# Case Study Analysis of Sustainable Supply Chain Redesign Linking with New Product Development

ELMIRA NAGHI GANJI, SATYA SHAH, ALEC COUTROUBIS
[1]Applied Engineering and Management, Faculty of Engineering and Science,
University of Greenwich, UK
Chatham Maritime, Central Avenue, Medway, ME4 4TB
UNITED KINGDOM
e.n.ganji@gre.ac.uk; s.shah@gre.ac.uk; a.d.coutroubis@gre.ac.uk

*Abstract:* - This research seeks to investigate the new product development (NPD) approaches and the supply chain redesign strategies as part of the sustainable development. A systematic approach of literature review will be undertaken in order for effective gathering a set of structured data to act as a basis for the further discussions. The case of Boeing Dreamliner provides with a qualitative research method in order for critical analysis of the main concepts of the research. According to the inclusive Dreamliner's development programme and the risks and threats associated with supply chain redesign, this paper defines a comprehensive framework in order to minimise the potential failures and delays within the future aircraft development approaches. The paper studies the supply chain redesign of NPD programme within the aircraft industry; therefore, there is a need for other types of industries to be investigated due to their different features and necessities. The systematic review of Dreamliner case provides an opportunity for creating a well-defined framework addressing supply chain sustainability and NPD project management challenges. All the supply chain entities especially within aircraft industries would benefit from the paper results in order to receive the best advantages from NPD practices and global supply chain methods.

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

## 1 Introduction

The global manufacturing environments are largely impacted due to the changing aspects of political, economies and social interactions within the industries. With the large impacts of globalisation, handling the industrial and economic changes are now very important to businesses and firms due to their continued competition to survive in the changing markets. Among all of these rapidly fluctuating transformations, many individual customers are considered as the most effected as well at those of the independent bodies as the purpose of all supply chain entities is towards fulfilment of the needs of the end user.

Given the competitive scenarios and changing market demands, NPD is considered a key activity that allows firms to shift towards improvement of product quality, higher level of customer satisfaction, increased profitability and prosperity in future. Since the last decade, many research studies have presented the coordination of SCM and NPD perspectives together. However, in this particular aspect the "demand" factor needs to have the focus through the supply chain to provide the key necessities of the NPD process and the research and development entities closely aligned with the overall manufacturing processes. However, even through the precedence of key advantages of NPD approaches, it could prove to be a highly challenging issue if the firms are not utilising sufficient supply chain and engineering enterprise capacity within their environments. It has also been seen that many of new products face challenges when entering new markets, especially as evident from research study that in 2012, the rate of NPD success in UK, Europe and Asia were 67.5%, 56.8% and 48.6% respectively [1].

As a major aerospace manufacturing company such as Boeing, it adopted a practice of supply redesign strategy to reduce the development costs and time to market for its new 787 Dreamliner aircraft products [2]. The authors consider this case as the key example to discuss within this research

paper as it enables the further examination of the supply chain redesigning practices within the NPD process as well as the key advantages and disadvantages and the motivational drivers influencing the decisions within its adoption practices. This research aims towards investigating the opportunities towards sustainable NPD approaches considering the various sustainable supply chain practices. The findings aims to analyse the most appropriate manufacturing cases such as that of Boeing Dreamliner which faced the unprecedented challenge towards their product development processes and that of its redesigned supply chain operations.

A systematic critical method is deemed to be the most appropriate within this research study to provide solid foundations in order to establish sufficient data from methodical aspect, thus identifying gaps within existing practices in industry and practical environments. The research uses logical sequence and different systematic review steps identified through [3], hence the authors are able to organise the secondary resources in to address the research questions more appropriately. It has been evident through earlier research studies that the potential risks of supply chain restructuring are through the identification of gaps within project management and sustainability issues. Hence, on the basis of project scope of this research, the paper aims to develop a clear framework and well defined strategies to minimise the key gaps between NPD and SCM approaches. The following research questions are addressed within this paper which also acts as the key analysis points for future research based upon the findings of this paper.

Question1. Which are the key NPD approaches adopted within the supply chain?
Question2. What frameworks are defined towards sustainability within supply chain?
Question3. What are the main threats and risks that are associated with the restructuring of the supply chain?
Question4. What are key benefits of aligning the three above concepts together?

# 2 Literature Review

The research paper aims to explore through current literature all the existing theories towards the linkage of the sustainable supply chain and new product development processes allowing the researchers to form the foundations of this paper and to explore future possibilities within this content. The key research areas for this study focuses towards the potential risks of the redesigned supply chain, its approaches within the criteria and that of the risk management strategies required for the fulfilment of the key aspects of the research. The approach of systematic review will provide unbiased and focussed results that will contain comprehensive and multi-dimensional knowledge towards future research analysis in this context [4].

## 2.1 New product development (NPD)

Since the priority of any company is gaining competitive advantages, new product development is 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 investigated the coordination of supply chain management and NPD, as product development process necessitates integration and collaboration among all entities of the supply chain particularly the suppliers and consumers.

The prospect of term "'product development" is traditionally defined as the transformation process of market opportunities and set of assumptions related to product technology into converting products that are accessible to the marketplace [5]. Utilising several methods, NPD evaluates and incorporates customer attributes and needs such as price, speed and reliability into engineering characteristics of the product. However, concept "Development" refers not only to the product innovative specifications but also to the expanded product client services and life-cycle.

As NPD is not a simple task to achieve, a large number of new products do not succeed while entering the market. According to a report on product development performance metrics and practices within 211 US businesses, 90% of the best performers, compared to only 44% of worst performers, have got a clear and well-defined NPD development process guiding NPD projects from idea to launch [6]. Moreover, in recent studies it is founded that the rate is potentially 95% in the US and 90% in Europe [7].

NPD approach is considered as a high-cost and time consuming issue. Various factors can influence on NPD approach success and the most important are characteristics of process, product, market and strategy [8]. One of the practices in the area of NPD is concurrent engineering which requires a multi-functional development team. This type of design mainly focuses on internal alliance but in today's world rivalry it is required to arise concurrent design with collaboration in the whole supply-demand chain [9].

Obtaining the best consequences from the NPD cycles, organizations need to be developed from "machinery companies" where strategies are dominant to "innovative companies" where the senior managers inspect to promote process developments by contribution of all the manufacturing personnel [10]. This could be a challenging issue, as most of the corporations often consider short-term fiscal outcomes and tangible assets such as equipment and buildings rather than evaluating the intangible assets of integrated NPD and customer satisfaction which brings their organization continuous success. A critical factor for NPD success is short time to market (TTM) and also short product life cycles. Therefore the right products should be rapidly developed and launched to the market effectively [9].

## 2.2 New product development and manufacturing

Research studies highlight that many manufacturing enterprises continuously update the product offering to satisfy the customer requirements and to remain highly competitive within the market. The supply chain networks and that of its features needs to be regularly utilised to fulfil the higher proportion of product introductions, business demands and that of fulfilment of delivering products as effectively and efficiently as possible. In order to deliver these products and achieving the right targets towards cost, time and quality, the NPD decisions should be better aligned to the overall supply chain of the organisation. This allows the manufacturing enterprises to address issues relating to product launch due to lack of product variances and its availability. This integrated model of SCM-NPD enterprises provides the benefits towards increased stability of supply chain, thus having an increased performance and that of product variations within the business [11]. The following figure illustrates the interface between product design and manufacturing system design in NPD projects. Due to the high dependency between their functions and deliveries, there is a need for collaborative work and efficient communication [12].

New product development (NPD) is related to many of the departments within most manufacturing enterprises. The marketing, design and that of the key engineering activities should be incorporated within the main sections. The key activities and roles of the marketing departments is to identify and capture the customer requirements and the knowledge, the analysis of the markets and that of the opportunities and threats of new products within the market space. The design department provides the key definition of the product that meets the requirements of the customer and that of the market expectation, which could be approved by the customer groups. The manufacturing activities are the engineering department that allows the definition of requirement of material purchasing, the distribution and that of the entire supply chain measures. Earlier studies have identified that new product development innovation is mainly important to achieve the success within the processes of manufacturing and to successfully meet the expectations and the requirements of the customer. However, many times innovation within businesses is highlighted as tool towards change management which is either incremental or radical within the product and process operations and seen as a key measure for the success of the given product of the particular business. In the current global markets, businesses thrives to adopt and implement more innovative measures and methods within their product and service activities, allowing them to be more competitive and to reduce lead and demand times within the product lifecycle [13]. Research has highlighted that product innovation is observed as a critical element towards the performance and success of the product and that it relates towards the sustainability of the business for expansion, growth and maturity in new markets.

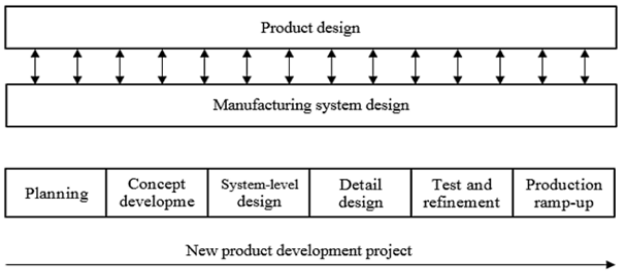


**Fig. 1** Product design and manufacturing systems design in NPD process [12]

Similar to product innovation, process innovation focuses towards adoption of new innovative production and operation methods by making use of technological advancements such as that of additive manufacturing techniques to improve the product processes overall. Researchers have highlighted the importance of process innovation impact on product innovation and similarly product innovation impacts towards overall process innovation within manufacturing companies. This highlights the strong connection between both the product and process innovation and hence an important key factor towards the new product development aspects within any company [14]. And finally, market innovation has been

considered as more new approach that businesses have been adopting to scale and utilise the market opportunities for any new products. This has been linked towards the paper's earlier discussion on product and process innovation, including market research, advertising and promotion methods including that of the four Ps concepts including new opportunities in market and entry and threats of new competition within these markets. Hence, it could be suggested that market innovation is also the key aspect of importance towards product innovation and towards the overall product novelty [13].

In Toyota Product development System (TPDS), a chief Engineer is responsible for each car that is being manufactured from start to finish, and make decisions about car design based on technical knowledge codifications and using tested data from trade-off diagrams [15]. Afterwards all the information will be monitored within process checklists and technical archives to senior managers in order to do the final inspection. This approach is developed over many years and they called it set-based concurrent engineering. Moreover, they completely integrate the strategic suppliers into their product development to develop engineer's technical qualifications and build a culture for their continuous improvement and beneficial competence. According to vice president of Toyota in 2012, these engineering approaches help them to decrease the development time as well as engineering cost reduction [16]. Moreover, according to Toyota's vice president of global R&D, they substituted the traditional method of development (model-by-model) by using modular engineering strategy which is based on multiple development models within the platform [16].

## 2.3 New product development and supply chain

New product development, also referred as NPD is an element that empowers supply chain drivers and enables the fulfilment of market growing requirements, although many times has been referred as an expensive and time resourced activity within a firm [8]. Research studies explored the factors that achieve uncertainty to the process of NPD and causes tension for companies for single on time delivery of their products, services and projects [17]. These uncertainties are highlighted as resource capability, social or economic situations, market adjustments, technological advances and changes, organisational structure changes, supply and demand changes and that of any governmental or regulatory bodies' fulfilments [17]. 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 have been identified [18]. 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 [19].

With the focus towards all of the existing research towards the complications of NPD and that of uncertainties, a more thorough and long term success might be possible through the collaboration of different supply chain providers within the entire development process [20]. Through the help of theoretical models, supplier association acts a key component of NPD and customer involvement is applied with a positive effect including cross-functional integrations. However, other factors created allow the integration of NPD leading to the success of the financial performance of any product development process [21].

The term "Interdepartmental connectedness" is defined as capturing the degree to which an organizations' culture facilitates effective communication across functional areas [22], 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 traditional roles with minimum engagement in the organisation's NPD processes [19].

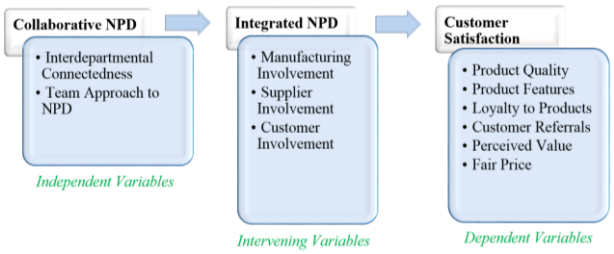


**Fig. 2** Identified framework linking NPD and supply chain [21]

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 [19].

The linkage between NPD and SCM through a Swedish furniture company in investigated [9]. In 2004, Alpha made a decision to transform its

business strategy and focus on innovative and unique products with premium prices in order to become customer-oriented instead of mass production and low cost competition with companies such as IKEA. Doing so, they defined some phases for NPD process success. One of the NPD success factors is market intelligence to identify the opportunities for obtaining a profound knowledge about customer demands and strategic market plan (SMP) instead of just focusing on technology innovations. As the priorities of different customers vary from each other, market segmentation model including several customer segments based on their psychographic and desired design styles is needed. With the aid of market segments, the products could be developed to create a genuinely customer-desired company. It is required for supply chain entities to be involved in sharing the information with NPD operations.

In terms of rapid shipping, for instance, at the start of each season of the year Nike and other fashion designers ensure to provide enough Stock Keeping Units (SKU) for their global suppliers. In an equal manner, in introducing a videogame to the market, more than one third of products are sold within the first 24 hours by peoples who wait for the release time long hours in front of the shops. According to these examples, it should be focused on new products availability at the right time rather than just designing and finishing in the labs. American P&G Company which is renowned for its high quality products adopted a strategy called "Moments of Truth" to measure the products quality even in the store shelves in order to become customer-oriented. As a result they found that about 2-10% of the goods damaged on the shelves, however in the factory less than 0.1% defects identified. This demonstrated that the packaging design was inappropriate for the supply chain environment [23].

## 2.4 Sustainable supply chain management

The concept of *sustainable supply chain management (SSCM)* defined in literature as "involvement of the planning and management of sourcing, procurement, conversion and logistical activities involved during the pre-manufacturing, manufacturing, use and post use stages through a complete life-cycle stage between companies, through explicitly considering the social and environmental implications towards achieving a shared vision"[24]. This application of SSCM implementation is not widely used in practice [25], and this is identified as due to the lack of progress and well defined frameworks towards effective SSCM. Theoretical frameworks towards sustainability in supply chain are highlighted as figure 3 [26]. The core concepts in sustainability including its three pillars with four supporting elements that contributes to 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 [26]. 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 [19].

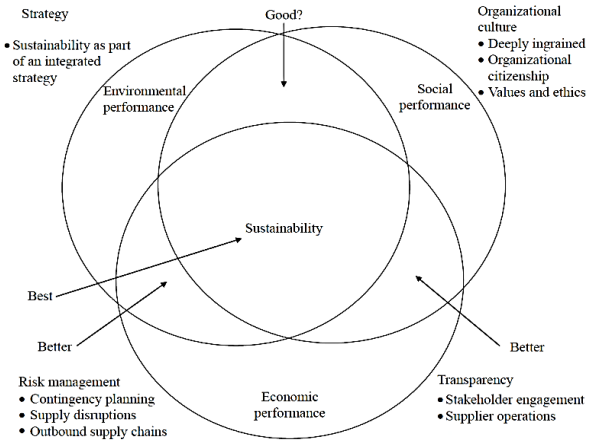


**Fig. 3** Sustainable supply chain management (SSCM) [26]

Alongside the financial factors, legislative and staff pressures; market pressures and competition also play an important roles towards change in industrial behaviour towards sustainable practices. Whereas, some companies set guidelines called "suppliers charter" that introduces the environmental criteria that are required from their supplier firms [28]. For example, the government institutions and departments in Germany are required to purchase sustainable goods such as that of recycled papers within their operations. US giant Walmart and B&Q in UK require their suppliers for the use and development of eco-friendly products and adoption of environmental practices within their operations. One of the largest supermarkets in Denmark have established their own technical research programme in 90's that set out new environmental policies while prohibiting the use of Polyvinyl chloride (PVC) within its product packaging and enforced their suppliers to adopt and

use more recycled packaging materials within their operations [28].

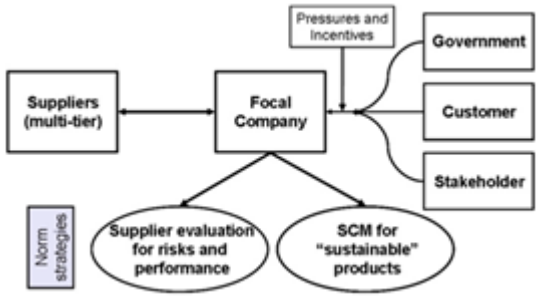


**Fig. 4** Triggers for Sustainable Supply Chain Management (SSCM) [29]

The above figure shows the triggers for SSCM which shaped two different strategies as a result. The first one is the supplier management for risks and performance which demands environmental and social standards. The second one is the SCM for sustainable products that requires the life-cycle based standards within the supply chain [29].

## 2.5 NPD and sustainable supply chain management integration

McDonald as a multinational corporation which has adopted SSCM practices is dominant in world fast food industry by integration of marketing, supply chain and DCM techniques [30]. Through the application of various management approaches such as fast speed production and delivery, high standards of staff training, process control, economies of scale, bargaining power, and development of demographic research; McDonald enabled to survive in the food retailing market. From the NPD and marketing perspective, they have been implementing the marketing four main pillars. The "Price" factor has been reflected in their successful competitive advantage over their world rivals such as Burger King. "Place" factor has been fulfilled through their high number of stores all around the world and "Promotion" factor can be considered in Golden Arches, Ronald McDonald and other market segments such as the specific options for children. "Product" consistency seems to be a very important element in this case, since it has been well preserved its famous meals such as Big Mac in a very reliable way. However, according to an investigation of the franchises in the mature geographic locations such as Australia, it is discovered that McDonald was in a tight competition due to the reducing rate of eating out in Australia, since the principal reasons for people eating fast food is now changing from being convenient to having special occasions or breaking the routines. Moreover, as stated by a senior executive, McDonald faced competition issues by the new indirect rivals such as coffee shops and the other informal restaurants. Therefore, it needs to correspond with the new consumer values by expanding the menu variety and providing menu solutions rather than just promotional items, price reduction and cost efficiencies [30].

## 2.6 Boeing Dreamliner programme overview

The case of Boeing 787 development program and the risks associated with managing an unconventional supply chain is investigated [2, 31]. 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 [31]. 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 [31]. 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 [19, 31].

### 2.6.1 Boeing 787 Dreamliner Aircraft redesign

A remarkable transformation was substituting 50% of the aircraft structure with lightweight composite materials (Instead of former Aluminium) that allowed the passenger cabin to maintain appropriate humidity and pressure in severe conditions and besides enabled the long haul and non-stop flights between different locations. Moreover, the new composite design reduced the maintenance and replacement costs in comparison with the aluminium made aircrafts that need constant repairs. Boeing desired to secure intellectual property (IP) rights for using composite technology in Dreamliner aircraft [31].

### 2.6.2 Supply chain redesign for Boeing 787 Dreamliner

Apart from the material changes, Boeing 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 5 illustrates the traditional supply chain model of Boeing [19].

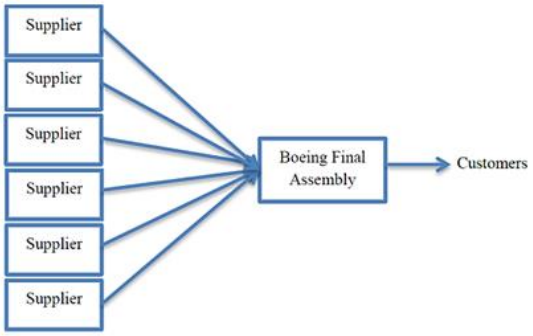


**Fig. 5** Traditional Boeing Supply Chain Model [2]

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.

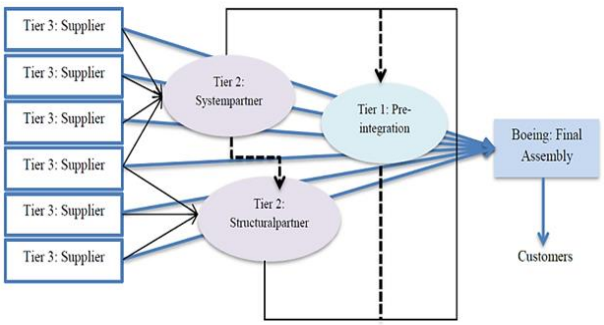


**Fig. 6** New supply chain model of Boeing Dreamliner [2]

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, responsible for designing, building and shipment of the complete sections of 787 to Boeing; therefore, it is based on a tiered structure [31]. Likewise, 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 [31]. Besides, tier-1 suppliers have more extensive and integrated responsibilities regarding the materials they are supplying [32]. 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.

### 2.6.3 Advantages of more outsourcing

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 programmes 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 [19].

### 2.6.4 Reducing financial risks

According to the new supply chain changes, Boeing established a new risk-sharing contact 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 being penalized and need to work slower and this would be a challenge for risk-sharing contract objectives [33].

Reducing the issues of risk-sharing contact and the proposed penalties to Boeing customers, it needs to amend the contract by making some rewards and incentives for its strategic suppliers in order to encourage them with the on time delivery. This would be a win-win strategy as the suppliers, Boeing and its customer will all take the benefits and will be satisfied from the mentioned contract.

### 2.6.5 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, 31]. 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 [34].

- ***Technology Risks*** - Engine interchange ability and security concerns of new computer networks increased the delivery delays. Utilising composite materials brought Dreamliner some safety issues [35] 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 [36] 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]. As authors recommend, improving the flow of information the supply chain, Boeing should not be solely depended on alerts generated by the Exostar program but also have to require all the suppliers to provide them with the most up to dated information [39].

- ***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, 31].

- ***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 [37]. 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 [38]. 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 [31].

## 2.7 Supply chain strategies of Boeing 787 vs. Airbus A380

Through the post 9/11 tragedies, the cost and competitive market space for airline industry has forced aircraft manufacturing to lower their prices, while still offering better products and services to attack and satisfy their customer base. However, with the pressure to lower profit margins, it has become evident that more aircraft manufacturers, including the larger manufacturers such as Boeing and Airbus have started to adopt "risk sharing partnerships" through their supplier networks. This allows them to achieve reductions in costs within their entire supply chain networks. This has been seen through the examples of the Boeing 787 and that of Airbus A380 development programmes at these companies [32].

This has now made many of the suppliers to take wider responsibilities within their product design, development and manufacturing compared to that of previous practices. For example, Airbus identified this through its partnership model and flexible global outsourcing strategies. However, on the other hand Boeing has adopted a more advanced model similar to their existing "system integration" model that involves risk sharing partners through the entire design, development and manufacturing phases for all of its component and assembling processes. This allows Boeing to reduce its throughput and final assembly to three days, by the adoption of higher level integration at the supplier level. They manage to achieve this through the reduction of their parts and components, allowing subassemblies and sections to go through the final assembly stages of the process. Along with this, major suppliers had also been selected to enable more complementary components and systems allowing them to achieve their technical capabilities which results in more efficient and effective design solutions for the products. Comparing to the Boeing 787 programme, the outsourcing strategies adopted by Airbus towards their A380 programme is more towards the traditional approaches. However, airbus has allowed partnerships since its inception through creating "champions" within their respective European areas. This allowed them to keep in-house their core technologies relating to the complex or key airframe components for their products. The major differences between Airbus and that of Boeing outsourcing activities within the Asia-Pacific regions demonstrate the different outsourcing practices between the two rival companies [32].

To provide and enable more collaborative business models within their partners, both the companies use advanced information system capabilities that facilitates communications between different partners and units throughout the world that streams current inter-organisational process between them. Earlier research studies identified that most of these companies utilised Electronic Data Interchanges (EDI) to exchange business documents (i.e. order placement, proposal requests, any order or shipping information) and also technical data (relating to specifications, complex engineering drawings, tooling requirements, test and analysis requirements, etc) with their customer base. Both Airbus and Boeing has also installed the "supplier-portal" information system that facilitates the exchange of information on business processes through their key suppliers [32].

### 2.8 Implications for SCM strategies

Increasing the cost element within the airline industry and that of intensive rivalry between companies such as Boeing and Airbus, allows increasing competition within the airline industry in general. In order to remain competitive, many of the airline manufacturers are now adopting more aggressive approaches towards cutting down costs while expanding its capabilities and maintaining their agility. Many of the airline manufacturers are outsourcing more activities to their key suppliers that are based in non traditional supply regions such as Asia and Europe, through various measures of offset settings or agreements based upon the cost functions. This clearly suggests that future supply chains in airline industry are to change towards more global allowing cross dimensional collaboration between partners. With the advancement and adoption of more common technological tools towards the data sharing and communications within this global supply chain environments, where many of the attributes and variables from different organisations are now located in various geographical regions through constant and challenging collaborative environments. This could also allow manufacturers to decrease time to market downfall and further improve product quality. With these advancements of technology, suppliers have to be aware of these changes in modern IT enabled environments to facilitate the business cooperation with their supplier networks and that of their customers [32].

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 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 [19].

## 3 Case Study Analysis

The literature review analysed at the start of the research which allowed the researchers to identify key research gaps and knowledge within this aspect of the research study. Combination of research methods and approaches such as critical literature review analysis, case study method investigating the Boeing 787 Dreamliner programme are highlighted within this study that allowed the evaluation of the company towards their sustainable supply chain adoption. To identify and address the key research gaps for the Boeing Dreamliner programme, different aspects were investigated within the areas of key benefits, risk, threats and hurdles that were linked with the development of the product.

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

| Article | Year | Study Design | NPD - SC | SSCM | NPD Performance | Boeing Case |
|---|---|---|---|---|---|---|
| Markham and Lee | 2013 | Analytical | ✓ | | ✓ | |
| Tang and Zimmerman | 2009 | Descriptive | ✓ | | ✓ | ✓ |
| Krishnan and Ulrich | 2001 | Descriptive | ✓ | | | |
| Copper and Edgett | 2012 | Descriptive | | | ✓ | |
| Ogawa and Piller | 2006 | Descriptive | | | ✓ | |
| Sharifi et al. | 2006 | Descriptive | ✓ | ✓ | | |
| Hilletofth and Eriksson | 2011 | Descriptive | ✓ | | ✓ | |
| Mintzberg | 1989 | Descriptive | | | ✓ | |
| Van Hoek and Chapman | 2007 | Descriptive | ✓ | | ✓ | |
| Nafisi et al. | 2016 | Descriptive | | | ✓ | |
| Vinayak and Kodali | 2014 | Descriptive | | | ✓ | |
| Radeka | 2007 | Descriptive | ✓ | | ✓ | |
| Martinich | 2015 | Descriptive | | | ✓ | |
| Mu et al. | 2009 | Analytical | | | ✓ | |
| Moreno et al. | 2011 | Descriptive | | ✓ | ✓ | |
| Tan and Tracey | 2007 | Analytical | ✓ | | ✓ | |
| Sethi and Nicholson | 2001 | Analytical | | | ✓ | |
| Van Hoek and Chapman | 2006 | Descriptive | ✓ | | ✓ | |
| 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 | | ✓ | | |
| Seuring and Müller | 2008 | Descriptive | ✓ | ✓ | | |
| Rambird | 2004 | Descriptive | | ✓ | | |
| Kotha and Srikanth | 2011 | Descriptive | ✓ | ✓ | ✓ | ✓ |
| Horng and Bozdogan | 2007 | Descriptive | ✓ | | ✓ | ✓ |
| Kwon et al. | 2009 | Analytical | | ✓ | | ✓ |
| Rai et al. | 2006 | Descriptive | | ✓ | | |
| Grant | 1996 | Descriptive | | | ✓ | |
| Williams et al. | 2002 | Analytical | | ✓ | | ✓ |

As highlighted through research literature, suppliers and customers are considered as intervening variables [21], and hence Boeing needs to be cautious regarding the strong and efficient integration as it faces challenges in bridging the NPD performance and customer satisfaction together. In addition to this, applying sustainable supply chain framework and considering sustainability are the key focus of the three pillars of sustainability studies [26]. Hence, Boeing is required to maintain better transparency with its key stakeholders as well as consistent project planning measures. While on the other hand, 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"* [39].

### 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 can be generally used by all the companies for NPD purposes.

**Table 2** SSR framework [19]

| Prioritised Elements to be Adopted by Boeing | Essential Development Factors |
|---|---|
| *Prioritize SWOT and key NPD issues* | ▪ Strategic fit assessment<br>▪ Maximise strengths and opportunities<br>▪ Minimise weaknesses and threats. |
| *Effective collaboration with expert suppliers* | ▪ Searching professional suppliers to avoid delays<br>▪ Utilising stakeholders as NPD project forces. |
| *Stakeholder's coordination* | ▪ Consult with Tier-1 and Tier-2 Suppliers before the project start<br>▪ Predict the possible delays and minimise them<br>▪ Personnel reward system<br>▪ Ask key suppliers for the quality assurance of Tier-2 and Tier-3 suppliers<br>▪ In-advance contact with customers for launch date updates<br>▪ Offering benefits or discounts to customers for the delay compensation. |
| *Establishment of a project management teams* | ▪ Employment of high-level university staffs and research institutions<br>▪ Establish project and risk management teams related to every single project |
| *Solving IT and technological issues before project start* | ▪ Applying an updated effective supply chain software system<br>▪ Train the suppliers through preparation workshops for IT software<br>▪ Using proven and validated technologies |

## 4 Conclusions

The research highlights the understanding on the importance of adoption of the sustainable supply chain within the NPD of aircraft manufacturing industries. In order to fulfil the aim, the research identified the research objectives earlier within the paper.

The paper proposes the method to link the NPD strategies within the context of supply chain practices in view of sustainability approaches within the framework. The case of Boeing for the development of their Dreamliner product is evaluated as the main case of this research paper. This case demonstrated the weakness of the supply chain restructuring risks, and highlighted the importance and relevance of the strategies towards design and development of framework to minimise the potential risks within the future development of manufacturing processes and practices of the product.

A number of successful companies could benefit from the adoption of demand chain management (DCM) principles within their businesses that could increase their profitability and allow them to achieve competitive advantage through the close partnership of supply and customer elements including product availability, delivery accuracy and responsiveness. Demand chain is deemed to be applied within such environments rather than supply chain management approaches that emphasises on market mediation towards greater than its role of ensuring efficient physical supply of products. Therefore, there is a need for this balance between customer satisfaction and that of supply chain efficiency. DCM concept is conceptualised as the harmony between the supply and demand processes within the inside and outside of the organisational margins with the aim of gaining higher competitive advantage. This allows the major necessities for the DCM implementation to comprise the organisational capabilities, the supply and demand chain associations and that of IT functionalities supported within the environments. DCM is not only specific kind of supply chain management approach that can be applied for the reduction of supply chain redesign risks, but also a dynamic interaction between the supply and demand and towards their linkage to achieve the overall competitive advantages.

The paper focuses on the investigation of global manufacturing company and one of their products that represents one aspect of the wider aircraft manufacturing industry, and the research findings of this paper could be further extended within other sectors of product development manufacturing industries. There is also need to identify and address the significance of different environmental impacts, including the use of full life cycle analysis and that of the product lifecycle management within any production environment. The research also demonstrated the key understanding towards the NPD approaches adopted within businesses where innovation and optimisation are considered towards the

enhancement of supply chain processes with the use of the advancement of technological and innovative capabilities that enhances the overall customer experience and profitability for any company.

Finally, the research findings within the paper have enabled the further understanding of the systematic review towards the Dreamliner product development case and the use of project management and sustainability strategies. The paper also intends upon other researchers to adopt similar case examples in order to further investigate industrial practices in similar manufacturing companies such as that of Boeing and Airbus that allows and adopts the redesigning of their supply chain more effectively and efficiently within their global supply chain networks.

*References:*


[1] S.K. Markham, H. Lee, Product development and management association's 2012 comparative performance assessment study, *Journal of Product Innovation Management*, Vol. 30, No. 3, 2013, pp. 408–429.

[2] C.S. Tang, and J.D. Zimmerman, Managing New Product Development and Supply Chain Risks: The Boeing 787 Case, *Supply Chain Forum: An International Journal*, Vol. 10, No. 2, 2009, pp. 4-86.

[3] K.S. Khan, R. Kunz, J. Kleijnen, G. Antes, Five steps to conducting a systematic review. *JRSM*, Vol. 96, No. 3, 2003, pp. 118–121.

[4] M.J. Saenz, X. Koufteros, Special issue on literature reviews in supply chain management and logistics, *International Journal of Physical Distribution & Logistics Management*, Vol. 45, No. ½, 2015.

[5] V. Krishnan, K.T. Ulrich, Product Development Decisions: A Review of the Literature, *Management science*, Vol. 47, No. 1, 2001, pp. 1-21.

[6] R.G. Cooper, S.J. Edgett, Best practices in the idea-to-launch process and its governance, *Research-Technology Management*, Vol. 55, No. 2, 2012, pp. 43-54.

[7] S. Ogawa, F.T. Piller, Reducing the risks of new product development, *MIT Sloan management review*, Vol. 47, No. 2, 2006, 65.

[8] H. Sharifi, H.S. Ismail, I. Reid, Achieving agility in supply chain through simultaneous "design of" and "design for" supply chain, *Journal of Manufacturing Technology Management*, Vo. 17, No. 8, 2006, pp. 1078-1098.

[9] P. Hilletofth, D. Eriksson, Coordinating new product development with supply chain management, *Industrial Management & Data Systems*, Vol. 111, No. 2, 2011, pp. 264-281.

[10] H. Mintzberg, *Mintzberg on management: Inside our strange world of organizations*, Simon and Schuster, 1989.

[11] R. Van Hoek, P. Chapman, How to move supply chain beyond cleaning up after new product development, *International Journal of Supply Chain Management*, Vol. 12, 2007, pp. 239-244.

[12] M. Nafisi, M. Wiktorsson, C. Rösiö, *Manufacturing involvement in new product development: An explorative case study in heavy automotive component assembly*, Procedia CIRP, Vol. 50, 2016, pp. 65-69.

[13] K. Vinayak, R. Kodali, The relationship between NPD innovation and performance: the moderating role of NPD best practices in Indian manufacturing industry, *Measuring Business Excellence*, Vol. 18, 2014, pp. 39-59.

[14] E. Maravelakis, N. Bilalis, A. Antoniadis, K.A. Jones, V. Moustakis, Measuring and benchmarking the innovativeness of SMEs: a three-dimensional fuzzy logic approach, *Production Planning and Control*, Vol. 17, 2006, pp. 283-292.

[15] K. Radeka, The Toyota product development system: integrating people, process and technology by James M. Morgan and Jeffrey K. Liker, *Journal of Product Innovation Management*, Vol. 24, No. 3, 2007, pp. 276-278.

[16] H. Greimel, Like its rivals, Toyota revises product development. [Online] Available at: www.autonews.com/article/20120423/OEM01/304239961/like-its-rivals-toyota-revises-product-development [Accessed 20 April 2017], 2012.

[17] L. Martinich, Excellent execution in new product development: Reducing uncertainty, *IEEE Engineering Management Review*, Vol. 43, No. 1, 2015, pp. 17-19.

[18] J. Mu, G. Peng, G.L. MacLachlan, Effect of risk management strategy on NPD performance, *Technovation*, Vol. 29, No. 3, 2009, pp. 170-180.

[19] E. Naghi Ganji, S. Shah, A. Coutroubis, Bridging New Product Development with Sustainable Supply Chain Management Practices, *In Proceedings of 21st CSCC International Conference on Circuits, Systems, Communications and Computers*, 14-17th July 2017, Crete, Greece.

[20] A. Moreno, F. Cappellaro, P. Masoni, Application of product data technology standards to LCA data, *Journal of Industrial*

*Ecology Impact & Description*, Vol. 15, No. 4, 2011, pp. 483-495.

[21] C.L. Tan, M. Tracey, Collaborative new product development environments: Implications for supply chain management, *Journal of Supply Chain Management*, Vol. 43, No. 3, 2007, pp. 2-15.

[22] R. Sethi, C.Y. Nicholson, Structural and Contextual Correlates of Charged Behavior in Product Development Teams, *Journal of Product Innovation Management*, Vol. 18, 2001, pp. 154-168.

[23] R. Van Hoek, P. Chapman, From tinkering around the edge to enhancing revenue growth: supply chain-new product development, *Supply Chain Management: An International Journal*, Vol. 11, No. 5, 2006, pp. 385-389.

[24] F. Badurdeen, D. Iyengar, T.Y. Goldsby, H. Metta, S. Gupta, I.S. Jawahir, Extending total life-cycle thinking to sustainable supply chain design, *International Journal of Product Lifecycle Management*, Vol. 4, No. 18, 2009, pp. 49-67.

[25] S. Brockhaus, W. Kersten, A.M. Knemeyer, Where Do We Go From Here? Progressing Sustainability Implementation Efforts across Supply Chains, *Journal of Business Logistics*, Vol. 34, No. 2, 2013, pp. 167-182.

[26] C.R. Carter, D.S. Rogers, A framework of sustainable supply chain management: moving toward new theory, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 5, 2008, pp. 360-387.

[27] C.R. Carter, P.L. Easton, Sustainable supply chain management: evolution and future directions, *International Journal of Physical Distribution & Logistics Management*, Vol. 41, No. 1, 2011, pp. 46-62.

[28] D. Mackenzie, L. Moss, J. Engelhardt, R. Martyn, *Green design: design for the environment*, London: Laurence king, 1991.

[29] S. Seuring, M, Müller, From a literature review to a conceptual framework for sustainable supply chain management, *Journal of cleaner production*, Vol. 16, No. 15, 2008, pp. 1699-1710.

[30] M. Rainbird, Demand and supply chains: the value catalyst, International *Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 3/4, 2004, pp. 230-250.

[31] S. Kotha, K. Srikanth, Managing A global partnership model: Lessons from the Boeing 787 "Dreamliner" program, *Global Strategy Journal*, Vol. 3, No. 1, 2013, pp. 41-66.

[32] T.C. Horng, K. Bozdogan, Comparative Analysis of Supply Chain Management Practices by Boeing and Airbus: Long-Term Strategic Implications, (Doctoral thesis, Massachusetts institute of Technology, University of MIT, Massachusetts. [Online] Available from: dspace.mit.edu/bitstream/handle/1721.1/83234/PL_07_BO2_Bozdogan_Comparative_Analysis.pdf?sequence=1 [Accessed 1 April 2017], 2007.

[33] D. Kwon, S.A. Lippman, K. McCardle, C.S. Tang, *Time-based contracts with delayed payments.* Working paper, Los Angeles: UCLA Anderson School, 2009.

[34] A. Rai, A. Patnayakuni, N. Seth, Firm performance impacts of digitally enable supply chain integration capabilities. *MIS Quarterly*, Vol. 30, No. 2, 2006, pp. 225–246.

[35] J. Wallace, P-I. Reporter, Aerospace notebook: Lightning a weighty issue for the 787. [Online] Available from: www.seattlepi.com/business/277220_air12.html [Accessed 22 March 2017], 2006.

[36] R.M. Grant, Toward a knowledge-based theory of the firm. Strategic Management Journal, Vol. 17, No. S2, 1996, pp. 109–122.

[37] B. Rigby, T. Hepher, Boeing strike impact to be felt globally. Reuters. [Online] Available from: reuters.com/article/us-boeing-idUSN0529451820080909 [Accessed 20 March 2017], 2008.

[38] J. Crown, Will Boeing pay for delays? Spiegel Online International. [Online] Available from www.spiegel.de/international/business/flying-into-trouble-will-boeing-pay-for-delays-a-545365.html [Accessed 1 April 2017], 2008.

[39] T. Williams, R. Maull, B. Ellis, Demand chain management theory: Constraints and development from global aerospace supply webs, *Journal of Operations Management*, Vol, 20, No. 6, 2002, pp. 691–706.