

Towards a Sustainable Demand Chain Framework: Successful Product Development Integration and Drivers

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Abstract—The study seeks to fulfil the ultimate step of the previous researches on demand chain concepts within manufacturing environments, with a specific focus on sustainability criteria. In this case, New Product Development (NPD), Industry 4.0 and smart manufacturing act as effective tools towards production of updated products facilitating both business survivability and customer satisfaction. This paper utilizes a brief overview of the literature studies as a knowledge platform and further investigates the case of two German manufacturing companies using a mixed research method. The outcomes and findings will then be analyzed to examine the study hypothesis towards creation of a comprehensive conceptual framework defining interconnections between NPD and Sustainable Demand Chain Management (SDCM) within global manufacturing domain. The novelty of this research is to develop the results of previous stages of this study including comparison of practices within several manufacturing companies in terms of the linkage between SDCM and NPD projects. This will be completed by creation of the main conceptual framework of this study introducing the new concept called sustainable demand-driven product development (SDPD).

Keywords—customer satisfaction, demand chain management, IT applications, innovative marketing practices, new product development (NPD), sustainability, sustainable demand chain management (SDCM)

I. INTRODUCTION

During the last two decades, there has been a huge growth of competition within the businesses worldwide. Hence, it is natural that the businesses are constantly revise their strategies and executive operations in order to win across the markets. Particularly, manufacturing businesses are even more struggling, cause in addition to changing the business strategies and supply chain efficiency, their core business functionality is relying on the regular update of services, products and new product development (NPD) programs. NPD is usually being considered within the R&D entities of the manufacturing company and established with the form of projects or project portfolios. However, NPD programs are not easy to fulfil, since they involve three main departments within the company comprising design, engineering (manufacturing) and marketing.

Therefore, it requires a robust collaboration between these entities as well as integration with upstream suppliers and downstream end-users. Besides, the concept of customer responsiveness and customer satisfaction has become a key aspect within the business strategies due to the enhanced competition between companies. Customers are also changed within the last few decades and they are more cautious regarding the quality and price of products they need to choose in their routine life. This is also the reason for the authors and researchers to suggest the transition from supply chain management (SCM) towards the term demand chain management (DCM). Therefore, for the companies who tend to update and develop new products, marketing departments play a significant role by means of targeting potential markets and identifying variable customer demands. Adding sustainability as an interesting topping provides us with the opportunity to address the association between NPD and DCM more efficiently, merely due to the fact that sustainability pillars are inevitable factors in today's world. This study will first investigate the relevant literature within the same criteria and then uses a qualitative method to conduct a case study within German manufacturing entities in order to shed some lights on the study criteria. Finally, the company case study and its relevance to literature will be interpreted and discussed. This study is part of final stages of a broader project and hence, the value and impact of the paper is to analyse and finalise the previous discussions towards the final interpretations and results within the future stages.

II. LITERATURE REVIEW

This section provides with a foundation knowledge of existing literature regarding each key element of the research including transformation of SCM to DCM, DCM principles, the role of NPD and sustainability on DCM. According to the literature review and research gaps within this field, a preliminary framework will be created and afterwards questionnaire will be conducted to the company towards discovery of the research gaps. The study of interrelationships between the research's components help us to be able to design an effective preliminary research framework to be tested afterwards.

A. Demand Chain Management (DCM): The New Era of Supply Chain

Several factors have influenced the core focus of businesses shifting from purely fulfilling quality and price towards fluctuating demand of markets and customers. On the other side, enhancement of localization and technological advancements are boosting this situation by means of providing the end-users with open information sharing and hence, increasing their expectations. Day by day, world businesses are changing dramatically causing the transformation within consumption patterns and therefore, causing the tight competition between organizations in addressing the customer needs. In this regard, the novel DCM practices are within early stages of progress towards getting shaped and being validated within both academia and industry. Such shift from SCM to DCM can be interpreted as moving from efficiency to effectiveness [1].

There are only few DCM frameworks and models existing regarding the principles, elements and their interconnections. Besides, different interpretations have been made towards understanding DCM and its main goals. One is more focusing on the aspect of real-time information through application of IT technologies for effective track of the ongoing material flow and reduction of supply chain lead time to benefit the end-users [2]. The other attitude is more focused on marketing role as an intervening variable and borderline between company and customers and hence, transforming the supply based operations to demand driven ones [3,4,5]. This is also due to the fact that in today's business world, pushing the products into markets is not beneficial and fruitful in the long term and therefore, there is a vital need to make pull system by means of attraction of customers towards new products. This pull system would be a win-win trade system since the manufacturers will achieve higher profitability and customers will get fulfilled by their special desires [5]. The interesting point is that in this way, customers become the prominent and leader parties within the supply chain, meaning that their involvement on product development projects and even the level of required services act as inputs for decision-making of the business leaders and establishing the main strategies of the companies.

B. Sustainability Effect into Demand-Driven Chains

The influence of sustainability triple bottom lines is already comprehensively discussed within the literature and also practiced within industries, by means of integrating all the strategies and operational levels of the supply chain towards becoming green, ethical and economical [6,7,8,9]. Among the benefits of sustainable supply chain management (SSCM), several factors have been mentioned including corporate social responsibility (CSR), long-term economic performance, greening of supply process, greening of product development within manufacturing, usage and recycling level. Moving the supply chain focus from purchasing towards marketing flow, there would be a need to revise the sustainability contribution on different entities of the chain. Therefore, the term SDCM as a newly coined concept [10] needs to be thoroughly investigated. A conceptual framework has been introduced for SDCM with the main purpose of creation of sustainable customer value and creation of a value chain to a greater extent [10]. The

framework's important inputs are customer requirements and market potentials taking into account the sustainability pillars. It then continues with sustainable value delivery and sustainable value propositions. In the ultimate step and as final results of implementation of SDCM, customer relationship management, demand management, NPD and commercialization and even procurement will be enhanced [10]. The mentioned framework is a key point considered within this study and the conceptual framework at the later stages, as it is currently the only study elaborating SDCM.

C. Integration of NPD and SDCM

As discussed within the previous section, the enhanced NPD and commercialization are parts of the wider outcomes of sustainable supply network activities in order to fulfil the existing demand of new products and services in a sustainable manner [10]. Hence, in terms of SDCM fulfilment, these are the marketing entities who make connections between the manufacturing company and customers. On the other side, the success of NPD programs in the long term is highly relying on customer experiences, their interest, trust, commitment and loyalty to the products. Again, these are the marketing entities playing the role as borderlines and linkages between R&D teams, marketing and end-users. In general, the main pillars of the research can be classified into three main groups comprising of supply chain, sustainability and new product development as illustrated in figure 1.



Fig. 1. Main Research Pillars

The key question is that which tools are going to facilitate such integration between NPD and SDCM and to what extent have these tools been investigated will present. According to the reviews of literature, two main factors have been found playing as mediating variables among the linkages of SDCM and NPD. IT applications and innovative marketing practices are providing with real-time information, effective and novel customer relationship management methods which are the essentials of such linkage (Figure 1). In the next section, the comprehensive review of literature will be used to identify the key questions towards designing the preliminary research framework.

III. RESEARCH METHODOLOGY

According to the systematic literature review within the broader accomplishments of the same study, the key concepts and existing gaps of this study have been identified, synthesized and evaluated based on the five main steps in conduction of systematic reviews as suggested by [11,12]. The vital key question is remaining unexplored on how to effectively manage the associations between company and customers in order to satisfy their needs through NPD in a sustainable manner. In other words, *“To what extent, how, why and under what conditions does sustainable demand chain approaches influence success of NPD projects?”*.

As a result of the study, a preliminary conceptual framework had been created to be further examined as a final stage of this research. In this study, a revised version of the previous model is used to design the questionnaire towards testing the propositions within the last stage of study (Figure 2). As it is obvious, the triple bottom lines of sustainability act as inputs towards prosperity of both SDCM and NPD practices, moving them towards applying IT and innovative marketing practices which finally lead to the ultimate new concept of SDPD.

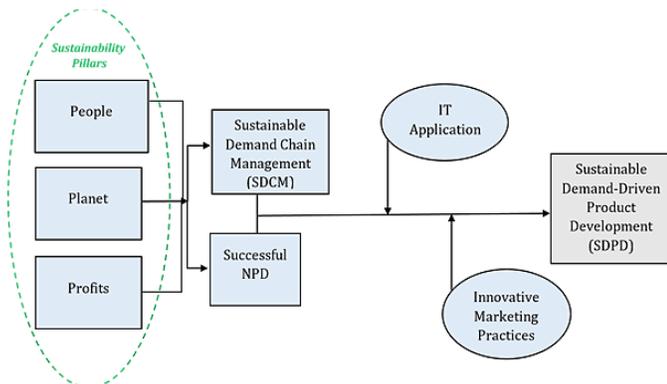


Fig. 2. Proposed conceptual framework for effective linkage of SDCM-NPD [Adopted from [13]]

The data collection is in the form of qualitative method and based on survey questionnaire along with an interview to ask for any extra explanations which might have been out of the research criteria and also any comments and ideas towards their improvement. Prior to the meeting, the questionnaire had been sent to the respondents along with a cover letter in order for them to have enough time to review it.

A. Questionnaire Design

The questionnaire is comprised of four main sections based on qualitative data and designed in five-point Likert scale questions being rated from not important at all to very important (Table I). According to the generated framework in figure 2, the questionnaire tends to evaluate the linkages between the major keys of the research with their special criteria and the main aim of adoption of sustainable demand-driven product development (SDPD) as a result of the comprehensive framework. Within different variables in the figure, there are different interrelations and hypothesis which need to be tested and afterwards proved or rejected based on the resulted data from the survey questionnaire. However, this is the ultimate step of the research

and in this paper, the authors attempt to gather some preliminary data towards the early understanding of the created framework and also to find out the interrelations between NPD and SDCM. The criteria of the questions are based on the reviewed literature as well as the previous studies of the authors which has been also referred within Table 1.

TABLE I.
RESEARCH SURVEY QUESTIONS

No.	Question	Research Objective	Ref
1	To what extent is your company engaged in adoption of sustainable pillars towards customer satisfaction?	<ul style="list-style-type: none"> • Identification of sustainable customer values • Identification of target customer/markets • Mining customer consumption patterns • Supply chain redesign towards a demand-driven chain (customer-oriented chain) • Top management commitment 	[4, 5, 10, 13]
2	To what extent is your company engaged in implementation of sustainable pillars towards success of NPD projects?	<ul style="list-style-type: none"> • Eco-friendly product development • Suppliers environmental evaluation • Sustainable logistics (e.g. Zero-emission vehicles, CO2 emission calculation, sharing transportation with other companies) • Recycling of materials • Waste reduction • Workplace health and safety • Certification of EMS (Environmental Management System) • Pollution prevention (e.g. Solar Energy, Geothermal Energy) 	[6, 7, 8, 9, 10, 13]
3	To what extent applications of IT are important regarding both customer satisfaction and success of NPD projects?	<ul style="list-style-type: none"> • Demand chain information • Industry 4.0 • Customers knowledge flow • Delivery track and updates • Additive manufacturing (3D Printing) 	[2, 10]
4	To what extent sales and innovative marketing practices are important regarding both customer satisfaction and success of NPD projects?	<ul style="list-style-type: none"> • Customer relationship management (CRM) • Customer service management (e.g. after sales service and maintenance, technical know-how) • Postponement • Mass customisation • Collective customer commitment 	[4, 10]

IV. DATA COLLECTION AND ANALYSIS

As highlighted in previous section, the research is focused towards the use of survey analysis methods to achieve better understanding on the status of Company A and B customer responsiveness and the needs of relevant entities towards satisfaction of our research objectives. Though, this section presents the collected data and results adopted from the company investigations.

This study has been conducted in collaboration with two manufacturing companies in Germany. The reason of choosing Germany was due to its high importance as largest European economy as well as being the fourth largest economy in the world based on its nominal GDP of \$3.5 trillion in 2017 [14]. Surprisingly, Small and medium-sized companies are comprising 99% of German companies providing with 60% of all jobs in the country [15]. The eastern city of Dresden is the traditional capital of Saxony having one of the most dynamic economies in Germany, also dominated by high-tech companies such as AMD, Infineon Technologies, Motorola, EADS (Manufacturer of Airbus A380), Volkswagen and a branch of GlaxoSmithKline [16]. This study is conducted in collaboration with two manufacturing companies based in Dresden namely company A and Company B. Within the data collection and analysis section of this study, the companies will be referred as Company A and Company B in order for more convenience.

1) *Company A*: This is a classic and old mechanical engineering company since 150 years ago and a family-run business having 70 personnel. The operations and products of this company are ranging within a wide variety from square balers, cutting rotors and special agricultural machines as well as assemblies and components. It has got the capability to serve and provide its customers with everything from individual parts to drawings, development and production of complex machines. Despite having low number of staff, the pay off and annual turnover of the company is remarkable and more than half of the company production is being exported worldwide [17]. The respondent within this company was the owner-manager who is the most knowledgeable regarding all the operations within the company.

2) *Company B*: Having 250 personnel, this company is a worldwide market leader and an expert for high-voltage test and measurement systems with an export share of approximately 90%. Precisely, they develop and manufacture systems for testing electrical energy transmission equipment, such as transformers, cables and switchgear as well as providing with research and teaching facilities regarding their systems [18]. Their operations are based on “modernization, customer orientation and fast market response” which makes them unique towards participation within this research. For the company, modernization is interpreted as finding the best solution for the upgrade of existing plants rather than immediate replacement which is surely costly for high-voltage components [18]. The respondent within this company was the production manager who is also having broad knowledge regarding the sustainable operations and product developments of the company.

Question 1:

Within Company A, the products are highly specialized and the number of total customers worldwide are 50. This is in the situation that 90% of the company revenues is generated by only 5 customers. Company A is a small company having big suppliers and bigger partner customers which help them through marketing of their products. The company usually forecasts the production volume based on month and annual basis. Moreover, there is no need for the company to plan towards redesigning the supply chain, as they already have an effective relationship with their long-term strategic customers. Top management commitment is among the factors which needs special consideration within company A, since the owner-manager has got a huge responsibility within all the operations of the company including production management, commercial management and sales management. The government imposes national regulations regarding satisfaction of sustainable factors which also influences on better fulfilment of sustainable customer needs. As stated by Company B, the identification of sustainable values and top management commitment are being considered to a high extent. This is in parallel with the fact that top management commitment is among the highly important factors when it comes to practicing the sustainable approaches within any company.

Question 2:

For Company A, among the sustainability factors within NPD projects, the most important ones are stated as materials recycling, workplace health and safety and pollution prevention. Due to the remote area of the company plant, it is almost impossible to transport the goods through train and therefore, they use logistic service providers acting as a consolidation entity putting together different goods of different companies together, also considering calculation of CO₂ emissions. Considering that factors such as waste reduction depends on the production volume, meaning that for mass production or higher number of products, it worth more to use technologies to reduce the wastes. The company also uses external consultants in order to meet the high standards of health and safety. The pollution prevention generated by small articles from metal cutting is being conducted with the help of professional waste and disposal companies. For Company B, the health and safety and certification of EMS are also being considered to a high extent, as they have replaced their lights to LED. Moreover, they have also eliminated part of the production system in order to reduce the wastes. Also, they find it expensive to use zero emission vehicles and sustainable logistics and therefore, kind of neutral mind-set in this regard. The wide range of eco-friendly approaches are proper platforms for the manufacturing companies to practice at least part of them and benefit from the economic savings, ethics improvement and environmental protection.

Question 3:

Regarding the application of IT practices within the introduced framework, Company A only utilises Email and ERP system in order to get the exact demand required by the customers. Company A is not also applying any Industry 4.0

systems or additive manufacturing to their production systems. However, they believe that it is possible to produce steel from the 3D printing machineries, but it is extremely costly for both company and customers to pay for such a premium price. Again, the Company B, despite its higher number of personnel, does not use any technological applications such as Industry 4.0 and additive manufacturing. This can be interpreted that still there is a long journey for the companies all over the world towards moving to innovative IT and technological platforms, even the developed countries and Germany which is itself the founder of fourth industrial revolution.

Question 4:

Since Company A is an SME, the innovative marketing practices can be interpreted within the form of sales management, network management and personal connections rather than the new methods of CRM and marketing approaches. Their strategy is to maintain the important customers being big companies, especially the five top customers that provide the company with 90% of their total revenues. As the owner of Company A stated, *“Our CRM strategies are based on finding new customers and building long-term relationships with them which has been the key to return on investment and annual revenues during all the time”*. They use an undocumented and informal way towards CRM, and the strategy behind is that they can evaluate easier the customer problems in order to find more effective solutions. Moreover, dealing with different dimensions and challenges and processing all the information and knowledge would be a hard task for the owner-managers within SMEs and therefore, it is more preferred to rely on informal information. Company A is providing its products to other companies which sell the products under their own brand. Hence, regarding customer service management, the end users mostly nor know the production company neither are able to contact it regarding the after sales, technical know-how and maintenance. Therefore, it is important for Company A to keep the contact with the sales department of their customer company in order to give them proper know-how toward helping the final end-users. Regarding innovative marketing practices, Company A is practicing the postponement to a high extent, meaning that they first predesign and build some generic components and after receiving customer order, it takes 4-6 weeks for them to assemble the final goods. Company B, is also based on make-to-order and therefore is practicing the mass customisation to a high extent and a bit of collective customer commitment, however, has not yet considered the postponement.

V. DISCUSSION AND FINDINGS

From the very early stages of the study, it is revealed that there is a broad variety of sustainability related concepts which can be discovered ranging from sustainable supply chain, sustainable demand chain and sustainable NPD approaches. In order to narrow down the primary topic and to identify the research scope, one of the mentioned concepts had to be selected. In doing so, an inclusive literature review is investigated for in-depth study of the main research concepts

together with the linkages and associations between them. After investigating the literature and conducting the case studies as industrial investigation, the author started to evaluate different challenges and aspects of SDCM. The reason was that SDCM is a very recent concept within literature and only a very few papers exist related to it. Hence, the structure and scope of this research was on incorporation of SDCM and NPD that is considered by all the business ecosystem entities to facilitate the product portfolio novelty and to create unique competitive advantages through linkage of customer values by an effective flow of information and goods/services.

Information regarding the customer value drivers will be provided by the analysis of the market potentials and therefore the value propositions consider the sustainability dimensions desired by customers. It is stated that the sustainable value performance is a concept that needs to be defined from the customer sustainability dimensions as an output rather than the suppliers' perspective that results in creation of sustainable value proposition [13]. Afterwards, there is a need to consider the sustainable delivery of the value propositions. All the mentioned factors act as components for formation of SSN where different components of supply chain utilize different resources towards adopting sustainability agenda within the form of a value chain rather than an isolated organization giving authority to suppliers. The model also illustrates the association between marketing and purchasing departments at the sustainable value delivery stage [13] and hence, these two entities would be selected as main respondents of the study survey questionnaire in order for better consistency with the literature principles and also better analysis of sustainable supply and demand chain elements.

Moreover, there is a vital necessity for the government executives to make closer associations and relationships with different components of the supply-demand chain in order to motivate, convince and support organizations towards making extra investments, achieving the strategic growth and adoption of environmental sustainability practices within their distribution network operations. This will lead them through exploiting the advantages of SDPD approach along with minimizing the costs, saving the resources and planet and also enhancement of social satisfaction. Furthermore, the good news is that there is a gradual growing rate around greening knowledge and SSCM practices within the current industrial generations that would be improved day by day to finally create a global commitment and responsibility which would act as inseparable backbones of supply chain. As also indicated within the last stage of this study, the ongoing development is particularly the case within the developed countries, whereas in developing countries, there is a different situation which surely needs more effort and consideration by both industrial experts and governments. The extracted interpretations from the two conducted case studies are impactful for this paper authors as moving through the next stages of the study, namely the hypothesis testing and framework validation.

VI. CONCLUSION AND FUTURE RESEARCH

The three main pillars of sustainability are broadly examined in literature from corporate social responsibility (CSR), environmental friendly products and sustainable distribution networks. Making a linkage between environmental sustainability approaches to supply and demand chain management, several frameworks have been already developed, mainly through an upstream view from suppliers' point of view for purchasing of green raw materials, regardless of the end users' massive influence on this issue. Therefore, there are still lack of appropriate integration between sustainable approaches and supply chain practices and require further investigations to discover the advantages of such linkage within global manufacturing industries. On the other side, due to today competitive markets and risks associated with conventional supply chain practices, many authors are trying to explore the sustainability applications based on demand chain perspective and market segmentations. Numerous papers have already investigated the SSCM and SDCM terms and relevant frameworks were discussed, however, the most comprehensive and uprated ones tried to be covered within this paper. Previous studies provided with several empirical researches and conceptual frameworks on sustainability application within distribution networks both from upstream and downstream viewpoints considering the strengths and benefits of each. This paper sought to achieve a profound background for future investigations within the form of a multidisciplinary case study discovering sustainability dimensions both from supply and demand side of distribution worldwide channels and evaluate to what extent the senior manager of manufacturing organizations can impact on the level of implementing sustainable logistics and other entities within supply chain.

However, more theoretical and empirical research in order to apply such method within manufacturing environment, this paper focused to utilise questionnaire and interview results adopted by German companies that adopts running NPD projects associated with customer segments considering sustainability concerns and environmental impacts. Hence, the structure and scope of this research sought to incorporate the SDCM and NPD considered by all the business ecosystem entities to facilitate the product novelty and to create competitive advantages through linkages of customer values by an effective flow of information and goods/services. There is a necessity in both academia and practice in order to move from supply chain towards demand driven chain approaches due to the fact that still there is a gap especially in literature investigating the demand chain concepts specifically considering sustainability dimensions. One of the main values of this paper was the classification of the three major principles of the research project (Sustainability, NPD and DCM) as well as design of the framework towards illustration of the linkages and interconnections between them as a major aspect of the research findings.

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