

Building and Security Measures of China's Large Civil Aircraft Industry

Independent Innovation Network

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Abstract

In order to build the third Large Civil Aircraft (LCA) industry after Boeing and Airbus, China's Large Civil Aircraft (LCA) project emerges under promotion of the national volition. But how to fundamentally improve the industrial capability of independent innovation has become the main problem. Since Chesbrough published his book in 2003, the concept of "open innovation" has received wide attention from practitioners and researchers. The concept of "open innovation" tends to be rather broad, and includes a number of different "modes" ranging from what Chesbrough and Crowther (2006) denote the inbound kind (which deals with the inflow of ideas) to the outbound kind (the outflow of ideas from the organization). This study is focuses on the former, or more specifically on the use of collaborative modes of external knowledge sourcing, which is an important capability of CoPS firms (Bergek et al, 2008) whose main competitive advantage lies in the integration of various sub-components and sub-systems into functioning complex systems (Hobday et al, 2005). Earlier studies have highlighted the general collective and "open" nature of innovation in CoPS industries (Hobday, 1998; Prencipe, 2000). Based on the supply system of Large Civil Aircraft and the current situation of China's Large Civil Aircraft industry, an independent innovation network which includes not only the suppliers and users, but the universities, external research institutes, financial Institutions and government is approached in the study. And then the study illustrates the key nodes and the operation modes of the network. Finally four security measures were proposed to the network.

Key Words: Large Civil Aircraft industry; Independent innovation network; Operation modes; Open innovation

Introduction

In May 2008, Commercial Aircraft Corporation of China, Ltd. (CACCC) was founded in Shanghai. In September 2009, the prototype of the first R&D project that is C919 made its debut. And China's LCA would be produced. As the national volition, LCA project is one of the 16 major projects which is identified by Outline Of The National Program For Long-And -Medium-Term Scientific And Technological Development (2006-2020). Developing the LCA industry is the major strategic decision that building an innovative country and raising the capability of China's independent innovation and enhance the core competitiveness of the country.

However, the fact that the key components like engines and avionics systems are almost purchased abroad makes us have to face the problem that how to raise the independent innovation capability of China's LCA industry. In fact, it is not only the LCA industry, but the major technical equipment manufacturing industry has problems in independent innovation capability. Sendi Zhu(2009) has discoursed that China's major technical equipment manufacturing industry makes unbalanced investment in the innovation modes of digestion, absorption and improvement of introduced that China invests heavily in introduce but under-capitalization in digestion and absorption, which has significant differences which Japan, South Korea and other countries. Yue Chen(2008) believes that the existing problem in the major technical equipment manufacturing industry is that companies isn't the principal of independent innovation and the lack of qualified personnel is one of the reasons that the capability of China's independent innovation is weak. Guobao Zhang(2008) has proposed that there are three problems in the independent innovation capability of the major technical equipment manufacturing industry. Firstly, the government doesn't make an effective management and coordination mechanism for the equipment imports and technology introduction. Some companies only pay more attention to equipment imports but neglect the technology introduction or only concern

about technology introduction but neglect digestion and absorption. And the problem that repeated introduction is very serious. Secondly, state-owned enterprises show lack of motivation of independent innovation and low-level replication is prevailing. Thirdly, the investment in independent innovation is not enough.

In addition to digestion, absorption and improvement of introduced, there are two independent innovation modes that are original innovation and integrated innovation. The objective of the three modes is raising the capability of independent innovation. As matters stand, independent innovation capability of China's LCA industry is weak. As a complex product, it's impossible to be manufactured independently by only one country, but if we rely on technology import completely it will be contrary to the original intention. Therefore, it's needed for China's LCA industry to have a global purchasing as the main manufacturers through open and integrated innovation mode and then build an independent innovation network which is conducive to raising the capability of China's independent innovation. According to the discussion about Enterprise Innovation Network Type by Yunfu Huo et al(2002), the network we should build is hybrid independent innovation network with both vertical relation and horizontal relation that not only including suppliers and customers, but universities, external research institutes, financial institutions and government.

1 Manufacturing Supply System of LCA Industry

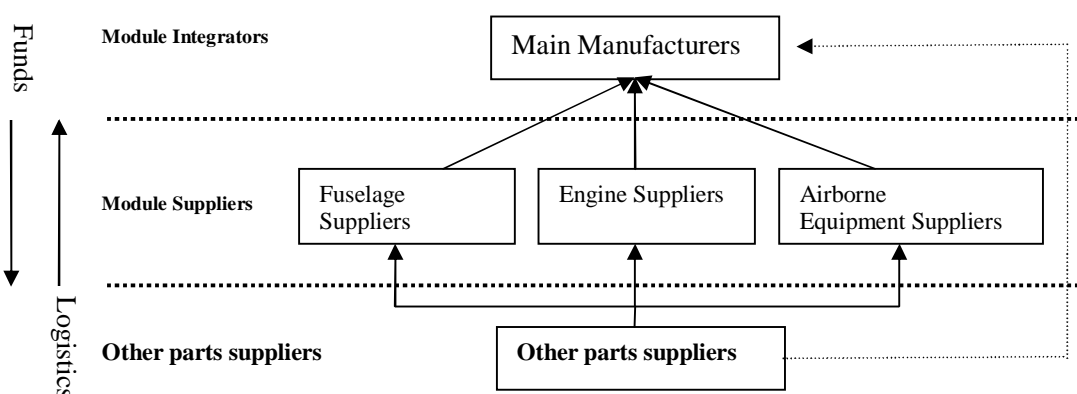


Fig.1. Manufacturing Supply System of LCA Industry

There are three levels in the manufacturing supply system of LCA industry. And the direction of logistics move from suppliers to the main manufacturers, but that of capital is opposite.

Module integrators are on the first level, which are primarily responsible for design, assembly, key technology research and related test of LCA and they also do a part of manufacturing business. The companies on this level have Type Certificate (TC), Production Certificate (PC) and Airworthiness Certificate. They are standard-setters and leaders of technological innovation in the manufacturing supply system. The objective of CACC is to be the third main manufacturers after Boeing and Airbus.

According to the structures of LCA, the second level includes fuselage suppliers, engine suppliers and airborne equipment suppliers, which provide the main manufacturers with module supports and related services. Because of the high rate of outsourcing, the companies on the second level play an important role in LCA Industry and the main manufacturers have to collaborate with them in order to deliver products on schedule.

By the end of March 2009, CACC has disseminated announcement to domestic potential suppliers about the information consultation and launched the bidding of body structures and system equipments. More than 400 suppliers participated in the bidding and in May 2009, CACC established the initial 9 suppliers which provides body parts such as landing gear, doors, wings and so on.

Table 1
9 Domestic Suppliers of CACC

Name	Order	Parent Company
The Research Institute for Special Structures of Aeronautical Composite (RISAC) AVIC	Design, manufacturing, testing of radome and Airworthiness Certificate	Aviation Industry Corporation of China
AVIC Xi'an Aircraft Industry (Group) Company Ltd.	Manufacturing of fuselage (including the Central Wing), outer warily box (including a fixed front and rear edge), flaps, trailing edge flaps, leading edge slats and spoilers	
Shenfei Civil Aircraft Company Ltd.	Design the fuselage tail with CACC together	
Chengdu Aircraft Industry (Group) Company Ltd.	Manufacturing of aircraft nose	
Harbin Aircraft Industry (Group) Co., Ltd.	Providing composite on airframe	
Hongdu Aviation Industry Group Ltd.	Manufacturing of forward fuselage and aft fuselage structure	
Changhe Aircraft Industry Group Ltd.	Research and manufacturing of wing spoiler and other parts	China Aerospace Science and Industry Corp.
The Research Institute for Special Material and technology of Aeronautical	Providing four packages including winglets, aileron, spoiler and aft fuselage caudal	
Xizi UHC	Provision of non-hermetic doors	Private Company

On the hand of engine suppliers, CACC has accepted the proposals about the power plant of LCA

project which submitted separately by Pratt & Whitney, Goodrich and CFM that is the joint venture of GE and Snecma. And one of them will be established to be the engine supplier of China's LCA. What's more, because of the objective of proprietary intellectual property rights, AVIC Commercial Aircraft Engine Corporation Ltd. will become the engine supplying partner of CACC.

Since China can't independently manufacture the airborne equipments, aviation electronic systems, power systems, air management systems, flight control systems, hydraulic energy systems, fire protection systems, water supply / water treatment systems and other important systems will be provided by the suppliers from the U.S., Germany, Switzerland, France and other countries.

The other parts suppliers are on the third level whose main business is providing the companies on the second level with parts, raw materials and related services. As the lowest-level suppliers in Manufacturing Supply System of LCA, it's possible to become the model suppliers for them through technological innovation and learning. So they are the potential suppliers of main manufacturers. Accordance to the strategic cooperation agreement, Baosteel Group Corporation and Aluminum Corporation of China will provide China's LCA industry with technological support of dedicated materials which can be manufactured on a large scale by several developed country such as the U.S., Japan, Germany and so on.

2 Building of China's Large Civil Aircraft industry independent Innovation Network

2.1 Main nodes of independent innovation network

The building of independent innovation network is based on the Manufacturing Supply System of LCA Industry whose participants are the initial technology sources of integrated innovation. The participants are located in the vertical nodes on the independent innovation network. But in order to make sustainable innovation, the builder has to integrate universities, financial institutions and other resources outside the Manufacturing Supply System and make them the key horizontal nodes in the independent innovation network.

(1) CACC and its suppliers

In the independent innovation network, as the main manufacturers CACC is technology innovation leader and it is responsible for identifying the market demand and setting the standard of technological innovation. What's more important, CACC is the industrial technology integrator. Being different from others innovation networks, there is only one core company in China's LCA industry independent innovation network and the links between all the nodes rely on CACC.

Module suppliers and other parts suppliers are the upstream suppliers of CACC and the direct sources of technology. They play an important role in collaborative innovation with CACC.

(2) Civil Airlines and Aircraft Leasing Corporations

Domestic and international large-scale civil airlines and aircraft leasing corporations are located on the downstream nodes in the industry chain and they are the sources of LCA orders. They promote the technological innovation and lead the way of innovation.

(3) Financial Institutions

Financial institutions are the capital sources and circulation medium of independent innovation network. Firstly, the main manufacturer needs plenty of funds to complete the design, R&D, assembly and other business. Secondly, financial institutions are essential to financing for the module suppliers and other parts suppliers. Thirdly, financial institutions are the capital sources of aviation leasing industry, and even sometimes financial institutions would join in the global value chain as the aviation leasing corporation like BOC Aviation.

(4) Government

LCA industry locates a strategic position for a country, and the LCA industries of the U.S. and France develop gradually under the supports of government. Through the formulation of industrial policies government guide and manage the technological innovation of this industry and the leading of government has a great effect on the financing and demand.

(5) Domestic and Foreign Universities And Research Institutions

In addition to the research institutions which participant in the manufacturing process as suppliers, domestic and international universities and research institutions which have strong research

capabilities will connect with CACC as horizontal nodes. Universities propagate basal knowledge and they could provide qualified scientists and technicians. Research institutions could provide some key technologies directly or help the corporations finish the technological innovations.

It should be noted that external collaborative knowledge sourcing in China's Large Civil Aircraft industry independent Innovation Network does not only take place vertically in the supply chain but also through horizontal inter-firm relationships between competitors or firms in related industries.

2.2 Operation Modes of Independent Innovation network

On the vertical hand, other parts suppliers, module suppliers, CACC, aircraft leasing corporations and civil airlines constitute an industry chain of LCA and every node is connected with each other. Different kinds of companies are on the different nodes. Over the business process, companies communicate with each other widely and closely, which make a global large supply chain.

Innovation activities in the supply chain start downstream. As the sources of orders, civil airlines and aircraft leasing corporations would determine the demand of products and technologies which will be conveyed to CACC and promote the innovation of network.

As the module integrator, through forecasting the demand and exchanging the information CACC begins the leading design under the technological situation and then manufactures the leading products and determine the interface rules and system rules. The innovation rules and interface definition set by CACC will be conveyed to body suppliers, engine suppliers and airborne equipment suppliers. Because technological innovation can make suppliers get comparative advantages and the capability of bargaining, suppliers have enough motivation to upgrade the products and technologies. Meanwhile, there are interface knowledge communications between module suppliers.

Through integrating the technological innovation information of module suppliers and the information of interface knowledge, CACC lays foundations for developing the innovation rules and interface definition and finish the co-ordination of module suppliers. CACC raises the module integration innovation capability through developing the innovation of design and assembly.

Module suppliers are both the absorption sides and technology innovators. Their innovation activities will ask the companies upstream for raw materials and parts which meet the technical

requirements and better services. It promotes the innovation of raw materials and technology of other parts suppliers. Other parts suppliers are guided in the independent innovation network and their innovations are dominated by CACC and module suppliers.

The medium and low end companies which have not core technologies in the innovation network have comparative inferiors and less market share. As the technology development of supply chain, their technologies will not be compatible. They will gradually be eliminated in the independent innovation network. But the potential entrants who master some core technologies through technological innovation will be incorporated into the innovation network. In this way, it will generate a study effect and build a healthy competitive environment in which suppliers constantly go through technical innovation.

On the horizontal hand, financial institutions, government and domestic and foreign universities and research institutions link the supply chain by contractual agreements, policies, social relations and information network. Domestic and foreign universities provide the innovation network with knowledge through basic research and supply qualified scientists and technicians. In addition to companies, research institutions are the important technological innovators. Universities and research institutions provide the main innovators with knowledge, technology and personnel support. What's more, financial institutions play an important role in innovation activities which provide consumers, CACC, module suppliers, other parts suppliers and domestic and foreign universities and research institutions with funds. They make the operation of manufacturing and technological innovation go well. Government is in outermost position of the innovation network and it influences the innovation activities with policies and regulations. Every innovator has to finish the innovation within the policy space built by government and comply with the knowledge and technology property rights policy, environmental protection standards and technology standards.

There is bidirectional information flow between the nodes in independent innovation network. Funds, human resources, technologies and knowledge flow from financial institutions, universities and research institutions to industry supply chain. In the supply chain, funds flow upstream which is in a direction opposite to logistics and the two flows unilaterally.

The innovation activities are not isolated in independent innovation network, since CACC would build collaborative innovation relationship with suppliers. Firstly, CACC establishes a stable procurement relationship with suppliers with orders and in this process they could communicate with each other about technology and personnel. Secondly, as the leader company CACC could build a project team for some key technologies and intellectual property rights are divided by contracts. Thirdly, CACC may found joint ventures with some suppliers and incorporate the JV into innovation network.

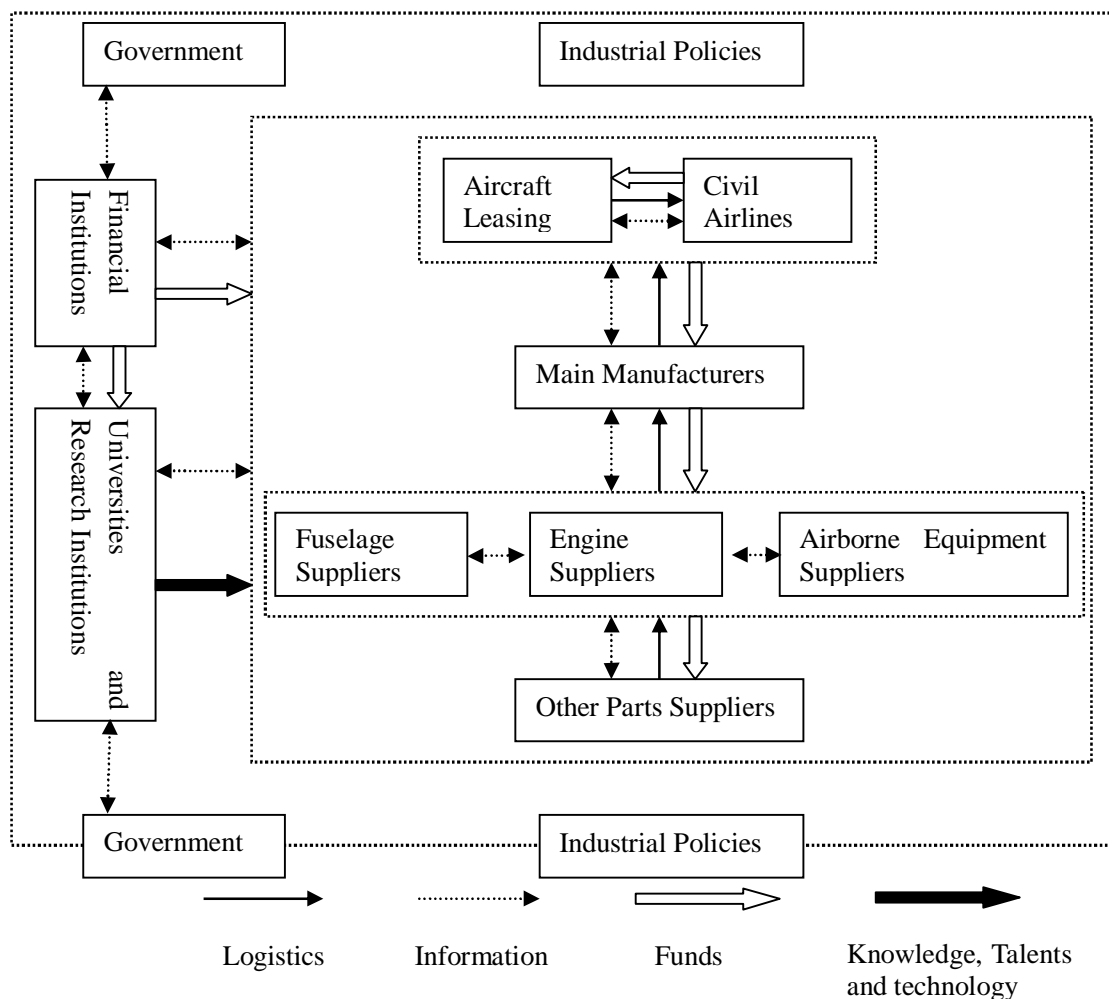


Fig.2. Structure of China's Large Civil Aircraft Industry Independent Innovation Network

At present, the leader model of CACC is C919 which has five features that are security, economy, reliability, comfort and environmental protection. The first essential feature is security and the next two are economy and reliability. Meanwhile, comfort and environmental protection are considerable respect. In addition to assembly technology, CACC concentrates its technology of leader design on the fuselage parts.

On the hand of raw materials, in order to reduce the total weight of the body and make the noise reduced C919 will use a large number of advanced composite materials such as aluminum-lithium alloys, titanium and so on. The engine is the core component of LCA whose fuel efficiency and noise are the considered main factors when CACC chooses the engine supplier. But for airborne equipment CACC pay more attention to compatibility and stability. For fuselage parts, C919 is needed to be redesigned on forward fuselage, wings and tail fins for energy-saving and in order to make passengers more comfortable CACC has to make improvement on cabin size, location of luggage compartment and seat layout.

3 Security Measures of China's Large Civil Aircraft Industry Independent Innovation

Network

3.1 Developing Industry Cluster of LCA

Attract international and domestic module suppliers and parts suppliers with assembly business and then build a professional and international industry cluster. In this region there is widely, closely and complex communication between companies. A company needs to be provided by other companies and then it will provide products to the market. The mode of industry cluster intensifies the competition and enhances the efficiency of innovation through shortening innovation cycles.

In the sight of lay out of China's aviation industry, Harbin and Tianjin in the north, Shanghai in the east, Xi'an in the west and Jiangxi in the center have objective advantages to build industry cluster of LCA. What's more, government should provide policy supports. The corporations like CACC and Harbin Aircraft Industry (Group) Co., Ltd. and financial institutions have to cooperate with each other. In June 2009, Airbus A320 aircraft assembly line settled in Tianjin, which makes a great exploration for the industry cluster of China's LCA.

3.2 Enhancing Governance of Independent Innovation Network

Governance of China's LCA industry independent innovation is dynamic process including governance of coupling mechanism and management of technological property right.

Coupling mechanism of independent innovation network includes coupling structure and coupling rules (Shoukui Zhang et al, 2009). For governance of coupling mechanism, since it is not only necessary to ensure the benefit of all the nodes and enhance the flexibility and scalability, but to enhance the reusability of innovation nodes to avoid the asset specificity, China's LCA industry independent innovation network should use loosely coupling mechanism that is emphasizing the dynamic coupling process and stressing organizing and management of cooperation between nodes. For management of technological property right, on one hand, contract governance between nodes makes technological innovation sustainable. On the other hand, there are mission conflict and cultural differences all over the innovation network where contract governance doesn't work. It's necessary that relation governance coordinates conflict and differences which should be built on credit, communication atmosphere and learning mechanism in order to increase the soft capability of independent innovation network.

Management of technological property right should be implemented on three points. Firstly, a clear division of labor is necessary. Stakeholders establish their innovation responsibilities by contracts and commitments. Secondly, integrators should conclude confidentiality agreement with suppliers or suppliers conclude confidentiality agreement with each other and security measures should be used during technical handover. Thirdly, internal security institutions and mechanism of technological property right should be built.

3.3 Building Perfect Supplier Performance Evaluation System

The problems that the increasing of number of suppliers and the differences from culture, geography, labor conditions between different countries and regions increase the risk of independent innovation network. So establishing a supplier performance evaluation system will help integrators implement governance which ensure the collaborative innovations go well. And the supplier performance evaluation system is the guarantee for delivery on time.

Learn from Boeing's experience of suppliers performance evaluation and then combine with innovation demand of China's LCA industry to build suppliers performance evaluation system including quality, delivery period, technological innovation and General Performance Average(GPA).

GPA is that experts of CACC evaluate the suppliers from research, manufacturing, support service and shared service and the evaluation factors are management, schedule, technology, cost and quality. The total score is 5. According to performance evaluation form CACC will average performance for 12 months and divide it into five classes.

CACC should reward the suppliers whose performance evaluation is first class or second class in 12 consecutive months and communicate with those whose performance evaluation is fourth class or fifth class or change suppliers when it is necessary.

3.4 Boosting Training and Introduction of Talents

Talents are essential to operation of independent innovation network, so boosting training and introduction of talents is significant.

First of all, establish a rational innovative talents training mechanism. It's necessary to implement human capital investment strategy and increase investment in education. Build a learning society through adjusting the education system and communicate with universities and research institutions through directive breeding and education cooperation. Secondly, deepen the reform of personnel system and establish a market leading and government guiding human resources allocation mechanism as soon as possible. Improve the incentive and competition mechanism and motivate innovative talents. Thirdly, make a great effort to attract international talents. Build an information network for international talents and analysis the policy of other countries and talents flow trend. On this basis, work out the introduction policy of talents. Provide the talents with generous benefits, good project and perfect talents plan. What's more, develop technical immigration laws to motivate international talents to start career in China (Fan Ye, 2006).

Conclusions and future research

China's LCA industry has just started and faced the market competition with Boeing and Airbus. China's LCA has to experience a tortuous process of exploration. This paper has several conclusions as follows:

Firstly, since China's LCA industry is restricted by industry characteristics, it can't rely on complete independent research. And this industry is very important to country's strategy, so the mode of digestion, absorption and improvement of introduced doesn't work. It's the unique choice that developing independent innovation through the way of integrated innovation.

Secondly, China's Large Civil Aircraft industry independent innovation network relies on the manufacturing supply system. On the vertical hand, consumers are incorporated into the network. On the horizontal hand, CACC combines with financial institutions, government and universities and research institutions. Ensure the openness of innovation network that the suppliers include international companies and domestic private companies.

Thirdly, in order to ensure the operation of China's Large Civil Aircraft industry independent innovation network, it is necessary that implement security measures about developing industry cluster, enhancing network governance, building perfect supplier performance evaluation system and boosting training and introduction of talents.

It should be noted that we have not investigated other forms of openness than technology sourcing through various forms of formal agreements. This implies first and foremost that we have not been able to assess the general degree of openness on different system hierarchy levels. It also implies that there may be other strategies for external knowledge sourcing in use for new product development on a systems level. And the China's Large Civil Aircraft industry independent Innovation Network will also need to be tested and other empirical researches on that will be necessary. All these issues should be topics of further research.

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