Virtual Integration as a Predictor for Product Innovation: A Preliminary Insight

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Abstract

The intense competition in manufacturing industry has forced manufacturing firms to switch their product development approach from traditional to concurrent engineering in order to stay competitive in term of product differentiation and innovation. In order to support concurrent engineering practice, both internal and external participants contributing to product development should be located into close proximity; therefore physical integration of team becomes the key enabler of concurrent engineering. However, as the paradigm has been shifted from adopting "centralized integrated product development", physical integration is no longer efficient and should be replaced by virtual integration. This conceptual paper intends to explore ways in which virtual integration of internal and external constituents would contribute to product innovation. Concurrent engineering represents the internal constituents, while external constituent is reflected by customer involvement. Based on past literatures in the related field, some prepositions are generated to highlight the implications of virtual integration on product innovation.

Keywords: Virtual Integration; Product Innovation; Concurrent Engineering; Customer Involvement

1. Introduction

Global competitiveness is one of the most important issues in manufacturing industry nowadays. Almost every company in this business industry is affected by it and they are looking for new ways to stay aligned and competitive. In recent years, the long term success of some manufacturing companies has been enhanced by their ability to bring new features and produce innovative products. However, it seems that a number of issues and deficiencies in the organizational and managerial processes are disregarded here. Indeed, the criteria for competitiveness in the market have been changing continuously. For instance, levels of product complexity, extent of globalization of markets and degree of consumer awareness (Pawar & Sharifi, 2000).

Introducing new products to the market place remains a key weapon in firms' battle for competitive advantage. In addition, manufacturing firms must be more flexible and responsive to the changing needs of customers. Within this context the role of design as a function within organizations has changed significantly (Pawar, 1994). This requires companies to change their practices in order to develop products rapidly as demanded by customers. Therefore, concurrent engineering (CE), is ideal to fulfill organization's expectations under such circumstances.

Concurrent engineering integrates experts from engineering, production, marketing and any other functional area which has a vested interest in the development project. An external constituent such as customer also actively involved in the team. The team is formed to work on a specific project and stays together throughout the development of the product. The continuity in team membership underscores the need to establish long-term relationships with the core team members and also with both customers and suppliers or subcontractors. In order to ensure the effectiveness and continuity of the team, members contributing to design and development of new product should be located close to each other. Integration and collocation of team has been considered as one of the main tools for enabling concurrent engineering (Bergring & Andersin, 1994).

Integration and collocation of team is used to increase interactions among team members, provide ease for informal communication, and moreover increase efficiency in using resources (Bergring & Andersin, 1994). However, nowadays as the competitiveness in manufacturing industry getting more intense, the paradigm in adopting "centralized integrated product development" activities should be shifted. Physical integration which is mostly adopted by manufacturing companies may no longer be efficient, especially when it comes to the usage of resources (Rafii, 1995). Business requirements such as product development and changes in service forced manufacturing companies to apply virtual team collocation, with the aid of advanced electronic communication technology, in order to be closer and more responsive to customer's needs (Henry & Hartzler, 1997).

Since new product development success is very much depended on the ability of firms to generate new features or innovative product (Koufteros, Vonderembse, & Doll, 2001), it is worth to study the implications of virtual integration on product innovation. Therefore, this conceptual paper would provide a preliminary insight on the relationship among those two variables.

In this paper, we first present a brief theoretical rationale for this study. We then present, in the main body of the paper, literature reviews of related variables such as internal constituents (concurrent engineering), external constituent (customer), virtual integration, and product innovation, which are followed by a theoretical model and a brief research methodology which will be used for empirical study of this paper is also discussed. Lastly, prepositions are generated along with some concluding remarks.

2. Literature Review

2.1 Theoretical rationale

Intense competition has forced manufacturing firms to explore the best practices that suite their needs. Successful firms must be able to cope with the competitive environments. One of the sustain power to be competitive is by involving all constituents in new product development as early as possible (Koufteros et al., 2001). This means that effective new product development (NPD) requires a good integration and collaboration between internal and external participants (Koufteros, Vonderembse, & Jayaram, 2005).

Several empirical studies support the positive effect of strategic integration on new product development performance. Koufteros et al. (2005) conducted a study among discrete-part manufacturing firms and confirmed the importance of internal and external integration. Droge, Jayaram, and Vickery (2000) in their study of NPD in automotive supplier industry also affirmed the significant causal relationship of synergistic integration which includes cross-functional team, and new product development performance. Further in a more recent study (Droge, Jayaram, & Vickery, 2004), they found that both internal and external integration are related to time-based performance and in turn significantly result in higher financial performance.

In the context of innovation, adequate communication and collaboration between internal-external participants is among the primary importance. A well-structured information processing enables internal and external participants to share knowledge and interpretation (Daft & Lengel, 1986). In addition to that, knowledge management implementation and electronic communication technology assist the NPD team to engender creativity and innovation (Akgun, Dayan, & Di Benedetto, 2008).

The perceived need for integration in product development is explained in uncertainty reduction theory (Gupta, Raj, & Wilemon, 1986). Since the existence of uncertainty in new product development is unavoidable, the need of integration among product development practices is compulsory to support the NPD team in order to cope with the fuzziness of their task environment. Furthermore, organizational theory also propose the integration of internal and external parties as a structural mechanism that firms employ to deal with the information processing requirements for developing and launching new product. Recent study of integration in new product development by Koufteros et al. (2005) indicate that internal integration acts as an important predecessor of external integration. However, neither uncertainty reduction theory nor organizational theory discusses the internal-external integration of NPD practices where the constituents are geographically distributed.

In order to investigate the existing gap of those theories, this study generates a model which is adapted from product concept to economic value chain (Syamil, Doll, & Apigian, 2004) which is presented in Figure 1. Product concept to economic value chain is a causal chain of product development, starting from product concept and ending with economic value. This chain of categories of variables reflects the importance of process performance, i.e. teamwork, team productivity, and engineering change time, to intervene the relationship of product development process and overall project performance. Hence, this study emphasizes on the effectiveness of virtual integration to mediate the correlation of internal-external practices integration and NPD performance. However, product concept to economic value chain does not particularly focus on the strategic integration among parties involved in the project.

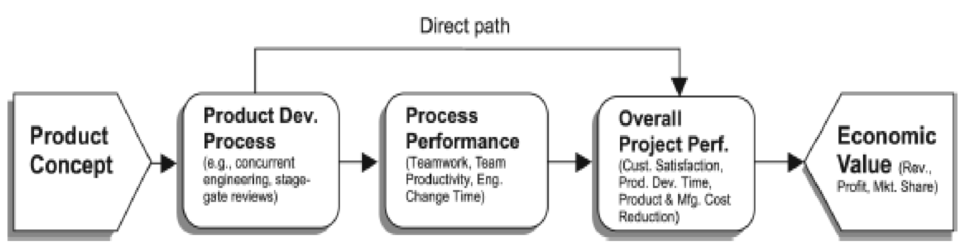

Figure 1. Product concept to economic value chain diagram (Syamil et al., 2004)

2.2 Internal Integration: Concurrent Engineering

The significant changes in manufacturing industry, especially in product development related area, forced manufacturing companies to get products of ever higher quality to customers in shorter period of time. Products life cycles are decreasing and product price-performance ratios are being analyzed more carefully. One solution to overcome this problem is to switch the product development approach implemented, from traditional-sequential approach to concurrent engineering.

Over the years, concurrent engineering has evolved as a new paradigm for product development since the old paradigm, traditional-sequential approach, which is based on serial contribution by disparate functions along the value added chain, proven to be slow and non-adaptive for manufacturing environment (Turino, 1992)

Concurrent engineering is a concerted corporate effort to achieve maximum efficiency, economy, and quality throughout the total business cycle. The concept involves cross-functional teamwork, communication, culture, commitment, customer satisfaction, company competitiveness, and early attention to manufacturing, test, and support issues (Turino, 1992). It is a strong and dependable product development methodology which can be continuously upgraded and modified. It leads to a significant reduction in cost and development time without sacrificing any of the desired product specifications. Moreover, concurrent engineering is easy to implement in diverse nature of product development activities (Dwivedi, Sharan, Prasad, & Garg , 1990).

In addition, concurrent engineering has been a notably internal integration process in NPD practices. Droge et al. (2004) expose concurrent engineering as one of the "design process integration" along side design for manufacturability, standardization, and computer aided design/ computer aided manufacturing. In a more recent study, Koufteros et al. (2005) also put concurrent engineering as the internal integration which acts as an antecedent to external integration

2.3 External Integration: Customer Involvement

Customer integration is critical in today's business, especially those that closely related to high degree of innovativeness. The presence of customers in new product development team provides a good understanding of current customers' requirements out there in the market. Moreover, customer involvement gives extra knowledge for the internal constituents to produce product that customers really demanding. It is believed that close collaboration and relationship with customers would enhance timely responsiveness.

In recent studies, many researchers have investigated the contribution of customer on new product development (Callahan & Lasry, 2004; Kleinschmidt & Cooper, 1991; Ulwick, 2002). Studies have emphasized the importance of customer satisfaction as a critical factor for success. Developing products according to the customer's needs has long been promoted to achieve customer satisfaction. Hence, customers need to be involved in new product development process since their contribution and idea is vital, especially during the early stage of idea generation (Gruner & Homburg, 2000).

Customer contribution toward new product development was found to be varied during each stage of new product development. Researchers agreed that customer involvement is compulsory during the initial stage of new product development (Callahan & Lasry, 2004; Enkel, Perez-Freije, & Gassmann, 2005; Gruner & Homburg, 2000; Ulwick, 2002). During the initial stage, customer input is necessary in order to generate ideas and thoughts about the product. Customers are also needed to provide major input on the specific area where problems usually occurred. The importance of customer involvement during the initial stage was confirmed by Lagrosen (2005). In his case study of six companies based in Sweden, it was clearly stated that four companies involve their customers intensively during the initial stage of the development process. Furthermore, Kaulio (1998) in his study which discussed about customer involvement methods, mentioned that majority of the methods are implemented during the opening stage of product development.

Customer involvement remains intensive during the following stage of requirement definition and conceptual design stage. The importance of customer involvement during this period is closely correlated with market research method intensity (Callahan & Lasry, 2004). Throughout this stage, customers are involved extensively in a wide range of design and development tasks (Nambisan, 2002). Furthermore as mentioned in Nambisan (2002), customers who play a role as cocreator of new products could participate and contribute to a variety of product design as well as establish development process priorities.

In contrast, customer involvement would decrease significantly during the technical development stage (Callahan & Lasry, 2004). However, customers tend to be involved and contribute a lot throughout the trials and testing period (Callahan & Lasry, 2004; Nambisan, 2002). During this period, the entire product would be tested internally and prototype version of the product is released. In product testing, customers provide a major contribution in detecting defects or faulty components in the product. This product testing is highly important in new product development since the testing result would help companies to prevent costly redesign and rework should the problem is found during the latter stages.

Furthermore, the intensity of customer involvement would determine customer’s contribution. The more intense involvement of customers, the higher contribution customer would offer. This preposition was validated by Callahan and Lasry (2004) in their study of 55 computer telephony equipment manufacturers and software developers. Result of their study indicated that there are significant correlations between method intensity and dimensions representing product newness. In addition to that, Gruner and Homburg (2000) found the positive relationship of the intensity of customer interaction on new product success, especially during the idea generation and product concept development. This provides a clear idea that customer contribution positively effect product innovation, especially in high equivocality environment (Koufteros et al., 2005).

2.4 Virtual Integration

Centralized integration product development is no longer efficient in globalized manufacturing and trade world (Rafii, 1995). Centralized integration team such as physical collocation team should be switched to a more widespread group of people, thus virtual collocation team becomes the preference to manufacturing firms nowadays. According to Bal & Teo (2000) there are four main drivers of virtual integration, such as organizational trends, business requirements, new and emerging technology application, and level of expertise that the team members have. Paradigm shift forced by current global competitiveness has promoted virtual integration become a solution to product development. Duarte and Snyder (1999) stated that virtual collocation team is formed as a result to new ways of working, being introduced as a reaction to current business requirements.

Shift in organizational trends also affect manufacturing firms to start applying virtual collocation team. According to Haywood (1998), mergers, acquisitions, downsizing, and outsourcing are the examples of organizational trends which contribute to the rapidly growing trend in implementing virtual team. Furthermore, cross organizational product development and significant changes in products and services are also the main drivers for virtual team.

Other factors contribute to the success of virtual team that have been identified, are those which closely related to the common characteristics of virtual teams. As concluded from several studies from the past, there are at least five key factors contributing to the effectiveness and failure of virtual team. The key factors include: (1) Clarifying objectives (Earnhardt, 2009); (2) the use of communication technology (Duarte & Snyder, 1999; Earnhardt, 2009); (3) team forming (Earnhardt, 2009); (4) trust (Earnhardt, 2009); and (5) leadership (Duarte & Snyder, 1999).

Another important aspect in making virtual collocation team applicable is the rapid development of technologies. Advanced electronic communication media allows the virtual team to perform effectively and efficiently. It also facilitates the development of virtual team. On top of that, the use of virtual collocation team allowing higher return on investment due to decrease in cost of bandwidth (Haywood, 1998).

2.5 Product Innovation

According to Koufteros et al. (2001), product innovation can be referred as the capability of organizations to introduce new products and features. Thus, new product development success is very much depended on the ability of firms to generate new features or innovative product. Continuous innovation is required for manufacturing firms to be able to cope with fast technological change and to meet customers' needs and expectations (Blackburn, 1991).

The success of new product can not be separated from proper development of innovation strategy. As indicated by Cooper and Kleinschmidt (1994), as well as Olson, Orville, Walker, and Ruekert (1995), innovation strategy significantly relates to cross-functional team and NPD performance. In addition, the extensive communication and shared value of functional representatives involved in cross-functional team enhance concurrent activities in new product development. Through the aid of computer technology, cross-functional teams are able to share information rapidly and reduce equivocality. Beside for the purpose of information sharing and communication, computer technology is also favorable to support the team to produce innovative product (Sanderson, 1992). Therefore, concurrent engineering also positively influence product innovation (Koufteros et al., 2002; Koufteros et al., 2005; Koufteros et al., 2006).

4. Research Methodology and Theoretical Model

This study will use a quantitative approach in order to conduct the data analysis. Hypothesis testing will be undertaken in order to explain the variance of dependent variable. The variables involved in this study are presented in the theoretical model as shown in Figure 2. Moreover, structured questionnaire will be used to measure the variables whereby the items are adopted from past literatures.

The population of this study will be manufacturing firms in Semenanjung Malaysia as listed in Federal Malaysian

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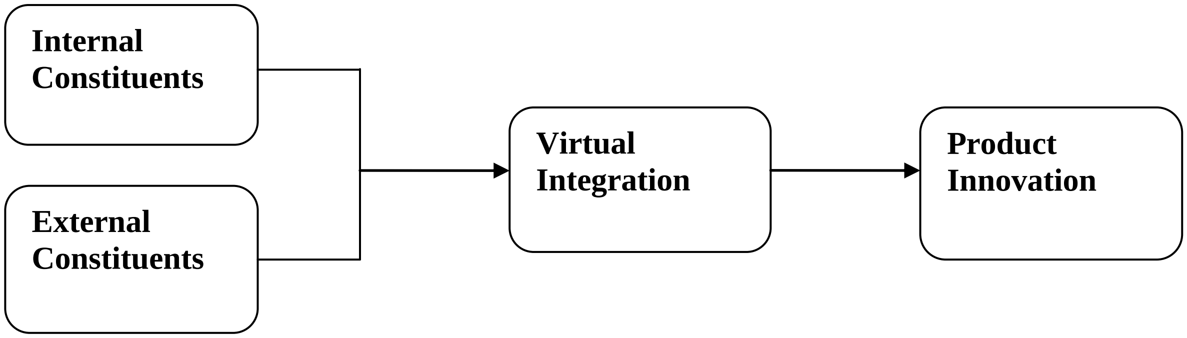

Figure 2. Theoritical model of virtual integration as predictor to product innovation.

Manufacturing (FMM). The data for this study will be collected from product manager, operation manager, or those managers who involve directly with new product development. Thus, unit of analysis for this study will be the manufacturing firms which are represented by the potential respondents.

5. Discussion and Expected Results

In order to enhance strategic integration, manufacturing firms must be able to accurately choose the best NPD practices which can accommodate both internal and external necessitates. Thus, an internal NPD practice such as concurrent engineering is compulsory to improve company's overall NPD performance. One of the most influential enablers for perceived benefits of concurrent engineering is integration of multi-functioned project teams and deployment of collocation teams (Maylor & Gosling, 1998).

As cited in Koufteros et al. (2001) there are several advantages of involving people with different expertise in NPD practice. High functional diversity within a product development team also engenders transfer of knowledge and ideas. Moreover, Droge et al. (2004) and Akgun et al. (2008) confirmed that the greater the functional areas being represented in an NPD team, the higher the ability to acquire, process, and utilize knowledge, which at the end enhance the degree of team's innovativeness and creativity. Therefore, we propose that:

P1: High level of internal integration would promote the ability of product development team to acquire, process, and utilize knowledge, which result in product innovation.

Along side internal integration, customer integration is also one of the critical elements in new product development. It is a valuable way to achieve new product success (Gales & Mansour-Cole, 1995; Gruner & Homburg, 2000). The presence of customers at every stage of new product development would benefit companies in many ways (Callahan & Lasry, 2004; Gales & Mansour-Cole, 1995). New product ideas, enhanced product development effectiveness, market uncertainty reduction, and reduced time to market are among the benefits arising from close customer partnership. On top of that, customer integration also positively effect product innovation, especially in high equivocality environment (Koufteros et al., 2005). Thus, external constituents such as customer play a pivotal role in NPD, especially when it comes to idea generation and product concept.

P2: High level of customer integration would reduce market uncertainty and engender new product ideas, which result in product innovation.

Integration of internal and external constituents during the initial stage of new product development is critical. As stated in theory of organizational information processing (Daft & Lengel, 1986), early planning and collaboration between design and manufacturing is important to reduce uncertainty. Moreover, exchange of information and shared of visions, missions, and values should eliminate information gaps among constituents and further less design and manufacturing problems are generated. Beside structural purposes, integration of internal and external constituents also benefits the team to select and integrate the technological resources. Organizational and technology integration is achieved should constituents are involved early during the initial stage of new product development (Hong & Roh, 2009).

Furthermore, due to the recent trend towards corporate restructuring, change in business requirements such as cross organizational product development, and intense competition in manufacturing industry, firms are forced to work with others which are often dispersed across space, time, and organizational boundaries (Bal & Teo, 2000). In specific, shift in organizational trends affect manufacturing firms to start applying virtual collocation team. According to Haywood (1998), mergers, acquisitions, downsizing, and outsourcing are the examples of organizational trends which contribute to the rapidly growing trend in implementing virtual team. Another important aspect in making virtual collocation team applicable is rapid development of technologies. Advanced technology and communication tools allow the virtual team to perform effectively and efficiently. They also facilitate the development of virtual integration and allow higher return on investment due to decrease in cost of bandwidth (Haywood, 1998).

On top of that, virtual integration of internal constituents and customers improve the output of knowledge creation as well as knowledge distribution (Nambisan, 2002). Nambisan (2002) also stated that virtual integration supports the implementation of knowledge acquisition and knowledge creation. Advanced communication technologies enable internal constituents and customer to interact and collaborate intensively which trigger innovative and creative ideas.

P3: Intensive virtual integration among internal constituents and customer through concurrent engineering approach would increase product innovation and value creation.

6. Conclusion

In conclusion, this study tries to provide a theoretical and practical highlight on virtual integration of NPD practices and product innovation. To be specific, this study emphasizes on the effectiveness of virtual team to mediate the effect of internal-external practices integration on product innovation. Furthermore, the result of this study is expected to generate answers to ambiguous and contradict outcomes from previous studies about NPD performance, especially to those which relate to geographically distributed environment.

References

Akgun, A.E., Dayan, M., & Di Benedetto, A. (2008). New product development team intelligence: antecedents and consequences. *Information and management*, 45, 221-226.

Bal, J. & Teo, P.K. (2000). Implementing virtual teamworking part 1: a literature review of best practice. *Logistics Information Management*, 13 (6), 346-352.

Bergring, J. & Andersin, H. (1994). Designing performance measurement systems for improving the visibility of the concurrent engineering process. *Proceedings of the Concurrent Engineering research and Applications Conference*, West Virginia, August.

Blackburn, J. (1991). *Time-based competition*. Business One Irwin, Homewood, IL.

Callahan, J. & Lasry, E. (2004). The importance of customer input in the development of very new products. *R&D Management*, 34(2), 107-120.

Cooper, R.G. & Kleinschmidt, E.J. (1994). Determinants of timeliness in product development. *Journal of Product Innovation Management,* 11, 381-396.

Daft, R.L. & Lengel, R.H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32 (5), 554-571.

Droge, C., Jayaram, J., & Vickery, S. K. (2000). The ability to minimize the timing of new product development and introduction: An examination of antecedent factors in the North America automobile supplier industry. *Journal of Product Innovation Management*, 17, 24-40.

Droge, C., Jayaram, J., & Vickery, S. K. (2004). The effects of internal versus external integration practices on time-based performance and overall firm performance. *Journal of Operations Management*, 22, 557-573.

Duarte, D.L. & Snyder, N.T. (1999). *Mastering virtual teams*, Jossey-Bass, San Franscisco, CA.

Dwivedi, S.N., Sharan, R., Prasad, R., & Garg, R. (1990). Concurrent engineering: why and what? *IEEE*.

Earnhardt, M.P. (2009). Identifying the key factors in the effectiveness and failure of virtual teams. *Leadership advance online*, Issue XVI, Spring 2009.

Enkel, E., Perez-Freije, J., & Gassmann, O. (2005). Minimizing market risks through customer integration in new product development: Learning from bad practice. *Creativity and Innovation Management*, 14(4), 425-437.

Gales, L. & Mansour-Cole, D. (1995). User involvement in innovation projects: Toward an information processing model. *Journal of Engineering and Technology Management*, 12, 77-109.

Gruner, K. E. & Homburg, C. (2000). Does customer interaction enhance new product success? *Journal of Business Research*, 49, 1-14.

Gupta, Raj, & Wilemon (1986). A model for studying R&D-marketing interface in the product innovation process. *Journal of Marketing*, 50 (2), 7-17.

Haywood, M. (1998). *Managing virtual teams: Practical techniques for high-technology project managers*, Artech House, Norwood, MA.

Henry, J.E. & Hartzler, M. (1997). *Tools for virtual teams*, ASQC Quality Press, Milwaukee, WI.

Hong, P. & Roh, J. (2009). Internationalization, product development and performance outcomes: A comparative study of 10 countries. *Research in International Business and Finance*, 23, 169-180.

Kaulio, M.A. (1998). Customer, consumer, and user involvement in product development: A framework and a review of selected methods. *Total Quality Management and Business Excellence*, 9 (1), 141-149.

Kleinschmidt, E.J. & Cooper, R.G. (1991). The impact of product innovativeness on performance. *Journal of Product Innovation Management*, 1991, 8, 240-251.

Koufteros, X., Vonderembse, M., & Doll, W. (2001). Concurrent engineering and its consequences. *Journal of Operation Management*, 19, 97-115.

Koufteros, X., Vonderembse, M., & Jayaram, J. (2005). Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy. *Decision Science*, 36 (1), 97-133.

Lagrosen, S. (2005). Customer involvement in new product development. *European Journal of Innovation Management*, 8 (4), 424-436.

Maylor, H. & Gosling, R. (1998). The reality of concurrent new product development. *Integrated Manufacturing Systems*, 9 (2), 69-76.

Nambisan, S. (2002). Designing virtual customer environments for new product development: Toward a theory. *Academy of Management Review*, 27 (3), 392-413.

Olson, E.M., Walker, O.C., & Ruekert, R.W. (1995). Organizing for effective new product development: The moderating role of product innovativeness. *Journal of Marketing*, 59, 48-62.

Pawar, K.S. (1994). Implementing framework for concurrent engineering in the European context. *Proceedings of the 1st Conference on Concurrent Engineering, Research and Application (CERA)*, West virginia, August, pp. 111-118.

Pawar, K.S. & Sharifi, S. (2000). Virtual collocation of design: coordinating for speed. *International Journal of Agile*, 2 (2), 104-113.

Rafii, F. (1995). How important is physical co-location to product development success. *Business Horizons*, January-February, pp. 78-84.

Sanerson, S. (1992). Design for manufacturing in an environment of continuous change. In: Susman, G. (Ed.), *Integrating design for manufacturing for competitive advantage*. Oxford University Press, NY, pp. 36-55.

Syamil, A., Doll, W.J., & Apigian, C.H. (2004). Process performance in product development: measures and impacts. *European Journal of Innovation Management*, 7 (3), 205-217.

Turino, J. (1992). *Managing concurrent engineering: buying time to market*, 1st ed., New York, USA: Van Nostrand Reinhold.

Ulwick, A.W. (2002). *Turn customer input into innovation*. Harvard Business Review, 80(1), 91-97.