The Analysis of China's Large Aircraft Industry Technology Development Path Based on Production Function[1]

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Abstract

By using production function to analysis our country technology, the contribution rate of capital, Labor and political elements in the large aircraft industry, this paper concluded that technological progress to our country the development of large aircraft industry contribution rate is very low. On the basis of the above, we also use CES utility function to analyze the current situation in our country only relying on the enterprise itself to develop large aircraft industry and prove that the development is very difficult. Finally it is concluded that under the government-led development of enterprise independent innovation path.

Keywords: Large aircraft industry; production function; contribution rate

1. Introduction

All the large aircraft mentioned in this context are non-military aircraft owns over 150 seats. Large aircraft owns features as wide radiating surface, long industry chain, high diffusion rate of technology, which will bring the group breakthrough of key technology in many fields and pull fast development of numerous high-tech industry. Facing the huge need in civil market and international "duopoly", large commercial aircraft industry has been (put) on the agenda once again. It is certificated that the importance of this industry and it needs a clear development path urgently.

2. The discussion of the complicated path about large aircraft and the bottleneck's limitation.

2.1 The review of the large aircraft industry

The step of imitation and measuring design Yong-7 independent research step Yong-10, international cooperation "Proceeding in three steps", MD-82/90 and AE-100, change style research step-new boat 60, independent research and new steps- ARJ21's development history in almost half a century.

1.The research project of the research base about Shanghai's soft science :Build the research framework of strategic emerging industrial competitiveness-take the new energy vehicles for example(13692180600) ;The graduate research innovation project in Shanghai University of Engineering Science :The development strategy research of the large aircraft industry in Shanghai(A-0903-13-01031)

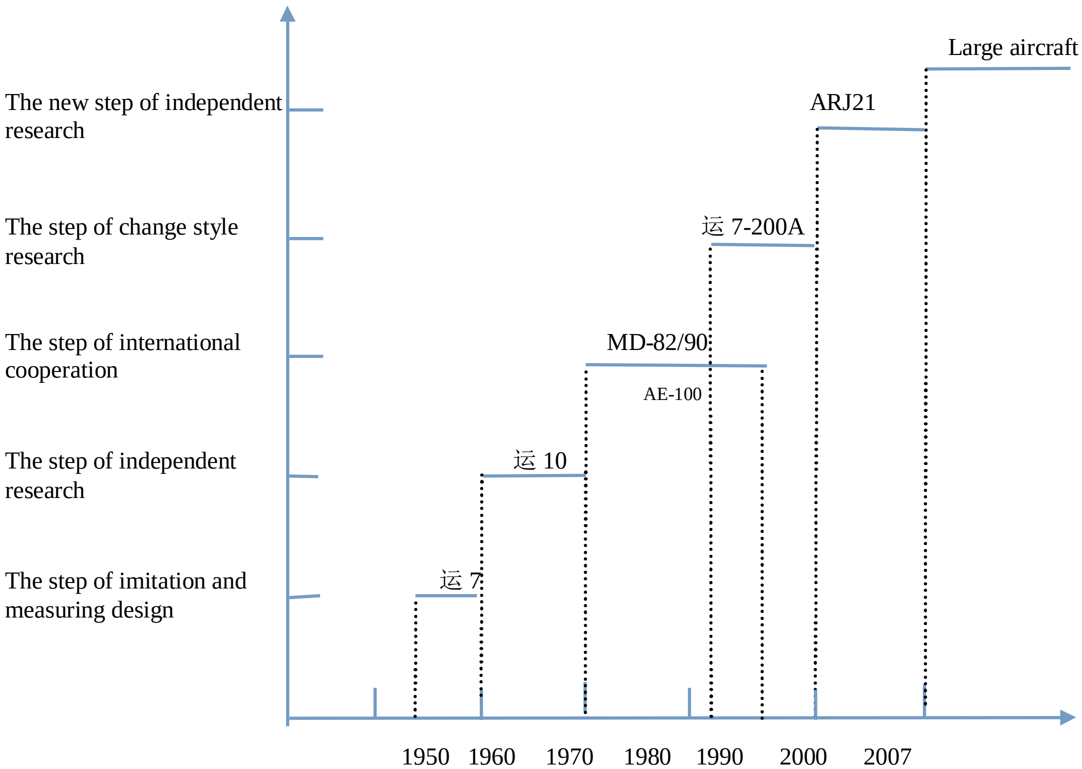

Fig.1.The development history of the large aircraft

From independent creation Yun-10 to international alliance production: MD82/83/90、AE100、A320, reviewing the history of China aviation manufacture industry, China civil aircraft manufacture has suffered a long and winding path with "failure after failure" and "keep on fighting". "Own by China" is a dream from times to times. In past several decades, China's experience is a pity and has caused people to think deeply. In conclusion, technology can't keep pace with the times.

2.2 Demonstration of bottleneck issue in the process of the development of large aircraft industry

To illustrate the low contribution rate of technology during the process of aircraft industry development, in this context, Douglas production function will be applied to analyze the development of aircraft manufacture in several years.

Douglas production function: $Y = A_{(t)} K^{\alpha} L^{\beta} \mu$ (1)

Y: Industry output

$A_{(t)}$: Comprehensive technology level

L: Number of Labor force

K: Investment (generally fixed clean capital)

α: Coefficient of elasticity of output of labor force

β: Coefficient of elasticity of capital output

μ （$\mu \leq 1$）: The influence on random disturbance

From this formula, main factors which decide the development level of industrial system are L, K, $A_{(t)}$ (including the level of management and operation, the quality of labor force, importing advanced technology). According to the consequence of α and β, it has three styles:

When α+β>1, which is called "increasing returns", it is beneficial to expand the production scale based on the technology at the moment.

When α+β<1, which is called "reducing returns", it is invaluable to increase output by expanding the production scale on basis of the technology at present.

When α+β=1, which is called "returns remaining", it means that production efficiency will not enhance with expanding production scale. Only if the level of technology improved, will bring and raise the economy benefit.

Based on Douglas production function, aerospace industry as the research aim, value of industrial output as Y: "aerospace manufacture's main business returns", capital of investment K: "total assets of aerospace vehicle manufacture", number of labor force L: "average number of all staff".

It is hard to differentiate military aircraft and civil aircraft because of the limitation of statistics. Therefore, to inspect whether political factors have direct effect on aircraft manufacture, "variable politics P" is added on basis of the Douglas production function. Significant military strategic accidents occurred to China in particular years, set "variable politics" as 1, other particular years as "0".

The model has been changed as the following:

$$LnY = LnA + \alpha LnK + \beta LnL + \gamma P \tag{2}$$

Main economy's and staff's situation in aerospace manufacture in recent 11 years

Table 1. The situation of output, capital, labor force in aerospace manufacture (1999-2009)

year	the main business revenue in aerospace manufacture (one hundred million Yuan)	The total manufacturing assets in aerospace vehicle (one hundred million Yuan)	The average number of all the employees (thousand person)	Political variable
1999	16.18	11.49	11.07	1
2000	49.03	83.56	10.29	0
2001	66.58	88.82	9.19	1
2002	55.58	102.46	9.76	0
2003	547.22	1191.63	344.18	0
2004	498.37	1096.95	271.79	0
2005	781.37	1425.54	304.69	0
2006	798.88	1526.21	297.83	0
2007	1006.36	1881.15	301.42	1
2008	1162.04	2205.44	314.07	0
2009	1322.85	2723.35	325.27	1

Source of data: 《China statistics yearbook》(1999—2009)，data have been clarified

Through the analyze of statistics software SPSS 16.0, confident level as 95%, regression equation and all systems' statistics (Table 2)

Table 2: Analysis of statistics outcome in China aerospace manufacture

	F	Significance F	Coefficient of determination R^2	Adjust multiple correlation coefficient
Regression analysis	554.7877	1.11E-08	0.995812	0.991047

Significance F is P <0.95 confidence level, F is 554.7877, far larger than P. Multiple linear regression is effective, R^2 access to 1, which could certificate the relationship between independent variable and dependent variable

Table 3: The regression outcome of production function in aerospace manufacture

	coefficient	T statistics	P value
Constant term	0.361938	2.239491	0.060123
LnK	0.712854	11.92266	6.64e-06
LnL	0.177906	2.836155	0.025183
P	0.204358	2.586544	0.036126

Therefore, production function formula of aerospace manufacture:

$$LnY = 0.362 + 0.713LnK + 0.178LnL + 0.204P \quad (3)$$

Considering the result, count capital and coefficient of elasticity of labor force in total is $\alpha + \beta < 1$. Under present technology condition, large aircraft industry can't rely on capital and devotion of labor force to get increasing profit. By calculating production factors' contribution rate to illustrate aerospace industry adhere increasing economy benefit. The quota of output increasing speed (technology improvement)

$$E_A = \left(\frac{\Delta A}{A} \Big/ \frac{\Delta Y}{Y} \right) \times 100\% \quad (4)$$

E_A : Technology contribution rate (technology progress to economy increasing speed of contribution rate)

Capital and labor force to contribution rate of output increasing speed

$$E_A = \alpha \left(\frac{\Delta K}{K} \Big/ \frac{\Delta Y}{Y} \right) \times 100\% \quad (5)$$

$$E_L = \beta \left(\frac{\Delta L}{L} \Big/ \frac{\Delta Y}{Y} \right) \times 100\% \quad (6)$$

China aerospace industry production factors contribution rate:

Table 4: Contribution rate of aerospace factors

year	capital	labor	technology	year	capital	labor	technology
2000	112.22	-1.96	-10.26	2006	200.15	-21.47	-78.68
2001	13.32	-12.47	99.16	2007	59.20	1.12	39.68
2003	68.08	29.91	2.01	2008	72.26	6.24	21.49
2005	38.10	5.27	56.64	2009	105.42	5.98	-11.40

Ps: In 2002 and 2004, aerospace industry main business was at a loss

From the results of analysis, aerospace industry needs large economy investment. It is not evident that technology brings benefit to this industry.

Faced such problems, the most urgent task is to construct the creation system of technology in aircraft industry. This is the top priority

3. Recommendation on technology creation and advice to large aircraft industry

But the current situation in our country, realizing the independent innovation with independent brands is not possible; our country must depend on exogenous factors, such as government, and foreign enterprises of large aircraft, and so on.

The following introduce a mathematical model to explain why the use of exogenous forces.

Supposing there are n similar product brands of the general parts of the large aircraft, from the lens of the consumers, the total utility "U" of buying the different brands can be expressed by the CES utility function:

$$U = \left\{ \sum_{i=1}^{n} q_i^{\rho} \right\}^{\frac{1}{\rho}}, 0 < \rho < 1 \quad (1)$$

In this formula, ρ is the consumer index, the elasticity of substitution $\sigma = 1/(1-\rho) > 1$ and q_i shows the consumption numbers of the i-th brand.

Supposing that the expenditure budget of the consumer is I ,which is equivalent to $\sum_{i=1}^{n} p_i q_i$.

Considering $\sum_{i=1}^{n} p_i q_i = I$ as the constraint condition and together with the first-order condition of calculating the utility maximization in formula (1) ,we can deduce that $q_i = \frac{p_i^{-\sigma}}{\sum_{i=1}^{n} p_i^{1-\sigma}} I$ .Supposing $\frac{I}{\sum_{i=1}^{n} p_i^{1-\sigma}} = \lambda$ and considering the numerous brands and the minimal price impact of single brand , λ can be regarded as constant. Supposing that there is an enterprise named A whose fixed cost of production is c_0 and marginal cost is c ,then its profit is $\pi = (p_A - c) q_A - c_0 = (p_A - c) \lambda p_A^{-\sigma} - c_0$ .We can get the price of the maximum profit by calculating $\max_{p_A} (p_A - c) p_A^{-\sigma}$ and the price is $p_A = \frac{c(\sigma - 1)}{\sigma} = \frac{c}{\rho}$.

The general parts enterprises of large aircraft belong to the labor intensive. So c which is I/m can be regarded as the ratio between the fixed price of labor " I "and variable marginal product. So we can reduce $\pi = \lambda(1-\sigma)(l/p)^{1-\sigma} m^{\sigma-1} - c_0$ easily.

Making $\phi = \lambda(1-\sigma)(l/p)^{1-\sigma}$,

Then $\pi = \phi m^{\sigma-1} - c_0$ (2)

In this formula, m depends on the production efficiency of the enterprise and shows an increasing trend which are based on the increasing of the embedding strength in the global value chain and the function of learning effects, coordinating effects and the technology exportation of the enterprise. But to a certain extent, m will meet the bottleneck due to technology blockade of leading enterprises.

Supposing that the embedding strength will increase with time, then m can be expressed as

$$m\begin{cases} (1+\beta t_i), 0 < t_i < t_\theta \\ (1+\beta t_\theta), t_i \geq t_\theta \end{cases} \qquad (3)$$

In this formula, m_0 is the marginal product of the initial state, β is the coefficient and t_i is the spent time from the initial state to the i-th moment. Seen from the formula (2) 、 (3) ,we can know that the longer the time of the embedding and the higher the strength of the embedding are, the higher the profit will be before the moment of t_0 .The profit will reach the maximum after the moment of t_0 .

Assume that China's enterprises enter the ranks of the machine manufacturing and sales by creating the brand independently. Before entering the market, the market is controlled by the duopoly of Boeing and Airbus. The market will be composed of three brands after the entering of China's own brand. Supposing the original two oligarchs and China's own brand are p_1 、 p_2 and p_3 separately, then the CES utility function of large aircraft consumers can be regarded as

$$U = (q_1^{\rho'} + q_2^{\rho'} + q_3^{\rho'})^{\frac{1}{\rho'}} \qquad (4)$$

Supposing that the consumer budget is I' and considering it as the constraint condition, we can deduce that the sales volume of our own brand is

$$q_3 = \frac{p_3^{-\sigma'}}{p_1^{1-\sigma'} + p_2^{1-\sigma'} + p_3^{1-\sigma'}} \qquad (5)$$

Supposing that the fixed cost of producing the own brand is c_0' and the marginal cost is c', $\lambda' = \frac{I'}{p_1^{1-\sigma'} + p_2^{1-\sigma'} + p_3^{1-\sigma'}}$ which is greatly affected by the variable price of the single brand.

The marginal cost c' can be regarded as ratio between the fixed capital investment "k"and variable marginal product" m' ".That is $c' = k/m'$ .So we can deduce the maximum profit which is $\pi' = \lambda'(1-\sigma')(k/\rho')^{1-\sigma'}(m')^{\sigma'-1} - c_0$.

Making $\phi' = \lambda'(1-\sigma')(k/\rho')^{1-\sigma'}$,

Then $\pi' = \phi'(m')^{\sigma'-1} - c_0'$ (6)

The marginal production will increase based on the scale effect which can be expressed as

$$m' = (1+\beta' t_j)m_0', t_j \geq 0 \qquad (7)$$

The condition of terminating the OEM of components and parts

It is likely to cause retaliatory measures of Oligopoly market for China's enterprises to develop their own brand and the OEM contract of parts will be terminated. In this condition, the motivation for China's large aircraft industry to choose its own brand is to meet $\pi' > \pi$, that is

$$\phi'(m')^{\sigma'-1} > \phi m^{\sigma-1} + (c_0' - c_0) \qquad (8)$$

In this formula, the right side represents the opportunity cost $(\phi m^{\sigma-1})$ which is lost base on the termination of the OEM contract and the switching cost $(c_0' - c_0)$ of developing the own brand.

In the early development of the independent brand of large aircraft, the marginal product m' is so low, but the marginal product of parts which has embedded in value chain is high. In addition, Huge R & D investment and marketing expenses also produced high switching cost. Based on the formula (3) ,we can know that the longer the embedding time is ,the greater the difficulty of the establishment of the formula (8) is.

2. The condition of continuing the OEM of components and parts

Supposing that there was no retaliatory measure of Oligopoly market and the former business of the OEM of components and parts during the period of developing the independent brand and in this condition, the motivation for China's large aircraft industry to choose its own brand must meet

$$\phi'(m')^{\sigma'-1} > c_0' - c_0 \qquad (9)$$

And in this condition, as long as profits can be greater than the costs of conversion, it will generate the motivation of developing the independent brand.

In both cases, the high switching cost is the key factor of impacting the development of the independent brand. If there was no exogenous force to intervene, assume and reduce the switching cost, it will be difficult for the enterprises to develop the independent brand.

Known from the analysis of the above, our country at present, the development of the large aircraft industry walk in the way of a multilateral cooperation embodies in the following aspects:

First, focus on the main force in the integrated innovation and the key technology research and development.

Second, we can through the learning across the value chain to get rid of technology dependence on a single value chain.

Third, we can through Greenfield investment access to knowledge spillovers in host countries.

Last but not the least; Government should increase funding in this field, more policies and regulations.

4. Summary

This paper reviews the historical development of China's large aircraft industry for decades and combines with the production function research of aerospace manufacturing industry in our country, from the qualitative and quantitative analysis of the results of a breakthrough in technology for a long time dependence, then through independent innovation to master the core technology, no longer subject to international competition become large aircraft industry development priority. By raising the core technical ability to change the large aircraft industry "big but not strong" fundamental disadvantage, it is necessary to solve the large aircraft industry development in our country's real challenge.

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