

Bridging New Product Development with Sustainable Supply Chain Management Practices

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Abstract: - This paper proposes a novel method linking new product development (NPD) strategies and the supply chain management practices considering sustainability approaches. The paper highlights the first stage of research study through current literature and a critical review which are based on a systematic approach by gathering a set of structured data as inputs of research findings. Using a descriptive research method and qualitative analysis, the study involves Boeing Company's evaluation of Dreamliner development. Given the comprehensive literature regarding the Dreamliner's development program, its weaknesses and supply chain restructuring risks, the paper establishes coherent strategies and a well-defined framework towards minimising the potential risks associated with the future series of aircraft manufacturing practices. Paper investigates the Dreamliner's case that only represents aircraft manufacturing industry, whereas the characteristics of other industries might necessitate different approaches. Besides, minimising the environmental impacts of aircraft manufacturing industry, a full life-cycle analysis is required. Effective NPD approaches would be considered by all the businesses desiring to make innovation and alter their supply chain and advanced project management practices in order for their profitability enhancement. The research aims to develop an early understanding of systematic review of Dreamliner's case towards emerging a clear framework addressing project management and sustainability issues. The paper would be considered by the industrial entities especially Aircraft industries which tends to receive the highest advantages from redesigning their global supply chain adoption methods.

Key-Words: - Sustainable Supply Chain, New Product Development (NPD), Boeing, Manufacturing, Supply Chain Management (SCM),

1 Introduction

Our world is being affected by a day to day alteration in various aspects such as politics, industries, economics and socials. As an impact of globalization, dealing with the industrial and economic changes would be vital to the business owners, hence, they confront a severe competition towards survivability. Amongst all these rapid transformations, the individual customers could be considered as the most vulnerable as well as most influential bodies, since the purpose of all the supply chain entities is to fulfil the needs of ultimate users.

Given the tight competition in business scenes, NPD act as a key scheme activity which moves them towards improving products quality, high-level of consumer satisfaction, profitability enhancement and long-term prosperity. Over the past decades, many researchers have studied the coordination of

supply chain management (SCM) and NPD. In this regard, the "demand" paradigm needs to be focused through the supply chain, whereas this necessitates the NPD process and research and development (R&D) entities to be in closed alignment within the manufacturing sector. Moreover, in spite of high advantages of NPD approach, it can be a controversial issue if the firms do not adopt the sufficient supply chain management and engineering expertise. Not surprisingly, a huge number of new products face issues while entering the market in 2012, the rate of NPD success in US, Europe and Asia were 67.5%, 56.8% and 48.6% relatively [1].

As a world major aircraft manufacturer, Boeing tended to practice a supply redesign strategy in order to slightly reduce the development cost and time for its brand-new 787 Dreamliner aircraft [2]. Hence, Dreamliner's case would be an appropriate

case for the purpose of this paper as it enables us to examine the supply chain redesigning practices within the NPD process as well as the advantages, disadvantages, drivers and hurdles of doing so. This paper seeks to investigate the opportunities for a sustainable NPD approach considering the various sustainable supply chain practices. It also attempts to analyse the most relevant manufacturing cases such as Boeing Dreamliner that faced some challenges towards their product development processes and supply chain redesigning.

A critical systematic review would be very beneficial in this case to provide a proper foundation to establish sufficient data in a methodical manner; hence addressing the existing gaps within both industrial and practical areas. Utilising a logical sequence and the different systematic review steps introduced by [3], the author would be able to organize the secondary resources more effectively towards better perception of the research questions and data analysis.

As research highlights, the potential risks of supply chain restructuring emerge as a result of project management gaps and sustainability issues. Therefore, based on the project scope, the paper will generate a clear framework and well-defined strategies in order to minimise the potential gaps of the NPD and supply chain approaches. Being more specifically, the following research questions will be analysed at the final stage:

- Q1. NPD – which NPD approaches have been adopted to the supply chain?
- Q2. Sustainable Supply-chain Success Factors – what frameworks has been defined for the sustainability of a supply chain?
- Q3. Supply-chain Redesign Threats – what are the main risks and threats associated with supply-chain restructuring?
- Q4. NPD, Sustainability and Supply-chain Redesign – what are the key benefits for bridging the three concepts together?

2 Literature Review

This section aims to explore the world literature in order to outline the relevant existing theories within the context of sustainable supply chain and NPD practices; therefore make a good foundation to develop future research agendas. The key research areas of this study aims to focus towards the potential risks of the supply chain redesigning, the supply chain approaches within this criteria and also

the risk management strategies of doing so. A systematic review approach will provide the unbiased and focused results containing comprehensive and multi-dimensional knowledge towards further analysis [4].

2.1 NPD and Supply Chain

The term “product development” is classically defined as the transformation process of a market opportunity and a set of assumptions regarding product technology into a product accessible for marketplace [5]. It is an element which can empower supply chain drivers and cause the fulfilment of market growing requirements; however, it is mentioned as an expensive and time-consuming practice [6]. Research paper explores the factors that bring uncertainty to the process of NPD and cause struggles for companies for on-time delivery of products or projects [7]. The uncertainties are declared as resource capability, social or economic situations, market situations, technology changes, organizational changes, supply changes and regulatory changes [7]. Using a three-dimensional model based on risk management approach and a survey data conducted to Chinese businesses; the most significant risk parameters impacting on NPD performance includes technological, organizational and marketing risks [8]. They suggest future authors to find out the most effective risk reduction methods for NPD approaches within a comprehensive set of managerial schemes to other business contexts rather than Chinese businesses.

Despite all the existing studies regarding NPD complications and uncertainties, a long-term NPD success might be possible by collaboration of different supply chain companies within NPD processes [9]. Based on a theoretical model, supplier association act as key components of NPD and customer involvement applies a positive effect on it as well as cross-functional integrations, whereas all of the three factors create and integrated NPD and lead to the success of financial performance and NPD [10]. The following framework presents the mentioned claim in detail.

The term “Interdepartmental connectedness” is defined as capturing the degree to which an organizations’ culture facilitates effective communication across functional areas [11], whereas the contacts within the enterprise been considered by the open information sharing and relationships to bridge the borders between different

parties and members of the firm. The middle box contains three different functions that act as a traditional roles with minim engagement in the organisation's NPD processes. Hence, the increased involvement from the manufacturing staff, suppliers and customers is required towards bridging better relationships between the independent and the dependant variable which is the ultimate purpose of customer satisfaction with six established factors.

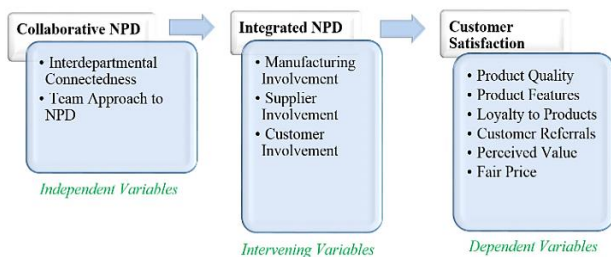


Fig. 1. Identified framework linking NPD and supply chain [10].

2.2 Sustainable Supply Chain Management

Sustainable supply chain management (SSCM) is defined as, “involvement of the planning and management of sourcing, procurement, conversion and logistics activities involved during pre-manufacturing, manufacturing, use and post-use stages through the life-cycle stages between companies by explicitly considering the social, environmental implications to achieve a shared vision” [12]. The application of SSCM implementation is still low in practice [13], and this could be due to insufficient progress and the lack of well-defined framework for effective SSCM. A theoretical framework for sustainability within supply chain is recommended according to figure 2 [14]. The core concept is sustainability including its three pillars with four supporting elements contributing to the SSCM. The triple bottom line of sustainability provides with the company with numerous achievements such as lower costs, shorter lead-times, improved product quality, reduced disposal costs, improved working conditions and enhanced company's image leading to both supplier and customer satisfaction [15]. The model will be utilised in the research analysis for the better perception of sustainability and accountability of the supply chain while proposing the NPD processes, especially in the Boeing case that exactly faced the same issues in Dreamliner's development case.

Along with the financial factors, legislations and staff pressure; market pressure plays an important role in changing the industrial behaviour towards

sustainable practices whereas some companies set some guidelines called “suppliers' charter” introducing the environmental criteria they require from their supplier firms [16]. For instance, the government institutions and departments in Germany are required to purchase sustainable goods such as recycled papers. Wal-Mart Retailing Corporation in US and B&Q in the UK are asking their suppliers for the development of eco-friendly products and adoption of environmental practices. One of the largest supermarkets in Denmark established its own technical research programme in early 90's and set new environmental policies while prohibiting the use of PVC in product's packaging and enforced its suppliers to utilise replacing packaging materials [16].

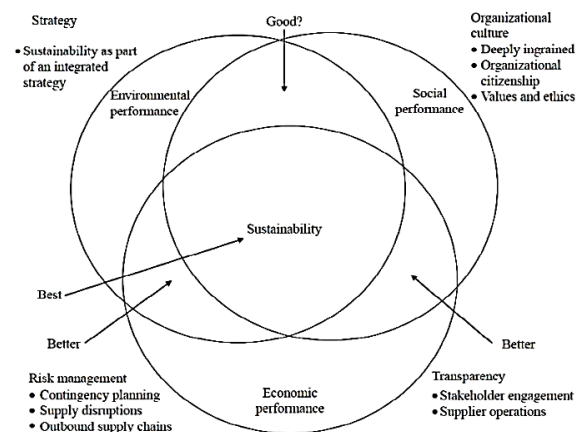


Fig. 2. Sustainable Supply Chain Management (SSCM) [14].

2.3 Boeing Dreamliner Programme Overview

The case of Boeing 787 development program and the risks associated with managing an unconventional supply chain is investigated [2, 17]. Boeing planned to create an aircraft (787 Dreamliner) by applying value-creation strategy offering many advantages both for the immediate customers (airlines) and end customers (passengers), such as cost-effectiveness, fuel efficiency and reduced noise pollution [2]. Given the existing challenges towards the independent and distinct global value chains, the integration challenges within Boeing NPD programme is highlighted [17]. Among all, Boeing endeavoured to address the challenges through guiding resources to different partners' locations, forming an integration support centre and utilising the bargaining power and competitive advantage in order to facilitate changes [17]. It is stated that two important primary objectives were applied by Boeing as integration tools; firstly by increasing the visibility of actions

and knowledge networks across suppliers and secondly, motivating suppliers to be engaged in visibility improvement actions [17].

2.3.1 Supply Chain Redesign for Boeing 787 Dreamliner

Apart from the material changes, they applied some changes in supply chain structure and outsourcing. These alterations imposed some challenges to Boeing as they brought some uncertainties in terms of unproven technology, unusual supply chain and also ineffective IT coordination systems. They shifted from the traditional supply chain system and employed an unusual supply chain strategy, which aims to highly mitigate the development cost and time. Figure 3 illustrates the traditional supply chain model of Boeing.

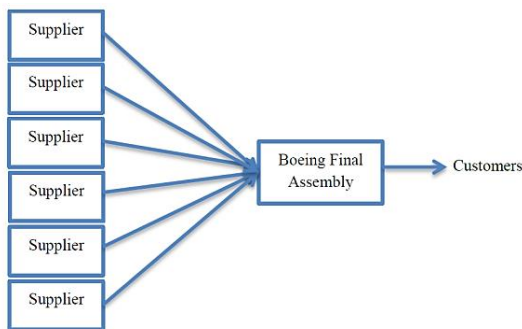


Fig. 3. Traditional supply chain model of Boeing [2].

Comparing the former and new supply chain in figures 3 and 4, in the traditional one, subsystems were provided by several thousand suppliers and then Boeing was responsible for the final assembly within 30 days. Hence, Boeing acted as a very typical key manufacturer, which is responsible for assembly of all the entire parts and subsystems provided by thousands of suppliers. In the traditional one, every single split in the supply chain system results in long delays in the final production.

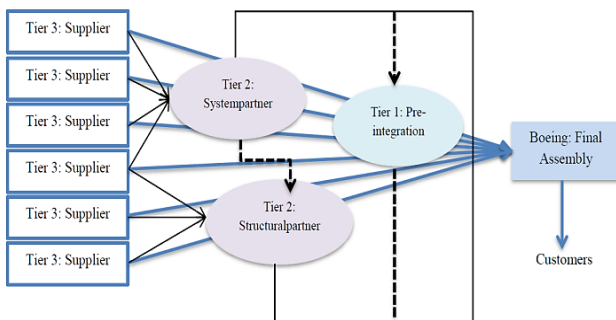


Fig. 4. New supply chain model of Boeing Dreamliner [2].

The new 787 program was similar to Toyota's supply chain plan for its new cars development [2], and was based on a 3 Tiers structure which Boeing had a strategic partnership with 50 suppliers in tier-1 [17]. Partners in tier-1 assemble different components and subsystems manufactured by tier-2 suppliers and ship entire sections to Boeing to assemble them only within 3 days. In other words, Boeing were previously focused on detailed specifications and assembly of smaller sections, but following the new strategies, they shifted a broad range of their responsibilities to their close partners to use their own competency to design and produce the major sections of the aircraft for final assembly in Boeing plant [17]. Besides, tier-1 suppliers have more extensive and integrated responsibilities regarding the materials they are supplying [18]. This alteration was made based on the assumption that their structural partner would have essential expertise, however, following the major delays, this assumption proved to be invalid.

Many advantages associated with the new supply chain model were identified [2]. By outsourcing 70% of the manufacturing operations and development of all the parts in parallel, Boeing was enabled to hugely reduce the Dreamliner's cycle time. In this case, by decentralizing the manufacturing process, the final assembly of 30 days for Boeing 737 drastically reduced to only 3 days in 787 programme that would be done in Boeing's plant. Moreover, shifting more assembly operations to the tier-1 suppliers provided Boeing with huge savings on development costs that lead to production capacity growth without the need for additional investments. In order to facilitate more collaboration with suppliers, Boeing utilised internet based planning software called Exostar to organize the supply chain activities and gain control of critical business processes.

According to the new supply chain changes, Boeing established a new risk-sharing contract that the strategic suppliers would only receive the payments after the main delivery of first 787 to the airlines. This undertaking sought to involve the suppliers in 787 development program. It was also beneficial for the suppliers as it allowed them to own their intellectual property and even being licensed to other corporations in the future. Besides, by collaborating in development of the larger sections of the plane instead of the small parts, the profitability of tier-1 suppliers could be increased and therefore they found more incentives to accept this payment term. However, due to probable delays

of other suppliers, the strategic partners might unfairly be penalized and need to work slower and this would be a challenge for risk-sharing contract objectives [19].

2.3.2 Supply Chain Risks and Responsive Risk Management Strategies

In spite of utilising the new supply chain model, great potential for cost and time development reduction and growing Boeing stock price between 2003 and 2007, receiving huge amount of orders from more than 50 airlines for 895 Dreamliner aircrafts, resulted in a series of issues in aircrafts delivery schedules, continual delays and negative market response in late 2007. Using different unproven technologies caused Boeing to experience technical issues and major delays in 787 development program [2, 17]. It is stated that the effective integration of the supply chain entities is significant for network efficiency as it incorporates the integration of material flow, information flow and financial flows through the whole supply chain [20].

▪ **Technology Risks**

Engine interchangeability and security concerns of new computer networks increased the delivery delays. Utilising composite materials brought Dreamliner some safety issues [21] as well as 8% overweightness [2]. Regarding the computer networks security, they searched for a new design to separate the aircraft's computer systems and passengers' electronic entertainment systems. Covering the safety issues, they tended to modify the fuselage design by using additional materials and besides, they redesigned its installation process to reduce the changeover time. Moreover, the management team were continuously working to reduce the aircrafts weight and tried to ensure the customers about fulfilling the gaps within the final version.

▪ **Supply Risks**

Due to the cultural gaps, tier-2 and tier-3 suppliers revealed a lack of technical know-how since they did not often enter regular and updated information to the Exostar planning system. This resulted in unawareness of Boeing and tier-1 suppliers regarding the delays, and that they faced struggle to make a quick respond to those issues, since a very small break in the supply chain would cause significant delays of the final production. Moreover, integrating knowledge and information across multinational enterprise (MNE) would be difficult

due to differences in language, culture [22] and authority sources. Solving this problem, Boeing decided to separate some of its purchasing unit by unit in order to gain direct control over the supply. Boeing also paid \$125 million to one of its suppliers in order to ensure it about continuing the vital operations [2].

▪ **Process Risks**

Despite the fact that Boeing was usually keeping safety stocks, dependency of the aircraft delivery schedule on just-in-time deliveries of the major sections of Dreamliner by tier-1 suppliers caused late delays. Relying Boeing on its key suppliers for subassembly of the sections was risky and hence, addressing this issue, Boeing started to send hundreds of its key staff to its tier-1, tier-2 and even tier-3 supplier's global sites in order to provide them with proper consultation to solve the technical issues that caused the delay in the 787's development. In order to select more powerful and capable tier-1 suppliers, Boeing could make more effort to assess supplier's technical capabilities and their supply chain proficiency if they are able to fulfil the orders of key sections on time. Boeing would also require their key suppliers to appraise the tier2 and tier3 suppliers to prove the quality assurance of the sections that leads to reduction of potential delays [2, 17].

▪ **Management Risks**

Due to the transformation of 787 supply chain design, it was essential for Boeing to establish a leadership team consisting of highly professional members in supply chain risk management field in order to prevent the different risks associated with the new unconventional supply chain to manage and address the problems resulted by delays more effectively [2].

▪ **Labour Risks**

Due to more outsourcing undertakings and staff concerns about losing their jobs, 25,000 employees took part in a strike. The strike, reduced work schedule, order cancellations and delivery delays all imposed a negative impact on strategic partners as they also tried to reduce the working hours for manufacturing of Boeing sections [23]. To ensure the personnel regarding their job security and to cover the outsourcing issues, Boeing attempted to make a limitation to the amount of operations done by their suppliers. They also agreed to provide the labour with an additional 15% wage over the next four years. As authors recommend, following the disapproval of the union for outsourcings strategy,

Boeing should not have outsources about 70% of its tasks. After applying the strategy due to its financial advantages, Boeing could have prevented the labour strikes and could have managed its staff by appropriate discussions and providing job assurances [2].

▪ **Demand Risks**

Following the announcement of delivery delays, many Boeing customers lost their trust in Boeing’s aircraft development program and either started to cancel some of their Dreamliner orders or shifted from direct purchasing to leasing contracts. Firstly, enhancing the customer satisfaction, Boeing decided to supply some of its customers such as Virgin Atlantic with the new Boeing 737 or 747 instead of 787. Secondly, by sharing its progress information on the website, communication enhancement and conduction of a publicity campaign for Dreamliner’s technology promotion, Boeing made effort to work on its marketing strategies in order to revive its business public image [24]. Furthermore, by setting proper expectations for customers, Boeing could have made a better customer relationship during the development process and also would have helped airlines to effectively manage their orders by replacing 787 aircrafts by 737 or 747 [17].

The current literature is examined in terms focusing on NPD-supply chain integration, sustainable supply chain and mainly the investigation Boeing Dreamliner’s case. As part of the systematic review, the following table tends to organize and summarize the current literature with a special focus towards aircraft industry supply chain and more specifically, Boeing. A summary of the review is presented in Table 2.1. As evident, not many articles exist regarding the supply chain approaches of Boeing, and this gap might be further addressed by conduction of questionnaire survey to the similar industries. Hence, the existing literature creates a good foundation for the proper analysis of the next sections.

3 Case Study Analysis

The literature review conducted extensively at the initial stages of the research and identified the research gaps in knowledge within this area. A combination of research methods and approaches has been employed within this research. This included the use of critical literature review analysis, case study based method investigating the Boeing 787 Dreamliner programme. Investigation of the case and proper evaluation of the company for

sustainable supply-chain potentials were performed with the aid of the secondary data. In order to shed some lights to the research gaps, different aspects of the Boeing Dreamliner programme would be investigated along with the key benefits and the risks and threats and hurdles associated with that would be analysed.

As literature suggests, suppliers and customers are considered as intervening variables [10], where Boeing needs to be cautious regarding the strong and efficient integration with them as it faced challenges in bridging the NPD performance and customer satisfaction. In addition, applying sustainable supply chain framework and considering sustainability as the heart of the 3 main pillars [14], Boeing would be able to make a better transparency with its stakeholders, as well as a consistent project planning. On the other side, Demand chain management (DCM) could be adopted as *“the management of supply production systems designed to promote higher customer satisfaction levels through electronic commerce that facilitates physical flow and information transfer, both forwards and backwards between suppliers, manufacturers and customers”* [25].

Table 1. Presentation of the characteristics of the articles included in systematic review.

Article	Year	Study Design	NPD - SC	Sustainable SC	NPD Performance	Aircraft Industry
Markham and Lee	2013	Analytical	✓		✓	
Tang and Zimmerman	2009	Descriptive	✓		✓	✓
Krishnan and Ulrich	2001	Descriptive	✓			
Sharifi et al.	2006	Descriptive	✓	✓		
Martinich	2015	Descriptive			✓	
Mu et al.	2009	Analytical			✓	
Moreno et al.	2011	Descriptive		✓	✓	
Tan and Tracey	2007	Analytical	✓		✓	
Sethi and Nicholson	2001	Analytical			✓	
Badurdeen et al.	2009	Descriptive		✓		
Brockhaus et al.	2013	Descriptive		✓		
Carter and Rodgers	2008	Descriptive		✓	✓	
Carter and Easton	2011	Descriptive		✓		
Mckenzie et al.	1991	Descriptive		✓		
Kothes and Srikanth	2011	Descriptive	✓	✓	✓	✓
Horng and Bozdogan	2007	Descriptive	✓		✓	✓
Kwon et al.	2009	Analytical				✓
Rai et al.	2006	Analytical			✓	
Grant	1996	Descriptive			✓	
Williams et al.	2002	Analytical		✓		✓

3.1 Defined plan towards Boeing NPD approach

According to the aforementioned Dreamliner's challenges and based on the literature studies, a well-defined plan is created in order to develop the current practices of Boeing to cover the research purposes; determining how to take advantages of the business positive points to create a platform for NPD approaches towards a more sustainable supply-chain in order to avoid the similar launch delays and challenges they faced in 2007. The following plan contributes to a Successful Sustainable Supply-chain Redesign approach called SSR framework:

Table 2. SSR framework

Prioritised Elements to be Adopted by Boeing	Essential Development Factors
<i>Prioritize SWOT and key NPD issues</i>	<ul style="list-style-type: none"> ▪ Strategic fit assessment ▪ Maximise strengths and opportunities ▪ Minimise weaknesses and threats.
<i>Effective collaboration with expert suppliers</i>	<ul style="list-style-type: none"> ▪ Searching professional suppliers to avoid delays ▪ Utilising stakeholders as NPD project forces.
<i>Stakeholder's coordination</i>	<ul style="list-style-type: none"> ▪ Consult with Tier-1 and Tier-2 Suppliers before the project start ▪ Predict the possible delays and minimise them ▪ Personnel reward system ▪ Ask key suppliers for the quality assurance of Tier-2 and Tier-3 suppliers ▪ In-advance contact with customers for launch date updates ▪ Offering benefits or discounts to customers for the delay compensation.
<i>Establishment of a project management teams</i>	<ul style="list-style-type: none"> ▪ Employment of high-level university staffs and research institutions ▪ Establish project and risk management teams related to every single project
<i>Solving IT and technological issues before project start</i>	<ul style="list-style-type: none"> ▪ Applying an updated effective supply chain software system ▪ Train the suppliers through preparation workshops for IT software ▪ Using proven and validated technologies

4 Conclusions

The research seeks to address the importance and adoption of frameworks such as SSR within the NPD projects in aircraft industry. To achieve the aim of the study, the research derived some key research objectives. The authors have attempted to discover appropriate answers concerning initial questions of the study which help to delineate the scope of the research. The research proposed a novel method towards linking the new product development (NPD) strategies within the context of supply chain practices with the importance of sustainability approaches within the framework. As it is evident from the literature study and the critical review, the case of Boeing towards the development of their Dreamliner product was evaluated within this paper. The analysis of case of the Dreamliner development programme demonstrated the weaknesses of the supply chain restructuring risks, highlighting the importance of coherent strategies and to design a well-defined framework to minimise the potential risks within the future development of the product's manufacturing practices.

Many successful companies like benefit from adoption of the DCM principles to their businesses in order to increase their profitability and competitive advantage by close association of supply and customer elements such as product availability, delivery accuracy and responsiveness. Demand chain could be applied in such industries as a supply chain management approach that emphasizes on market mediation to a greater than its role of ensuring efficient physical supply of the product and therefore, there is a need for the balance between customer satisfaction and supply chain efficiency. DCM is also conceptualised as a harmonisation between the supply and demand processes within outside and inside of the organisation margins with the aim of gaining higher competitive advantage. Hence, the major necessities for the DCM implementation comprise the organisational capabilities, supply-demand chain association and IT support. DCM is not only a specific kind of supply chain approach that can be applied for reducing the supply chain redesign risks, but also indicates a dynamic interaction between supply and demand and their linkage with competitive advantage.

The paper focuses towards the investigation of a major world manufacturing companies and one of their product lines, which represented only one aspect of the aircraft manufacturing industry, and the research findings could certainly be extended

within other sectors and product development manufacturing industries. There is also a need to identify and address the significance of different environmental impacts, for instance with the use of full life-cycle analysis within the product development environments. The research also demonstrates the meaning of NPD approaches within businesses where innovation and optimisation is considered towards enhancement of supply chain process with the use of advanced technological and innovation capabilities to enhance the overall customer experience and profitability.

As a final point, the research findings in this paper have developed further understanding of the systematic review of the Dreamliner product development case and the use of project management and sustainability strategies. The paper intends other researchers to adopt these case examples to further investigate other industrial practices within other manufacturing companies such as that of Boeing to redesign more effective and efficient global supply chain networks within their environments.

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