The Potential Moderating Role of Supply Chain Capabilities on the Relationship between Supply Chain Technology and Concurrent Engineering in Product Design

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Abstract

Today's business and competitive environment challenge firms to adopt new technologies, processes, and competences. Firms with strong technological capabilities generate more value from technology investment and achieve higher order of collaborative gains in product design. The aim of this paper is to improve the conceptual framework of the determinant of product design in supply chain management. Through an intensive literature review, the paper develops a conceptual model of the relationships between supply chain technology, capabilities, and concurrent engineering in new product design. The study has practical implications to managers and practitioners in supply chain management. The study also contributes to existing literature and theory of product design and development.

Key words: Supply chain technology, advanced manufacturing technology, information technology, supply chain capabilities, concurrent engineering, product design

1. Introduction

The business environment is becoming more globalized and companies are under pressures to adopt new technologies and processes aim at satisfying their customers at reduced costs [1]. Among other responsibilities, today's supply chain is required to improve product design in order to satisfy customers [2]. The product design process is also shifting away from silo design practices to concurrent engineering approach where technology and managerial capabilities interact. From an analytical point of view, a supply chain is "simply a network of material processing cells with supply, transformation and demand characteristics" [3].

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The relationship between new product design and the supply chain is increasingly attracting the interest of the academic and practitioners [4]. A principle of product design maintains that once engineering determines product design, at least 80 per cent of the product cost and quality are set [5] [6]. As a result, many leading visionary companies have already embedded design thinking in designing supply chain strategies [7]. Early concurrent engineering of product design are concerned with large technology-oriented companies especially in mechanical engineering products, computer industry, motor vehicles, electronics company, and aerospace [8]. However, the trend is changing to other sectors of manufacturing industry.

For instance concurrent engineering of product design has been investigated in pharmaceuticals and cosmetics industry [9]; ceramic industry [10], fashion retail industry [7]; toy industry [11]; biorefinery [12]; women apparel [13]; chemical product design [14]; eyeglass frame [15]; packaging design [16]; soaps, shampoos, detergents, tooth pastes, body creams and lotions [17]; furniture industry and home appliance firms [18].

Ref. [7] found that integrating product design and supply chain improves resiliency, responsiveness, market position and competitive advantages of a company. However, a study conducted by Ref. [19] shows no significant difference in product design performance using concurrent or sequential engineering and further suggests that group which uses technology to cooperate on product design does not perform better than those who do not. As such there is no significant relationship between computer-supported concurrent engineering and product design. In this paper, we argue that firms learn more from investing in new technologies than from old ones. Secondly, supply chain capabilities explain the inconsistencies findings in relationships between technology and concurrent engineering in product design.

Despite large bodies of studies, research on the relationship between concurrent engineering and supply chains has been addressed less frequently [20]. Ref. [7] suggest the need to investigate the interactions of technology and product design in supply chain studies. ref. [7] suggested for further studies that investigates product design and supply chain in order to improve costs and performance. Inconsistency in results of previous studies on the impact of technology and product design may suggest the need for further research by taking into account supply chain capabilities as moderating the influence of supply chain technology and concurrent engineering of product design. To date, this type of relationships remains unknown in the literature.

2. Literature Review

Investment in new technology is usually influence by technological capabilities and competence to ensure firm technological innovation performance. In the same way knowledge of previous collaboration influences supply chain partners to seek for more productive relationships [21]. Various technologies that aid product design process include design technologies such as computer-aided design (CAD), computer-aided process planning (CAPP) and computer aided manufacture such as robotics, bar coding, automatic assembly machines [1]. Based on the research model proposed by Ref, [22], this study proposes a framework of the interactive role of supply chain capabilities on concurrent engineering in product design as below:

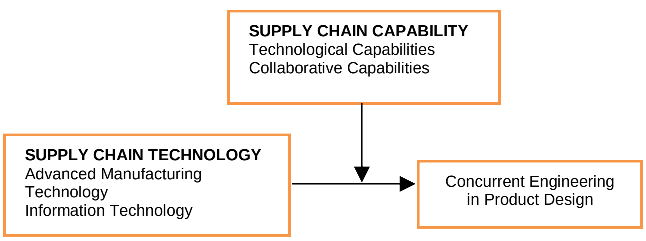

Figure 1: Conceptual Framework

The above framework shows that supply chain technology consists of advanced manufacturing technology and information technology. The interaction of these technologies is essential for any meaningful collaborative engineering of product design. Supply chain capabilities is operationalized as technological capabilities and collaborative capabilities. A brief explanation of the research framework is provided on the sub-headings below:

3. Supply Chain Technologies

Since the industrial revolution, technology has been depicted as the instrument of productivity, wealth creation and economic growth [23]. Ref. [24] define supply chain technology as "technologies that can be applied in isolation or in combination with other technologies or the supply chain business processes and supply chain network structure to create supply chain innovations". These technologies include global positioning systems (GPS), bar coding, radio frequency identification (RFID), electronic data interchange (EDI), advanced planning system (APS), enterprise resource planning (ERP), manufacturing execution system (MES), internet, e-auctions. In the context of this study, Supply chain technology is defined as the application of manufacturing technology and information technology/system that facilitate design and development of products, integration and information sharing, and collaborative processes of the supply chain with the aim of producing quality products, at the right time and cost.

Supply chain involves the flow of raw materials, transformation of the raw materials into finished goods and the marketing/distribution of the finished to final consumers. As such production facilities plays impeccable role in the supply chain of manufacturing companies in terms of production of quality, quantity goods in time. Information technology is important in the efficient and effective flow of goods, finance, services, and information between the upstream and downstream supply chain [25].

3.1 Advanced Manufacturing Technology (AMT)

Improving the competitiveness of manufacturing system through investment and use of advance manufacturing technology has gained exceptional recognition [26]. Advance manufacturing technology (AMT) is no longer an internal manufacturing process that used to be. Buyers increasingly use AMT to integrate suppliers in concurrent engineering of new product design and prototyping [27]. Ref. [28] show that AMT requires teamwork and communication from cross-functional multi-skilled workers. Ref. [29] emphasized that building competitive advantage from AMT implementation requires a balanced attention to both technology and people.

AMT is defined as "a group of computer-based technologies, which includes computer-aided design, computer-aided manufacturing, manufacturing resources planning, robotics, group technology, flexible manufacturing systems, automated materials handling systems, computer numerically controlled (CNC) machine tools, and bar-coding or other automated identification techniques and any technology, which is new or advanced to a company when compared to its previous or current manufacturing technology" [30].

3.2 Information Technology (IT)

Information technology (IT) is an important tool for the timely and accurate flow of information, speedy flow of products as well as ensuring an 'integrated supply chain' [31]. Integration of Information systems across supply chain partners is the backbone of information sharing and flow of goods in supply chain management. Information technology alignment refers "to the extent by which supply chain partners maintain the compatibility of their communication technology with other partners in order to streamline and improve the efficiency of their supply chain activities" [32]. In other words, it is the similarity, connectivity, and compatibility of information technology infrastructure between supply chain partners [33] [34].

Ref. [35] define supply chain information system as "computer and communication technology which facilitates the creation, storage, transformation, and transmission of information between two or more companies". Information technology consists of any form of technology such as computers, data communications technologies, and other hardware and services designed to handle information related to one or more business processes. The use of information technology in supply chain enables effective and efficient inter and intra-organizational concurrent engineering and collaborative efforts among supply chain partners. Information technology link the internal organizational processes through enterprise resource planning (ERP), link with the customers through customer relationship management (CRM), and link with the suppliers through supply chain management systems (SCMS).

3.3 Concurrent Engineering in Product Design

Concurrent engineering is a manufacturing philosophy where internal and external partners' work simultaneously from the design of a product to its market success [36]. It is thus, the simultaneous grouping of people with diverse skills in a multifunctional team to design and develop new product [37] [38]. It was initial used in high-tech companies. However, small and medium enterprises have started implement it in order to gain competitive advantages [19]. An evaluation of traditional sequential method of new product development shows that 50-80 per cent of the products under sequential method were not delivered to the market on time.

In a competitive market characterized by short product life cycles, concurrent engineering (CE) enable companies to produce quality goods, reduce rework and costs, speed market introduction, and increase the market success and profitability of product [39]. Ref. [38] show that CE is both team oriented and computer oriented philosophy. The team oriented involves simultaneous involvement of various functional experts, material suppliers and customers in design process. The team-based approached is being improved by the computer-based concurrent. As such, improving peoples' skills and competencies are elemental to the success of concurrent engineering.

3.3.1 Product Design Process

Product design and development is one of the basic elements of a successful marketing and competitive strategies of firms. Product design bears a strategic role and determines the direction and competitive advantage of a firm [40]. Firm's competitive advantage is significantly associated with its ability to develop new products [41]. Studies have found that about 80% of product life cycle costs is assessed at the design stage [42]. Therefore, crafting innovative strategies for product design is requisite as companies now realized that the supply chain "begins on the drawing board" [43].

There are significant relationships between product design and supply chain performance. Product design alignment with supply chain partners increases customer responsiveness [44], firm competitiveness and performance [7]. It also enhances the effectiveness of new product introduction, reduces the possibility of failed product launches, and decrease the tendency for rework [45]. While Ref. [46] point that the worst case in manufacturing process is when supply chain is not supported by product design, Ref. [4] did not find any significant relationship between product design and supply chain efficiency and responsiveness. The barrier to product design practice appears to be the lack of skilled personnel within the company as well as in the market [47].

3.4 Supply Chain Capabilities

Supply chain capability refers to the "ability of an organization to identify, use, and assimilate both internal and external resources and information to facilitate entire supply chain activities" [48] [49]. Ref. [33] classify supply chain capabilities as relational capabilities, logistics capabilities, and supply chain responsiveness. In this study, supply chain capabilities is conceptualized as technological capabilities and collaborative capabilities.

3.4.1 Technological Capabilities

Technological capabilities are crucial for firm performance, survival, future innovation and competitive advantage [50]; [51]. Firms with strong technological capabilities is able to generate more value from technology investment and achieve higher level of collaborative gains [52] [53]. Technological capability is defined as "a generic knowledge intensive ability to jointly mobilize different scientific and technical resources which enables a firm to successfully develop its innovative products and/or productive processes, by implementing competitive strategy and creating value in a given environment" [54].

Even though several studies have suggested significant relationship between technological capabilities and firm performance, Ref. [55] found that technological capabilities moderate competitive strategies and performance. Furthermore, it has been reported that supply chain capabilities enhance relationship between technological resources and product design value [48]. IT capabilities have significant relationship with firm performance through absorptive capacity and supply chain agility [56]. Ref. [57] suggest that relational capabilities must be combined with internal capability to increase technology investment effectiveness.

3.4.2 Collaborative Capabilities

Collaborative capabilities are the knowledge and competence to build and sustain productive cooperation with partners [58]. Collaborative capabilities help firms to identify new opportunities and design new products and processes. collaborative capabilities is the ability to link with people, select the right partners, share and use their ideas, and maintain productive relationships, identify and pursue innovation opportunities with other firms' [59]. In line with the social exchange theory, collaborative competencies are essential for a firm's performance [60]. Supply chain partners with collaborative competence are open to new ideas and thus achieve superior relational rents. Knowledge of past collaborative efforts nurture a strong tendency to effectively collaborate in the future.

Technological and collaborative capabilities are crucial for product design success. Technological competencies are defined as 'performance standards relating to the operation of a technology in order to achieve an intended outcome' and collaborative competencies are defined as 'standards of interaction with other members of a group that contribute to the collective solving of a problem or completion of a task' [61]. Supply chain collaboration are based on mutual commitments for acquiring technological and managerial resource [60].

3.5 Theoretical Lenses of the Study

Dynamic capabilities theory and social exchange theory are expected to explain relationship among the variables used in this studies. Dynamic capabilities theory examines how firms build, integrate, configure, and reconfigure their internal and external processes and competencies to foster innovation in order to achieve competitive advantage [32].

3.5.1 Dynamic Capabilities Theory

A dynamic capability is "the capacity of an organization to purposefully create, extend, and modify its resource base" [62]. The core dynamic capabilities are reconfiguration, leveraging, learning and knowledge creation, integration, and sensing and seizing [63]. Reconfiguration is the transformation and recombination of resources [61]; learning is a core first-order capability that permits firms to acquire and use knowledge in order to renew its capability and resource base [64]; integration is the internal and external coordination of socio-technical resources to achieve innovation and above average performance [65]; sensing is the use of capabilities to identify opportunities in the external environment while seizing is the timely investment to identify opportunities that improve organizational performance [63].

The theory shows that organizations with higher dynamic capabilities performs better than those with lower [66]. Alignment of technological capabilities with the knowledge capabilities will foster product and process innovation which will attract positive response from customers and thus enhance firm's performance [66]. In the context of this study, dynamic capabilities are supply chain technology and supply chain capabilities. These capabilities must be constantly renewed as business and competitive environment change. For a supply chain to be innovative, it has to relinquish their old configuration and reconfigure. Firms have to investment in new supply chain technologies, reconfigure their internal processes such as competences and knowledge in order to collaborate and achieve effective and efficient product design.

3.5.2 Social Exchange Theory

Ref. [67] shows that "any interaction between individuals is an exchange of resources". Social exchange theory is concerned with the process of mutual reward that comes about as a result of exchanges and transaction [68]. It is applicable in supply chain management because collaboration is a central tenet in business-to-business (B2B) and business-to-customer (B2C) relationship [69]. Reciprocity or repaying obligations is one of the basic tenets of social exchange theory [70]. Positive exchange interactions and outcomes increase the partners' relational norms, trust, and commitment to maintain the exchange relationship.

Social exchange theory (SET) demonstrates that parties enter into new and maintain old relationships with the expectation that doing so will be rewarding [67]. The expected reward include tangible and intangible resources such as goods, assets, money, advice, information, friendship or services [70] [67]. These rewards are rooted and can be obtained from social networks of interrelated people, groups or nations with common interests [71]. The theory further posits that each partner in the relationship has a valuable resource to offer and of which the other partner wants. The transaction relationship would end as soon as either one of the partner or even both partners perceive that the relationship is not rewarding.

4 Conclusion

The integration of supply chain technology with human capability will help concurrent engineering to achieve shorter lead time, reduce rework, increase time to market, and improve quality of product [72] [37]. Manufacturing companies sustain their profitability by offering products consumers want. Thus, the first step in product development is to determine what customers want, at what time, quality, and time. Ref. [73] shows that to improve time to market, lead time, and product cost, and human interface in design practices, companies must upgrade their design technology, manufacturing systems, and office technology. Thus, concurrent design teams must use technologies to make interconnected product design decisions regarding the features, cost, and quality of product.

This study has both managerial and theoretical implication. Findings from this study shall help executives, managers, and practitioners in manufacturing companies to acquire insights about the influence of technological capabilities, supply chain capabilities on concurrent engineering of new product design. Managers can use the research framework to design products that are customer satisfying. Findings from this study shall also improve the body of literature and theory on product design.

REFERENCES

[1] I. Bonney, M., Ratchev, S., & Moualek, "The changing relationship between production and inventory examined

in a concurrent engineering context," *Int. J. Prod. Econ.*, vol. 81, pp. 243–254, 2003.

[2] R. B. Jacobs F.R. & Chase, *Supply chain management, concepts and cases.*, Eastern Ec. Prentice-Hall of India Private Limited, New-Delhi, 2013, pp. 202–205.

[3] G. Rota, K., Thierry, C., & Bel, "Supply chain management: a supplier perspective," *Prod. Plan. Control.*, vol. 13, no. 4, pp. 370–380, 2002.

[4] D. Lo, S.M., & Power, "An empirical investigation of the relationship between product nature and supply chain strategy," *Supply Chain Manag. An Int. J.*, vol. 15, no. 2, pp. 139–153, 2010.

[5] J. Hong, P. & Roh, "Internationalization, product development and performance outcomes: A comparative study of 10 countries," *Res. Int. Bus. Financ.*, vol. 23, no. 2, pp. 169–180, 2009.

[6] W. Stank, T.P. Dittmann, J.P, & Autry, "The new supply chain agenda: a synopsis and directions for future research," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 41, no. 10, pp. 940 – 955, 2011.

[7] A. Khan, O., Christopher, M., & Creazza, "Aligning product design with the supply chain: a case study," *Supply Chain Manag. An Int. J.*, vol. 17, no. 3, pp. 323–336, 2012.

[8] P. Wallace, G., & Sackett, "Integrated design for low production volume, large, complex products," *Integr. Manuf. Syst.*, vol. 7, no. 3, pp. 5–16, 1996.

[9] R. J. Gurumoorthy, A. V., & Smith, "Positioning 'chemical product design' in the chemical engineering curricula in India," *Educ. Chem. Eng.*, vol. 8, no. 2, pp. e41–e43, 2013.

[10] R. Chiva-Gómez, R., Alegre-Vidal, J., & Lapiedra-Alcamí, "A model of product design management in the Spanish ceramic sector," *Eur. J. Innov. Manag.*, vol. 7, no. 2, pp. 150–161, 2004.

[11] Z. Wu, P. S., Yuen, T. H., & Fuliang, "A strategic approach to integrated product design for small–to medium-sized companies," *Integr. Manuf. Syst.*, vol. 6, no. 5, pp. 39–44, 1995.

[12] D. K. Chemmangattuvalappil, N.G., & Ng, "A systematic methodology for optimal product design in an integrated biorefinery," *Eur. Symp. Comput. Aided Process Eng.*, vol. 32, no. June, p. 91, 2013.

[13] D. Miller, N.J., Campbell, J.R., Littrell, M.A., & Travnicek, "Instrument development and evaluation for measuring USA apparel product design attributes," *J. Fash. Mark. Manag.*, vol. 9, no. 1, pp. 54–70, 2005.

[14] V. (2014) Heintz, J., Belaud, J. P., & Gerbaud, "Chemical enterprise model and decision-making framework for sustainable chemical product design," *Comput. Ind.*, vol. 60, no. 3, pp. 505–520, 2014.

[15] J. F. Lu, W., & Petiot, "Affective design of products using an audio-based protocol: Application to eyeglass frame," *Int. J. Ind. Ergon.*, vol. 44, no. 3, pp. 383–394, 2014.

[16] B. Rundh, "Packaging design: creating competitive advantage with product packaging," *Br. Food J.*, vol. 111, no. 9, pp. 988–1002, 2009.

[17] A. Martín, M., & Martínez, "A methodology for simultaneous process and product design in the formulated consumer products industry: The case study of the detergent business," *Chem. Eng. Res. Des.*, vol. 91, no. 5, pp. 795–819, 2013.

[18] Y. Chang, W. C. & Hsu, "Strategic Groups, Performance, and Issues related to Product Design Strategy," *Int. J. Innov. Manag.*, vol. 9, no. 2, pp. 133–154, 2005.

[19] G. A. Shanmugan, "Managing concurrent engineering in Malaysia small and medium enterprises," *Procedia – Soc. Behav. Sci.*, vol. 57, pp. 119–125, 2012.

[20] J. J. Marsillac, E., & Roh, "Connecting product design, process and supply chain decisions to strengthen global supply chain capabilities," *Int. J. Prod. Econ.*, vol. 147, pp. 317–329, 2014.

[21] R. C. M. Yam, W. Lo, E. P. Y. Tang, and A. K. W. Lau, "Analysis of sources of innovation , technological innovation capabilities , and performance : An empirical study of Hong Kong manufacturing industries," *Res. Policy*, vol. 40, no. 3, pp. 391–402, 2011.

[22] M. A. Tan, C.L., & Vonderembse, "Mediating effects of computer-aided design usage: from current engineering to product development performance," 2005.

[23] A. Parasuraman, "Technology readiness index (TRI): a multiple-item scale to measure readiness to embrace new technologies," *J. Serv. Res.*, vol. 2, no. 4, pp. 307–320, 2000.

[24] K. B. (2011). Arlbjørn, J. S., de Haas, H., & Munksgaard, "Exploring supply chain innovation," *Logist. Res.*, vol. 3, no. 1, pp. 3–18, 2011.

[25] L. R. Vijayasarathy, "An investigation of moderators of the link between technology use in the supply chain and supply chain performance," *Inf. Manag.*, vol. 47, no. 7, pp. 364–371, 2010.

[26] M. Evans, L., Lohse, N., Tan, K.H., Webb, P., & Summers, "Justification for the selection of manufacturing technologies: a fuzzy-decision-tree-based approach.," *Int. J. Prod. Res.*, vol. 50, no. 23, pp. 6945–6962, 2012.

[27] E. Sweeney, "The 'new normal' operating environment.," in *Being a conference presentation organized by the Gattorna Alignment on the theme: Supply chain "thought leadership" through Innovation – Design thinking – Alignment at The Fullerton Hotel, Singapore between 12-15 June*, 2012, p. June.

[28] S. S. Mora-Monge, C.A, Gonza´lez, M.E., Quesada, G. & Rao, "A study of AMT in North America: A comparison between developed and developing countries," *J. Manuf. Technol. Manag.*, vol. 19, no. 7, pp. 812–829, 2008.

[29] H. M. Small, M.H. & Yasin, "Advanced manufacturing technology: implementation, policy, and performance," *J. Oper. Manag.*, vol. 15, no. 4, pp. 349–70, 1997.

[30] Abd Rahman; D Bennett, "Advanced manufacturing technology adoption in developing countries: The role of buyer-supplier relationships.," *J. Manuf. Technol. Manag.*, vol. 20, no. 8, pp. 1099–1118, 2009.

[31] R. L. Craighead, C.W., & Laforge, "Taxonomy of information technology adoption patterns in manufacturing firms," *Int. J. Prod. Res.*, vol. 41, no. 11, pp. 2431–2449, 2003.

[32] E. Kim, D., Cavusgil, S.T., & Cavusgil, "Does IT alignment between supply chain partners enhance customer value creation? An empirical investigation," *Ind. Mark. Manag.*, vol. 42, pp. 880–889, 2013.

[33] M. J. Rajaguru, R., & Matanda, "Effects of inter-organizational compatibility on supply chain capabilities: Exploring the mediating role of inter-organizational information systems (IOIS) integration," *Ind. Mark. Manag.*, vol. 42, pp. 620–632, 2012.

[34] Z. Ye, F. & Wang, "Effects of information technology alignment and information sharing on supply chain operational performance," *Comput. Ind. Eng.*, vol. 65, pp. 370–377, 2013.

[35] P. Youn, S. H., Yang, M. G. M., Kim, J. H., & Hong, "Supply chain information capabilities and performance outcomes: An empirical study of Korean steel suppliers," *Int. J. Inf. Manag.*, vol. Journal in, 2014.

[36] J. C. Liang, "An integrated product development process in automotive industry," *Int. J. Prod. Dev.*, vol. 8, no. 1, pp. 80–105, 2009.

[37] M. Z. Meybodi, "The links between lean manufacturing practices and concurrent engineering method of new product development: An empirical study," *Benchmarking An Int. Journal,*, vol. 20, no. 3, pp. 362–376, 2013.

[38] M. R. Sapuan, S.M., & Mansor, "Concurrent engineering approach in the development of composite products: A review," *Mater. Des.*, vol. 58, pp. 161–167, 2014.

[39] A. Kowang, T.O. & Rasli, "New product development in multi-location R&D organization: a concurrent engineering approach," *African J. Bus. Manag.*, vol. 5, no. 6, pp. 2264–2275, 2011.

[40] J. J. Hong, P., Kwon, H.B., & Roh, "Implementation of strategic green orientation in supply chain," *Eur. J. Innov. Manag.*, vol. 12, pp. 512–532, 2009.

[41] R. Rozenfeld, H., De Oliveira, C.B.M., & Omokawa, "Development of a concurrent engineering education environment," *Int. J. Comput. Integr. Manuf.*, vol. 13, no. 6, pp. 475–482, 2000.

[42] S. Kovács, G., Mezgár, I., & Kopácsi, "Concurrent design of automated manufacturing systems using knowledge processing technology," *Comput. Ind.*, vol. 17, no. 2, pp. 257–267, 1991.

[43] K. T. Krishnan, V., & Ulrich, "Product development decisions: A review of the literature," *Manage. Sci.*, vol. 47, no. 1, pp. 1–21, 2001.

[44] L. L. Ellram, L.M. & Stanley, "Integrating strategic cost management with a 3DCE environment: Strategies, practices, and benefits," *J. Purch. Supply Manag.*, vol. 14, no. 3, pp. 180–191, 2008.

[45] P. van Hoek, R. & Chapman, "From tinkering around the edge to enhancing revenue growth: supply chain – new product development alignment," *Supply Chain Manag. An Int. J.*, vol. 11, no. 5, pp. 385–389, 2007.

[46] T. Pero, M., Abdelkafi, N., Sianesi, A. & Blecker, "A framework for the alignment of new product development and supply chains," *Supply Chain Manag. An Int. Journal,*, vol. 15, no. 2, pp. 115–28, 2010.

[47] S. Allal-Chérif, O. & Maira, “Collaboration as an anti-crisis solution: the role of the procurement function,” *Int. J. Phys. Distrib. Logist. Manag.*, vol. 41, no. 9, pp. 860–877, 2011.

[48] S. R. T. Wu, F., Yeniyurt, S., Kim, D., & Cavusgil, “The impact of information technology on supply chain capabilities and firm performance : A resource-based view,” *Ind. Mark. Manag.*, vol. 35, pp. 493–504, 2006.

[49] P. Hee, S., Ga, M., Yang, M., Hwan, J., & Hong, “Supply chain information capabilities and performance outcomes,” *Int. J. Inf. Manage.*, pp. 1–12, 2014.

[50] A. Lamin and D. Dunlap, “Complex technological capabilities in emerging economy fi rms : The role of organizational relationships,” *J. Int. Manag.*, vol. 17, no. 3, pp. 211–228, 2011.

[51] G. Cerulli and A. Filippetti, “The complementary nature of technological capabilities : Measurement and robustness issues,” *Technol. Forecast. Soc. Chang.*, vol. 79, no. 5, pp. 875–887, 2012.

[52] F. Garcia, L. Avella, and E. Farnandez, “Learning from exporting : The moderating effect of technological capabilities,” *Int. Bus. Rev.*, vol. 21, pp. 1099–1111, 2012.

[53] J. Wu, “Cooperation with competitors and product innovation : Moderating effects of technological capability and alliances with universities,” *Ind. Mark. Manag.*, vol. 43, no. 2, pp. 199–209, 2014.

[54] F. E. Garcia- Muina and J. E. Navas-Lopez, “Explaining and measuring success in new business : The effect of technological capabilities on firm results,” *Technovation*, vol. 27, pp. 30–46, 2007.

[55] R. José, M., & Ortega, “Competitive strategies and firm performance : Technological capabilities ’ moderating roles,” vol. 63, no. 12, pp. 1273–1281, 2010.

[56] H. Liu, W. Ke, K. Kee, and Z. Hua, “The impact of IT capabilities on fi rm performance : The mediating roles of absorptive capacity and supply chain agility,” *Decis. Support Syst.*, vol. 54, no. 3, pp. 1452–1462, 2013.

[57] Y. Voudouris, I., Lioukas, S., Iatrelli, M., & Caloghirou, “Effectiveness of technology investment : Impact of internal technological capability , networking and investment ’ s strategic importance doi:10.1016/j.techn,” *Technovation*, vol. 32, no. 6, pp. 400–414, 2012.

[58] R. F. Zacharia, Z.G., Nix, N.W., & Lusch, “Capabilities that enhance outcomes of an episodic supply chain collaboration,” *J. Oper. Manag.*, vol. 29, no. 6, pp. 591–603, 2011.

[59] A. Fitjar, R.D., Gjelsvik, M., & Rodríguez-pose, “The combined impact of managerial and relational capabilities on innovation in firms,” *Entrep. Reg. Dev. An Int. J.*, vol. 25, no. 5–6, pp. 500–520, 2013.

[60] F. Yan, Y., Zhang, S. H., & Zeng, “International firm ’ s relational capabilities : an empirical study 18(6), 473–487. doi:10.1080/0965254X.2010.525251,” *J. Strateg. Mark.*, vol. 18, no. 6, p. 473, 2010.

[61] M. Bower, “Synchronous collaboration competencies in web conferencing environments – their impact on the learning process.,” *Distance Educ.*, vol. 32, no. 1, pp. 62–83, 2011.

[62] C. E. Helfat, “Stylized facts, empirical research and theory development in management,” *Strateg. Organ.*, vol. 5, no. 2, pp. 185–192, 2007.

[63] D. J. Teece, “Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance,” *Strateg. Manag. J.*, vol. 28, no. 13, pp. 1319–1350, 2007.

[64] G. Zahra, S. A., & George, “Absorptive capacity: A review, reconceptualization, and extension,” *Acad. Manag. Rev.*, vol. 27, no. 2, pp. 185–203, 2002.

[65] O. A. Pavlou, P.A., & El Sawy, “Understanding the elusive black box of dynamic capabilities,” *Decis. Sci.*, vol. 42, no. 1, pp. 239–273, 2011.

[66] J. A. Miles, *Management and organization theory*. 2012, p. A Jossy–Bass Reader: A Wiley Imprint, www.josseyba.

[67] G. C. Homans, “Social behaviour as exchange,” *Am. J. Sociol.*, pp. 597–606, 1958.

[68] R. M. Emerson, “Social exchange theory,” *Annu. Rev. Sociol.*, vol. 2, pp. 335–362, 1976.

[69] R. . Lambe, C.J., Wittmann, C.M., & Spekman, “Social Exchange Theory and Research on Business-to-Business Relational Exchange,” *J. Business-to-bus. Mark.*, vol. 8, no. 3, pp. 1–36, 2001.

[70] A. W. Gouldner, “The norm of reciprocity: A preliminary statement,” *Am. Sociol. Rev.*, no. 161–178, 1960.

[71] E. W. Inkpen, A.C., & Tsang, “Social capital, networks, and knowledge transfer,” *Acad. Manag. Rev.*, vol. 30, no. 1, pp. 146–165, 2005.

[72] K. Z. Chen, "Integration of design method software for concurrent engineering using axiomatic design," *Integr. Manuf. Syst.*, vol. 9, no. 4, pp. 242–252, 1998.

[73] B. Haque, "Problems in concurrent new product development: an in-depth comparative study of three companies," *Integr. Manuf. Syst.*, vol. 14, no. 3, pp. 191–207, 2003.