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Effect of Supply Chain technology, Supply Chain Collaboration and Innovation Capability on Supply Chain Performance

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ABSTRACT: *The aim of this study was to examine the mediating effect of innovation capability on the relationships between supply chain technology and supply chain performance on the one hand, and supply chain collaboration and supply chain performance on the other. The study was based on cross-sectional survey of 286 manufacturing companies. Cluster and stratified random sampling were employed and self-administered questionnaires were distributed to the selected companies. Data was analyzed using structural equation modeling. Result of mediation analysis revealed that innovation capability is a full mediator on the relationship between supply chain technology and supply chain performance as well as on supply chain collaboration and supply chain performance. The study enhances literature of the supply chain performance through the integration of supply chain technology (advanced manufacturing technologies and information technology), supply chain collaboration (concurrent engineering of product design, collaborative planning, forecasting, & replenishment, and collaborative marketing), and innovation capability. For practice, the study provides guidance by which managers can follow to improve the supply chain performance. Limitations and suggestions for further studies were provided.*

Keywords: Supply chain technology, Supply chain collaboration, and Supply chain performance.

Supply chain management (SCM) is dynamic strategy for firm competitiveness and performance. Proponents of the dynamic capabilities theory suggest that firms continuously build, integrate, and reconfigure technological and network competencies for innovation performance (Teece, 2010). As a dynamic resources, supply chain technology (SCT) influences the transformation of raw materials into finished goods (Meybodi, 2013), reduction of costs and lead-time, improved quality and on-time delivery (Das and Nair, 2010) and subsequently firm success (Prasad and Heales, 2010). Technology also facilitates communication, real-time information sharing, as well as reduced costs of inventory and transaction (Prajogo and Olhager, 2012). Despite these benefits, research that examines the effect of supply chain technology on supply chain performance (SCP) is not only scarce but the few results conflicts. For example, Richey et al. (2012) found a significant relationship between SCT and SCP However, Omar et al., (2006) concluded that SCT does not influence manufacturing performance. Furthermore, the literature shows that creating technological competencies is hampered by high cost of the technology, weak corporate culture for technology, technological uncertainties and paradox, lack of technological expertise, under-utilization of technology, and technological incompatibility. These obstacles affect the effect of SCT on SCP negatively and therefore, need to be addressed.

Equally, supply chain collaboration (SCC) is a dynamic processes for partners to 'move as one' (Bolstorff & Rosenbaum 2012). Collaboration improves information visibility and sharing, development of mutual plan, forecast and replenishment, sense of responsibilities, and end-customer satisfaction (Sandberg, 2007). These subsequently influence supply chain performance (Liao and Kuo, 2014). Despite these benefits, literature generally emphasizes antecedents of SCC such as goal congruence, decision synchronization, incentive alignment, (Cao and Zhang, 2011) and top management commitment (Anbanandam et al., 2011) at the detriment of its processes. The few empirical research on the collaborative processes are not only limited but suggest inconsistent findings.

For example, significant relationship was found between SCC and SCP (Kumar and Nath, 2014; Ramanathan and Gunasekaran, 2014). However, Hadaya and Cassivi (2007) suggest that collaborative planning do not influence SCP. Furthermore, difficulties such as breakdown of trust, different goals and priorities, incompatible supply chain structure have made supply chain collaboration delicate to implement (Nagashima et al. 2015). The inconsistencies of findings between SCT and SCP, as well as SCC and SCP with their associated obstacles remain gaps to be addressed. To cover this gap, the paper aims to investigate the intervening role of innovation capability on supply chain technology and supply chain performance on the one hand, and supply chain collaboration and supply chain performance on the other. In this regard, we argue that innovation capability could reconcile the inconsistent findings on the relationship between SCT and SCP as well as SCC and SCP. Innovation capability is a 'learning-to-learn type' (Collis, 1994), the "cultural readiness and appreciation of innovation' (Hult et al., 2004). Innovation capability builds knowledge and propel innovation orientation (Börjesson, et al., 2014) which subsequently influences supply chain performance (Panayides and Lun, 2009). It is suggested that that firms with greater dynamic resources compete better than those with less (Teece, 2007). Likewise, Pavlou & El Sawy (2011)shows that the reconfiguration and revamp of capabilities influence knowledge creation.

Theoretical Background

The research framework extends the recommendation for future studies by Ageron et al. (2013) through the theoretical lens of the dynamic capabilities theory (DCT) (Teece, 2007). While technology is a dynamic capability, collaboration is a dynamic process. These capability and process must continuously be modified for mutual benefits in order to enhance innovation capability and the supply chain performance. As technological and collaborative innovation are increasing among Nigerian firms, the DCT remains an important theoretical lens. Additionally, the top management of Nigerian manufacturing companies play important role on technology acquisition and implementation as well as how to establish collaboration with major partners. Thus, the research framework of this study is presented in Figure 1.

(See Figure 1 in appendix)

Hypothesis Development

Supply chain technology and supply chain performance in the presence of innovation capability: Firms implement new technologies to build competences across the supply chain (Wu, 2014). The aim is to develop innovation orientation and achieve competitive advantage (Teece, 2007). Firms with strong technological competences achieve higher level of gains than those with lower (Garcia, Avella, and Farnandez 2012; Singhry, Abd Rahman, and Ng, 2014). Although significant relationship between advanced manufacturing technology (AMT) and SCP have been suggested (Roh et al., 2014; Sha et al., 2008), Small and Yasin (1997) concluded that not all AMT influence performance. Gunasekaran (1999) suggested that AMT alone does not guarantee customer and market success. Similarly, despite the benefits of information technology in the supply chain, many organizations were disappointed with the outcomes of their IT investment due to productivity paradox (Ye and Wang, 2013). Although Hortinha et al. (2011) found that innovation capability mediates the relationship between technology orientation and performance of manufacturing companies, the meditating role of innovation capability on the relationship between supply chain technology and supply chain performance is not clear. Based on the argument above and the DCT which demonstrates the need to modify and implement new technologies for innovative knowledge creation and supply chain performance, it is therefore proposed that:

H1: Innovation capability mediates the relationship between supply chain technology and supply chain performance.

Supply chain collaboration and supply chain performance in the presence of innovation capability: The knowledge-based of the dynamic capabilities theory shows that acquiring, combining, and sharing knowledge become more critical to innovation and competitive advantage (Zahra et al., 2007). Petti and Zhang (2013) found that collaboration influences knowledge exploration and exploitation as well as firm performance. Although Koufteros and Vonderembse (2005) found a significant relationships between concurrent engineering of new product development and innovation performance, Valle and V’azquez-Bustelo (2009) suggested that in a period of uncertainties and for companies pursuing radical innovation, concurrent engineering does not influence product development time and quality. Furthermore, Hadaya and Cassivi (2007) did not find significant relationship between collaborative planning and SCP. Although, Seo et al. (2014) found an indirect effect of innovativeness on the relationship between integration and supply chain performance, the intervening role of innovation capability on the relationship between supply chain collaboration and supply chain performance remains unclear. Based on the knowledge-based view of the dynamic capabilities theory and the preceding arguments, it is postulated that:

H2: Innovation capability mediates on the relationship between supply chain collaboration and supply chain performance.

Method and Measurement

This study employs quantitative research methodology based on cross-sectional survey. Data was collected from members of Manufacturers’ Association of Nigeria (MAN) between August 2014 and November 2014. MAN is a body that moderates the interest of Nigerian manufacturing companies. With 1574 companies on its database, 1035 companies were targeted and 323 companies were randomly selected. The cluster and systematic sampling techniques were used to select the respondents. The companies were selected based on location (Branches) and sectors. Subsequently, a systematic sampling was conducted to select the companies that participated in this survey. Personal (face-to-face) questionnaire administration was applied with the help of 8 research assistants. The research assistants were the staff of MAN in the 8 branches respectively and have experience of administering questionnaires in their branches. They are familiar with the managers because of previous interactions. The sample size was computed from the table of sample size determination as suggested by Krejcie and Morgan (1970). Of the 323 distributed questionnaires, 292 were returned and 286 were found usable. The response rate was 90.4% and higher than suggestion made by Sudman et al. (1965) who point that self-administered questionnaires have a completion rate of about 76%. Even though face-to-face questionnaire administration is expensive in terms of time, money, and efforts, it performs better than mail and telephone surveys (Szolnoki and Hoffmann 2013).

The entire research instruments in this study have been validated in previous literature. They were directly adapted in some while adopted and modified in others to suit the context of this study. All items have been measured on 7 point Likert-type scale from 1 = strongly disagree to 7 = strongly agree. AMT measurement was extracted from Bülbül et al. (2013), Dıaz et al., (2003), Koc and Bozdag (2009), and Mora-Monge et al. (2008). Information technology was picked from Chen and Paulraj (2004), McCarthy-Byrne and Mentzer (2011), and Wu et al.(2006). Concurrent engineering of product design was mined from Chen and Paulraj (2004) and Feng and Wang (2013). CPFR was chosen from Maltz and Kohli (1996), McAllister (1995), and McCarthy-Byrne and Mentzer (2011). Collaborative marketing was selected from Acur et al. (2012), Doney and Cannon (1997), Ganesan (1994), Green et al. (2012), McCarthy-Byrne and Mentzer (2011). Innovation capability was adopted and modified from Storer and Hyland (2009) and Zacharia et al. (2011). Supply chain performance was adopted from Cirtita and Glaser-Segura (2012), Rajaguru and Matanda (2013), Stank et al. (1999) and Ye and Wang (2013).

Result

We began by assessing that the Cronbach’s reliability and factor loading to classified the dimensions of the constructs. The items reliability ranges between .54 and .93 (Nunnally, 1978) while the factor loading between .71 and .91. Next, the common method bias was assessed based on Harman's single factor test. Exploratory factor analysis show that all constructs' have % of variance and sums of squared of 25.650 less than 30%. This suggests that common method bias was not a major issue in this study (Podsakoff et al., 2003). Table 1 represents the item reliability and constructs' factor loadings.

(See Table 1 in appendix)

Confirmatory Factor Analysis – Validity

Construct, convergent, and discriminant validities were assessed in this study. Two approaches were used to evaluate the construct validity of this study. The first was the four conditions suggested by Mokkink et al. (2010). The second is the Pearson correlation coefficients as suggested by Farag et al. (2012) and Rod et al. (2013). The output of this process suggested bivariate correlations with positive coefficients between 0.144 and 0.602 (refer to Table 3). There are no variables that correlated above 0.85 and therefore multicollinearity was not an issue in this study (Awang 2014).

Convergent validity was evaluated based on recommendations by Fornell and Larcker (1981) and Hair Jr, et al. (2013). First, item loading should be > .70 and significance. Second, composite reliability of each construct must be > .80. Third, average variance extracted (AVE) of all construct must be > .50 (Fornell and Larcker, 1981). However, on the first condition, Hair et al. (2012) argue that items with factor loading above .4 should be retained if their deletion could affect either construct validity or composite reliability. Results from Table 2 shows that item loading of all constructs range between .71 and .91. The composite reliability of all constructs range between .81 and .93; average variance extracted (AVE) of all constructs were between .53 and .68. Therefore, evidence of convergent validity exist (Anderson and Gerbing, 1988)

Discriminant validity was assessed based on the criterion recommended by Fornell and Larcker (1981). The criterion states that "the square root of AVE for each construct must be greater than its correlations with all other constructs". In order words, "AVE should exceed the squared correlation with any other construct" (Hair Jr et al., 2013). The bold values represented on diagonal in Table 2 shows that the square root of AVE for each construct is greater than its correlation with all other constructs (Fornell and Larcker 1981). Furthermore, values above the bold diagonal are the squared correlations of all construct and are smaller than AVE (Hair Jr et al., 2013). The values in Table 2 indicate that each construct is empirically and statistically distinct from another construct (Chin, 1988). Therefore, evidence of discriminant validity exist (Anderson and Gerbing 1988).

(See table 2 in Appendix)

Validating the Structural Model

The mediated structural model is validated based on suggestion by Hayes (2009). Four conditions must be satisfied for mediation to occur: "(a) the total effect of X on Y (t) must be significant; (b) the effect of X on M (α) must be significant; (c) the effect of M on Y (β) must be significant; (d) the direct effect of X on Y adjusted for M (t') must be smaller than the total effect of X on Y" (Baron and Kenny, 1986; Mathieu and Taylor, 2006). The first criteria shows that the relationship between supply chain technology and supply chain performance is significant ($\beta = 0.254$; $P < 0.001$). Similarly, supply chain collaboration influences supply chain performance ($\beta = .43$, $P < 0.01$). The test for the second condition revealed that supply chain technology is significantly related with innovation capability ($\beta = .51$, $P < 0.01$). Correspondingly, supply chain collaboration influences innovation capability ($\beta = .42$, $P < 0.01$). Furthermore, the third condition indicated that innovation capability is positively and significantly related with supply chain performance ($\beta = .65$, $P < 0.01$). Figure 2 and Table 3 present the results of the first three steps of the mediation analysis.

(See Figure 2 & Table 3 in Appendix)

Test of the Mediating Effects of Innovation Capability

Data from Figure 2 and Table 3 are used to compute the mediation effects. Table 4 shows a full intervening effect of innovation capability on supply chain technology and supply chain performance [(β for X→M = 0.512; M→Y = 0.553; and X→Y = -0.046)]. Accordingly, innovation capability is a full mediator between supply chain collaboration and supply chain performance [(β for X→M = 0.415; M→Y = 0.553; and X→Y = 0.191)].

(See table 4 in appendix)

Discussion

The first stage of the mediation results shows a positive relationship between supply chain technology and supply chain performance. This finding is consistent with Richey et al. (2012) who suggested that technological complementarity influences logistics quality. Agus (2008) suggested that the adoption and use of new technology in supply chain has statistical relationship with product quality and business performance. Henderson et al. (2004) observed that the integration of AMT and information technology influence firm performance. Likewise, there is a significant relationship between supply chain collaboration and supply chain performance. This finding is similar to Nix and Zacharia (2014) suggest that collaborative engagement directly influences operational and relational outcomes. van Hoof and Thiell (2014) found that SCC influences cleaner production and sustainable competitive advantages. Ramanathan and Gunasekaran (2014) found that collaborative alliances improve supply chain performance.

The introduction of innovation capability into the model changed the relationship between supply chain technology and supply chain performance to negative and non-significant (Stage 4 – Table 3). Therefore, innovation capability has a full mediating effect between supply chain technology and supply chain performance. This finding connotes that Nigerian manufacturing companies could enhance cost efficiency, customer patronage, and market performance through the integration of computer-aided manufacturing, computer-aided engineering, computer-aided design, computer-numerically controlled machine, computer-aided inspection, automated guided vehicles. Other technological competences include automated materials handling systems, automated storage, and compatible IT to connect and transmit real-time information. The integration must influence technological and collaborative capabilities to enhance the supply chain performance. Although this finding is unique, it is similar even though not directly related with Hortinha et al. (2011) who found that innovation capability (exploitative and explorative) mediates the relationship between technology orientation and performance. Additionally, Chang et al. (2015) found that joint dynamic capabilities mediate between information technology investments and collaborative value.

Similarly, the introduction of innovation capability between supply chain collaboration and supply chain performance changed the positive relationship into non-significant. Thus, innovation capability is a full mediator between supply chain collaboration and supply chain performance. This shows that relationship with suppliers, customers, and among organizational functional units enhance knowledge creation, innovation orientation and consequently improve the supply chain performance. This finding is similar but not directly related with Chen et al.(2013) who found an indirect effect of marketing capability on the relationship between collaborative communication and customer performance. Equally, Shin and Damon (2012) found an indirect effect of marketing capability on customer orientation and firm performance. Nigerian manufacturing companies should maintain collaboration in order to improve their innovation capability.

Conclusion

This paper presented a post-positivism worldview which investigated the mediating effect of innovation capability on the relationship of supply chain technology, supply chain collaboration, and supply chain performance. The study reveals that the relationship between supply chain technology and supply chain performance, as well as supply chain collaboration and supply chain performance is more complex than what has been suggested in the isolated literature of operation and strategic management. The mediation effect indicates that innovation is an action-based concept that cannot measure supply chain performance directly (Rhee, Park, and Lee, 2010). Therefore, we found that innovation capability is the mechanism through which technology and collaboration enhances better cost reduction, customer agility, and market performance. The findings of this paper yield some interesting theoretical and practical contributions.

Theoretically, the paper is the first to introduce innovation capability as a mediator variable between supply chain technology; collaboration and supply chain performance. The intervening effect of innovation capability explained the mixed results in previous studies. The introduction of innovation capability into the model alters the direct relationship of supply chain technology and collaboration with SCP, and therefore caused full mediation effects. The mediation effect indicates that higher SCP depends on enhancement of process and collaborative capabilities. This demonstrates that higher SCP depends on development of process and collaborative capabilities. Thus the paper contributes toward resolving the inconsistent findings of SCT and SCP and SCC and SCP.

Practically, the findings could guide chief executives and managers of manufacturing companies on strategies to integrate technologies and collaboration to reduce supply chain challenges such as poor transportation and distribution networks, less advanced production and information technologies, and low level of manufacturing skills. The objective is to reduce inventory costs, manufacturing costs, bullwhip effect, lead times, late delivery, and weak collaboration. Nigerian manufacturers are thus encouraged to take proactive measures to developed ability to apply technologies for continuous improvement and customer focus concepts, work effectively with individuals within and outside our organization and internationally, take advantages of new knowledge, select partners for effective collaboration, and learn from prior collaboration experiences. The study will also guide managers on how to develop innovative behaviours and cultures toward adopting and using new technologies as well as seek for new collaborative opportunities (Škerlavaj et al., 2010). Innovation in technology without corresponding increase in employees skilled usually has negative consequences (Soosay et al., 2008). As such upgrades of innovation capability is pre-requisite for supply chain success.

Limitations and Recommendations for Further Study

Despite the important findings of this study, it was not without limitations. First, a single respondent in each firm was asked to fill a questionnaire on the different sections of the questionnaire. Although, the respondents were top managers who have adequate information about their companies, it is very difficult for a single manager to supervise the whole supply chain. Therefore, there is need to collect data from dyadic, tripartite, or across all supply chain partners. Second, a case-based approach as well as longitudinal could help overcome some of the limitations of the cross-sectional study. Furthermore, some variables could add interesting results in this study which have not been observed. Thus, we recommend future research to investigates how organizational culture influences supply chain technology, collaboration and performance. Organizational culture generally refers to the organizational values communicated through norms, artifacts, and observed behavioral patterns (Hogan and Coote 2014). Accordingly, this study recommends the investigation of Schein's model of organizational culture. Despite the value of Schein's model, empirical studies in relation to the supply chain is scarce.

Secondly, the underlying risks of supply chain technology and collaboration should be investigated. Disruption in sourcing, production, and distribution can cause immediate shortages and lack of capacity utilization. These could increase the susceptibility of the supply chain. Lastly, the effect of quality management in supply chain technology and collaboration need investigation. Quality management is important for maintain technological capabilities (Zu and Kaynak 2012). It has been suggested that quality management could influence customer satisfaction and profit (Kuei et al. 2002). Finally, the current findings should be interpreted with cautions and within the cultural context of Nigerian manufacturing industry. This is because Nigerian manufacturing companies operates in an unstable environment with infrastructural disadvantages and poor manufacturing supports. Therefore, future studies can be conducted in other economies such as Malaysia, Brazil, South Africa, and Egypt to compare the findings of this study.

References

1. Acur, N., D. Kandemir, and H. Boer. 2012. "Strategic Alignment and New Product Development: Drivers and Performance Effects." *Journal of Product Innovation Management* 29 (2): 304–18.
2. Agus, A. 2008. "The Importance of Incorporating New Technology and Innovation in Supply Chain Management (SCM) Processes in Enhancing Performance. Paper Presented at the Proceedings Of." In *In Proceedings of (Vol. 16).*
3. Anbanandam, R., D.K. Banwet, and R. Shankar. 2011. "Evaluation of Supply Chain Collaboration: A Case of Apparel Retail Industry in India." *International Journal of Productivity and Performance Management* 60 (2): 82–98.
4. Anderson, James C., and David W. Gerbing. 1988. "Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach." *Psychological Bulletin*,.
5. Awang, Z. 2014. *A Handbook on SEM for Academicians and Practitioners: Step by Step Practical Guides for the Begineers*. Vol.2 Firs. Perpustakan Negara Malaysia: MPSW Rich Resources.
6. Baron, Reuben M, and David A Kenny. 1986. "The Moderator-Mediator Variable Distinction in Social Psychological Research : Conceptual , Strategic , and Statistical Considerations." *Journal of Personality and Social Psychology* 51 (6): 1173–82.
7. Bolstorff, P., and R. Rosenbaum. 2012. *Supply Chain Excellence*. Amacom, New York.
8. Börjesson, S., M. Elmquist, and S. Hooge. 2014. "The Challenges of Innovation Capability Building: Learning from Longitudinal Studies of Innovation Efforts at Renault and Volvo Cars." *Journal of Engineering and Technology Management* 31: 120–40.
9. Bülbül, H., N. Ömürbek, T. Paksoy, and T. Bektaş. 2013. "An Empirical Investigation of Advanced Manufacturing Technology Investment Patterns: Evidence from a Developing Country." *Journal of Engineering and Technology Management* 30 (2): 136–56.
10. Cao, M., & Zhang, Q. 2011. "Supply Chain Collaboration: Impact on Collaborative Advantage and Firm Performance." *Journal of Operations Management* 29: 163–80.
11. Chang, Kuo-hsiung, Yung-ray Chen, and Hsu-feng Huang. 2015. "Information Technology and Partnership Dynamic Capabilities in International Subcontracting Relationships." *International*

Business Review 24 (2). Elsevier Ltd: 276–86. doi:10.1016/j.ibusrev.2014.08.003..

12. Chen, Injazz J, and Antony Paulraj. 2004. "Towards a Theory of Supply Chain Management: The Constructs and Measurements." *Journal of Operations Management* 22: 119–50.
13. Chen, Y-C, P-C Li, and T.J. Arnold. 2013. "Effects of Collaborative Communication on the Development of Market-Relating Capabilities and Relational Performance Metrics in Industrial Markets." *Industrial Marketing Management* 42 (8): 1181–91.
14. Chin, W.W. 1988. *Commentary: Issues and Opinion on Structural Equation Modeling*. JSTOR.
15. Cirtita, H., and D.A. Glaser-Segura. 2012. "Measuring Downstream Supply Chain Performance." *Journal of Manufacturing Technology Management* 23 (3): 299–314.
16. Collis, D.J. 1994. "How Valuable Are Organizational Capabilities?" *Strategic Management Journal* 15: 143–53.
17. Das, A., and A. Nair. 2010. "The Use of Manufacturing Technologies–an External Influence Perspective." *International Journal of Production Research* 48 (17): 4977–5006.
18. Dıaz, M.S., J.A.D Machuca, and M.J. Álvarez-Gil. 2003. "A View of Developing Patterns of Investment in AMT through Empirical Taxonomies: New Evidence. , ." *Journal of Operations Management* 21 (5): 577–606.
19. Doney, P.M., and J.P. Cannon. 1997. "An Examination of the Nature of Trust in Buyer-Seller Relationships." *Journal of Marketing*, 35–51.
20. Farag, I, C Sherrington, S.J Kamper, M Ferreira, A.M Moseley, S.R Lord, and I.D. Cameron. 2012. "Measures of Physical Functioning after Hip Fracture: Construct Validity and Responsiveness of Performance-Based and Self-Reported Measures."
21. Feng, T., and D.. Wang. 2013. "Supply Chain Involvement for Better Product Development Performance." *Industrial Management & Data Systems* 113 (2): 190–206.
22. Fornell, Claes, and David F. Larcker. 1981. "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error." *Journal of Marketing Research*, 39–50.
23. Ganesan, S. 1994. "Determinants of Long-Term Orientation in Buyer-Seller Relationships." *The Journal of Marketing*, 1–19.
24. Garcia, Francisco, Lucia Avella, and Esteban Farnandez. 2012. "Learning from Exporting : The Moderating Effect of Technological Capabilities." *International Business Review* 21: 1099–1111. doi:10.1016/j.ibusrev.2011.12.001.
25. Green, K.W, D. Whitten, and R.A Inman. 2012. "Aligning Marketing Strategies throughout the Supply Chain to Enhance Performance." *Industrial Marketing Management* 41 (6): 1008–18.
26. Gunasekaran, A. 1999. "Agile Manufacturing: A Framework for Research and Development." *International Journal of Production Economics* 62 (1): 87–105.
27. Hadaya, P., and L. Cassivi. 2007. "The Role of Joint Collaboration Planning Actions in a Demand-Driven Supply Chain." *Industrial Management & Data Systems* 107 (7): 954–78.
28. Hair, Joe F, Marko Sarstedt, Christian M Ringle, and Jeannette A. Mena. 2012. "An Assessment of the Use of Partial Least Squares Structural Equation Modeling in Marketing Research." *Journal of the Academy of Marketing Science* 40 (3): 414–33.
29. Hair Jr, Joseph F, Tomas Hult, G M, Christian Ringle, and Marko. Sarstedt. 2013. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Sage Publications.
30. Henderson, S.C, P.M Swamidass, and T.A. Byrd. 2004. "Empirical Models of the Effect of Integrated Manufacturing on Manufacturing Performance and Return on Investment." *International Journal of Production Research* 42 (10): 1933–54.
31. Hogan, Suellen J., and Leonard V. Coote. 2014. "Organizational Culture, Innovation, and Performance: A Test of Schein's Model." *Journal of Business Research* 67 (8). Elsevier Inc.: 1609–21. doi:10.1016/j.jbusres.2013.09.007. http://dx.doi.org/10.1016/j.jbusres.2013.09.007.
32. Hortinha, P., C. Lages, and Lages L. Filipe. 2011. "The Trade-off between Customer and Technology Orientations: Impact on Innovation Capabilities and Export Performance." *Journal of International Marketing* 19 (3): 36–58.
33. Hult, G T M, R F Hurley, and G. A. Knight. 2004. "Innovativeness: Its Antecedents and Impact on Business Performance." *Idustrial Marketing Management* 33 (5): 429–38.
34. Koc, T., and E. Bozdag. 2009. "The Impact of AMT Practices on Firm Performance in Manufacturing SMEs." *Robotics and Computer-Integrated Manufacturing* 25 (2): 303–13.
35. Koufteros, Xenophon, and Mark Vonderembse. 2005. "Internal and External Integration for Product Development : The Contingency Effects of Uncertainty , Equivocality ," 36 (1): 97–134.
36. Kuei, Chu-Hua, Christian N. Madu, Chinho Lin, and Wing S. Chow. 2002. "Developing Supply Chain Strategies Based on the Survey of Supply Chain Quality and Technology Management." *International Journal of Quality & Reliability Management* 19 (7): 889–901. doi:10.1108/02656710210434793. http://www.emeraldinsight.com/doi/abs/10.1108/02656710210434793.

37. Kumar, G., and B.R. Nath. 2014. "Supply Chain Collaboration Index: An Instrument to Measure the Depth of Collaboration. Benchmarking:" *An International Journal*, 21 (2): 184–204.
38. Maltz, E., and A.K. Kohli. 1996. "Market Intelligence Dissemination across Functional Boundaries." *Journal of Marketing Research*, 47–61.
39. Mathieu, J.E, and S.R. Taylor. 2006. "Clarifying Conditions and Decision Points for Mediational Type Inferences in Organizational Behavior. , 27(8), ." *Journal of Organizational Behavior* 27 (8): 1031–56.
40. McAllister, D.J. 1995. "Affect-and Cognition-Based Trust as Foundations for Interpersonal Cooperation in Organizations." *Academy of Management Journal* 38 (1): 24–59.
41. McCarthy-Byrne, T.M., and J.T. Mentzer. 2011. "Integrating Supply Chain Infrastructure and Process to Create Joint Value." *International Journal of Physical Distribution & Logistics Management* 41 (2): 135–61.
42. Meybodi, M.Z. 2013. "The Links between Lean Manufacturing Practices and Concurrent Engineering Method of New Product Development: An Empirical Study." *Benchmarking: An International Journal*, 20 (3): 362–76.
43. Mokkink, Lidwine B, Terwee, Caroline B, Patrick, Donald L, Alonso, Jordi, Stratford, Paul W, Knol, Dirk L, . . . de Vet, Henrica Mokkink, CW., Terwee Lidwine B, Patrick Caroline B, Alonso Donald L, Stratford Jordi, Knol Paul W, . . . Dirk L, and Henrica CW. de Vet. 2010. "The COSMIN Study Reached International Consensus on Taxonomy, Terminology, and Definitions of Measurement Properties for Health-Related Patient-Reported Outcomes." *Journal of Clinical Epidemiology*, 63 (7): 737–45.
44. Mora-Monge, C.A, M.E. Gonza´lez, G. Quesada, and S.S. Rao. 2008. "A Study of AMT in North America: A Comparison between Developed and Developing Countries." *Journal of Manufacturing Technology Management* 19 (7): 812–29.
45. Nagashima, M., F. T. Wehrle, L. Kerbache, and M. Lassagne. 2015. "Impacts of Adaptive Collaboration on Demand Forecasting Accuracy of Different Product Categories throughout the Product Life Cycle." *Supply Chain Management: An International Journal* 20: 4.
46. Nunnally, J. 1978. *Psychometric Theory*. New York: McGraw-Hill.
47. Omar, R, S Zailani, M Sulaiman, and T. Ramayah. 2006. "Supplier Involvement, Customer Focus, Supply Chain Technology and Manufacturing Performance: Findings from a Pilot Study." In *IEEE, Management of Innovation and Technology, International Conference*.
48. Panayides, Photis M, and Y H Venus Lun. 2009. "The Impact of Trust on Innovativeness and Supply Chain Performance." *Intern. Journal of Production Economics* 122 (1). Elsevier: 35–46. doi:10.1016/j.ijpe.2008.12.025. http://dx.doi.org/10.1016/j.ijpe.2008.12.025.
49. Pavlou, P. A., and O. A. El Sawy. 2011. "Understanding the Elusive Black Box of Dynamic Capabilities." *Decision Sciences* 42 (1): 239–73.
50. Petti, Claudio, and Shujun Zhang. 2013. "Technological Entrepreneurship and Absorptive Capacity in Guangdong Technology Firms." *Measuring Business Excellence* 17 (2): 61–71. doi:10.1108/13683041311329447. http://www.emeraldinsight.com/10.1108/13683041311329447.
51. Podsakoff, P.M, S.B MacKenzie, J-Y Lee, and N.P. Podsakoff. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." *Journal of Applied Psychology* 88 (5): 879 – .
52. Prajogo, Daniel, and Jan Olhager. 2012. "Supply Chain Integration and Performance : The Effects of Long-Term Relationships , Information Technology and Sharing , and Logistics Integration." *Intern. Journal of Production Economics* 135. Elsevier: 514–22. doi:10.1016/j.ijpe.2011.09.001. http://dx.doi.org/10.1016/j.ijpe.2011.09.001.
53. Prasad, A., and J. Heales. 2010. "On IT and Business Value in Developing Countries: A Complementarities-Based Approach." *International Journal of Accounting Information Systems* 11 (4): 314–35.
54. Rajaguru, R., and M.J. Matanda. 2013. "Effects of Inter-Organizational Compatibility on Supply Chain Capabilities: Exploring the Mediating Role of Inter-Organizational Information Systems (IOIS) Integration." *Industrial Marketing Management* 42: 620–32.
55. Ramanathan, U., and A. Gunasekaran. 2014. "Supply Chain Collaboration: Impact of Success in Long-Term Partnerships." *International Journal of Production Economics* 147: 252–59.
56. Richey, R.G., F.G Adams, and V. Dalela. 2012. "Technology and Flexibility: Enablers of Collaboration and Time-Based Logistics Quality." *Journal of Business Logistics* 33 (1): 34–49.
57. Rod, K.D., P.S. Ruth, L.M. Kerry, D. Marsha, and R.P. Russell. 2013. "Construct Validity of Selected Measures of Physical Activity Beliefs and Motives in Fifth and Sixth Grade Boys and Girls." *Journal Of Pediatric Psychology, June* 38 (5): 563–76 doi: 10.1093/jpepsy/jst013.

58. Roh, J., P. Hong, and H.. Min. 2014. “Implementation of a Responsive Supply Chain Strategy in Global Complexity: The Case of Manufacturing Firms.” *International Journal of Production Economics* 147: 198–210.
59. Seo, Y-J, J. Dinwoodie, and D-W. Kwak. 2014. “The Impact of Innovativeness on Supply Chain Performance: Is Supply Chain Integration a Missing Link?” *Supply Chain Management: An International Journal* 19 (5/6): 733–46.
60. Sha, D.Y, P.K Chen, and Y-H Chen. 2008. “Exploring the Effects of Advanced Manufacturing Technology and E-Commerce in the Alignment of Supply Chain Coordination and Competitiveness Performance.” *Journal of the Chinese Institute of Industrial Engineers* 25 (5): 399–412.
61. Shin, S., and A.K. Damon. 2012. “The Mediating Role of Marketing Capability: Evidence from Korean Companies.” *Asia Pacific Journal of Marketing and Logistics,* 24 (4): 658–77.
62. Singhry, Hassan Barau, Azmawani Abd Rahman, and Ng S. I. 2014. “The Potential Moderating Role of Supply Chain Capabilities on the Relationship between Supply Chain Technology and Concurrent Engineering in Product Design.” *Int. J Sup. Chain. Mgt* 3 (2): 132–39.
63. Škerlavaj, M, J.H. Song, and Y. Lee. 2010. “Organizational Learning Culture, Innovative Culture and Innovations in South Korean Firms.” *Expert Systems with Applications* 37 (9): 6390–6403.
64. Small, M.H, and M.M. Yasin. 1997. “Advanced Manufacturing Technology: Implementation Policy and Performance.” *Journal of Operations Management* 15 (4): 349–70.
65. Soosay, C.A., P.W. Hyland, and M. Ferrer. 2008. “Supply Chain Collaboration: Capabilities for Continuous Innovation.” *Supply Chain Management: An International Journal* 13 (2): 160–69.
66. Stank, T.P, P.J Daugherty, and C.W. Autry. 1999. “Collaborative Planning: Supporting Automatic Replenishment Programs.” *Supply Chain Management: An International Journal* 4 (2): 75–85.
67. Storer, M., and P. Hyland. 2009. “Dynamic Capabilities and Innovation in Supply Chains.” *CINet*, 912–23.
68. Sudman, Seymour, Andrew Greeley, and Leonard Pinto. 1965. “The Effectiveness of Self-Administered Questionnaires.” *Journal of Marketing Research*, 293–97.
69. Szolnoki, Gergely, and Dieter Hoffmann. 2013. “Online, Face-to-Face and Telephone surveys—Comparing Different Sampling Methods in Wine Consumer Research.” *Wine Economics and Policy* 2 (2): 57–66.
70. Teece, D.J. 2007. “Explicating Dynamic Capabilities: The Nature and Microfoundations of (sustainable) Enterprise Performance.” *Strategic Management Journal* 28 (13): 1319–50.
71. Teece, David J. 2010. “Alfred Chandler and ‘ Capabilities ’ Theories of Strategy and Management” 19 (2): 297–316. doi:10.1093/icc/dtq008.
72. Valle, Sandra, and Daniel V’azquez-Bustelo. 2009. “Concurrent Engineering Performance : Incremental versus Radical Innovation.” *Int. J. Production Economics* 119: 136–48. doi:10.1016/j.ijpe.2009.02.002.
73. Wu, F., S. Yeniyurt, D. Kim, and S. R. T. Cavusgil. 2006. “The Impact of Information Technology on Supply Chain Capabilities and Firm Performance : A Resource-Based View.” *Industrial Marketing Management* 35: 493–504.
74. Wu, Jie. 2014. “Cooperation with Competitors and Product Innovation : Moderating Effects of Technological Capability and Alliances with Universities.” *Industrial Marketing Management* 43 (2). Elsevier Inc.: 199–209. doi:10.1016/j.indmarman.2013.11.002. http://dx.doi.org/10.1016/j.indmarman.2013.11.002.
75. Ye, F, and Z Wang. 2013. “Effects of Information Technology Alignment and Information Sharing on Supply Chain Operational Performance.” *Computers & Industrial Engineering* 65: 370–77.
76. Zacharia, Z.G., N.W. Nix, and R.F. Lusch. 2011. “Capabilities That Enhance Outcomes of an Episodic Supply Chain Collaboration.” *Journal of Operations Management* 29 (6): 591–603.
77. Zahra, Shaker A, Donald O Neubaum, and Bárbara Larrañeta. 2007. “Knowledge Sharing and Technological Capabilities : The Moderating Role of Family Involvement.” *Journal of Business Research* 60: 1070–79. doi:10.1016/j.jbusres.2006.12.014.
78. Zu, Xingxing, and Hale Kaynak. 2012. “An Agency Theory Perspective on Supply Chain Quality Management.” *International Journal of Operations & Production Management* 32 (4): 423–46. doi:10.1108/01443571211223086.

Appendices

Figure 1. Research framework of supply chain innovation and supply chain performance

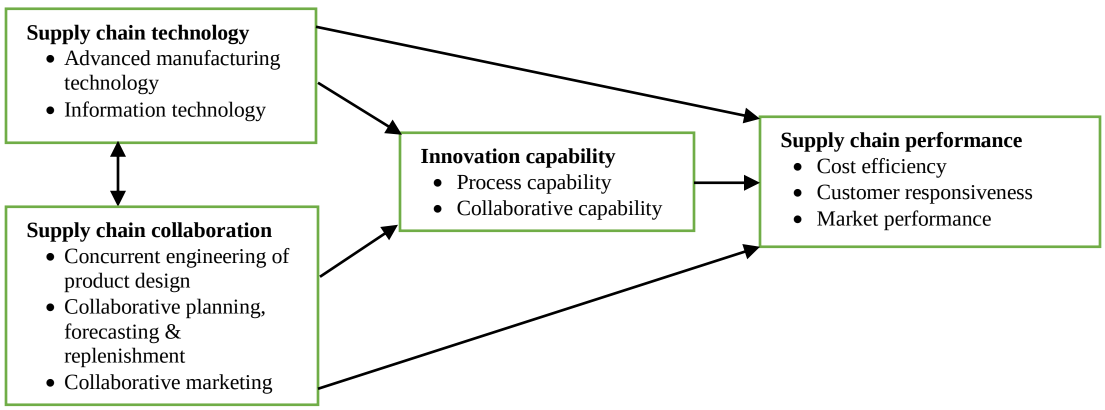

Figure 2. Model of supply chain innovation and supply chain performance

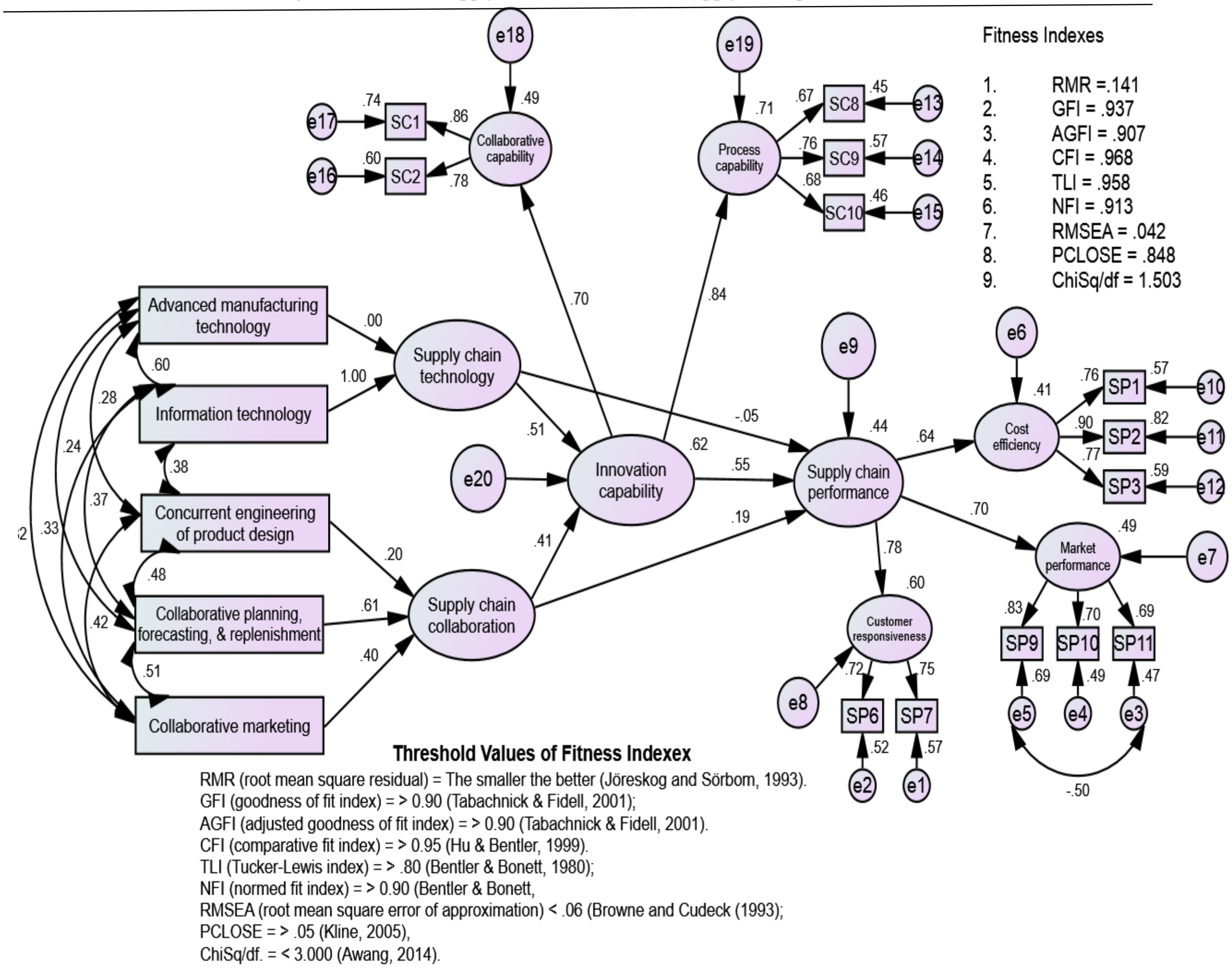

Table 1. Reliability and factor loading

Constructs and Items		**Reliability Cronbach's (α)**	**Factor loading**
Advanced manufacturing technology			**.905**
MT1	We use computer-aided engineering (CAE)	.71	
MT2	We use computer-aided design	.63	
MT3	We use computer numerically controlled machine tools	.72	
MT4	We use computer-aided inspection (CAI)	.87	
MT5	We use automated guided vehicles (AGV)	.85	
MT6	We use automated materials handling systems	.68	
MT7	We use automated storage	.68	
Information technology			**.813**
FT1	There are direct computer-to-computer links with our key supply chain partners	.59	
FT2	Our IT system is compatible with those of our supply chain partner	.90	
FT3	Our IT system can be seamlessly connected with those of supply chain partners	.83	
FT4	We transmit information to our major customers electronically	.90	
FT5	We receive information from our customers electronically	.83	
Concurrent engineering of product design			**.825**
CE1	There is a strong consensus in our firm that major supplier involvement is needed in product design/development	.57	
CE2	We involve major suppliers at product design and development stage	.59	
CE3	We have joint planning committees on key issues with major suppliers	.90	
CE4	Major customer was an integral part of the design effort for new product	.73	
Collaborative planning, forecasting, & replenishment			**.710**
CP1	We often adjust our production system to meet the requirement of our customers.	.92	
CP2	We often work with major customers to determine the delivery schedules that will best meet their needs.	.58	
CP3	We try to incorporate our suppliers' and customers' forecast into our forecast	.54	
CP4	We work with major suppliers and customers to help them improve their forecast accuracy	.68	
CP5	We work with supply chain partners to develop joint sales forecast for replenishment	.80	
CP6	We can depend on our suppliers to provide us with good market forecast and planning information	.76	
CP7	If we request forecasting data from our customers, they would respond constructively and caringly	.69	
Collaborative marketing			**.815**
CM1	Future markets are explicitly addressed in our interactions with major customers	.60	
CM2	We often participate in our customer's decisions regarding retail pricing	.93	
CM3	We often consult with this customer to help design promotional activities that are exclusive to this relationship	.86	
CM4	We work with major customers to plan and execute a pricing strategy for the sale of products	.73	
CM5	We work with major customers to plan and execute a promotion strategy for the sale of products	.76	
CM6	We work with major customers to plan and execute a distribution strategy for the sale of products	.74	
CM7	Our major customers are always frank and truthful with us	.72	
CM8	We believe the marketing information major customers provides us	.91	
Innovation capability			**.782**
NC1	We have developed more ability to select partners to collaborate with	.86	
NC2	We have developed more ability to learn from prior collaboration experience	.77	
NC3	We have developed more ability to apply continuous improvement and	.69	

	customer focus concepts.		
NC4	We have developed more ability to understand the interconnection of supply chain management with other disciplines.	.73	
NC5	We have developed more ability to manage incremental improvements and changes to products, processes and systems.	.68	
Supply chain performance			**.818**
SP1	Supply chain helps us reduce manufacturing cost	.75	
SP2	Supply chain helps us reduce total cost	.91	
SP3	Supply chain helps us reduce inventory cost	.76	
SP4	Supply chain helps us increase customer responsiveness/service	.72	
SP5	Supply chain helps us deliver product on time	.76	
SP6	Supply chain helps us reduce out of stock rate	.83	
SP7	Supply chain helps us improve market share	.70	
SP8	Supply chain helps us improve sales growth	.68	

Table 2. Construct, convergent and discriminant validities

Variable	Mean	SD	AMT	IT	CEPD	CPFR	CM	IC	SCP	CR	AVE
AMT	33.038	8.801	**.738**	.362	.081	.056	.099	.133	.026	.893	.546
IT	26.543	4.923	.602**	**.822**	.148	.138	.110	.308	.099	.911	.676
CEPD	31.794	5.235	.284**	.384**	**.726**	.226	.176	.154	.075	.809	.527
CPFR	38.271	4.355	.237**	.371**	.475**	**.725**	.260	.192	.150	.883	.525
CM	42.636	5.831	.315**	.332**	.419**	.510**	**.787**	.145	.125	.928	.620
IC	28.895	3.074	.365**	.555**	.392**	.438**	.381**	**.749**	.181	.864	.561
SCP	47.595	3.968	.162**	.316**	.273**	.387**	.354**	.425**	**.762**	.917	.581

Table 3. Result of standardized and unstandardized regression estimate of the model

		Std. Beta	**R^2**	**Actual Beta**	**S.E.**	**C.R.**	**P**
Stage one X→Y	Supply chain technology and supply chain performance	.254		.022	.007	3.305	***
	Supply chain collaboration and supply chain performance	.428	.333	.022	.007	3.118	.002
Stage two X→M	Supply chain technology and innovation capability	.512		.051	.009	5.948	***
	Supply chain collaboration and innovation capability	.415		.028	.007	3.843	***
Stage three M→Y	Innovation capability and supply chain performance	.553		.403	.148	2.718	.007
Stage four	Supply chain technology and supply chain performance	-.06		-.003	.009	-.383	.702
	Supply chain collaboration and supply chain performance	.191		.010	.006	1.664	.096
	Innovation capability		.618				
	SCP		.437				
	*NS = not significant and not supported						

Table 4. Supply chain technology and supply chain performance in the presence of innovation capability

Hypothesis statement of path analysis H1	**Path estimate**	**Actual estimate**	**P-Value**	**Results**
SCT and Innovation capability	0.512	.051	0.000	Significant
Innovation capability and SCP	0.553	.403	0.007	Significant
SCT and SCP	-0.046	-.003	0.702	Not significant
1. The indirect path effect (standardized path estimate) = 0.512 x 0.553 = 0.2831 2. The direct part (standardized path estimate) = -0.046				

3. Both the indirect path (standardized path estimate) of X → M and M → Y are positive and significant and greater than ($\beta = 0.051$, $P > 0.001$) respectively.
4. Since the product of indirect effects (.512 x .553 = 0.2831) is greater than direct effect (-0.046), full mediation occurs
5. The type of mediation is full mediation since the direct effect is no longer significant ($P > 0.05$) after innovation capability enters the model.

Supply chain collaboration and supply chain performance in the presence of innovation capability

Hypothesis statement of path analysis H2	Path estimate	Actual estimate	P-Value	Results
SCC and innovation capability	.415	.028	***	Supported
Innovation capability and SCP	.553	.403	.007	Supported
SCC and SCP	.191	.010	.096	Not supported

1. The indirect path effect (standardized path estimate) = .415 x .553 = 0.2295
2. The direct path (standardized path estimate) = .0191
3. Both the indirect path (standardized path estimate) of X → M and M → Y are positive and significant ($\beta = 0.415$, $P < 0.01$).
4. Since the product of indirect effects (.415 x .553 = 0.2295) is greater than direct effect (0.191), mediation occurs
5. The type of mediation is full mediation since the direct effect is no longer significant (P >) after IC enters the mode