Communications of the IIMA

Volume 13 | Issue 2 Article 2

2013

The Effect of Supply Chain Strategy on Quality and U. S. Competitiveness

Xin James He
Fairfield University

The Effect of Supply Chain Strategy on Quality and U. S. Competitiveness

Xin James He
Fairfield University, USA
xhe@fairfield.edu

ABSTRACT

This research investigates the effect of global supply chain strategy on product quality and U. S. competitiveness by analyzing the case of Boeing 787 Dreamliner recent lithium-ion battery overheating incident. Boeing 787, a new and complex product, has outsourced 70% of its parts and components with a redesigned global supply chain strategy. The grounding of all 50 Boeing 787s already in service by the U. S. FAA on January 16, 2013, has trigged a renewed debate on product quality as a result of extensive outsourcing and its impact on the overall U. S. competitiveness. While this incident is a result of in-flight battery fire with Japan Airlines, along with a similar case occurred earlier in January 2013 in Boston with the same airline company, many believe Boeing's new aggressive supply chain strategy may have contributed to its quality and safety problems. Managerial implications are discussed to generalize the impact of various global supply chain strategies on product quality and overall U. S. competitiveness.

Keywords: Global supply chain, supply chain strategy, product quality

INTRODUCTION

The initial trend of global supply chain began more than a decade ago when companies typically outsourced non-critical parts and components of their products. These components were important to the overall business operations, but often secondary to the core value or quality concerns of the products and therefore could be entrusted to offshore suppliers or contractors. As time went on, more parts and components were outsourced until some entire companies moved overseas. In addition to lower costs in developing countries or emerging markets, lack of skilled labor force, as a result of weakening U. S. manufacturing competitiveness, is also cited in the literature. In extreme cases, firms simply did not question if outsourcing or offshoring was the most beneficial to their global supply chain strategy in the long run but rather assumed that outsourcing would have a positive effect by default.

This research investigates the effect of global supply chain strategy on product quality and overall U. S. competitiveness by analyzing the case of Boeing 787 Dreamliner's recent lithium-ion battery overheating incident. Boeing 787, a new and complex product, has outsourced 70% of its parts and components with a redesigned global supply chain strategy. However, the grounding of all 50 Boeing 787s by the U. S. FAA on January 16, 2013 has touched the nerve of not only its quality concerns but also its global supply chain strategy. This grounding decision is a result of an in-flight battery fire with Japan Airlines, along with a similar scenario occurred earlier in January 2013 in Boston with the same airline company. This research focuses on how

Boeing's new aggressive supply chain strategy may have contributed to its quality and safety problems and generalizes its impact on product quality and overall U. S. competitiveness.

In this research, we first try to scrutinize root causes of the in-flight battery fire by asking such questions as: Is it an isolated problem related only to lithium-ion batteries? Is it a much broader quality or safety issue to all new and complex products? Does the new aggressive supply chain strategy for Boeing 787 exacerbate the problem? If so, what lessons can we learn, and how can we maintain high product quality under today's large-scale global supply chain networks? Then we try to analyze how to take advantages of outsourcing and offshoring and at the same time maintain high product quality and overall U. S. competitiveness in terms new product design and innovation.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 analyzes the impact of global supply chain strategy on product quality. Section 4 discusses managerial implications. Finally, section 5 summarizes the research findings.

LITERATURE REVIEW

We review the literature from the following three aspects: i) Boeing 787 supply chain strategy and its lithium-ion battery problem, ii) supply chain strategy and product quality, and iii) outsourcing and offshoring on U. S. competitiveness.

Boeing 787 Supply Chain Strategy and its Lithium-ion Battery Problem

The Boeing 787 Dreamliner, designed to use 20% less fuel and expected to be 10% lower in cost-per-seat mile, is not only a revolutionary aircraft, but it also serves as a role model with an unconventional supply chain strategy.

In responding to global competition and fuel economy, Boeing Commercial Airplanes in 2004 launched the 787 Dreamliner. Boeing 787 has a new lightweight composite materials fuselage, as opposed to traditional aluminum materials (Hawk, 2005). In addition, Boeing 787 has outsourced a full 30% of its parts and components that are managed by its tie-one suppliers, contrary to its Boeing 747 with only 5% outsourced and managed by its tie-one suppliers. This new global supply chain strategy was designed to reduce the new product development cost from $10 billion to $6 billion. However, a series of supply chain delays had cost Boeing over $5 billion late delivery penalty charges prior to the battery overheating incidents in January 2013.

Figure 1 shows the traditional supply chain for airplane manufacturing where Boeing has direct oversights on all major suppliers. Figure 2 depicts the redesigned supply chain for Boeing 787 where Boeing has direct oversights only on Tier 1 suppliers, who are in charge of Tier 2 and Tier 3 suppliers. According to Tang and Zimmerman (2009), the rationale of Boeing 787 redesigned supply chain with more outsourced parts and components is to reduce direct supply base and delegate more so that Boeing would be able to focus its attention more on new designs, processes, and technologies. It hoped to reduce financial risks and increase production capacity without incurring additional production costs. Nevertheless, since a new aircraft with brand-new composite materials, along with a number of other new designs, is a challenge all by itself,

changing the supply chain strategy and the assembly process all at once is probably a recipe for disaster.

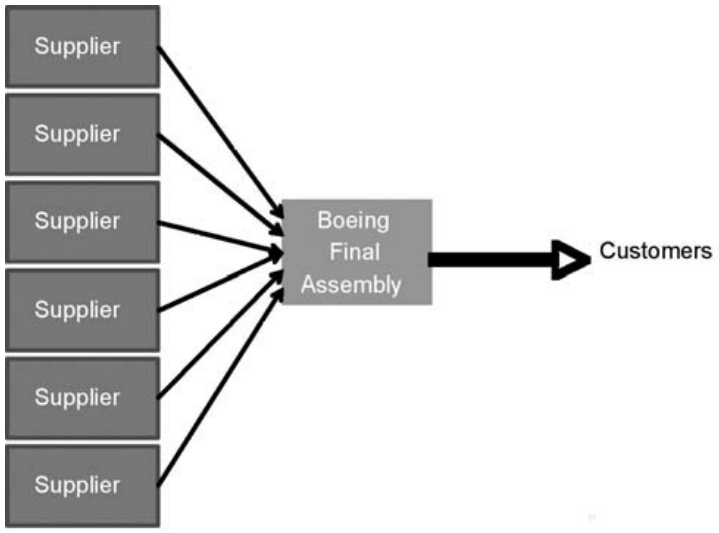


Figure 1: Traditional Supply Chain for Airplane Manufacturing.

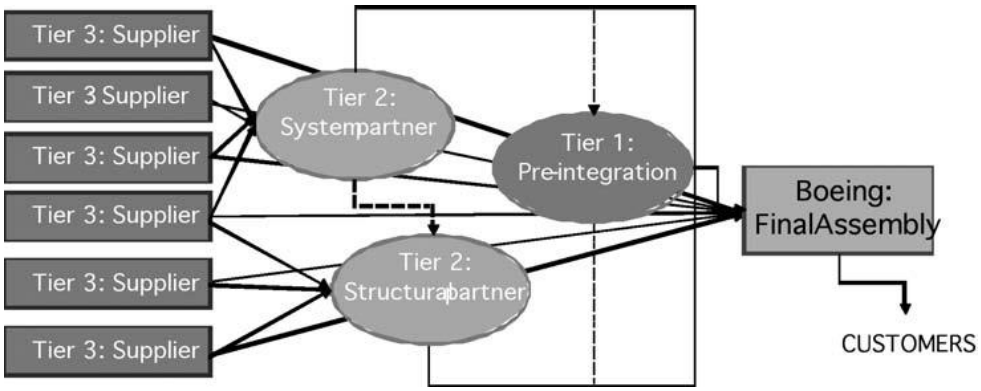


Figure 2: Redesigned Supply Chain for Boeing 787 Dreamliner.

Boeing 787 Dreamliner has suffered numerous electrical system problems in addition to the lithium-ion battery overheating incidents in January 2013 that led to all 50 Boeing 787 planes already in service around the world grounded by the U. S. FAA on January 16, 2013. According to Boeing engineers with knowledge of the situation (Gates, 2013), the FAA allowed Boeing 787 to use lithium-ion batteries, instead of more traditional battery chemistries, because Boeing 787 wanted to use more battery power in order to save fuel. Mike Sinnett, the 787's chief engineer, acknowledged that while the root causes of the lithium-ion battery problems are still under investigation, there could be as many as 80 different ways that the batteries could fail (Mouawad, 2013). Since a Boeing 787's global supplier makes all the lithium-ion batteries in Japan, some Boeing engineers blame the 787's aggressive global supply chain strategy that poor-quality components are coming from subcontractors that have operated largely out of Boeing's direct supervision. According to one Boeing 787 electric engineer, the real problem is the Power Panels

(not just the lithium-ion batteries), which are "like Radio Shack" with parts that are "cheap, plastic and prone to failure" (Gates, 2013).

As shown in Figure 2, the redesigned Boeing 787 supply chain contracted with a top tier of about 50 suppliers, handing them complete control of the design of their pieces of the plane. Boeing only knows what is going on with its Tier 1 supplier, but it has no visibility, no coordination, no real understanding of how all the pieces fit together (Tang & Zimmerman, 2009).

Supply Chain Strategy and Product Quality

The Boeing 787 in-flight battery fire incident, along with a series of supply chain delays that lead to over $5 billion late delivery fines, signifies the importance of this research to the strategic level: Would a complex new product combined with an unproven new supply chain strategy always lead to a disaster? No matter what conclusions are, the findings of this research may be generalized to other new and complex products with high degree global supply chain networks and high quality and safety expectations.

To determine if outsourcing is a viable option, a company needs to look beyond costs and balance sheets and assess long-term benefits. Costs, such as raw materials, labor, production, and shipment, must be taking into consideration, but non-monetary factors, including effects on the product quality and overall manufacturing competitiveness, should not be overlooked. As the trend to expand overseas operations continued, many multinational corporations tend to not ask critical questions or understand potential negative effects, especially when the overall global economy is doing well. This is one of the major factors that has negatively attributed to the current U. S. manufacturing competiveness and the product quality such as Boeing 787.

Table 1 displays the importance of each of the strategic drivers for outsourcing and offshoring. In 2006, for example, the most cited driver of offshoring was to cut costs. Other drivers in descending order where competitive pressure, improving service levels, accessing qualified personnel, changing rules of the game, industry practice, business process redesign, access to new markets and enhancing system redundancy. This is consistent with the widely held believe that the main reason of outsourcing and offshoring is to reduce costs.

Offshoring Strategic Drivers	Percent of Respondents Citing Driver as Important
Taking out costs	93
Competitive pressure	69
Improving service levels	56
Accessing qualified personnel	55
Changing rules of the game	41
Industry practice	37
Business process redesign	35
Access to new markets	33
Enhancing system redundancy	27

Source: Lewin & Peeters (2006, p. 226)

Table 1: Strategic Drivers of Outsourcing.

As more companies moved overseas, *global supply chain* became buzzwords for every firm, whether large or small. Firms developed relationships with overseas suppliers for parts and components needed throughout different stages of the manufacturing process. Global supply chain networks include all steps necessary to transform raw materials into finished goods and spread into entire products that are often new in technology and more complex with parts and components. On one hand, it is advantageous for multinational corporations to outsource labor-intensive parts and components. On the other hand, it is debatable for capital and high-tech intensive parts and components to be outsourced due to concerns of technological innovation, product quality, and intellectual property protection. As an alternative, companies may purchase raw materials and produce finished goods altogether domestically within the U.S., especially for such products as furniture and large machinery due to resource availability, shipping cost, and proximity to the markets. In fact, there are other reasons for using domestic suppliers, which ensures the product quality and reinforces the overall manufacturing competitiveness. The challenge however is what products to be outsourced or offshored and how much and what products to stay domestically in light of the advantages and disadvantages of the global supply chain.

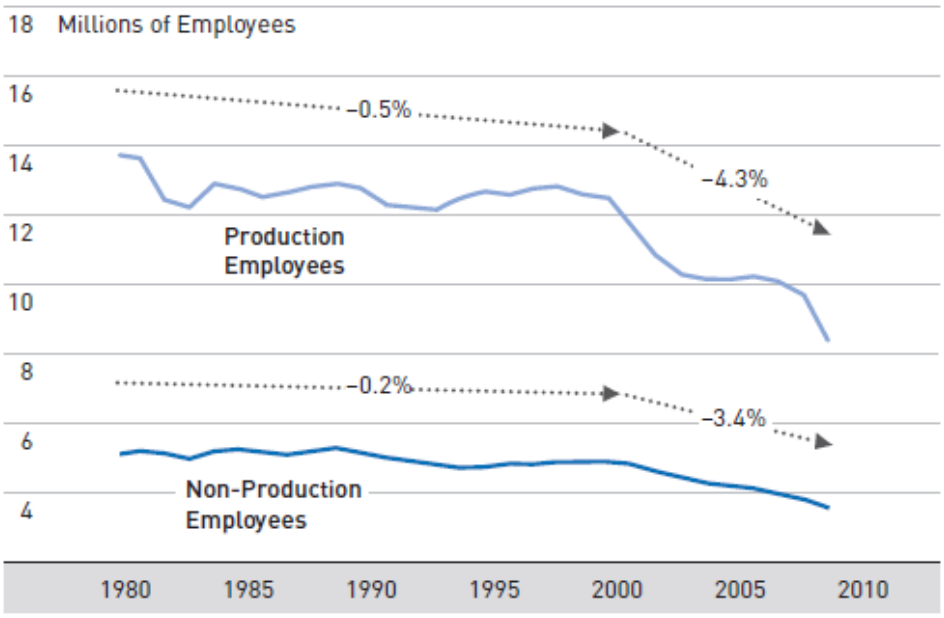
Outsourcing and Offshoring on U. S. Competitiveness

Manufacturing is typically thought of as the assembly line production of goods. According to the Bureau of Labor Statistics (2012b, para. 1), however, "the manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products." This includes plants, factories, or mills, which create products using power-driven machinery or material-handling equipment. Many people would not consider places like bakeries, candy stores and custom tailors as manufacturers, but they are in fact classified as such through the North American Industry Classification System (NAICS).

Figure 3 shows the trend of manufacturing jobs moving overseas prior to 2010. It is seen from Figure 3 that the decline for the number of U. S. manufacturing employees was moderate between 1980 and 2000, but the decline accelerated for the period 2000 through 2010. In other words, the major decline of the U. S. manufacturing jobs occurred over the last 10 years or so, instead of over the last 20 years as many intuitively believed. Specifically, manufacturing employment for production jobs dropped at an annualized rate of 0.5% for the period between 1980 and 2000, as opposed to a much steeper 4.3% annual decrease between 2000 and 2010. This sharp decline of U. S. manufacturing jobs over the last decade matches the trend of increased activities in terms of outsourcing and offshoring during the same period, indicating a negative correlation between U. S. manufacturing jobs and outsourcing and offshoring activities. Figure 3 does not provide, however, a quantifiable relationship between the two, nor does it provide any information on the impact of global supply chain on product quality or on U. S. competitiveness.

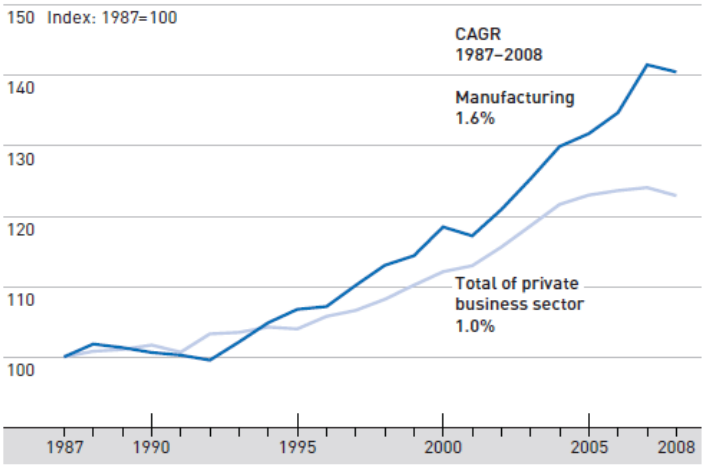
Figure 4 illustrates that while the manufacturing jobs decreased in the U. S. over the last two decades, the manufacturing productivity increased during the period. One possible interpretation is that as companies either contract their inefficient manufacturing processes overseas or move their entire manufacturing operations offshores all together, their existing operations become

more effective and efficient in terms of productivity, along with technological advancements such as Internet and mobile applications. According to Kaushal, Mayor, and Riedl (2010, p. 33), "For more than 20 years, the U. S. manufacturing sector disproportionately propelled growth in multifactor productivity (the changes in economic output per unit of combined inputs) –a critical key to prosperity." Nonetheless, Figure 4 does not capture the impact of financial crisis that began in 2008 and its subsequent prolonged high unemployment rate despite of the continued trend of outsourcing and offshoring.



Source: As cited in Kaushal, Mayor, & Riedl (2010, p. 34)

Figure 3: U. S. Manufacturing Employees, 1980-2010.



Note: CAGR is compound annual growth rate.

Source: As cited in Kaushal, Mayor, & Riedl (2010, p. 33)

Figure 4: Productivity in the United States.

According to Pisano and Shih (2012), R&D and manufacturing interdependence is one of the criteria to determine if extensive global supply chain networks would have an adverse effect on product quality and new product innovation, which can be analyzed by introducing the concept of modularity and maturity. When R&D and manufacturing are independent and modular, variability in the major characteristics of the product are not determined by production process, outsourcing and offshoring should be encouraged. When manufacturing technologies are immature and R&D and production are interdependent, however, companies rely on process innovation to thrive; outsourcing and offshoring, therefore, should be discouraged or limited.

Personal computer, for example, is product whose manufacturing process is mature and the value of integrating product design with manufacturing process is low, aggressive global supply chain networks make sense. However, Boeing 787, for another example, is a new and complex product whose manufacturing process evolves rapidly that can have a significant effect on quality of the product and the value of integrating R&D and manufacturing is extremely high. As a result, the risks of separating design and manufacturing may be more than offsetting the benefits of outsourcing and offshoring.

ANALYSIS

The impact of global supply chain strategy on the quality of Boeing 787 is not just limited to lithium-ion batteries. Instead, it is related to its overall outsourcing and offshoring strategy and the overall quality of Boeing 787, which may be true for any new and complex product with aggressive supply chain strategies. Specifically, we try to investigate: (1) root causes of the Boeing 787 quality issues, (2) the impact of global supply chain strategy on product quality, (3) criteria to high product quality and overall U. S. competitiveness in light of global supply chain networks, and (4) the effect of global supply chain on U. S. competitiveness.

Root Causes of the Boeing 787 Quality Issues

First, we try to analyze root causes of the Boeing 787 lithium-ion battery overheating problems. Since a sustainable supply chain needs a reliable quality as a prerequisite, quality at the source is the only way to keep the global supply chain sustainable. Of the four quality categories (appraisal, prevention, internal failure, and external failure), on one hand, prevention is the only category that would achieve high product quality with low cost. External failure, on the other hand, is the worst-case scenario that would lead to the highest quality cost and worst publicity, which is the scenario every company would want to avoid. Unfortunately, Boeing 787 lithium-ion battery overheating problems obviously fit the definition of an external failure as a result of the redesigned supply chain strategy where Boeing has direct oversights only on tie 1 suppliers. Consequently, Boeing has been struggling to fix the problems after all 50 planes were delivered to various airline companies with extensive external failure costs and negative publicities.

The Impact of Global Supply Chain Strategy on Product Quality

Now we try to analyze three alternative global supply chain strategies that Boeing could be facing:

a) To deploy technical representatives to each vendor site to oversee thousands of contracts to improve quality but with increased expenses to dispatch representatives
b) To reduce outsourcing to the 747's successful 5% level and to only outsource *non-critical* components
c) To bring the 787 in-house to Boeing's headquarters in Chicago, Illinois, at 100%.

Analyzing these alternatives would help us understand the pros and cons of different global supply chain strategies. Alternative a) is ideal in theory, but it is not feasible in practice because the cost to deploy technical representatives to each vendor site to oversee thousands of contracts would more than offset any potential cost savings associated with outsourcing and offshoring. Alternative c) means to make every part and component in the U. S. within Boeing's own facilities, which will significantly increase the manufacturing costs for Boeing since the average manufacturing hourly labor compensation (including benefits) in U. S. is $35.35 in 2011, as opposed to $2.01 in the Philippines and $6.48 in Mexico (U.S. Bureau of Labor Statistics, 2012a). Finally, alternative b) means to delegate only 5% non-critical parts and components to top tie suppliers and hand them complete control of the design of their pieces of the plane as described in Figure 2, but to maintain the rest of the supply chain structure as described in Figure 1 where Boeing has direct oversight of its suppliers. We believe that alternative b) takes advantage of lower manufacturing costs via outsourcing and offshoring and, at the same time, keeps critical parts and components produced either by themselves or by well-established suppliers.

Criteria to High Product Quality in Light of Global Supply Chain Networks

Since outsourcing and offshoring will continue as long as competitive advantages exist, the challenge is what, how, and how much for a specific product to tradeoff between cost and quality. Here we try to use the Modularity-Maturity Matrix shown in Table 2 below as a theoretical basis to pin point what product should be outsourced or offshored and what should not (Pisano & Shih, 2012).

Maturity	Low Modularity	High Modularity
High	**Process-embedded innovation** Process technologies, though mature, are still highly integral to product. Subtle changes in process can alter the product's characteristics in unpredictable ways. *Design cannot be separated from manufacturing*, e.g., craft products, advanced materials fabrications	**Pure product innovation** The processes are mature, and the value of integrating product design with manufacturing is low. *Outsourcing manufacturing makes sense*, e.g., computers, cons electronics, active pharmaceutical ingredients, commodity semiconductors
Low	**Process-driven innovation** Major process innovations are evolving rapidly and can have a huge impact on the product. The value of integrating R&D and manufacturing is extremely high. *The risks of separating design and manufacturing are enormous*, e.g., biotech drugs, nano-materials, e-displays, super-miniaturized assembly	**Pure process innovation** Process technology is evolving rapidly but is not intimately connected to product innovation. While locating product design near manufacturing is not critical, proximity between R&D and manufacturing is, e.g., advanced semiconductors, high-density flexible circuits

Table 2: Modularity-Maturity Matrix

A related question is, "Can we move the factory back to the U.S.?" since the global supply chains are extensively and major U. S. multinational corporations are so relying on outsourcing to save costs. In addition, the costs of moving well-established manufacturing networks overseas back home would result a loss of connectivity to the current suppliers, which may be further hindered by the weakening industry clusters in the U. S. that are essential to link all the suppliers. Steve Jobs, the former CEO of Apple, stated the industry clusters in the supply chain:

> The entire supply chain is in China now . . . . You need a thousand rubber gaskets? That's the factory next door. You need a million screws? That factory is a block away. You need that screw made a little bit different? It will take three hours (Duhigg & Bradsger, 2012, para. 40).

This example explains the extent of Apple's supply chain network in China. The resources Apple needs to create their products are conveniently located within blocks of the factory that is a great asset to the business. The network that Apple has established is a main reason that Steve Jobs said that Apple's manufacturing jobs would not return to the United States in the foreseeable future. Moving manufacturing processes of a product back to the U. S. could be extremely costly for certain companies and products, which is also related to the overall U. S. manufacturing competiveness.

However, our focus here is to analyze in theory the criteria to high product quality in light of global supply chain, without taking into consideration of the current U. S. competiveness or skilled labor availability. When a product or component is defined as *Pure Product Innovation*, as shown on the upper right corner of Table 2, it is ideal for outsourcing and offshoring since its manufacturing processes are often with high maturity and its structures are of high modularity. In the example of Boeing 787, common components such as engines and landing gears are of high maturity and modularity and consequently subject to high degree of outsourcing and offshoring. In this case, the redesigned supply chain in Figure 2 should work best. However, when a product or component is defined as *Process-Driven Innovation*, as shown on the lower left corner of Table 2, it has least outsourcing and offshoring potential since its manufacturing processes are often with low maturity or even brand new and its structures are of low modularity. In the example of Boeing 787, the new lightweight composite materials fuselage (instead of traditional aluminum materials) and new lithium-ion batteries (instead of less powerful batteries) are of low maturity and modularity since both of these technologies are brand new. Consequently, the risks of separating these brand new designs from manufacturing processes via outsourcing and offshoring are enormous.

However, the majority of the parts and components for Boeing 787 can be defined in-between, either as *Process-Embedded Innovation* (upper left corner of Table 2) with mature technology but low modularity or as *Pure Process Innovation* (lower right corner of Table 2) with high modularity but low maturity. If they are to be outsourced or offshored, the traditional supply chain strategy in Figure 1 has the best fit since for these parts and components design cannot be completely separated from manufacturing processes for timely communication, feedback, and innovation.

Effect of Global Supply Chain on U. S. Competitiveness

Skilled Labor. One of the main impacts of outsourcing and offshoring on the overall U. S. competitiveness is lack of skilled workers in manufacturing, which makes the U. S. less competitive in the global marketplace. For example, China's exponential growth has provided a tremendous opportunity for jobs in manufacturing. As one Apple executive put it:

> About 8,700 industrial engineers were needed to oversee and guide the 200,000 assembly-line workers eventually involved in manufacturing iPhones. The company's analysts had forecast it would take as long as nine months to find that many qualified engineers in the United States. In China, it took 15 days. (Duhigg & Bradsher, 2012).

Manufacturing. Currently, U. S. factories produce about 75 percent of the products that the nation consumes. A series of identifiable actions and choice by business leaders, educators, and policy makers could lead to a robust, manufacturing-driven economic future and push that figure up to 95 percent. Alternatively, if the U. S. manufacturing sector remains neglected, its output could fall by half, meeting less than 40 percent of the nation's demand, and U. S. manufacturing capabilities could then erode past the point of no return (Kaushal, Mayor, & Riedl, 2010)

Research published by Booz & Company, along with the University of Michigan's Tauber Institute for Global Operations (Kaushal, Mayor, & Riedl, 2010), explains the significance of the current situation. The U. S. needs to make the necessary changes in order to increase the percentage of products produced and consumed in the United States to 95 percent. It is essential that industry not be neglected because the research concluded that this percentage could drop as low as 37.5 percent. Allowing the sector to be overlooked could result in a permanent reduction of manufacturing in the United States as a result of prolonged shortage of skilled labor force and lack of essential industry clusters. In turn, this would negatively affect manufacturing jobs and would lead to more American jobs moving overseas.

Manufacturing Renaissance in the U. S. The Boston Consulting Group (BCG) researched the wages and manufacturing in the U. S. and China and found that there will no longer be an extreme gap between wages in the two countries. The BCG (2011, para. 1) stated that, "within the next five years, the United States is expected to experience a manufacturing renaissance as the wage gap with China shrinks and certain U. S. states become some of the cheapest locations for manufacturing in the developed world." One may think that wages in the U. S. will remain higher than those in China in the near future, but this research proves otherwise. When comparing salaries of American and Chinese workers, for example, adjustments must be made in order to account for the higher productivity of American workers. Thus, wages in Chinese cities like Shanghai are expected to be about 30 percent lower than that in the U.S., which can be translated as a 10% to 15% cost advantage when a product is made in China vs. in U. S. because wages only account for 20% to 30% of the total cost of a product. The total cost advantage is virtually non-existent when higher inventory and shipping costs are considered overseas. In a study by the Boston Consulting Group, 37% of companies stated that they plan to move production back to the U. S. and that number increases to 48% among companies that brought in upwards of $10 billion in revenue.

Current Trend of U. S. Manufacturing. Industries that require technology that is more advanced are less likely to move production overseas because of intellectual property issues, as well as the need for workers with a unique skill set, in addition to what is outlined in the Modularity-Maturity Matrix shown in Table 2. Furthermore, the costs of shipping bulky products and the ample supply of wood in the U. S. make furniture manufacturing a prime candidate for domestic manufacturing. Additionally, companies that produce appliances, cookware, audio earphones, water heaters and various other products are likely to bring their parts or all of their manufacturing back to the U. S. due to rising labor costs in China along with the increase in shipment costs as a result of rising oil prices.

Nevertheless, computer equipment, metal products and transportation goods are less likely to move production back to the U. S. because they can be classified as *Pure Process Innovation* products (lower right corner of Table 2) and are ideal for outsourcing and offshoring. Textile products also have little hope of moving production to the U. S. although some of them are leaving China for lower labor cost countries such as Vietnam, Indonesia, and Bangladesh as the labor and land costs in China have been increasing much faster than most of other developing countries.

MANAGERIAL IMPLICATIONS

Now we discuss managerial implications that may be generalized from the findings of the case analysis in terms of the impact of global supply chain strategy on product quality with respect to new and complex products.

We find that a sustainable global supply chain not only takes advantage of low cost suppliers, but also maintains high product quality. On the one hand, a complex new product such as Boeing 787 often times can be categorized as *Process-Driver Innovation* in the Modularity-Maturity Matrix in Table 2, where major process innovations are evolving rapidly and the value of integrating R&D and manufacturing is extremely high. As a result, delegating such a new product extensively to unproven suppliers through outsourcing and offshoring could not only cause significant schedule delays but also suffer devastating quality nightmares. On the other hand, a mature product such as a personal computer often times can be categorized as *Pure Product Innovation* in the Modularity-Maturity Matrix in Table 2, where major components are highly modularized and the value of integrating product design and manufacturing is low. As a result, firms with a mature product should delegate more via outsourcing and offshoring in order to reduce their direct supply base and to focus their attention more on new product design, processes, and technologies.

In other words, we need to take into consideration of the relationship between R&D and manufacturing interdependence when we make a global supply chain decision. In general, more interdependence between R&D and manufacturing implies less outsourcing and offshoring and vise versa. Specifically, when R&D and manufacturing are highly modular (variability in the major characteristics of the product are not determined by production process) or when the processes are mature and the value of integrating product design with manufacturing is low, outsourcing should be encouraged. Examples include personal computers, consumer electronics,

active pharmaceutical ingredients, and commodity semiconductors. When manufacturing technologies are immature and companies can thrive by focusing on process innovation or when the risks of separating design and manufacturing are enormous, however, outsourcing should be discouraged or limited. Examples include biotech drugs, nano-materials, e-displays, and super-miniaturized assembly.

SUMMARY

This research investigates the effect of global supply chain strategy on product quality and overall U. S. competitiveness by analyzing the case of Boeing 787 Dreamliner recent lithium-ion battery overheating incidents. We find that Boeing 787 in-flight battery fire was not an isolated quality problem but rather related to its global supply chain strategy. The combination of a brand new product with lightweight composite fuselage plus new high power lithium-ion battery and an aggressive redesigned supply chain network, which delegates complete control of the design of outsourced parts and components to the suppliers as shown in Figure 2, exacerbates the potential external quality failures. According to Modularity-Maturity Matrix in Table 2, a product such as Boeing 787 can be defined as *Process-Driven Innovation* with high risks if design and manufacturing are separated.

Outsourcing and Offshoring will continue as long as competitive advantages exist. There are four challenges: What, how, and how much for a specific product (which varies from product to product). The impact of supply chain management on quality is not just limited to six-sigma implementation. Instead, it is related to the overall outsourcing and offshoring strategy, as well as the overall competitiveness of the U. S. manufacturing sections. The case of Boeing 787 makes everyone think we can take advantages of the global supply chain and, at the same time, maintain high quality products and overall U. S. competitiveness.

REFERENCES

Booz & Company. (2010, March 30). *China manufacturing competitiveness 2009-2010*. Retrieved from http://www.booz.com/global/home/what-we-think/reports-white-papers/article-display/china-manufacturing-competitiveness-2009-2010

Boston Consulting Group. (2011, May 5). *Made in the USA, again: Manufacturing is expected to return to America as China's rising labor costs erase most savings from offshoring* [Press release]. Retrieved from http://www.bcg.com/media/pressreleasedetails.aspx?id=tcm:12-75973

Duhigg, C., & Bradsher, K. (2012, January 21). How U. S. lost out on iphone work. *The New York Times*, p. A1. Retrieved from http://www.nytimes.com/2012/01/22/business/apple-america-and-a-squeezed-middle-class.html?pagewanted=all&_r=0

Gates, D. (2013, February 4). Boeing 787 problems include electrical systems flaws. *Seattle Times.* Retrieved from http://seattletimes.com/html/businesstechnology/2016310102_boeing25.html

Hawk, J. L. (2005). *The Boeing 787 Dreamliner: More than an airplane* [PowerPoint slides]. Retrieved from http://www.scsi-inc.com/Boeing%20Presentation%20by%20Jeff%20Hawk.pdf

Kaushal, A., Mayor, T., & Riedl, P. (2010). *Manufacturing's wake up call*. New York, NY: Booz & Company. Retrieved from http://www.tauber.umich.edu/docs/Manuf-WakeUp_w_Cover.pdf

Lewin, A. Y., & Peeters, C. (2006). Offshoring work: Business hype or the onset of fundamental transformation? *Long Range Planning 39*, 221-239. Retrieved from https://dipot.ulb.ac.be/dspace/bitstream/2013/9039/1/Lewin_Peeters_2006_LRP_Offshoring_business_hype_or_transformation.pdf

Mouawad, J. (2013, March 15). Boeing discloses fixes for lithium-ion batteries. *New York Times*, p. B3. Retrieved from http://www.nytimes.com/2013/03/16/business/boeing-details-its-fixes-for-787.html

Pisano, G. P., & Shih, W. C. (2012). *Producing prosperity: Why America needs a manufacturing renaissance*. Boston, MA: Harvard Business School Publishing.

Tang, C. S., & Zimmerman. J. D. (2009). Managing new product development and supply chain risks: The Boeing 787 case. *Supply Chain Forum, 10*(2), 74-86.

U. S. Bureau of Labor Statistics. (2012a). *International comparisons of hourly compensation costs in manufacturing, 2011* [News Release USDL-12-2460]. Retrieved from http://www.bls. gov/news.release/pdf/ichcc.pdf

U. S. Bureau of Labor Statistics. (2012b). *Manufacturing: NAICS 31-33.* Retrieved from http://www.bls.gov/iag/tgs/iag31-33.htm#about

This Page Was Left Blank Intentionally.