (0.294) is the most influential attribute for the government; in contrast, all producers, logistical dealers and other experts consider an effective and viable system (0.304) (0.331) (0.269) as more critical. Regarding logistical capability, temperature control (0.343) (0.368) (0.281) (0.337) is a key attribute in relation to the government, producers, logistical dealers and other experts.

4.2.3 The global weight analysis

Global weights are synthesized from the second level local weights multiplied by the first level local weights. The findings shown in Table 6 are that cultivation technique (0.102), agricultural product verification (0.090), getting mark of agricultural product (0.073), establishment of organic farming area (0.068) and promotion of agricultural product (0.068) are perceived by the government as the top five important criteria; The top five order of producers' perception are agricultural product verification (0.152), subsiding and inspiring to plant (0.107), acquisition of funds (0.105), effective and viable system (0.071) and certification institution management (0.069); Logistical dealers, however, consider the top five criteria are effective and viable system (0.097), agricultural product verification (0.088), cultivation technique (0.086), acquisition of funds (0.084) and transparent and reasonable pricing (0.069). In summary, agricultural product verification (0.101) is the most influential criteria, followed by acquisition of funds (0.092), cultivation technique (0.087), effective and viable system (0.073) and transparent and reasonable pricing (0.064).

5. Discussion and Conclusion

This purpose of this study was to examine the significance of various factors influencing the organic agricultural products supply chain in Taiwan through an AHP model. The main findings of this study are threefold. First, policy and regulations are the most critical factors influencing the first level, followed by production capability, marketing capability and logistical capability for all experts' perception. This result closely compares with [12], revealing that previous opinions of experts or current perception demonstrate that key factors rely on standard policies and regulations, producing high-quality products via excellent production capability and finally selling to customers.

Second, the government, producers and logistical dealers agree that agricultural product verification is the most crucial attribute that may improve competition in terms of policy and regulations. As to

production capability, acquisition of funds is perceived as the top attribute by producers and logistical dealers while the government considers cultivation technique as more critical. In terms of marketing capability, an effective and viable system is the most influential attribute according to producers and logistical dealers, but the government perceives the promotion of agricultural products as a critical attribute. Interestingly, the less significant criteria "promotion of agricultural products" for producers and logistical dealers is more critical for government, because it implies that consumers lack awareness about organic agricultural products. Therefore, the most urgent issue is positive for the education of consumers' awareness. To summarize, temperature control is regarded as the most critical attribute in logistical capability, for the process of organic agriculture from harvest to customers. Producers depend on temperature control technique to extend the storage life and quality of their products.

Finally, the most significant attribute influencing the supply chain is agricultural product verification, followed by acquisition of funds, cultivation technique, effective and viable system and transparent and reasonable pricing. This result is consistent with [12] in which agricultural product verification is a key factor in the organic agricultural product supply chain in Taiwan. Consequently, formulating standard policies and regulations may protect agricultural producers and gain the trust of consumers.

We may see cognitive differences in parts of factors and attributes about government, producers and logistical dealers. This study suggests the differences are due to three experts respectively in their fields, resulting in the discrepancy of perspective between production capability and marketing capability. Policies and regulations are perceived as critical factors. In addition, the consensus is that agricultural product verification is the most influential attribute. However, all experts have a discrepancy of cognition in seven attributes for subsiding and inspiring to plant, establishing organic farming areas, getting mark of agricultural product, transparent and reasonable pricing, effective and viable system, promoting of agricultural products, and temperature control. From a theoretical perspective, this study identifies crucial criterion influencing the organic agricultural products supply chain in Taiwan. Hence, this study proposes to bring policies into force by authorities, such as formulating standard and agricultural product verification, acquisition of funds, promoting cultivation technique, establishing an effective and viable system and setting transparent and reasonable prices.

However, there were two limitations in this study. First, the objects are government, producers and logistical dealers excluding consumers. Therefore, future studies should explore consumers' perspectives about the organic agricultural product supply chain and the discrepancy. Second, the scope of study was mainly about organic agricultural products produced in Taiwan. Therefore, future studies may expand the scope of research and examine the impact of different products for operation in the organic agricultural product supply chain.

Acknowledgments

This Research was supported by the Chung-Ang University Research Grants in 2017.

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Table 4. The first level local weight

Factors	Government		Producer		Logistical dealer		All experts	
	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
Policy and regulations	0.275	2	0.409	1	0.277	2	0.320	1
Production capability	0.312	1	0.282	2	0.271	3	0.293	2
Marketing capability	0.208	3	0.192	3	0.304	1	0.232	3
Logistical capability	0.205	4	0.117	4	0.147	4	0.155	4

Table 5. The second level local weight

Factors	Attributes	Government		Producer		Logistical dealer		All experts	
		Weights	Rank	Weights	Rank	Weights	Rank	Weights	Rank
Policy and regulations 0.320	Agricultural product verification	0.338	1	0.405	1	0.418	1	0.390	1
	Subsiding and inspiring to plant	0.178	4	0.285	2	0.226	3	0.228	2
	Certification institution management	0.228	3	0.184	3	0.228	2	0.217	3
	Establishment of organic farming area	0.256	2	0.126	4	0.128	4	0.164	4
Production capacity 0.293	Cultivation technique	0.329	1	0.215	2	0.255	2	0.269	2
	Acquisition of funds	0.211	3	0.386	1	0.260	1	0.285	1
	Scale of cultivation	0.103	5	0.117	5	0.159	4	0.126	5
	Classification of agricultural product	0.121	4	0.157	3	0.172	3	0.152	4
	Getting mark of agricultural product	0.235	2	0.124	4	0.154	5	0.168	3
Marketing capacity 0.232	Transparent and reasonable pricing	0.200	3	0.246	2	0.237	2	0.236	2
	Effective and viable system	0.175	4	0.304	1	0.331	1	0.269	1
	Promotion of agricultural product	0.294	1	0.170	4	0.142	4	0.199	3
	Brand reputation	0.225	2	0.194	3	0.114	5	0.175	4
	Product diversity	0.106	5	0.085	5	0.176	3	0.120	5
Logistical capacity 0.155	Temperature control	0.343	1	0.368	1	0.281	1	0.337	1
	Logistical timeliness	0.148	4	0.195	2	0.203	3	0.185	3
	Value-added services	0.072	5	0.165	4	0.084	5	0.102	5
	Preservation technology	0.273	2	0.189	3	0.255	2	0.240	2
	Pollution prevention when packaging and tallying	0.164	3	0.083	5	0.177	4	0.137	4

Table 6. Global weights and rank

Factors	Attributes	Government		Producer		Logistical dealer		All experts	
		Global weights	Rank	Global weights	Rank	Global weights	Rank	Global weights	Rank
Policy and regulations 0.320	Agricultural product verification	0.090	2	0.152	1	0.088	2	0.101	1
	Subsiding and inspiring to plant	0.047	11	0.107	2	0.048	10	0.059	6
	Certification institution management	0.061	8	0.069	5	0.048	11	0.056	7
	Establishment of organic farming area	0.068	4	0.047	8	0.027	18	0.042	13
Production capacity 0.293	Cultivation technique	0.102	1	0.059	6	0.084	4	0.087	3
	Acquisition of funds	0.065	7	0.105	3	0.086	3	0.092	2
	Scale of cultivation	0.032	15	0.032	14	0.053	7	0.041	14
	Classification of agricultural product	0.038	14	0.043	11	0.057	6	0.049	10
	Getting mark of agricultural product	0.073	3	0.034	13	0.051	8	0.054	8
Marketing capacity 0.232	Transparent and reasonable pricing	0.046	12	0.058	7	0.069	5	0.064	5
	Effective and viable system	0.040	13	0.071	4	0.097	1	0.073	4
	Promotion of agricultural product	0.068	5	0.040	12	0.041	14	0.054	9
	Brand reputation	0.052	10	0.045	9	0.033	16	0.048	12
	Product diversity	0.024	18	0.020	17	0.051	9	0.033	16
Logistical capacity 0.155	Temperature control	0.067	6	0.044	10	0.047	12	0.049	11
	Logistical timeliness	0.029	17	0.023	15	0.034	15	0.027	17
	Value-added services	0.014	19	0.019	18	0.014	19	0.015	19
	Preservation technology	0.053	9	0.022	16	0.043	13	0.035	15
	Pollution prevention when packaging and tallying	0.032	16	0.010	19	0.029	17	0.020	18

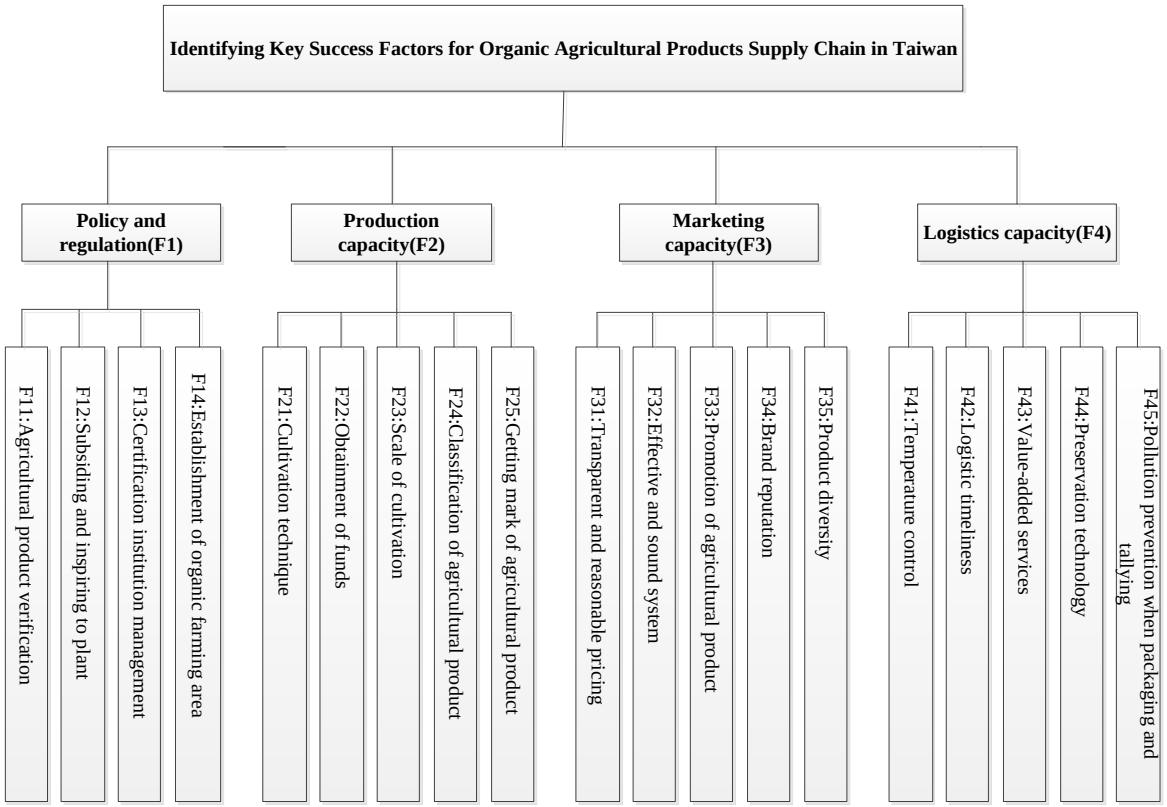

Figure 1 The AHP model