

Research on the Over-outsourcing in Aviation Manufacturing

Industry— Case Analysis based on the Boeing 787¹

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Abstract: In recent years, outsourcing has become a major trend with more and more companies contracting work out to 3rd parties. The aircraft giant—Boeing company’ also regards outsourcing as an important way of its production process. In 2003, under the influence of Toyota production system(TPS),Boeing adopted a new manufacturing model to produce the airplane—Boeing 787 Dreamliner. It outsourced more than 70% of the development and production of its aircraft under a 3-Tier system .However, the excess outsourcing has caused lots of problems such as communication issues, lengthy delays and unexpected increased costs. Starting from the practice of Boeing 787 project’s global supply chain strategy, this paper analyzes the reasons as well as problems faced by Boeing for outsourcing such a big project, and draw some lessons on how to strengthen the management from the failure of Boeing 787’s early outsourcing stage.

Key words: Boeing 787; Outsourcing; Cost control; Supply chain

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1 Background

At the end of the 1990s, with sales of 767 and 747-400 slowing down, Boeing considered replacement aircraft programs. Boeing has utilized and enjoyed the benefits from outsourcing several times in its early aircraft production. For its earlier programs 737 and 747, the outsourcing ratio was at around 35-50 percent. Their process was to outsource the non-core manufacturing parts and keep their competitive advantage—design in-house. In 2003, for the first time in Boeing’s history, it outsourced more than 70% of the design, engineering and manufacture of its new aircraft—Boeing 787 Dreamliner. Boeing wanted to leverage its extended supply chain and partner manufacturing resources as a competitive advantage to improve time-to-market and reduce total costs. It outsourced an unprecedented share of responsibility for the 787

manufacturing to overseas partners, the suppliers are located in four major continents. Some main outsourcers are shown in the figure 1.

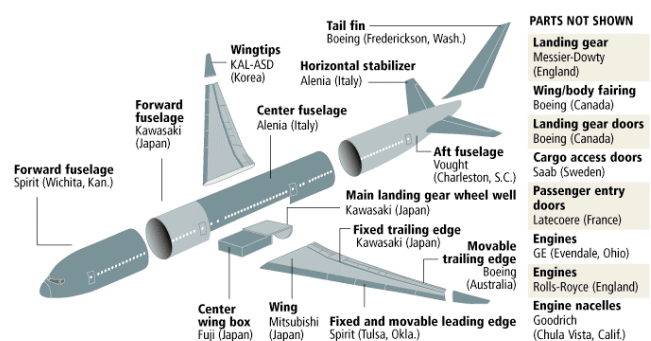


Fig.1 Suppliers on the Boeing 787 Dreamliner

(Source: www.boeing.com)

On the 787 project, Boeing adopted a new outsourcing model. Unlike its earlier aircrafts, in which Boeing played the traditional role of integrating and assembling different parts and subsystems produced by its direct suppliers, the

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787's supply chain was based on a 3-tiered structure that would allow Boeing to foster partnerships with around 15 Tier-1 strategic partners. These Tier-1 partners were to serve as "integrators" who assemble

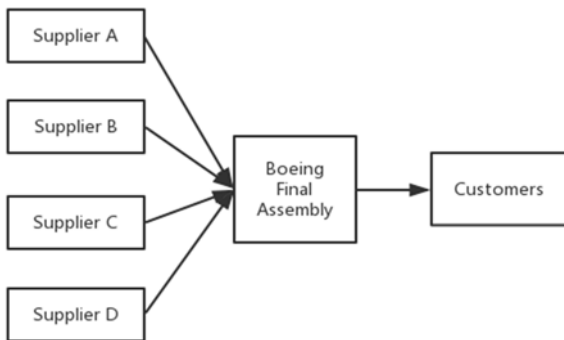


Fig.2 Traditional supply chain

different parts and subsystems produced by Tier-2 and Tier-3 suppliers.

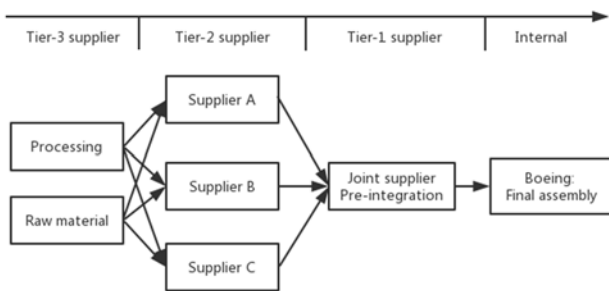


Fig.3 New supplier network

(Source: The Seattle Times)

Figure 3 illustrates Boeing's supplier network of Tier 1, Tier 2 and Tier 3 suppliers. Through such a three-tier supply chain network, Boeing could focus more attention and resources on its cooperation with Tier-one suppliers (pre-integration stage), instead of raw material procurement and early components.

2 Reasons of outsourcing

Outsourcing was a common practice in the Boeing company, it enthusiastically embraced outsourcing both locally and internationally, but it's quite rare that Boeing would choose to outsource such a significant proportion of the 787 Dreamliner, the main reasons are listed as follows.

2.1 Reducing costs

Cost reduction is one of the important reasons

for companies to implement outsourcing strategy. Before the 787 project started, Boeing's Board of Directors approved a development budget estimated at \$7 billion as Boeing management claimed that they would "require subcontractors to bear the majority of costs", which shows the most basic reason why they outsourced a lot on this project. Boeing wanted to reduce the production and development costs by leveraging suppliers' expertise. Outsourcing eludes the need to hire individuals in-house, hence recruitment and operational costs can be reduced to a great extent by taking advantage of the cheap labor force in other countries. There is less need for plants, inventory maintenance and labor. The outsourced company would maintain the resources inventory, pay the taxes and other fees for creating the parts.

2.2 Spreading the financial risks

Boeing 787 established a risk-sharing cooperation network with Tier-one suppliers to share research and development costs and resources. Outsourcing certain components of the business process helps the company to shift certain responsibilities to the outsourced vendor. The implementation of the global supply chain strategy enables enterprises to be more flexible and adapt quickly to changes in the external environment, thus realizing risk sharing with global partners. Since the outsourced vendor is more professional in the part outsourced, they can plan the risk-mitigating factors better and effectively enhance the ability to resist external shocks. Boeing 787 subcontracted a large amount of work to Tier-one suppliers, and established a long-term global partnership network with suppliers, bringing suppliers from the upper reaches of the industrial chain to the level of strategic partners.

2.3 Time saving

In 2003, the biggest competitor of Boeing—Airbus sold more airplanes than Boeing and introduced 5 new designs of aircrafts with Boeing still stuck with their next plane design. Airbus has more deliveries ever since. Boeing needed something to regain market share from Airbus. This

heavy competition was what drove Boeing to create a new plane that would help them reclaim dominance of the aircraft market. However, Time was urgent, they needed to complete the plane quickly and with minimum cost. By outsourcing 70% of the development and production activities, Boeing can shorten the development time by leveraging suppliers' ability to develop different parts at the same time. What's more, outsourcers have more professional technology, they can complete outsourcing tasks in a shorter time, thus saving time for Boeing. This is what drove Boeing to outsource a higher proportion of the new aircraft than any previous model.

2.4 Access to more international markets

The political reason for Boeing 787's large-scale of outsourcing was to gain the opportunity to do business in different countries. Boeing made a deal with several of the countries in East Asia that they contracted to perform work. The deal was that if the countries agreed to buy planes from Boeing, Boeing would outsource a portion of work to those countries. To some extent, it's the sales guarantee signed with the government of the country where the outsourced work is located. For example, Boeing has strengthened its partnership with suppliers in China. China's Shenyang Aircraft Company (SAC), Harbin Aircraft Manufacturing Company (HAMC) were all involved in 787 manufacturing. They were the only suppliers of corresponding components. Processing parts of Boeing 787 aircraft in China can reduce costs, but Boeing placed more emphasis on China as the fastest growing and largest aircraft market in the world, which can virtually bring it many business opportunities.

Boeing had several reasons in contracting the work out to different countries, not just the above mentioned. But whatever the reason is, it seems that this strategic decision could have the potential to reclaim the market share that Boeing has lost.

3 Problems faced by Boeing 787

Successful outsourcing strategy can bring many benefits to companies, helping them improve

efficiency and reduce cost. However, just like every coin has two sides, while giving suppliers unprecedented responsibility, it is also a risky attempt.

The 787 Dreamliner has been vexed since its inception, with the globalization of the supply chain, the risk of supply chain management caused by excessive outsourcing is also increasing. Hart-Smith had warned of the additional costs and risks of large-scale outsourcing in his paper, "Not only is the work out-sourced; all of the profits associated with the work are out-sourced, too."

3.1 Loss of Confidentiality & security

A major downside to outsourcing is that the business has to abandon some degree of privacy over its core business secrets. Boeing has been leading the aviation industry in design, it's one of its core competitiveness. But in the Boeing 787 project, it delegated much of the detailed design to sub-contractors, opting for lesser involvement. One of the reasons Boeing outsourced was to compete with Airbus but it might have created even more competition for itself by doing so. Additionally, it had to pass on information such as critical details about business processes and safety measures undertaken, so that the outsourced partner was able to perform the tasks in hand. Even if the partners were thoroughly tested for their internal security processes, there's always a risk of data getting stolen or fraud being committed.

3.2 Coordination and communication issues

Different parts of Boeing 787 are designed and manufactured in different locations in the world, the supply chain is stretched too long. Due to time difference and language barriers, coordination and communication issues among various outsourcers are unavoidable. The partners scattered around the world have limited access and visibility to the latest demand information from Boeing and that Boeing has little visibility to the outsourcers' ability to meet the delivery schedule. They were not able to discover the problems until the time when the airplane was supposed to go through final assembly. Boeing would then have to adjust the schedule and

possibly delay the arrival of other components. The problem of coordination and communication in the global supply chain has seriously affected the progress of the entire 787 project. All of these finally lead to Boeing 787 supply chaos.

3.3 Unexpected cost increase

The original intention of this large-scale outsourcing was to “reduce the 787’s development time from six to four years and development cost from \$10 to \$6 billion.” However, the result was exactly the opposite. This project was billions of dollars over the budget and three years behind schedule. At the end of 2013, the cost of producing a 787 airplane exceeded the purchase price. The analyst of JPMorgan estimated the program's loss to be \$45 million per airplane, decreasing as the program moves forward. As of May 2015, Boeing 787 had accumulated losses of nearly \$27 billion. Due to ballooning production costs, Boeing has spent \$32 billion on the program, estimates for the number of aircraft sales needed to break even vary

between 1,300 and 2,000. The main reasons for the cost increase are as follows:

3.3.1 Delayed delivery of aircraft leads to increased costs.

The parts of Boeing 787 were not provided in a timely manner or were delayed for reasons beyond the control of Boeing. In October of 2007, Boeing delayed the 787 by six months, the six-month delay cost the company over \$1 billion, with \$200 million coming from compensation paid to United Airlines and Air India. Deferred costs accounted for a large proportion of the 787 costs. This means that for each order that was delivered late, Boeing has to pay penalty fee for the delay. With deferred costs peaking in 2016 at \$3.3 billion, Leeham analyst Bjorn Fehrm believed Boeing couldn't make an overall profit on the program. Ted Piepenbrock, an academic affiliated with the MIT and the University of Oxford, forecasted the cumulative deferred costs to peak beyond \$34 billion. These penalty payments have brought unexpected cost increases to Boeing.

Table 1 Delays of Boeing 787 and explanations

Delay	Announcement Date	Cumulative Duration	Explanation(as reported by Boeing and discussed in the media)
1	September 2007	3 months	Unexpected shortages of fasteners and the inability of Spirit—a Boeing spinoff—to deliver the forward fuselage module.
2	October 2007	6 months	An unexpected shortage of fasteners –the“nuts and bolts”that hold an airplane together.
3	January 2008	9 months	Boeing blames startup challenges at its own factory and at factories in the extended global supply chain,specifically the supply chains and capabilities of Boeing’s subsidiaries and Tier 1 partners.
4	April 2008	1 year	Boeing blamed problems with carbon-fiber technology in the center wing box made by a Japanese partner.The wing box was too tight and needed strengthening.
5	November 2008	5 months	Incorrect fastener installation and the Boeing machinists strike

Source: Casewriter.Boeing Press Releases and Public Reports,<http://boeing.mediaroom.com>,accessed February 2015

3.3.2 Increased coordination and labor costs

Some parts from foreign outsourcers couldn't be assembled in the final assembly workshop due to size discrepancy or other problems.As a response to

suppliers' inability to meet production requirements and deadlines, Boeing decided that it must send key personnel to sites around the world to fill the management vacuum of suppliers and address

production issues in person. Boeing sent its engineers to the sites of Tier-1, Tier-2, or Tier-3 suppliers worldwide to solve various technical problems which appeared to be the root cause of the delay. This proved to be an expensive endeavor as personnel were pulled from responsibilities on-site at Boeing to solve supply and manufacturing issues at the sites of their outsourced partners. Mitigating the production and coordination issues required substantial and continuing communications with the partners and on-site involvement, thereby generating a large amount of additional costs.

3.3.3 Additional redesign costs

Boeing responded by throwing \$2 billion in additional research and development expenses at a series of components mismatch problems it faced with. It had to abandon part of the supply chain and spend a lot of time and money to redesign the product. The result was huge additional expenses. In addition, due to the excessive redesign, the first aircraft was 5,000 lb (2,300 kg) heavier than specified. Accordingly, some parts were redesigned over and over again to include more use of lighter materials. The direct impact was that the cost of each plane soared to \$193.5 million, which was 45% higher than the expected cost.

3.4 Safety and quality issues

Quality features both as an advantage and a disadvantage in this discussion. Outsourced partners, unless they have strict quality checks in place, can quickly nullify the advantages that enterprises originally saw in the whole concept of outsourcing. No company can make sure that the outsourced partners are doing exactly what they are asked for in terms of the quality of the product or service according to the specifications. The lack of strict quality control often leads to declining levels of output. Companies cannot easily write a set of procedures or steps that the third parties should follow to complete the work outsourced to them. They have no real way to measure the quality of the work being done by the outsourced company. Due to the wide distribution of outsourcers, Boeing 787's quality problems emerge one after another. The

components assembled in the final assembly plant from global partners often have the problem of over-standard size errors, which lead to the failure of all parts of the body to join. Many of the partner companies (Tier-1 suppliers) have struggled, either in assembling the components themselves, or getting the parts they need from others (Tier-2 suppliers), in time to meet Boeing's rigorous construction schedule. In order to catch up with the project progress blindly, some suppliers have frequent product quality problems. In 2013, the first year of service for the Boeing 787 Dreamliner, at least four aircraft suffered from electrical system problems stemming from lithium-ion batteries. These quality problems have brought huge negative impacts to Boeing and caused greater losses.

3.5 Loss of complete control over business

Once a business part is outsourced to a third party, the company is no longer in full control of that aspect. The day to day management of the work is definitely passed on to the outsourced partner. In spite of the fact that the outsourcing company may retain some degree of control over the work, they don't have the same degree of control they would have had on employees sitting in the same premise. During the implementation of Boeing 787 outsourcing contract, the competent department failed to carry out strict and effective monitoring of outsourcing suppliers, resulting in the company's lack of understanding of the control of outsourcing suppliers' technical capabilities, personnel qualifications, main equipment and key processes. Boeing had to manage Tier-1 suppliers and pay more attention to sub-suppliers. Once the small sub-suppliers had technical problems, the domino effect would appear on the assembly module of the terminal.

3.6 Blind imitation of Toyota's 3-tier supply chain

The 3-Tier supply chain on Boeing 787 came from Toyota—Car manufacturing giant in Japan. Toyota once outsourced about 70% to a group of trustworthy partners, which made Toyota successfully develop new cars in a shorter time. This

process has led Toyota becoming one of the biggest and most profitable cars manufacturing in the world. Boeing saw that Toyota would put the design and risk of the projects onto several different partners, it tried to utilize the same method and apply the Toyota Production System (TPS) to see how successful production process was operated. However, there were many fundamental differences between the two companies' production procedures. Toyota worked closely with its suppliers and responded to their concerns with integrity and mutual respect, establishing an impressive level of professional trust and high attention to product quality. By contrast, Boeing adopted the superficial structure of Toyota's tiered outsourcing model without the values and practices on which it rests. In addition, the average distance between Toyota and its suppliers' plants is much shorter than the corresponding distance for Boeing. The blind imitation eventually led to the outsourcing failure of Boeing 787.

In addition to the above problems, Boeing 787 project has also brought many other problems. For example, over-outsourcing resulted in a large amount of work being given to the outside of the enterprise, its internal employees may lose motivation to work hard due to the fear of unemployment. It is likely to lead to a decline in employees' professional ethics and performance, thus reducing productivity.

4 Results

Hart-Smith had warned of the additional costs and risks of large-scale outsourcing, it didn't cut costs and increase profits, he wrote, instead, it drove profits and knowledge to suppliers while increasing costs for the mother company. As a result of the over-outsourcing of Boeing 787, not only the delivery schedule was delayed again and again, but also the safety accidents occurred frequently after the delivery of the aircraft. A Japan Airlines (JAL) 787 experienced a fuel leak on January 8, 2013, and its flight from Boston was canceled. On January 9, United Airlines reported a problem in 787 with the wiring near the main batteries. Later, on January 11,

2013, another aircraft was found to have a fuel leak. On January 16, 2013, due to the continuous safety accidents, the US Federal Aviation Administration announced that all Boeing 787 Dreamliner planes were temporarily grounded.

4.1 Boeing took appropriate remedial measures after discovering a series of problems in the supply chain, but the effect was very limited. In December 2008, Boeing set up a "product operation center" to control all the suppliers' products and solve problems quickly. The center worked 24 hours a day and employed a variety of personnel: translators in 28 languages, purchasers, supplier managers, and global logistics experts.

4.2 After realizing that some Tier-1 strategic partners did not have the know-how to develop different parts of the aircraft or experiences in managing their Tier-2 suppliers to develop the requisite components for the sections, Boeing recognized the need to regain more control over the supply chain. Boeing announced plans to buy Vought Aircraft Industries' interest in Global Aeronautica; A later agreement was also made to buy Vought's factory in North Charleston.

4.3 Boeing introduced a web-based communications tool called Exostar in which suppliers were supposed to upload the latest information about the progress of their work, which aimed to provide visibility of the supply chain, improve control and integration of key business processes. However, this tool didn't play its due role, part of the suppliers did not input the accurate and timely information owing to cultural differences and lack of trust. As a consequence, neither Boeing nor Tier-1 suppliers became aware of the problems in a timely manner.

5 Lessons from the outsourcing failure

Outsourcing strategy is a double-edged sword for enterprises, it may be profitable, but the outsourcing company might also suffer losses due to over-outsourcing. Most critics claim that the lowered cost of operation comes along with the threats of reduced level of efficiency and that even if there is a

sense of accountability placed on respective vendors. Therefore, enterprises should decide whether to implement outsourcing strategy according to their specific actual situation, and pay attention to correctly guide and avoid risks in the implementation process, so as to obtain the expected benefits.

5.1 Outsourcing should be based on complete assessments of all of the costs

Make or buy decisions should not be made until after the product has been fully defined and the related costs established. The project of Boeing 787 went billions over budget. What's the reason? Before outsourcing, Boeing did not carry out a comprehensive control and analysis of all possible potential costs, resulting in the actual outsourcing costs significantly exceeding the budget, bringing huge losses to Boeing. According to Boeing's former CFO, Boeing will have to sell 1300-2000 planes to reach the break-even point. Therefore, Boeing should not excessively pursue Creeping elegance. The new technology adopted by Boeing 787 brings great risks to the project evaluation. The more new technologies, the more difficult it is to design and manufacture. However, there is no effective way to restrain the increase of unknown costs. As a result of inadequate cost budget, the Boeing 787 project experienced a sharp increase in material costs, delayed delivery and lost cost control capabilities. Deferred costs of 787 even peaked in 2016 at \$3.3 billion, Boeing's original development investment, estimated at least at a further \$20 billion, isn't included in these costs. If Boeing adopted more mature and robust technologies to conduct a comprehensive cost control analysis from the outset, the results might be greatly improved.

5.2 Establish an effective coordination mechanism

Since Boeing is operating as the final assembler, coordinating the many structural and systems partner locations around the globe is critical to the manufacturing success. Boeing needed awareness of partner activities throughout the network to fully comprehend the issues confronting them. It is

suggested that in a large-scale project like Boeing 787, specific person or team should be appointed to coordinate all communications to eliminate latency in communicating changes across multiple tiers, or use the industrial Internet and some IT technologies to realize the integration of real-time information among various suppliers. Each supplier must update the progress of the project in a timely manner, and corresponding restriction regulations should be implemented on the correctness of the information. Demand/supply and logistics information across multiple tiers need to be synchronized, in case of any problem, the supplier shall immediately communicate with the person in charge of coordination to make sure that key components arrive at the Boeing Everett, Washington facility at just the right time for final assembly. Coordination mechanism is of great importance for every project, effective communication can greatly improve outsourcing operation efficiency.

5.3 Perform risk assessment in advance

Outsourcing has both positive side as well as negative side. Any company should make a careful assessment whether the positive points outweigh the negative ones in that case. Before taking on a project, it's essential for the enterprise to assess both of operational and structural aspects to calculate the overall risk. A comprehensive risk assessment will cost a certain amount, but it's too insignificant compared with the sharp increase in project cost caused by insufficient evaluation. The Boeing 787 project was full of risks, such as the cultural and language differences of outsourcers, as well as the physical distances involved in the lengthy supply chain. Boeing could have prevented or reduced the bad consequences from taking place if they had performed a risk analysis of outsourcing. As a matter of fact, Boeing has adopted a risk management plan called "Boeing 787 Dimension Management Method". However, it has achieved little and the response was not timely. Subsequently, a large number of unexpected problems seriously affected the progress of the project. Therefore, risk assessment is crucial to all the outsourcing

decisions.

5.4 Establish an effective cooperation mechanism with trusted suppliers

There are many ways to diminish the disadvantages of outsourcing. One of them is to choose quality partners to outsource the tasks to. When selecting outsourcing partners, don't simply select the suppliers based on price. A number of alternative suppliers should be set up to be compared and evaluated beforehand from multiple dimensions such as technology, quality, progress and service. Boeing made an assumption that the chosen partners would have the required capabilities to do design and integration work, and build pre-assembled sections, but this assumption would prove invalid. What's more, Boeing relied on poorly designed contractual arrangements, which created perverse incentives by providing penalties for delay but no rewards for timely delivery. This has reduced the impetus of suppliers to some extent. In a word, effective cooperation mechanism with suppliers is indispensable. The outsourcing company should ensure that the partners are reliable, honest and will always deliver quality work. Only those who have proven their ability to deliver with the required timeliness, quality and continuous innovation should be selected as trustworthy partners. For supplier partners who delay delivery, corresponding penalty regulations should also be imposed. At the same time, reward is better to be given to suppliers who deliver in time and complete with high quality. This kind of incentive mechanism can promote suppliers to carry out production work more efficiently.

5.5 The project organization should not be too complicated

There are 135 partners involved in Boeing 787 aircraft manufacturing and fabrication worldwide. The supply chain was stretched to an unprecedented length. The former project manager of B787 pointed out that many suppliers recruited sub-suppliers, some suppliers subcontracted work to their suppliers and shrugged at problems with assembly, the sub-suppliers could not even meet the basic requirements of production. When Boeing 787

aircraft was first assembled at Everett assembly plant in March 2008, the components from partners around the world didn't fit together with others.

When one part was unavailable, the next one that depended on it could not be attached and the global supply chain was almost stuck. The stretched supply chain has added to the complexity of Boeing 787 project. So it's suggested that for large-scale projects, it is not only necessary to strengthen the control of the project process, but also to simplify the complexity of the program as much as possible in the prior stage.

5.6 Project progress must be strictly controlled

Boeing did not intervene early enough in the process to assist the suppliers and finally lead to the outsourcing out-of-control. Understanding the processes in the entire supply chain globally is crucial to delivery performance. Boeing and its partners needed a way to quickly identify potential problems across the supply chain and immediately analyze their impact on other partners or manufacturing processes. In order to effectively control the whole supply chain network and ensure the quality of products, the outsourcing company can send technical support teams to the sites as needed to supervise and control production process. For products whose technical parameters cannot be directly detected by the incoming reinspection, the technical support team shall conduct pre-acceptance at the production site and confirm in the report. If serious quality problems are found, outsourcing suppliers should be required to stop production and rectify. Through on-site supervision or application of new industrial Internet technology, it's easier to achieve effective control of the entire production process.

6 Conclusion:

More and more businesses have embraced the practice of outsourcing. But implementing the outsourcing strategy is a double-edged sword for enterprises. The original intention of Boeing to outsource a large number of projects was nothing

more than to save costs and turn its own factory into a final assembly workshop, but the result turned out to be the opposite. Although the Boeing 787 project has achieved great technological success, it has not met the schedule requirements and cost budget. As discussed in this paper, outsourcing should be based on a reasonable analysis of the situation of the enterprise, rather than blindly imitating the operation mode of other successful enterprises. The supply chain is a system of mutual connection and restriction. The "chain" integrates the originally separate enterprises together to form a community of interests with shared risks, benefits and common development. Therefore, any company who wants to outsource should carry out sufficient and thorough trade-off analysis whenever and wherever necessary, it's supposed to gradually establish and perfect the outsourcing management system, strictly implement it to ensure the quality of outsourced products.

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