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CHINA'S MANUFACTURING STRATEGY CHOICE: AN INTEGRATED STRATEGIC ANALYSIS FRAMEWORK COMBINING SWOT AND LOGICAL GROWTH MODELS

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ABSTRACT

One of the keys to China becoming the world's leading manufacturer in about 40 years is choosing the right manufacturing strategy. However, there is a lack of research on China's manufacturing strategy evolution over the past 40 years and future development. We used the resource-based SWOT model to analyze the strategic choices of China's manufacturing industry and used the logical growth model to analyze how mutual learning and competition between firms affect strategic choices for the first time. We established an integrated strategic choice analysis framework from the industry level to the enterprise level. We concluded that manufacturing companies should follow national strategies. In the past, low-cost strategies were the best choice for manufacturing in China. However, in the current period, the capabilities and the environment have changed dramatically. Chinese manufacturing should adopt a quality strategy to develop world brands. Improving quality requires lean production and new technologies, such as big data and intelligent manufacturing. Only by opening up to the world can the company's intelligent manufacturing capabilities develop faster.

Contribution/ Originality: This study is one of very few studies that analyze the strategic choices of China's manufacturing industry based on the resource-based SWOT and Logical Growth models.

1. INTRODUCTION

China is currently the world's largest manufacturer (Keith, 2010). China chose the right manufacturing strategy over the past 40 years. There have been many studies on China's manufacturing strategy in the past (Robb and Xie 2003, Robb *et al.* (2008), Pisano and Shih (2009), Elkrghli and Mohamed (2016)). But most of them focused on specific areas, and there is a lack of research on China's manufacturing strategy evolution over the past 40 years.

However, there are still many obstacles to future development. Due to the financial crisis in 2009, developed countries such as the United States must compete with China to increase employment. At the same time, in the competition with developing countries, increasing labor costs may weaken the competitiveness of Chinese manufacturing. With the development of 3D printing, big data, and intelligent manufacturing (IM), the German government announced Industry 4.0, and the Chinese government announced: "Made in China 2025". Therefore, in the context of a new competitive environment and the rapid development of intelligent technologies, the government and many scholars have begun to consider solutions to improve China's manufacturing capabilities.

There is also a lack of research on how Chinese manufacturing strategies are developed under new technologies. This article explores these gaps in research.

Based on the low cost, China's manufacturing industry has made great achievements in the past (Keith, 2010). Due to the huge market potential and relatively low production resource costs, more and more companies have moved to China (Robb and Xie, 2003). However, although the cost of manufacturing in China is very low, Robb *et al.* (2008) found that labor productivity in China is relatively low.

Today, China's manufacturing industry faces another threat. Developed countries like the United States want manufacturing to return to their own countries. Fratocchi *et al.* (2016) analyzed the return motivation of certain industries, such as clothing and footwear. Therefore, Chinese manufacturing companies are under heavy pressure from manufacturing restructuring. Chinese manufacturing companies should choose the right development strategy.

Manufacturing strategies are very important for a country's manufacturing development. An empirical analysis by Thun (2008) suggests that developing a manufacturing strategy in an enterprise may lead to better performance. Amoako-Gyampah and Acquaah (2008) have shown that there is an important and positive relationship between competitive strategy and manufacturing strategies for cost, delivery, flexibility, and quality.

In the low-cost strategy, China faces many quality problems. Compared with non-Chinese-made products, Chinese-made products are considered by consumers to be of lower quality (Schniederjans *et al.*, 2004). Even after a few years, the conclusion is the same (Schniederjans *et al.*, 2011). Although China's industry has been developing production, sales, and R&D capabilities to produce low-cost, high-quality products Pisano and Shih (2009), Elkrghli and Mohamed (2016) found that Chinese manufacturers need more market-oriented and quality-oriented to enhance their image. Therefore, China's manufacturing industry should shift from a low-cost strategy to a quality strategy, because the quality strategy can make Chinese manufacturing companies once again gain advantages. Kannan and Tan (2005) demonstrated that commitment to quality has the greatest impact on business performance. Amoako-Gyampah and Acquaah (2008) found that quality is the only factor in a manufacturing strategy that affects performance.

To adopt a quality strategy, companies should have a way to implement a quality strategy. Lean manufacturing is a popular way to improve quality because Toyota has repeatedly outperformed its competitors in quality (Spear, 2004). Since (Sugimori *et al.*, 1977) first published research on the Toyota Production System (TPS) at IJPR, many scholars have conducted extensive research on the TPS. Ciano *et al.* (2019) reviewed this topic on IJPR. Lean production is a mature implementation method.

In the artificial intelligent age, the production system has changed from Industrial 2.0 to Industry 4.0 (Yin *et al.*, 2018). In particular, as the Chinese government announces "Made in China 2025", China's manufacturing industry should develop a new strategy to gain an advantage in the new era, because intelligent technology should be integrated with lean production (Buer *et al.*, 2018). Brazilian manufacturers have combined Industry 4.0 with lean production (Tortorella and Fettermann, 2018).

In this paper, we used the SWOT model to analyze the strengths, weaknesses, opportunities, and threats of Chinese manufacturing. Panagiotou (2003) believes that SWOT is used more than any other strategic planning tool. While SWOT is primarily used to help organizations plan for future strategies, SWOT also helps to develop appropriate paths for countries, industry organizations, or other entities (Proctor, 1992).

Ou and Chai (2007) provided advice on doing business in Taiwan through SWOT analysis. Miaoyan (2007) recommended a development model using SWOT analysis to increase China's tourism industry. Jafari and Baratimalayeri (2008) used SWOT to check and recommend Iran's protection policy to ease the gasoline crisis. Sodhi and Tang (2008) conducted a SWOT analysis of the OR/MS ecosystem. Ho (2008) used SWOT in his comprehensive analysis. Fahy and Smithee (1999) argued that a resource-based view can help overcome some common SWOT framework issues. Wernerfelt (1984) created the resource-based view. There are certain key

resources, namely resources with characteristics such as value, duplication barriers, and proprietaries (Reed and DeFillippi, 1990). Helms and Nixon (2010) gave a comprehensive overview of SWOT analysis. In this paper, for the first time, we used the SWOT based in a resource context to analyze the advantages and disadvantages of Chinese manufacturing in different periods.

If China chooses a manufacturing strategy, how should Chinese manufacturing companies choose their strategies? We should understand the interaction between the strategies of different manufacturing companies. In other words, whether a company's strategy will affect the strategy of another company. We have therefore established a logical growth model to analyze corporate strategic choices because the logical growth model can portray the interaction between different companies' strategies.

The logical growth model is a classic evolutionary model. Pistorius and Utterback (1997) studied technological growth through the improved Lotka-Volterra model. Coupling coefficients are introduced in the model to characterize the impact of one technology on the growth of another technology, the sign of which determines the interaction between technologies. The positive sign indicates that the technologies are symbiotic and can promote each other.

This is the first time, this model has been used to study the manufacturing capacity growth of manufacturing companies. If the manufacturing strategies chosen by different companies are the same, manufacturing companies can learn from each other's manufacturing capabilities. Mutual learning can promote the growth of companies' capabilities (Schroeder *et al*., 2002).

The manufacturing capabilities between enterprises are symbiotic and mutually reinforcing. Ribeiro *et al*. (2014) proposed that the Verhulst-Lotka-Volterra equation could describe multiple ecological systems. We used their modeling techniques to study the sales competition of companies in the market. When the sales of one company increases, it often leads to a decrease in the sales of another company. We used these two logical growth models to study the strategic choices of companies under different national manufacturing strategies.

In section 2, we build an analysis method by integrating SWOT and logistic growth models. In section 3, we analyze the cost manufacturing strategy over the past 30 years, the current quality strategy, lean manufacturing strategy, technologies strategy, and intelligent lean strategy by using the analysis method in section 2. We conclude this article in section 4.

2. METHOD: INTEGRATING SWOT AND LOGICAL GROWTH MODELS

Just as SWOT is used in the literature to analyze an industry strategy, for the first time, we used SWOT to analyze China's manufacturing strategy. We can also use the SWOT model or other strategic analysis tools to analyze the strategic choices of individual manufacturing companies at the enterprise level. But if we want to analyze the strategic choices and interactions of multiple companies, we need to examine how a company's strategic choices influence the strategic choices of another company and SWOT is not suitable for this.

At the enterprise level, the relationship between enterprises is more complicated. Enterprises can enhance their abilities by learning from each other. There is no direct competition between companies for mutual learning. In other words, one enterprise does not weaken its own capability after other enterprises learn its ability and enhance their capabilities. But there will be competition between companies in the market.

For similar products, if the sales volume of a company increases, it will often lead to a decline in the sales of other similar companies. The logical growth model can be used to analyze mutual learning and competition between enterprises. Therefore, we chose the logical growth model to analyze the strategic choices at the enterprise level. Thus we built a strategic analysis framework from the industry level to the enterprise level.

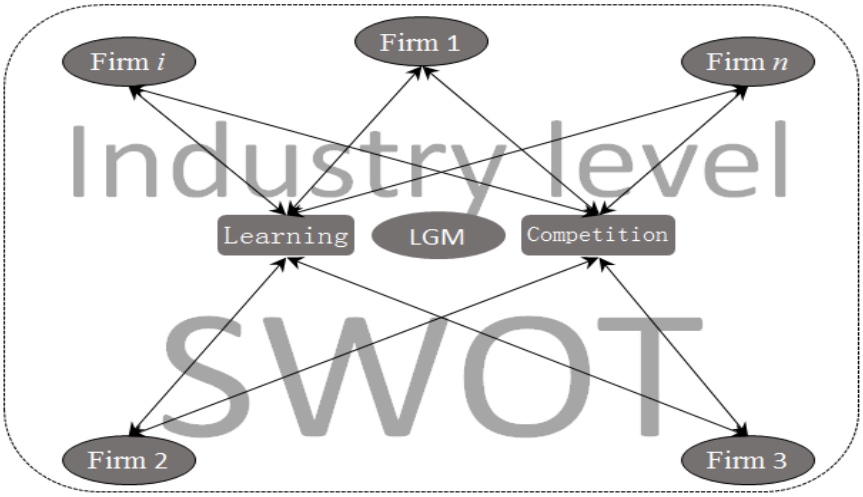

Figure-1. Integrating SWOT and LGM.
Source: Developed by authors according to our theory model.

As shown in Figure 1, we used SWOT to analyze the manufacturing industry's strategy. We used LGM to analyze how mutual learning and competition between companies affect the company's strategic choices throughout the manufacturing industry. Thus we have established an integrated framework for manufacturing strategy analysis from the macro to the micro-level.

2.1. SWOT

We used a resource-based SWOT to analyze China's manufacturing strategy i.e. to determine the advantages and disadvantages of Chinese manufacturing based on the resources owned by the state. In particular, we identified the advantages of unique resources owned by China that are not easily replicated in other countries. The disadvantage was the resources that were missing and difficult to change in the short term. Opportunities come from the market. The threat comes from competitors. For China, is the competitors are the other countries that may adopt the same strategy.

2.2. The Logistic Growth Model

We defined the following parameters and variables.

t : Time.

L_i, Capability of the ith firm, $i = 1, 2, \mathrm{L}\ , n$.

$c_{ij}\ (>0)$ The learning rate ith firm from the jth firm. It is the coupling coefficients in Pistorius and Utterback (1997) which studied technological growth through the improved Lotka-Volterra model. Coupling coefficients characterized the ability of one firm to influence the growth of another firm's capability. The positive sign indicated that the capabilities were symbiotic and could promote each other by learning.

P_i : Sales of the ith firm, $i = 1, 2, \mathrm{L}\ , n$.

$r_i(t)$: The intrinsic growth rate of the ith firm in sales at time t, $i = 1, 2, \mathrm{L}\ , n$.

K_i : The biggest potential sales of the ith firm, $i = 1, 2, \mathrm{L}\ , n$.

$a_i\ (>0)$: The competitive coefficient of the ith firm to all the n firms.

We first established a logical growth model of enterprise capability growth based on mutual learning referring to Pistorius and Utterback (1997) see Equation 1.

$$\frac{dL_i}{dt} = e_i L_i - k_i L_i^2 + \sum_{j=1, j\neq i}^{n} c_{ij} L_i L_j \tag{1}$$

When $\frac{dL_i}{dt} = 0$, the ability of the enterprise stops growing. Therefore, we get Equation 2.

$$e_i L_i - k_i L_i^2 + \sum_{j=1, j\neq i}^{n} c_{ij} L_i L_j = 0 \tag{2}$$

If the number of companies that the enterprise i learns is n_1 and n_2 respectively ($n_1 > n_2$), then from Equation 2, $\max L_i(n_1) > \max L_i(n_2)$。

At the same time, If the number of companies that enterprise k ($k \in (1,\mathrm{L}\ ,n)$) learns is n_1 and n_2 respectively ($n_1 > n_2$), then $\max L_k(n_1) > \max L_k(n_2)$. The capability increasing of enterprise k can lead to an increase in the capability of enterprise i. That is, $\max L_i(n_1, \max L_k(n_1)) > \max L_i(n_1, \max L_k(n_2))$.

Theorem 1 The more companies a company learns from, the faster its capability grows. The more companies learn from each other, the faster the companies' capabilities grow.

The potential sales of enterprise i are related to the capability gained. Let $L_i^* = \max L_i$, $K_i^* = K_i(L_i^*)$. K_i^* is an increasing function of capability. The logical growth model for the sales of all companies are Equation 3.

$$\begin{cases} \dfrac{dP_1(t)}{dt} = r_1(L_1^*, t)\left(1 - \dfrac{P_1(t) + a_1P_1(t) + a_1P_2(t) + \mathrm{L}\ + a_1P_n(t)}{K_1^*}\right)P_1(t) \\ \dfrac{dP_2(t)}{dt} = r_2(L_2^*, t)\left(1 - \dfrac{P_2(t) + a_2P_1(t) + a_2P_2(t) + \mathrm{L}\ + a_2P_n(t)}{K_2^*}\right)P_2(t) \\ \mathrm{M} \\ \dfrac{dP_n(t)}{dt} = r_n(L_n^*, t)\left(1 - \dfrac{P_n(t) + a_nP_1(t) + a_nP_2(t) + \mathrm{L}\ + a_nP_n(t)}{K_n^*}\right)P_n(t) \end{cases} \tag{3}$$

When $dP_i(t)/dt = 0$, $i = 1,2,\mathrm{L}\ ,n$, the sales of all the firms achieve the maximum. That is Equation 4.

$$\begin{cases} 1 - \dfrac{P_1(t) + a_1P_1(t) + a_1P_2(t) + \mathrm{L}\ + a_1P_n(t)}{K_1^*} = 0 \\ 1 - \dfrac{P_2(t) + a_2P_1(t) + a_2P_2(t) + \mathrm{L}\ + a_2P_n(t)}{K_2^*} = 0 \\ \mathrm{M} \\ 1 - \dfrac{P_n(t) + a_nP_1(t) + a_nP_2(t) + \mathrm{L}\ + a_nP_n(t)}{K_n^*} = 0 \end{cases} \tag{4}$$

From Equation 4, we can get Equation 5.

$$\begin{cases} P_1 + a_1 P_1 + a_1 P_2 + \mathrm{L} + a_1 P_n = K_1^* \\ P_2 + a_2 P_1 + a_2 P_2 + \mathrm{L} + a_2 P_n = K_2^* \\ \mathrm{M} \\ P_n + a_n P_1 + a_n P_2 + \mathrm{L} + a_n P_n = K_n^* \end{cases} \tag{5}$$

Let $\Sigma = P_1 + P_2 + \mathrm{L} + P_n$, we can get Equation 6 from Equation 5.

$$\begin{cases} P_1 + a_1 \Sigma = K_1^* \\ P_2 + a_2 \Sigma = K_2^* \\ \mathrm{M} \\ P_n + a_n \Sigma = K_n^* \end{cases} \tag{6}$$

From Equation 6, we can get Equation 7.

$$\left(1 + a_1 + a_2 + \mathrm{L} + a_n\right)\Sigma = K_1^* + K_2^* + \mathrm{L} + K_n^* \tag{7}$$

From Equation 7, we can get Equation 8.

$$P_i = \frac{K_i^*}{1 + a_1 + a_2 + \mathrm{L} + a_n} = \frac{K_i^*}{1 + \sum_{i=1}^{n} a_i} \tag{8}$$

Due to $\sum_{i=1}^{n} a_i > 0$, $P_i < K_i^*$.

$\sum_{i=1}^{n} a_i$ can be regarded as a competitive index. The larger n, the larger $\sum_{i=1}^{n} a_i$ is, the more intense the competition, so the smaller the sales P_i of the enterprise i. In addition to the competition affecting the sales of company i, we see that the maximum potential sales K_i^* also affect the sales P_i of company i. And K_i^* is an increasing function of capability. Therefore, the more companies company i learns, the faster its capability L_i^* grows. The market's maximum capacity for a product is constant, so $\sum_{i=1}^{n} K_i^*$ is constant. Enterprises need to compete with each other. If the K_i^* of the enterprise i increases, there must be a reduction in the potential sales of another company, for example, K_j^* of company j decreases. Therefore, the sales P_j of company j will inevitably decrease.

At the same time, the growth rate in the model is also related to learning. If the number of companies that enterprise i learns is n_1 and n_2 respectively ($n_1 > n_2$), then $L_i^*(n_1) > L_i^*(n_2)$, so $r_i\left(L_i^*(n_1), t\right) > r_i\left(L_i^*(n_2), t\right)$. Therefore, the more companies company i learn, the faster its strength grows, so the more competitive it is, and the faster its sales growth, the faster it can occupy the market.

Theorem 2 only if the number of companies that a company learns from is more than that of other companies, does this company then have an advantage in a sales competition.

Theorem 2 can also find relevant support in the literature. For example, Burt (2009) believes that the ability of companies to obtain information is directly proportional to the number of connections with other companies.

3. ANALYSIS AND RESULT

3.1. Low-Cost Manufacturing Strategy

In 1978, about 70% of China's population lived in rural areas (Jun, 2003). The value-add of the industrial sector has accounted for 45% of China's GDP (Jun, 2003). At the start of opening in 1978 that allowed foreign investment, what manufacturing strategy did China adopt? How did companies choose their strategies?

3.1.1. SWOT Analysis

Weaknesses: The Cultural Revolution made it impossible for a whole generation of young people to receive an education because almost all schools were closed (Zhang *et al.*, 2007). This situation caused China to fall behind in science and technology. The weaknesses of China's manufacturing include its delays in science and technology and its very low management standards over the past decades.

Strengths: China is the most populous country in the world, and its advantages include ample labor and low labor costs. Although the population advantage is not unique to China, China has adopted a strategy for early development of infrastructure, as evidenced by the popular slogan "Get rich, build roads first." (Wang, 2019). Esfahani and Ramírez (2003) reported on the contribution of centralized infrastructure to GDP through large panel data. Therefore, the Chinese government's infrastructure construction has established its unique advantages in developing countries. Sahoo *et al.* (2010) found that in the past few decades, the sustained rapid growth of China's economy and the improvement of manufacturing competitiveness have benefited from the large-scale development of infrastructure. The low labor force and the rapid development of infrastructure not only make processing costs but also make logistics costs low. Thus it has created a unique, low-cost competitive advantage in China.

Opportunities : In 1980, China adopted an export-oriented growth model that dominated China's economic development (Abeysinghe and Ding, 2003). Export-oriented manufacturers can enjoy a wide range of administrative supports, tax benefits, and subsidies, etc. (Lu and Tang, 1997). Because China's wages are very low, China's consumption is very low. Therefore, export-oriented manufacturing could seek opportunities in developed countries. And it is globalization that brings such opportunities. Branstetter and Lardy (2006) believe that China's adoption of one of the most open trade and foreign direct investment systems in the developing world is one of the most important achievements of the reform era.

Threats: Developing countries are the majority of the world, and they are Chinese competitors. However, China has found a way to succeed in this game. As stated in the advantages, China's large and low-cost labor force combined with the rapid development of infrastructure has enabled China to cope with the threats it faces.

In the strategy choices in the SWOT matrix in Table 1, various factors are identified and then paired, for example, strengths and opportunities, to motivate new strategic initiatives.

From Table 1, the strategy of China is openness and learning from the developed countries to improve in technology, education, and management. At the same time, the infrastructure is very important, so the first road became the strategy of China. Based on the technology and management from the developed countries and the infrastructure, the manufacturing strategy of China is to export low-cost products and adopt the OEM.

Synthesizing the above analysis, China adopted a low-cost strategy to develop manufacturing. Thirty years of development have shown that the low-cost strategy is successful. In the book The Chinese Century, the author states, "If you still make anything labor-intensive, get out now rather than bleed to death. Shaving 5% here and there won't work. You need an entirely new business model to compete" (Fishman, 2004). "' The China Price' is a bomb. They are the three scariest words in the U.S. industry. Cut your price at least 30% or lose your customers." (Engardio and Roberts, 2004).

Table-1. The SWOT matrix

	Weakness: **backward in technology, education, and management**	**Strength:** **Labor quantity and cost**
Threats: Developing countries	WT strategy: Openness and learning from developed countries	ST strategy: Low-cost products; The first road
Opportunities: The world market	WO strategy: Export low-cost products	SO strategy: Export low-cost products; OEM

3.1.2. Analysis Based on the Logistic Growth Model

Through the above analysis, at the beginning of China's opening in 1978, the low-cost strategy was the best choice for Chinese companies. But for some companies, are other strategies a better choice? We use the theorem 1 and theorem 2 obtained from the logical growth model to analyze this.

Due to China's unique, low-cost advantages, it also strengthens this advantage by strengthening infrastructure construction and choosing an export-oriented strategy to find market opportunities. The country's advantages can also become an advantage of the enterprise. And Chinese companies can also find their market opportunities in export-oriented economic policies.

A manufacturing company can only choose a low-cost strategy, consistent with the national strategy, and the more national resources it will receive. Therefore, the number of companies that choose a low-cost strategy is necessarily greater than the number of companies that choose other strategies. From theorem 1, the low-cost manufacturing capabilities of companies that choose low-cost strategies are growing fast, which has been confirmed in China (Zeng and Williamson, 2007). China's 30-year competitive tool in the past after reform and opening up was "cost innovation," including low-cost R&D, adoption of open architecture, innovation through process flexibility, and integrated innovation (Zeng and Williamson, 2007).

Quan *et al.* (2018) found that a Chinese auto company uses a vertical integration strategy to take advantage of local contextual factors, including labor supply (especially low-cost, highly skilled labor), a growing middle class, and local industry environment for innovation.

According to Theorem 2, the more companies that choose a low-cost strategy, the more intense the competition. Enterprises with strong competitive advantages will inevitably win a larger market share. Companies with weak competitiveness may face the risk of losing the market. However, due to China's export-oriented policy, Chinese companies' competitors include Chinese companies as well as foreign companies. Some companies do not have a competitive advantage in the face of competition from Chinese companies, but there may be advantages in the face of competition from foreign companies. Therefore, Chinese companies with weak competitiveness may still gain market access internationally.

If companies that are weak in a low-cost strategy choose other strategies, their capacity growth is limited. Such a company may be able to survive in a narrow market, but it cannot be the mainstream of this period.

Proposition 1 under China's national low-cost manufacturing strategy, companies should choose low-cost strategies and actively learn from other companies, and their competitive advantage is greater. Companies that choose other strategies cannot become mainstream.

3.2. Quality Strategy

3.2.1. SWOT Analysis

Today, China is the world's leading manufacturer. In the current global environment, whoever is better, cheaper, and faster will have a competitive advantage. Therefore, this study analyzes the future steps of China's manufacturing industry.

Strengths: China's current manufacturing characteristics include continuous improvement in manufacturing capabilities, significant cost advantages and global market share. China's first advantage is the labor force. China's manufacturing labor force is estimated to be about 100 million, possibly as high as 120 million. US manufacturing employment is about 11.5 million (Perry and Heilmann, 2011). The gross enrollment rate of higher education in China rose from 3.0% in 1991 to 21.6% in 2006 (Marginson and Wende, 2007). Over the past twenty years, the scale of China's MBA education has expanded rapidly. The MBA program grew from zero in 1990 to 236 at the end of 2011 (Zheng and Deakin, 2016).

The second advantage of China is management. China's management advantage is mainly reflected in its low-cost management capabilities. China's competitive tool is "cost innovation," which first provides high technology at a lower cost, secondly offers multiple options (more types), and third offers special products at a very low price (greater customization) (Zeng and Williamson, 2007).

China's third major advantage is technology. Young and Lan (1997) documented the importance of transferring technology from parent companies to subsidiaries in developing countries and the importance of imported machinery and innovation inputs through case studies. Export and import activities are important channels for technology transfer (Whalley and Xian, 2010).

Therefore, the advantages of China's manufacturing industry include labor costs, corporate management capabilities, a large number of high-quality labor, and the transfer of manufacturing technology in developed countries. Perhaps each aspect of these advantages are not unique to China, but the combination is China's unique advantage.

Weaknesses: China's first weakness is the labor costs growth rate. In China, wage growth is much faster than productivity growth. From 2000 to 2005, the wages and benefits of ordinary factory workers in China increased by 10% annually. From 2005 to 2010, wages increased by an average of 19% per year, while the cost of US production workers increased by only 4% (Sirkin *et al.*, 2011). The minimum wage growth rate in twenty China regions exceeded 20% (Sirkin *et al.*, 2011).

The second weakness of China is labor productivity. China has long maintained its position as a developing country. China's average income is still less than 10% of the US's average income. The productivity of Chinese workers is so low that American factories need an American worker, and Chinese factories need 9-10 workers (Perry and Heilmann, 2011). Woetzel *et al.* (2016) calculated that China's productivity in 2015 is still 15-30% lower than the OECD average.

China's third weakness is production and operations management research. According to Jasti and Kodali (2015), there were only seven lean production research papers in China from 1988 to 2011. During this period, there were 229 papers in Europe. There are 174 papers in North America. Compared with Europe and North America, China has little research on lean production. Although the research work cannot fully demonstrate the practice of lean production, it shows that Chinese academic circles are not interested in lean production. In the future, students cannot learn more about lean production at the university. Therefore, China's weaknesses include increased labor costs, low productivity, and management research.

Threats: After the financial crisis of 2009, the United States tried to regain its status as a leading manufacturer. Once transport, tariffs, supply chain risks, industrial real estate, and other costs are fully considered, for many commodities, the manufacturing cost gap between Chinese manufacturing and certain parts of the US will be minimized in the next five years (Sirkin *et al.*, 2011). Production of some commodities will be transferred from China to countries with lower labor costs, such as Vietnam, Indonesia, and Mexico (Sirkin *et al.*, 2011).

Opportunities: China joined the World Trade Organization and won a large and stable global market for its products and services. In recent years, China has adopted the "One Belt, One Road" (OBOR) national strategy. The Silk Road Economic Belt and the 21st Century Maritime Silk Road policy help provide the economic integration of China with Asia, Europe, and Africa (Du and Zhang, 2018). OBOR can help China establish a low-cost supply chain.

China's overseas direct investment (ODI) has risen significantly in the Belt and Road countries, with China's state-controlled takeovers playing a leading role in infrastructure (Du and Zhang, 2018). Therefore, China has copied its successful "first road" strategy to other countries.

Strategy Choice: As can be seen from Table 2, China's strategy is to improve productivity and quality. Some quality issues have affected Chinese manufacturing. Improving quality is the key to building a world brand. Production and operations management plays an important role in improving quality. If the plant's goal is to achieve world-class status, then the implementation of lean production system operations and human resource decisions is critical to meeting benchmark quality, productivity, delivery, and flexibility goals (Mefford and Bruun, 1998). Some scholars believe that quality is the only manufacturing strategy component that affects performance (Amoako-Gyampah and Acquaah, 2008). Therefore, we suggest that the Chinese manufacturing strategy should focus on quality.

Table-2. The SWOT matrix.

	Weakness: **Backward in technology and management; Labor cost increasing; Low productivity**	**Strength:** **The quantity of educated labor; Progress in technology and management**
Threats: Developing countries for low-cost products; Developed countries for high-quality products	**WT strategy:** Enhancing productivity against the developing countries; Enhancing quality against the developed countries	**ST strategy:** Enhancing productivity and quality
Opportunities: Economic globalization; Domestic consumptive power increasing OBOR	**WO strategy:** Enhancing productivity to lower the cost; Enhancing quality to satisfy the consumers	**SO strategy:** Enhancing productivity and quality

3.2.2. Analysis Based on the Logistic Growth Model

Although Chinese companies have mastered a large number of low-cost methods, as other low-cost countries become more competitive, China's advantages in low cost will gradually become disadvantages. Enterprises have reached low-cost potential, and there is no room for growth. Therefore, we must look for other potentials. Quality capability is one of the potentials of choice. In the sales competition of high-quality products, Chinese enterprises mainly face competition from enterprises in developed countries. Although the competition will be fierce, there is a huge potential for Chinese companies to rise.

According to the logical growth model, the more companies that value quality, the more enterprises a company can learn from, and the stronger the ability to improve the quality level. Although Chinese companies can learn from enterprises in developed countries, China has its own culture, environment, and other characteristics, and will encounter many unique problems in China. According to Theorem 1, as more and more companies pay attention to quality, their experience in solving quality problems will increase. It is like the massive cost innovation that Chinese companies make under low-cost strategies (Zeng and Williamson, 2007). Under the national quality strategy, if a large number of Chinese companies implement quality strategies, they can also make a large number of quality innovations. So we get Proposition 2.

Proposition 2 the more Chinese companies implement a quality strategy, the faster the quality management capabilities of Chinese companies will grow, and the greater the quality potential.

3.3. Lean Strategy

3.3.1. Strategy Analysis

The application of lean manufacturing in China began in the automotive industry in the late 1970s, ahead of manufacturers in the US and Europe (Taj, 2008). But the result is not good. Aoki (2008) found that not all of China's nine auto parts manufacturers surveyed have successfully transferred improvement activities.

Lean production has simple rules (Spear and Bowen, 1999). The key to success is persistence in continuous improvement (Netland and Ferdows, 2014). Even in Toyota's best factory, workers can complete more than 50 improvements in three days (Spear, 2004). Taj (2008) studied the lean practices of Chinese manufacturing and found that these practices were successful in some respects but not in others.

3.3.2. Analysis Based on the Logistic Growth Model

Some Chinese companies began to learn Toyota's lean production methods in 1978, but the results were minimal. According to Theorem 1, the number of companies studying was too small. Because Chinese companies are experiencing their problems in the process of learning, the more companies they study, the more experience they will have to solve problems. But the key is that Chinese companies have used low-cost strategies in the past.

Although lean production can reduce costs, it takes a long time to master lean methods. The key to the difficulty of implementing lean manufacturing in most companies is a lack of patience (Netland and Ferdows, 2014). According to Theorem 1, only a growing number of Chinese companies have long insisted on implementing lean production, and through mutual learning, everyone has more and more experience. It is even possible to create China's own unique lean production system. Again we can get Proposition 3.

Proposition 3 the more Chinese companies implementing lean production, the faster the lean production capacity of Chinese companies will grow, and the greater their potential.

3.4. Technology Strategy

3.4.1. Strategy Analysis

China is currently a leading manufacturer of many consumer products worldwide and is expanding its territory in the high-tech sector (Pinto, 2005). After decades of development, its GDP, and the size of its researchers have increased to second place, second only to the United States (Marginson and Wende, 2007). In terms of patent applications and registrations, China's share of domestic applicants is also increasing, which is a symbol of its technological capabilities (Motohashi, 2008).

In recent years, new technologies such as 3D printing, big data, and IM have played an increasingly important role in the manufacturing industry. Industry 4.0 is a move by the German government to have a place in the global manufacturing industry, while "Made in China 2025" is an initiative of the Chinese government to upgrade the Chinese industry. They all hope to gain a competitive advantage in manufacturing through new technologies.

In Section 3.2, we concluded that China's manufacturing industry should adopt a quality strategy. Dubey *et al.* (2016), Matthias *et al.* (2017) and Zhong *et al.* (2017a) find that big data can detect problems in real-time and diagnose the cause of the problem. So big data helps improve product quality. Nguyen *et al.* (2018) found that the interest of scholars and practitioners in the application of big data analytics in supply chain management is growing rapidly. Tiwari *et al.* (2018) found that the amount of data generated from end-to-end supply chain management practices increased exponentially between 2010 and 2016.

How to generate, capture, organize, and analyze data to provide valuable insights into the industry is also a challenge. Tao *et al.* (2018) thought big data offered a tremendous opportunity in the transformation of today's manufacturing paradigm to smart manufacturing. Big data empowers companies to adopt data-driven strategies to become more competitive.

According to Sanders *et al.* (2016), Industry 4.0 can improve product quality through joint manufacturing with suppliers, item tagging, machine-worker communication, self-maintenance assessment, predictive maintenance control system for maintenance, workpiece-machine communication, improved man-machine interface, process tracking, and integration & management for quality. Therefore, new technologies can also play an important role in quality strategy.

Zhou *et al.* (2018) and Zhong *et al.* (2017b) concluded that intelligent manufacturing could make continuous improvement of enterprises' product quality. Ben-Daya *et al.* (2019) found that the IoT is primarily used to deliver supply chain processes and food and manufacturing supply chains that can improve quality. Kusiak (2018) found the IoT, cloud computing, service-oriented computing, artificial intelligence, and data science to make smart manufacturing the hallmark of the next industrial revolution. Therefore, a technology strategy is very important for Chinese manufacturing.

3.4.2. Analysis Based on the Logistic Growth Model

In China, few companies can develop related technologies, so their progress is bound to be slow. According to Theorem 1, if we want to speed up the progress, we can only make progress faster if we open up to the world and learn from foreign companies. So we get Proposition 4.

Proposition 4 opening up to the world can make new technologies develop faster.

4. CONCLUSION

Combining SWOT and LGM, we have established a strategic selection analysis framework from the industry level to the enterprise level. Through SWOT analysis, China's advantage over the past 30 years is the low-cost manufacturing capacity of low labor costs and infrastructure. By adopting a low-cost manufacturing strategy, China has seized opportunities in the cheap commodity markets of developed countries. Due to the learning effect and competitive effect of LGM, the choice of manufacturing companies to adopt the same cost strategy and actively learn from other companies' experiences is more conducive to their rapid development. However, China's current capabilities and environment are very different from the past.

Through SWOT analysis, China's manufacturing industry needs to adopt a quality strategy to build a world brand and compete in the global high-end market. Through the analysis of LGM, the potential advantages of China's low-cost strategy have been exhausted. The more companies adopting high-quality strategies, the faster the quality capability of an enterprise grows due to the learning effect. The way to achieve quality strategy is to adopt lean production, big data, and IM technology in China's manufacturing industry. Opening up to the world is very important for the development of IM because there are more sources of new knowledge in the open world.

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