Structure innovation of agricultural supply chain in china: from farmers’ perspective

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Abstract

There are three serious problems in the traditional agricultural supply chain structure in China, namely, the blockage of information channels and the poor transmission of information, the subordination of farmers and the low distribution of network profits, the unstable contract and the loose supply chain. Among them, the first problem is the core problem. This paper attempts to design an innovative ASC structure to solve these problems. Firstly, from the perspective of farmers, this paper analyzes the agricultural sustainable development of network embedding, and draws the following conclusions: with the increase and deepening of farmers' network embedding relationship, farmers can obtain more effective information about the whole agricultural sustainable development, and finally improve their profit distribution ratio. But how to increase this network embedding relationship? To solve this problem, we introduce the platform theory and consider redesigning ASC by embedding the integrated management information platform (IMIP). Then, we made a mathematical analysis. Through the comparison of absolute value and relative value, we find that the innovative structure can not only increase the amount of effective information that farmers get from ASC, but also increase the total amount of information from all stakeholders and the proportion of farmers' information in the total amount of ASC information. In view of this, we believe that the innovative structure of ASC can effectively solve the problems existing in the traditional ASC structure.

Keywords: ASC; Network embedding; Platform; IMIP; Innovation design
AMS 2020 codes: 90C35
1 Introduction

In October 2015, the World Bank varied the poverty line standard from the daily expenses of $1.25 to $1.90. The poverty population of China is bound to over 200 million in statistics. What’s more, the vast majority of the poor lives in a remote village at the junction of provinces. China’s anti-poverty task is very arduous, especially in rural areas. Agriculture occupies a large proportion of the rural economic structure, and agricultural products sales become the main source of income of rural families, especially poor families. But, in traditional structure of ASC, the effective information farmer can obtain is far less than products processing enterprise, middleman and retailer. Under this situation, farmers are usually in a subordinate position in ASC when negotiating with other stakeholders and then lead to a low profit share. From forms’ perspective, we introduce the theory of network embedding and platform to creatively design a new organization structure of ASC, hoping to increase farmers’ income and reduce poverty.

2 Defects of traditional structure of ASC

Based on fieldworks, Chinese scholars have concluded the existing organizational model of ASC in China. Combined with the current situation of China's agricultural development, Zhang (2004) summed up three successful ASCs: sales cooperation organization of farmers, integrated enterprise including production, processing and sales, logistics management of food supply chain. From the prospective of organization’s motivation, Tan (2004) proposed that the ASC in our country should put the processing enterprise as the core or consider the logistics center as the core. Hu (2006) put forward “two element structure” theory of agriculture and paid attention to “supermarkets + leading enterprises + farmers” model, in which the supermarkets is considered as the core. According to the degree of integration, Wang (2009) divided the ASC in China into four types: family production, base production, “enterprises + farmers” model and “export” model. Zhang (2009) thought that we should taking the enterprise oriented wholesale market as the network core, or taking the agricultural group, containing production, processing and sale, as the network core, or taking the agricultural products distribution center as the network core. According to different subjects in the dominant position, in our paper, we can divide our existing ASC into four categories: no dominant subject, processing enterprise is the dominant subject, distribution center or middleman is the dominant subject, retailer is the dominant subject. The above figure displays a complete organization model of ASC. But we must pay attention to this fact: no matter what kind of model and who is in the dominant position, there are some problems in traditional structure of ASC.

Figure 1. Traditional structure of ASC
2.1 Blocked information channel and poor information transmission

Information channel is an essential carrier to connect all business entities of ASC, and will affect their economic behavior. The smoothness of the channel is related to the timeliness, comprehensiveness and usefulness of information transmission. Li (2004) believed that asymmetry information, resources and abilities among subjects will do harm to the safety of agricultural products. China doesn’t attach importance to the construction of information platform, which is critical to the operation efficiency of network organization. In such a situation, it is easy to occur “indirect selecting” and “moral risk”, which will increase many network costs, such as management cost, decision-making cost, procurement cost, transportation cost, packaging cost, processing cost and market cost.

Along with the increasing of social economy level, people’s consumption concept about agricultural products is changing gradually: from the pursuit of a single variety meeting life need to diverse, safe and quality varieties. But farmers are far from market information sources and “bullwhip effect” is obvious in the transmission of information. It’s hard for farmers and production cooperation organization to make effective decisions based on market information and consumer demand. Meanwhile, the fact that agricultural products stranded in supply chain network will undoubtedly reduce the freshness of agricultural products and consumer satisfaction. Because of the low transparency, consumers are difficult to learn accurate information about agricultural products’ production, processing and logistics and will appear lots of questions about agricultural products consumption. And also, they are difficult to purchase satisfied products because of narrow selection.

2.2 Farmers’ subordinate status and low network profit distribution

In the above, we summarize four models. But no matter which model, farmers are not able to seize the strategic core position of ASC. Due to fewer network resources and information, it’s hard for farmers to establish a stable contractual relationship with other business entities and often they have to subject to other actors. A subordinate position in ASC corresponds to a lower profit share, just as the figure 2 show us. And this will lead to serious consequences: even if the whole supply chain profit increases, its income effect and poverty alleviation effect are limited. Li (2006) insisted that farmers and production cooperative organizations should be the core of ASC.

![Figure 2. Defects of traditional ASC](image)

2.3 Unstable contract and loose supply chain

The resources and information acquisition models of interests relate units determine their participation mode and contract mode, and then their profit distribution pattern. Due to a lack of capital, technology, management methods and other critical market participation elements, in the existing market economy, farmers are in a passive and unfavorable position when they do negotiation and contract with other units. The result is: it is difficult for them to obtain long-term and stable contracts. Unstable contracts will take serious constraints of agricultural products’ timely production and sales and then increase the pressure of safety, quality and preservation. At the same time, the quality and quantity of agricultural products will suffer damage and waste in the process of transportation, storage and packaging.
3 Network embedding and platform theory

3.1 Network embedding

Most scholars agree with this view: the network embedding method has an influence on behavior subjects’ business performance, competitive advantage and profit level. Granovetter (1973) used the concept of weak ties earlier and believed that different patterns of ties will bring different information and knowledge to subjects and then the different business performances. Burt (1992) paid attention to enterprise network structure and raised the concept of structural hole, which is the essential place when information and resources flow through the network. So if an enterprise is located in the network structural hole, it can control more information and resources and win competitive advantage. McEvily and Marcus (2005) believed that the embedded ties that enterprises form in networks and alliances would indirectly influence its competitive position through competitive behaviors. Under the background of the strategic transformation of Chinese manufacturing enterprises, Liu (2009) took four manufacturing enterprises as research objects and constructed a conceptual model, in which enterprises network embedding method would impact on business strategy and then on operation performance.

We can understand like this: if a unit has more network embedding ties, it must be in the focus of network and own timely, comprehensive and effective network information. Moreover, it will get more trusts from other units and establish long-term, stable cooperative relations. And then, it’s easy for them to formulate a competitive strategy and finally get more profits.

![Figure 3. Farmers’ network embedding ties and poverty alleviation effect](image)

In the previous paper, we got a conclusion: no matter which model the supply chain is, farmers are in a subordinate position. Farmers fail to make full use of their identity of agricultural products supply source to embed into the ASC in a reasonable way and are far from structural hole. Thus, they can’t receive market information and network information timely and accurately and can’t establish a stable and reliable strategic partnership with raw material suppliers, processing enterprises, middlemen and retailers. Finally, they can’t develop scientific purchasing, production and marketing strategies and take effective measures to guard against operational risks and earn high profits. For existing embedding patterns, it is difficult for farmers to shake off poverty through producing and selling agricultural products. According to our summary of network embedding, we can get the following conclusion (just shown in figure 3): along with the increasing and deepening of farmers’ network embedding ties, farmers can obtain more effective information about the whole ASC and ultimately improve their profit distribution proportion.
3.2 Platform theory

Platform theory is based on modularity, and its appearance is in order to cope with the dynamic and uncertain information from industry technology, market demand and competitor. Because of platform theory’s easily understanding and universality, in recent years, it gets more and more attention form theoretical circles and industrial circles. Eisenhardt& Martin (2000) believed that platform is a structure, which is based on organization and dynamic capability and can store organization ability. Evans and Schmalensee (2007) thought that platform can promote different communities interactions and transactions by attracting and benefiting both sides of the transaction, and ultimately be good for the growth of system. Cusumano (2010) considered platform as an intersection center of technology system with indirect network effects. Gawer (2014) epitomized platform theory, in his opinion, platform is an constantly evolving and changing organization, which consists of one or more enterprises aiming at the creation of value. In addition, according to platform’s application range, platform should be divided into 3 types: enterprise internal platform, supply chain platform and industrial platform. However, all types of platforms have a common architecture: a modular architecture consists of one core and some peripheral organizations.

Service-oriented government cannot interfere the normal operation of market economy, but it can promote and advance the healthy and sustainable development of industry and market by formulating and implementing reasonable rules and regulations and establishing appropriate service organizations. As mentioned above, in the traditional ASC system, the information channel is blocked and the information transmission is poor, which is the key and source of other problems. Therefore, it is necessary for service-oriented government to guide the establishment and development of agricultural association, and refer to the experience of Britain and India to scientifically implanted social enterprises into rural areas, and ultimately form an IMIP, which can support related subjects of ASC in information collection, processing, evaluation and supply. Specifically, the IMIP has several advantages:

1) it can comprehensively grasp the whole information of ASC (including industry information, coming from farmers, agricultural products processing enterprises, distributors, retailers and end-users, and geographic information, such as topography, climate, vegetation and hydrology), and then transfer these effective information to related subjects quickly;

2) on the basis of obtaining complete information, management information platform has more professional personnel for agilely information processing, disposal and evaluation, eliminating useless information and deepening useful information so as to provide more efficient and effective information;

3) it can receive timely feedback information, and then conduct self-evaluation and adjustment to make it more adaptive to industry and market, thereby forming a virtuous circle.

4 Mathematic analysis

The information circulation of traditional structure includes two opposite directions: from farmers to consumers and from consumers to farmers. The core problem of traditional organization structure of ASC is the blocked information channel and poor information transmission, which lead to information asymmetry between farmers and other subjects in the ASC, thereby putting farmers onto a passive position during negotiations. Based on the analysis of network embedding and platform theory, we implant IMIP into ASC, redesign the organization structure and change the original information flow path (just as shown in figure 4). Now, to confirm the effectiveness of innovative
organization structure, we consider three problems in mathematic analysis. Firstly, whether farmers can increase their available information about ASC in the innovative structure or not. Secondly, whether the whole ASC, consists of consumer, retailers, middleman, products processing enterprise and farmer, can promote its amount of effective information. Thirdly, whether the proportion that the amount of effective information, farmers can obtain, holds the total number contained in the whole ASC can be improved.

![Diagram of information flow in traditional structure and innovative structure](image)

**Figure 4.** Information flow in traditional structure and innovative structure

To facilitate understanding, analysis and comparison, we make the following hypotheses in the mathematical simulation.

1) From production to consumption, an agricultural product (P) will experience five stakeholders, they are consumer (C), retailer (R), middleman (M), processing enterprise (E) and farmer (F). And the amount of information they contain are IC, IR, IM, IE and IF respectively.

2) Effective information includes three dimensions: timeliness, completeness and usefulness. It is on denying that these three aspects will be subject to a certain degree of loss in the process of information transmission. In this paper, we assume that each information transfer between two stakeholders will decrease the effectiveness of information by a%.

3) Stakeholders cannot grasp the whole information contained in themselves. In this paper, we assume that each subject is able to get b% of the whole information contained in itself.

Now, we define that the amount of effective information farmer can obtain from the whole ASC is EIE. Similarly, we can get EIE, EIM, EIR and EIC. So the total amount of information the whole ASC owns can be expressed as:

\[
\sum EI = EI_F + EI_E + EI_M + EI_R + EI_C
\]

Just as figure 4 shows us, in the traditional structure, IC must experience 4 information transfers to reach F, so the effective information farmer owns about consumer is IC(1 - a%)^4. Likewise, the effective information farmer owns about retailer, middleman and processor are IR(1 - a%)^3, IM(1 - a%)^2 and IE(1 - a%) respectively. Besides, the effective information farmer obtains about itself is IF b%. So, the whole amount of effective information farmer gets about ASC can be expressed as:

\[
EI_F = IC(1 - a%)^4 + IR(1 - a%)^3 + IM(1 - a%)^2 + IE(1 - a%) + IF b%  \tag{1}
\]
In the same way, we can get the whole amount of effective information consumer owns about ASC:

\[ EI_C = I_F(1 - a\%)^4 + I_E(1 - a\%)^3 + I_M(1 - a\%)^2 + I_R(1 - a\%) + I_C b\% \]  

(2)

When it comes to processor, middleman and retailer, the situation is different. They will receive information from two different directions. For example, processing enterprise is the connection of farmer and middleman, which means that information from farmer and middleman can only experience one transfer to reach processor, \( I_F(1 - a\%) \) and \( I_M(1 - a\%) \) respectively. Information from consumer must experience three transfers \( (I_C(1 - a\%)^3) \), and information from retailer must experience two transfers \( (I_R(1 - a\%)^2) \). The whole amount of effective information processor gets about ASC can be expressed as:

\[ EI_E = I_F(1 - a\%) + I_E b\% + I_M(1 - a\%) + I_R(1 - a\%)^2 + I_C(1 - a\%)^3 \]  

(3)

Similarly, we can get the whole amount of effective information retailer owns about ASC:

\[ EI_R = I_C(1 - a\%) + I_R b\% + I_M(1 - a\%) + I_E(1 - a\%)^2 + I_F(1 - a\%)^3 \]  

(4)

The middleman is in the core and intermediate position of the ASC, and it is the connection of products processing enterprise and retailer. Therefore, information from the two subjects is \( I_E(1 - a\%) \) and \( I_R(1 - a\%) \) respectively. Information from farmer and consumer should be transferred two times to get middleman, so we can use \( I_F(1 - a\%)^2 \) and \( I_C(1 - a\%)^2 \) to express them respectively. So, the effective information which is obtained by the dealer is:

\[ EI_M = I_F(1 - a\%)^2 + I_E(1 - a\%) + I_M b\% + I_R(1 - a\%) + I_C(1 - a\%)^2 \]  

(5)

Compared with traditional structure, the innovative one has been embedded into an IMIP, which serves as the information collector and processor of all stakeholders. Under this circumstance, all kinds of information from consumer, retailer, middleman, processor and farmer are firstly gathered to the IMIP, and then passed to every interest after integrating and processing. Take farmer as an example, he has two information channels, one is the understanding of self-owned information, and the other one is to obtain information from IMIP. We should pay attention to this fact that there will be some loss of information when IMIP gathers information from stakeholders. However, under normal circumstance, we hold that it will not exist the loss of information while IMIP transmits information to each subject because of the innovative, selflessness and timeliness of IMIP. So, in the new structure, the effective information farmer owns about the ASC can be expressed as:

\[ EI'_{F} = I_C(1 - a\%) + I_R(1 - a\%) + I_M(1 - a\%) + I_E(1 - a\%) + I_F b\% \]  

(6)

Similarly, we can get the amount of effective information, which processor, middleman, retailer and consumer can obtain.

\[ EI'_{E} = I_C(1 - a\%) + I_R(1 - a\%) + I_M(1 - a\%) + I_E b\% + I_F(1 - a\%) \]  

(7)

\[ EI'_{M} = I_C(1 - a\%) + I_R(1 - a\%) + I_M b\% + I_E(1 - a\%) + I_F(1 - a\%) \]  

(8)

\[ EI'_{R} = I_C(1 - a\%) + I_R b\% + I_M(1 - a\%) + I_E(1 - a\%) + I_F(1 - a\%) \]  

(9)

\[ EI'_{C} = I_E b\% + I_R(1 - a\%) + I_M(1 - a\%) + I_E(1 - a\%) + I_F(1 - a\%) \]  

(10)
To begin with, we compare the absolute amount of information farmer can obtain from traditional structure and the new one. To facilitate the operation, we define $X\ (0<X<1)$, which is equivalent to $(1-a\%)$. Now, formula (1) minus formula (6):

$$EI_F - EI'_F = I_C(X^4 - X) + I_R(X^3 - X) + I_M(X^2 - X)$$

It is easy to test these: $(X^4 - X) < 0$, $(X^3 - X) < 0$, $(X^2 - X) < 0$. So, $EI_F < EI'_F$, which suggests that farmer can get more effective information in the innovative structure of ASC.

And then, we consider the total amount of information all subjects own. Now, (1) + (2) + (3) + (4) + (5), we can get the following result.

$$\sum EI_F = I_F(X^4 + X^3 + X^2 + X + b\%) + I_E(X^3 + X^2 + 2X + b\%) + I_M(2X^2 + 2X + b\%) + I_R(X^3 + X^2 + 2X + b\%) + I_C(X^4 + X^3 + X^2 + X + b\%)$$  \(11\)

In the same way, (6) + (7) + (8) + (9) + (10), we can get $\sum EI_I$.

$$\sum EI_I = I_F(4X + b\%) + I_E(4X + b\%) + I_M(4X + b\%) + I_R(4X + b\%) + I_C(4X + b\%)$$  \(12\)

Formula (11) minus (12), if the result is smaller than 0, then we can know that stakeholders in the new structure holds more effective information than in the traditional one, and vice versa. After being sorted out, the following result can be gotten.

$$\sum EI_F - \sum EI_I = I_F(X^4 + X^3 + X^2 - 3X) + I_E(X^3 + X^2 - 2X) + I_M(2X^2 - 2X) + I_R(X^3 + X^2 - 2X) + I_C(X^4 + X^3 + X^2 - 3X)$$

It can be easily proved these: $(X^4 + X^3 + X^2 - 3X) < 0$, $(X^3 + X^2 - 2X) < 0$, $(2X^2 - 2X) < 0$. So, $\sum EI_F < \sum EI_I$, which shows that subjects in the innovative structure, compared to in the traditional one, owns more effective information.

At last, we think about the relative amount of effective information farmer owns about the ASC. In the traditional structure, the information amount farmer obtains is far smaller than other subjects. However, in the new structure, because IMIP is the main information channel of all stakeholders, and similar information IMIP transmits to each object, so the relative quantity of effective information farmer gets is bigger.

In summary, after the comparison of absolute value and relative value, the innovative structure can not only increase the effective information amount farmer gets form ASC, but also improve the total information amount coming from all stakeholders and the proportion farmers’ information amount occupies the whole ASC.
5 Structure innovation of ASC

![Diagram of Structure innovation of ASC](image)

Figure 5. Structure innovation of ASC

The first step to integrate supply chain is the establishment of ASC’s organization structure (Leng, 2005). According to the analysis of traditional ASC and network embedding theory, we make a strategic innovation design of ASC, just shown in figure 5. By the above analysis, this new structure can effectively solve the problems existing in traditional ASC.

First, it can dredge the information channel and expedite the information transmission between farmers and consumers. The most prominent feature of innovation model is the construction of integrated agricultural management information platform supported by agricultural association, social enterprise and service-oriented government. Based on modern information technology, such as CPS, GPS, GIS, RS, RFID and AC, it is the central controller, which can quickly collect, process and output network information and guide business subjects’ behaviors. It strengthens the information docking and interaction between farmers and consumers and reduces information loss when transferring in network.

Second, it can change farmers’ subordinate status and increase their network profit distribution. In this new structure, they have more network links and can timely and accurately receive market information and network information, so they can easily establish a stable and reliable strategic partnership with raw material suppliers, processing enterprises, middlemen, retailers and other related entities. Thus, they can develop reasonable strategies and take effective measures to guard against operational risks. So, farmers’ status has been highly upgraded and they will have more voice and profit distribution in the new structure. Meanwhile, it can integrate network resources, coming from production, processing, transportation, storage, promotion and consumption, and primary stakeholders, including government, enterprises, farmers, consumers and social organization, to increase network’s overall profit.
Third, farmers can easily sign long-term and stable contracts with other units. Because all entities in the new ASC are making decisions on the basis of similar market information and network information, so they will have more time to consider the details and future of the contracts referring to their interests. And also, other entities, such as processing enterprises and middlemen, can’t utilize the asymmetric information to do something immoral.

Practice is the measure of truth. Now we are striving to apply the research achievements to practice. And we will pay close attention to its application. Hoping that our research can help farmers to increase income and help Chinese government to alleviate poverty and solve “three rural issues”.

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