Determinants and Impacts on Performance of Supplier-supplier Collaboration in New Product Development: A Survey Based Study

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ABSTRACT

Increased level of competition and shorter product life cycle have pushed firms to keep innovating through new product development (NPD). NPD has become strategic activity for companies as more than 30% of firms’ total profit derived from new products. Many scholars have put their interest in investigating supplier involvement in NPD process as one of the best practices that can generate success in NPD performance. Meanwhile, the expansion of field in the study of supply chain management has encouraged scholars to include social network theory while studying organizational behavior as network perspective and has replaced dyads into triads as the smallest unit and fundamental building blocks of a network. While many literatures talk about the dynamics of supplier-supplier relationships and its implication to buyer’s and supplier’s performances, nevertheless, none of them have raised the topic of how supplier-supplier relationship may have impact on the buyer’s NPD performance.

With supplier-supplier relationship as focus of study, this paper aims to address the gaps in literature by interpolating the concern of supplier-supplier relationship into the scope of NPD and provides theoretical ideas and evidences of the determinants and impacts of supplier-supplier collaborate in NPD project performance. By employing survey and quantitative analysis in testing the theory, this research also intended to fill the gap in terms of methodology. The measurement instruments of survey developed from existing literatures and distributed to companies from automotive, electric domestic appliances, machinery, and packaging goods, across Italy and Indonesia and the data collected is subjected to a series of quantitative analysis.

As per the findings obtained, it suggests that buyer can positively influence the relational behavior of its suppliers during NPD process, whereas more efforts made by buyer will leads to a more robust supplier-supplier collaboration. Collaboration between suppliers is also empirically proven to have positive relationship with NPD project performance. This work makes contribution in terms of managerial implications and theoretical enrichment for the field of supplier-supplier relationship in triadic supply network study, specifically, in the scope of NPD.
SINTESA DEL LAVORO

L’aumento del livello di concorrenza e il ciclo di vita del prodotto più breve hanno spinto le aziende a continuare a innovare attraverso lo sviluppo di nuovi prodotti (NPD). L’NPD è diventata un'attività strategica per le imprese poiché oltre il 30% del profitto totale delle imprese derivava da nuovi prodotti. Molti studiosi si sono interessati allo studio del coinvolgimento dei fornitori nel processo NPD come una delle migliori pratiche in grado di generare successo nelle prestazioni NPD. Nel frattempo, l'espansione del campo nello studio della gestione della supply chain ha incoraggiato gli studiosi a includere la teoria dei social network mentre studiavano il comportamento organizzativo come prospettiva di rete e ha sostituito le diaide in triadi come la più piccola unità e blocchi fondamentali di una rete. Mentre molte letterature parlano della dinamica delle relazioni fornitore-fornitore e delle sue implicazioni per le prestazioni di compratore e fornitore, tuttavia nessuna di esse ha sollevato l'argomento di come il rapporto fornitore-fornitore possa avere un impatto sulle prestazioni NPD del compratore.

Con il rapporto fornitore-fornitore come oggetto di studio, questo documento mira a colmare le lacune nella letteratura interpolando la preoccupazione della relazione fornitore-fornitore nel campo di applicazione del NPD e fornisce idee teoriche e prove dei fattori determinanti e dell'impatto della collaborazione fornitore-fornitore in Prestazioni del progetto NPD. Utilizzando sondaggi e analisi quantitative per testare la teoria, questa ricerca ha anche lo scopo di colmare il divario in termini di metodologia. Gli strumenti misuratori di indagine sviluppati da letterature esistenti e distribuiti a società di automobili, elettrodomestici, macchinari e beni di imballaggio, in Italia e in Indonesia e i dati raccolti sono sottoposti a una serie di analisi quantitative.

In base ai risultati ottenuti, suggerisce che l'acquirente può influenzare positivamente il comportamento relazionale dei propri fornitori durante il processo NPD, mentre maggiori sforzi compiuti dal compratore porteranno a una collaborazione più forte tra fornitore e fornitore. È anche dimostrato empiricamente che la collaborazione tra i fornitori ha relazioni positive con le prestazioni del progetto NPD. Questo lavoro apporta un contributo in termini di implicazioni gestionali e di arricchimento teorico per il campo della relazione fornitore-fornitore nello studio della rete di fornitura triadica, nello specifico, nell'ambito della NPD.
Chapter 1 – Introduction

1.1 Topic and Thesis Purpose

Within last decades, shortened product life cycle, fiercely competitive and globalization of markets have made the companies to focus on new product development (NPD) process. NPD even has become strategic activity as more than 30% companies have relied on NPD to gain their profit (Lee and Markham, 2016). Due to its criticality, many scholars have put their interest in investigating best practices of NPD in order to help companies to achieve their desired performance and targets set by the executives, and become successful in business. One of the best practices is by involving the supplier during the process of NPD (Clark and Fujimoto, 1991). Supplier involvement has been widely discussed among scholars as it may generate success in NPD performance. Suppliers may contribute in gaining innovative ideas and technologies that are critical for the NPD success, thanks to their expertise, which allow company to reduce cost of developing product and time to market, enhance product quality and design, increase technological improvement and innovation, that eventually will lead to financial success (Bonaccorsi and Lipparini, 1994; Clark and Fujimoto, 1991; Handfield et al., 1999; Petersen et al., 2005; Ragatz et al., 2002; Wasti and Liker, 1997; Song and di Benedetto, 2008).

Meanwhile, the study of supply chain management has been expanded into greater fields rather than conceived as a dyadic subject and has encouraged scholars to include social network theory while studying organizational behavior as network perspective (Borgatti and Li, 2009). Developed from social psychology, anthropology and sociology, social network theory is relevant to unfold social phenomena between firms, and consequently has become the underpinning theory for triadic relational dynamics (Choi and Wu, 2009-a). Replacing dyads, triads have been regarded as smallest unit and fundamental building blocks of a network (Bastl et al., 2013; Choi and Wu, 2009-a; Choi and Wu, 2009-b). Various configuration of triads may presence in supply chain, including one buyer interacting with two suppliers, which is the focus of this study. Three archetypes of supplier-supplier relationships have been proposed by Choi et al. (2002), namely, competitive, cooperative, and co-operative, with additional archetype coexistent recently elaborated by Xu (2017). In competitive supplier-supplier relationship, buying firm may get the benefit by adopting dual sourcing policy, allows it to exploit market competitiveness, however, the information exchange between suppliers is limited with minimal
communication occurs (Choi et al., 2002). In contrary, cooperative supplier-supplier relationship aims to obtain a mutual win-win situation through sharing of tangible and intangible resources with possibility to engage in product development projects, exchange ideas, resources, and expertise to accomplish mutual goals (Borekci et al., 2015; Choi et al., 2002).

Many literatures have investigated the dynamics of supplier-supplier relationships and its implication to buyer’s and supplier’s performances (Choi and Wu, 2009-a; Choi et al., 2002; Wu and Choi, 2005; Wu et al., 2010), and numerous studies have emphasized the importance of integrating supplier in NPD project. Yet, none of them have raised the topic of how supplier-supplier relationship may have impact on the buyer’s NPD performance. This creates a vacancy in the literatures. Furthermore, most literatures that talk about supplier-supplier relationship are relying on theory and case study, with only few of them exerting quantitative analysis approach, and thus, create another possibility to fill in the gap in terms of methodology.

This paper aims to fill in the gap by interpolating the concern of supplier-supplier relationship into the scope of NPD. Indeed, engaging the suppliers to collaborate in NPD project could be beneficial for buyer as regards to social network theory, buying firm might be a tertius gauden in buyer-supplier-supplier triad, which means the third actor who has ability to control other two actors and getting profit by engaging them to collaborate (Choi and Wu, 2009-a). Another vacancy in terms of methodology is intended to be addressed in this study, by employing a survey and quantitative analysis to verify and infer the elaborated theory. This paper examines which variables among project complexity, project uncertainty, and buyer’s influence lead to supplier-supplier collaboration in NPD process and how this collaboration has impacted on NPD project performance. Complexity and uncertainty are two most discussed variables that can affect the level of difficulty of an NPD project and have been a motivation for partnering and early supplier involvement (Ahmad et al., 2013; Campbell and Cooper, 1999; Clark and Fujimoto, 1991; Mikkola and Skjoett-Larsen, 2003; Tatikonda and Rosenthal, 2000), while buyer’s influence or buyer’s intention in making suppliers collaborate, has been succeeded in making competitive suppliers to collaborate (Wu et al., 2010). The relationship between intensity of supplier-supplier collaboration and NPD performance are evaluated as well by measuring NPD project success through different dimensions, namely product effectiveness and process performance, with various measurement metrics. Finally, these two points of evaluation built a complete framework of study that will be subject to quantitative analysis.
Survey is prepared to collect data from companies covering four different industries, namely, automotive, electric domestic appliances, machinery, and packaging goods, across Italy and Indonesia. Questionnaires are synthesized and developed from several literatures. Pilot testing is conducted in order to examine the measurement instrument of the questionnaires and to evaluate the viability in the administration process of the survey (Forza, C., 2002; Teiljlingen and Hundley, 2001). After the data have been collected, series of tests to measure the quality of the data are performed with construct validity analysis yielded five unidimensional and reliable factors which linked to each measurement construct. Finally, all hypotheses are tested by applying multiple regression analysis, where evidence shows a positive relationship between buyer’s influence and supplier-supplier collaboration, and the same result identified between supplier-supplier collaboration and NPD project performance. Detailed analysis are presented and discussed thoroughly in this paper accompanied by observations on the coherence of results in comparison with previous literatures.

This study makes three contributions. First, it provides foundations of theory of supplier-supplier collaboration in NPD process that is supported quantitatively that can be useful for further study. Second, the methodology employed quantitative approach that can be a guideline for future research. Third, it offers some insights about the current situation that is happening in industry that can be useful for managers and provides managerial insights regarding how to achieve a successful NPD performance by exerting leverage of buyer towards its position in triadic perspectives.

1.2 Thesis Structure

Following is the general structure of this thesis:

**Chapter 1: Introduction** – Introduces the general statement about the topic and the thesis structure.

**Chapter 2: Literature Review** – Presents the previous researches and literatures that have been explored which are related to the thesis topic. This chapter provides a comprehensive foundation of theory covering the topic about the new product development (NPD) performance, supplier involvement in NPD, social network theory, and relationships in supplier network.

**Chapter 3: Theoretical Background and Hypothesis** – Highlights the scope of the research
and introduces research framework which is strengthen by relevant references encompass determinants of supplier-supplier collaboration in NPD, the intensity of collaboration, and measurement metrics of NPD performance, then followed by hypothesis.

**Chapter 4: Research Methodology** – Describes the methods used to collect the information for the study including measurement instruments and administration development, the source of data, pilot testing, and data collection procedure.

**Chapter 5: Data Analysis and Result Discussion** – Process the data collected with various analysis and outlines the findings found from the analysis including measuring the quality of the data collected and analysis for hypothesis testing. Subsequently, interprets the findings resulted from analysis by comparing it with the previous researches to support the statements made in hypothesis.

**Chapter 6: Conclusion** – Presents the contributions of the study made to the overall research about the topic and the limitations faced in the study, and provides some suggestions for addressing the limitations and for improvement in future study.

Appendix is enclosed at the end of the paper containing the original question items used in the survey and survey responses.
Chapter 2 – Literature Review

2.1 New Product Development

Over decades, many scholars have been raising the topic of New Product Development (NPD) and its importance in dynamic and evolving business environment. Various motivations in developing new product such as increased level of competition and shorter product life cycle have pushed firms to keep innovating. Moreover, innovation is believed as ability of management to re-define the development strategy to cope with rising costs and supply shortages environment and ability of the firm to design and develop new product which is accepted buy customers that will lead to success in free market economy (Cannon, T, 1978; Griffin, A, 1997).

The NPD best practices have changed and have become more sophisticated over the years, involving evolutionary process and resulting in more efficient and faster in NPD process (Griffin, A, 1997). Issues regarding NPD practices were first investigated by Booz, Allen and Hamilton where seven sequential stages have been developed: new product strategy development, idea generation, screening and evaluation, business analysis, development testing and commercialization (Booz, Allen, & Hamilton, 1982; Griffin, A, 1997). Several studies focused on analyzing how firms execute their NPD processes including techniques and tools, aimed to find the best and the most effective ones. In 1990, the Product Development & Management Association (PDMA) conducted its first study of NPD best practices, followed by continues series of research covering the trend of NPD process, portfolio management, NPD organization, technologies and tools supporting NPD, whilst the outcomes have been subjected to analysis by many academics (Barczak et al., 2009; Du et al., 2016; Lee and Markham, 2016; Schmidt et al., 2009). Other examined cross-functional cooperation as an effective technique and a key component of NPD accomplishment (Brown and Eisenhardt, 1995; Kim, B.Y., Kang, B.K, 2008).

Handfield et al (1999) defined Process of NPD as ‘a series of interdependent and often overlapping stages during which a new product (or process or service) is brought from the “idea” stage to readiness for full-scale production or service delivery’. Cooper (1990) has introduced Stage-gate system as both a conceptual and an operational model for moving a new product from idea to launch. It is a blueprint for managing the new product process to improve
effectiveness and efficiency. The idea is to subdivide the process into a number of stages or work stations, and quality control checkpoint is performed as a gate between each work station or stage. Ulrich (1995) defined product development process at basic level consisting four phases: concept development, system-level design, detailed design, and product testing and refinement. The process of NPD then developed into six phases starting from planning and idea generation before designing the concept and detail of product or service, then followed by a preliminary prototyping, validation and ramp-up of operation before ending in full scale production (Handfield et al., 1995; Ulrich and Eppinger, 1988).

Some studies emphasized the importance of NPD management associated to NPD success. Hultink et al (1997) have suggested that launch strategy requires both strategic decisions (what, where, when, and why to launch) and tactical decisions (how to launch). Strategic decisions should be taken early in the development cycle. This strategy includes the elements of product strategy such as project’s technological roots, degree of innovativeness, and time to market, as well as market strategy aspects such as breadth of the target market, market growth rate, and stage of the product life cycle. While tactical decisions generally involve marketing mix adjustments. Di Benedetto (1999) pointed out the importance of the launch timing including when the launch is conducted from the point of view of the company, the competition, and the customer) alongside the tactical launch activities performed in NPD. Other literatures have investigated the quality of interactions among members of NPD has contribution in achieving exceptional new product performance (Dayan and Di Benedetto, 2009).

Firms invest a lot of money for new product development and expect to get high percentage of sales and profit from it. Studies conducted by PDMA over two decades has revealed that more than 30% of firms’ total profit derived from new products (Lee and Markham, 2016). However, new product launch has no guarantee of success. Most of the commercialization failures occurred due to fault in its idea or its timing (Griffin, A, 1997). A study by Cooper and Kleinschmidt (2000) has uncovered what distinguishes successful new products from failures in industrial product firm with 42 NPD projects failure out of 110 total NPD projects from 55 Australian industrial products firms. Successful products identified excel in some aspects compare to other less successful products such as competitive advantage as superior product, with solid up-front homework taken before development and strong marketing
actions, and strongly supported by senior management.

### 2.2 Performance Measurement of New Product Development

#### 2.2.1 Difficulties Associated with Measuring NPD Performance

Many scholars have investigated the outcomes of NPD that can be expressed in several different performance measures. In fact, this study has become a subject of research itself over a few decades (Awwad and Akroush, 2016; Griffin, A and Page, A.L, 1996; Lilien and Yoon, 1989; Marinov, K, 2013; Page, A.L, 1993; Rogers et al, 2005). This is because measuring the performance of NPD itself is a complex and difficult task (Awwad and Akroush, 2016; Cairati and Cakili, 2014; Griffin and Page, 1996; Marinov, K, 2013; Rogers et al., 2005).

Griffin and Page (1996) argued that some measurement confusion arises due to the measurement of new product performance can be done at different levels, furthermore, most firms’ ultimate objective is financial success, which may complicate the issue as different product development projects may have different measurement needs than just financial success.

Marinov, K (2013) explained that measuring the NPD performance is a complex process due to several reasons:

- a) Managers who used the result of measurement may have different needs and may depend on different set of result in order to support their decision making,
- b) The result of NPD cannot be observed due to its intangible nature such as knowledge and organizational learning,
- c) Product innovation is related to nonstandard or nonroutine and extraordinary tasks. Some aspects can be easily to measure by the firm’s accounting systems, whereas NPD implies some novelty that exhibit a nonstandard or nonroutine tasks, and thus the established indicators may not be relevant to measure the performance,
- d) NPD involves insecurity in terms of market, technologies, intercompany organizations, and interaction with external organizations, that complicates the measurement of result,
- e) NPD performance is usually not concentrated in which involvement of different levels, various parties and even different actors such as suppliers, partners, distributors, and customer are required. Such organizational complexity often impedes NPD result measurement,
2.2.2 Dimensions of NPD Performance

Determining the success of NPD project can be done through different perspectives. Lilien and Yoon (1989) have summarized the major determinant of industrial innovation performance using three-dimensional framework: generality over innovations, decision focus, and managerial controllability. The empirical research has identified several factors as major determinants of new industrial products success such as:

a) Business, strategic, and organizational factors including top management’s support and interaction between departments,

b) R&D and marketing factors including product’s benefit, synergy, and interaction with customers,

c) Market/environmental factors including competition, market size and its growth,

d) Launch timing which is dynamically associated with the other factors listed above.

The study also confirmed the dynamic relationship between these determinants and launch time in particular in the case of original new products, where increase in the levels of production and marketing expertise, as well as rise in market growth rate and the degree of competition will result in longer delayed of new product entry time into the market.

Brown & Eisenhardt (1995) synthesized the research finding from empirical literature into a model of factors affecting the success of product development. This model distinguishes the product development success between: a) process performance such as lead time (speed) and productivity, and b) product concept effectiveness such as fit with market needs and fit with firm competencies, which are correlated with the financial success of the product development project. These performances were considered as indicator of how some agents including team members, project leaders, senior management, customers, and suppliers may affect the outcomes of the new product project.

Syamil et al (2004) raised the importance of measuring the process performance, whereas the measurement of how effectively the product development process is actually working. Process performance measured through three component dimensions: Teamwork, team productivity, and engineering change time, and become the mediator of the relationships between concurrent engineering and overall project performance.
According to Ahn et al (2006), another important dimension apart from business or financial performance is knowledge performance. Knowledge performance can be regarded as the degree of new knowledge creation, that can be seen as the outcome of the exploratory activity.

Awwad and Akroush (2016) discovered that NPD performance success measures is multidimensional construct consisting of five dimensions, namely: NPD financial performance, NPD internal learning, NPD capabilities improvement, NPD knowledge sharing, and NPD marketing performance.

**2.2.3 Performance Measurement Metrics**

Researchers understood the importance of defining a standard measurement by which efficiency, performance, progress, or quality of a plan, process, or product of the NPD project can be assessed. Therefore, several approaches were used such as categorizing the performances and investigating the correlation between variables with each category to evaluate the success of product development project.

Some literatures mainly focus on financial performance in their attempt to measure the success of the NPD (Lee, L.T.S., 2008; Page, A.L., 1993; Petersen et al., 2005). The main selected indicators are return on investment (ROI), return on sales (ROS), return on asset (ROA), return on equity (ROE), payback period, and internal rate of return. Companies may also consider nonfinancial criteria for their new product success measure such as Customers-based success including sales performance of new products, market share achieved, and customer satisfaction, as well as technical performance success including speed to market, quality specs, met performance specs, and innovativeness (Griffin, A and Page, A.L., 1996). However, sales performance and market share are arguably included as financial measures (Page, 1993).

Cairati and Cakili (2014) evaluated the success of NPD on their research about the contribution of supply network in NPD process in terms of time including speed to market, total development time, and compliance to scheduled time, in terms of cost including total development costs and respect of budgeted cost, in terms of quality including customer satisfaction and features quality, and in terms of innovativeness.
2.2.4 Level of Performance Measurement

The system of indicators used for measuring the success of NPD project may vary according to the level of measurement. Griffin and Page (1996) recommended to evaluate the success of NPD at project level and firm level, with different indicators employed at each level as described in Figure 1.

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<td>• Customer satisfaction</td>
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<td>• Market share goals</td>
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<td>• Number of customers</td>
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<td>Firm-Level Measures</td>
<td>• Development program ROI</td>
<td>• Overall program success</td>
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<td>• New products fit business strategy</td>
<td>• Program hit 5-year objectives</td>
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<td>• % Profits from new products</td>
<td>• Products lead to future opportunities</td>
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Marinov (2013) explained that measuring result of NPD can be performed at three levels, namely:

a) Separate new product project level
Indicators at this level are focused on the advance of a particular new product project, on quality, and on any other results of the project. Indicators that can be used at this level are level of achieving the results planned for each project phase, level of achieving performance indicators, schedule adherence level, budget adherence level, level of turnover in the main project team, number of changes in the product parameters, and level of using existing technical solutions.

b) Product innovation process level
At this level, the focus is to measure the process quality, the balance between the separate functional areas involved in the process, and any results achieved in the process. The indicators used are share of resource secured projects, share of projects satisfying the schedule and the
cost restrictions, time required for each phase, total NPV (Net Present Value) of developed products, share of new products achieving or exceeding the set goals, product development average investment amount, management time share devoted to new product development, and number of ideas entering the idea screening phase from the idea generating phase.

c) Strategic level
The objective of this level of measurement is to determine the strategic balance between participants in the process and the company’s financial goals achieved. Feasible indicators are share of the revenue from sales of new products/share of the number of new products launched on the market in the last x years, investments in new products as a share of sales, and shareholder value added.

2.2.5 Performance Measurement Tradeoffs
Assessing how well is the outcome of the new developed product involved multidimensional category of metrics. Some metrics such as time to market, product performance, and innovativeness are mainly associated with the success of NPD project and have become the strategic objectives of many firms (Cooper and Kleinschmidt, 2000; Lilien and Yoon, 1989). However, some researches have revealed that some of these goals may be conflicting to each other whereas some tradeoffs must be considered by the firms (Bajaj et al., 2004; Cohen et al., 1996; McNally et al., 2011).

Cohen et al (1996) has investigated the tradeoff between time to market and product performance with interest in understanding how the new product performance is affected by the time duration of each stage of the product development process (additive multistage model). The result demonstrated that faster launch of new product to the market is not necessarily deliver better outcomes. It is better on concentrating to develop a superior new product rather than to rush a product to the market when the margins of the new and existing products are high and the product category demand rate is large. On the other hand, developing an ambitious new product leads to delay on time to market and thus it is not recommended if the competitive performance level is very low or very high.

While McNally et al (2011) explored the mediating role between speed to market and product quality. Based on evidence, speed to market and product quality both improve product profitability and jointly mediate development expense by NPD phase and cross-functional
integration effects on product profitability. Bajaj et al (2004) identified a relationship between cost performance and time performance of both design and manufacturing phase of NPD of a leading avionics guidance systems manufacturer, how the management levers relating to oversight, the intensity of design specialization, and the level of interaction with the customer may contributes to the performances.

2.3 Supplier Involvement in New Product Development

2.3.1 Introduction of Supplier Involvement in NPD

The empirical research that focus on the role of suppliers in NPD has existed since 1980s. The first literature that raised this topic was carried out by Imai et al (1985). The study within Japanese companies pointed out how company’s NPD project benefits from the existence of an interrelated group of specialized suppliers on the outsides. Learning process between two parties enabling companies to achieve speed and flexibility within the product development process.

Suppliers involvement by definition according to Dowlatshahi, S (1998) means of integrating suppliers’ capabilities in the buying firm’s supply chain system and operation, in particular on product design and development (Dowlatshahi, S. 1998). Handfield et al (1999) explained supplier integration in NPD as a process of providing information and directly participating in decision making for purchased used in the NPD process. Van Echtelt et al (2006) proposed to make a distinction between the supplier’s contributions, tasks and responsibilities, to reflect the different dimensions of involvement, and thus supplier involvement refers to ‘the resources (capabilities, investments, information, knowledge, ideas) that suppliers provide, the tasks they carry out and the responsibilities they assume regarding the development of a part, process or service for the benefit of a buyer’s current and/or future product development projects.’

As today’s NPD has been more and more rapid and fiercely competitive, involving suppliers become essential to achieve success in the market. Early supplier involvement has become one of the best practice in creating successful NPD as recommended by the research of Clark and Fujimoto (1991). Handfield et al (1999) argued the reason why supplier involvement is fundamental because suppliers provide materials and services that account for majority of the cost developed product, therefore, it is important to involve supplier at earlier phase of NPD
project to reduce cost and development time, as well as improve product quality. Moreover, as the development process continues, the difficulty and cost to make design changes increase (Handfield et al., 1999). Another motive of supplier involvement is because suppliers may contribute in gaining innovative ideas and technologies that are critical for the NPD, as suppliers may have better knowledge and expertise rather than buying firms and thus complement buying firm’s internal capabilities (Handfield et al., 1999; Ragatz et al., 2002). Song and di Benedetto (2008) highlights the importance of supplier involvement in the new venture’s pursuit of radical innovation and suppliers as potential partners or even investors to provide investment funding for smaller firms in return for a share of the profit generated. Wasti and Liker (1997) conducted study on Japanese manufacturers investigating factors which influence the supplier involvement decision in design, as the result, the main factors are supplier’s in-house capability and technological uncertainty.

2.3.2 Benefits of Supplier Involvement in NPD

Integrating supplier in NPD project perceived as fundamental as it gives numerous benefits. Wynstra et al (2001) distinguished between short-term and long-term benefits:

- **Short-term benefits** are related to the specific development project that the supplier is involved in, in which it can be divided into two main areas: (1) development efficiency, including reduction of development cost and lead time, (2) and effectiveness, including reduction of product cost and increase of product value,

- **Long-term** benefits are associated with getting the access to the technological knowledge of suppliers and long-term alignment efforts or so-called ‘technology-roadmaps’ that companies frame together with suppliers for further collaboration.

To sum up, the benefits associated with supplier involvement in NPD are as following:

1. Reduce development lead time and time to market (Bonaccorsi and Lipparini, 1994; Clark, K.B, 1989; Clark and Fujimoto, 1991; Handfield et al., 1999; Imai et al., 1985; Zhang et al., 2017),

2. Enhance product quality and product design (Bonaccorsi and Lipparini, 1994; Clark and Fujimoto, 1991; Handfield et al., 1999; Petersen et al., 2005; Ragatz et al., 2002; Wasti and Liker, 1997),

3. Increase technological improvement and innovation (Bonaccorsi and Lipparini, 1994; Clark and Fujimoto, 1991; Handfield et al., 1999; Ragatz et al., 2002; Song and di
Benedetto, 2008),
4. Help to reduce cost of developing product (Bonaccorsi and Lippiari, 1994; Handfield et al., 1999; Ragatz et al., 2002).
5. Give contribution on firm’s competitive advantage (Clark and Fujimoto, 1991)
6. Improve financial returns (Petersen et al., 2005), engineering productivity (Clark, K.B, 1989), flexibility through information exchange (Imai et al., 1985), and design for manufacture (Wasti and Liker, 1997; Swink, M, 1999),
7. Increase supplier’s trust and commitment (Walter, A, 2003).

In spite of the above mentioned positive benefits that firms may obtain by involving the suppliers, some literatures stated that supplier involvement does not always generate improvements in project effectiveness and efficiency (Birou and Fawcett, 1994; Hartley et al., 1997). Eisenhardt and Tabrizi (1995) reported that greater supplier involvement slows the pace of product development, in contrast the hypothesis built. Additionally, supplier involvement does not exhibit significant improvement in projects dealing with product newness and new technological capabilities (Primo and Amundson, 2002; Swink, M, 1999). These evidences corroborate the need to distinguish the type of supplier involvement and the development situations and technicality when involving suppliers in NPD (Primo and Amundson, 2002; Wynstra and Pierick, 2000). However, Wynstra and Pierick (2000) stated that supplier involvement is not a poor strategy, but it should be managed carefully.

Clearly involving supplier is beneficial in NPD, but there are some aspects that need to be taken into accounts prior integrating the suppliers in practice. Handfield et al (1999) outlined some major questions that arise regarding firm’s effort in integrating its suppliers, namely:

- Which suppliers should be involved?
- Is the supplier able to meet the requirements?
- Is the supplier’s technology roadmap aligned with firm’s roadmap?
- Given the level of technical complexity, to what extent should the supplier be involved in the project?
- When exactly should the supplier be involved in the project?
2.3.3 Type and Level of Supplier Involvement in NPD

Since integrating suppliers consumes time, effort and money in its practice, Wynstra and Pierick (2000) introduced Supplier Involvement Portfolio as a tool to distinguish the type of supplier involvement in NPD which will help firms to set priorities making the supplier involvement more manageable and economical. The model as depicted in Figure 2, classified four types of supplier involvement according to two dimensions:

1) The degree of responsibility for product development that is contracted out to the supplier,
2) The degree of development risk.

![Figure 2. The supplier involvement portfolio](image)

Van Echtelt et al (2006) then developed the previous idea in classifying the type of supplier involvement by distinguish it according to two different arenas:

1) Strategic Management arena which covers long-time, strategic activities,
2) Operational Management arena which contains short-term, project-related activities.

Successful supplier involvement in this case is reflected by how firm is able to achieve both short-term and long-term benefits.
Petersen et al (2005) framed the level of responsibility model (Figure 3.), adopted from several literatures, representing the intensity or spectrum of supplier involvement as the following details:

a) No involvement, no exchange information related design and specification decisions,

b) White box, discussions about specifications or requirements between the buying company and supplier are held informally, but the buying company makes all the design and specifications decisions,

c) Grey box, the buying firm and supplier undergo an informal or sometimes formal joint activities, which may include information and technology sharing, and joint decision making regarding design specifications,

d) Black box, supplier is informed of the buying company’s requirements and is given almost complete responsibility for the purchased item, with only review and concurrence on the purchased item’s specifications by the buying company.

<table>
<thead>
<tr>
<th>None</th>
<th>“White Box”</th>
<th>“Gray Box”</th>
<th>“Black Box”</th>
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<tbody>
<tr>
<td>No supplier involvement. Supplier “makes to print”.</td>
<td>Informal supplier integration. Buyer “consults” with supplier on buyer’s design.</td>
<td>Formalized supplier integration. Joint development activity between buyer and supplier.</td>
<td>Design is primarily supplier driven, based on buyer’s performance specifications.</td>
</tr>
</tbody>
</table>

2.3.4 Timing of Involvement

The term ‘timing of involvement’ means the stage of the NPD process at which the lead manufacturer begins to search for suitable suppliers and make them aware of the project, regardless the how the development project is organized in sequential or overlapping way (Bonaccorsi and Lipparini, 1994). According to Bonacorsì and Lipparini (1994), supplier integration can take place: (1) in the concept stage; (2) in the development stage, after detailed
design is completed and technical specification is issued; (3) in the feasibility stage or at the very beginning of the development stage, whereas the stage between concept design and detailed design completion.

Handfield et al (1999) depicted the process of NPD into five series of stages in which supplier’s input and/or the active involvement of suppliers can take place at any point in the development process as seen in Figure 4.

Firm’s decision to involve supplier at early phase of NPD is reasonable as concept and design engineering phase account for 80 percent of the total cost of the product (Handfield et al., 1999). Decisions that made early in the design have significant impact on reduction of development cost and reduction of development lead-time, thanks to early and intensive communication with the supplier so that firm is able to prevent, reduce, and introduce design changes earlier, or also known as ‘first time right’ development (Wynstra et al., 2001).

However, not all suppliers necessarily have to be integrated in the early phase of NPD project. Handfield et al (1999) defined two major factors that should be considered in deciding the when the involvement of supplier should take place in NPD process: (1) the rate of change of the technology, (2) and the level of supplier expertise in the given technology. Firstly, if the technology is undergoing a significant amount of the technological change, it should be delayed on product development cycle (Handfield et al., 1999). Secondly, suppliers with high design and high technological expertise including suppliers of high value and complex parts and considered as either black box or grey box responsibility should be integrated early in the process (Clark and Fujimoto, 1991; Handfield et al., 1999; Johnsen. T.E, 2009). Figure 5.
describes the characteristics of suppliers at each stage of NPD process.

<table>
<thead>
<tr>
<th>Early supplier involvement</th>
<th>NPD process</th>
<th>Late supplier involvement</th>
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</thead>
<tbody>
<tr>
<td>Suppliers of complex items</td>
<td>Suppliers of simpler items</td>
<td></td>
</tr>
<tr>
<td>Suppliers of systems or subsystems</td>
<td>Suppliers of single components</td>
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<tr>
<td>Suppliers of critical items or technologies</td>
<td>Suppliers of less critical items or technologies</td>
<td></td>
</tr>
<tr>
<td>Strategic alliance suppliers</td>
<td>Non-allied suppliers</td>
<td></td>
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<tr>
<td>Black box suppliers</td>
<td>White box suppliers</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Characteristics of suppliers in NPD process

2.3.5 Critical Success Factor of Supplier Involvement

Many believe that firms who have successfully integrated their supplier in NPD have adopted a systematic process (Handfield et al., 1999; Petersen et al., 2005). Some studies have been developed in order to identify which are critical elements of supplier involvement that can lead to success in NPD. One that is considered as major in every list of critical elements is choosing the right supplier to be involved in NPD (Bonaccorsi and Lipparini, 1994; Handfield et al., 1999; Johnsen, T.E, 2009; Petersen et al., 2005; Song and di Benedetto, 2008). Handfield et al (1999) pointed out the importance of project team’s understanding in suppliers’ ability to meet cost, quality, and goals, as well as their technology roadmap, level of design expertise, and the volatility of technology being integrated. The importance of supplier selection is plausible as supplier technical capability have positive influence on supplier involvement (Johnsen, T.E, 2009; Wasti and Liker, 1997).

As supplier selection is essential, the role of purchasing here become important and requires to be integrated as well (Handfield et al., 1999; Wynstra et al., 2000). Bonaccorsi and Lipparini (1994) have discovered several factors that appeared to be critical in integrating suppliers during NPD process:

a) Partner selection and evaluation systems,

b) Proximity of the supplier network,
c) Mutual support between the manufacturer and its supplier, which ensured through constant social interaction, trust, and information exchange,

d) Continuity and stability of the relationship, maintained by means of system of shared division of labor inside the network, as well as cohesiveness and need balance,

e) Synchronization of the technical dimension of all the firms involved in the development process.

Walter, A (2003) examined relationship-specific factors which affect suppliers’ contributions to the buyer firm’s NPD project. As a result, supplier commitment and supplier trust were identified to be significant variables of supplier involvement in NPD.

Three important conclusions wrapped up from study from managerial perspective are:

1) Firms should move from arm’s length or adversarial relationships to close relationships with suppliers,

2) Supplier-specific adaptations should be conducted to develop close relationships with suppliers and to enhance their involvement in NPD,

3) People in buying firms who are responsible in managing supplier relationships must recognize their role as relationship-promotors.

Petersen et al (2005) introduced three critical elements that are necessary antecedents to successful supplier integration in NPD as following:

a) A detailed assessment of the suppliers being considered for involvement,

b) Supplier input and involvement in the assessment of the technical elements associated with the project,

c) Supplier input and involvement in the assessment of the cost, schedule and other business factors critical to the success of NPD project.

Finally, Johnsen (2009) synthesized research findings from literatures into a model highlighting critical success factor of supplier involvement in NPD within three main groups: (1) Supplier selection, (2) Supplier relationship development and adaptation, (3) Internal customer capabilities, with detail framework as described in Figure 6.
2.4 Social Network Theory

The study of supply chain management has been expanded into greater fields rather than conceived as a relational or dyadic subject (Borgatti and Li, 2009). Some scholars have given their attention to social network theories while studying organizational behaviour as network perspective views a system as interrelated actors, and thus it is able to clarify how organizations interact with one another (Borgatti and Li, 2009; Galaskiewicz, J, 2011). Borgatti and Li (2009) pointed out that social network theory itself is developed from several social science disciplines, including social psychology, anthropology and sociology, and thus provide useful explanations for social phenomena from a wide variety of disciplines.

Galaskiewicz (2011) explained the relevance and importance of social network analysis in studying the management of interorganizational relations as firms attempt to communicate and
do activities together. However, some concerns may emerge in supply chain networks such as cost reduction, customer satisfaction, different governance structures between organizations, trust issue and opportunism, that will create risks. Trust is necessary to deal with the risks, and network can generate trust. Therefore, social network ties among firms within the chain are important in building trust among actors that can facilitate information exchange, cooperation and coordination.

Galaskiewicz (2007;2011) differentiated network analysis into two perspectives: (1) study of networks as a collection of arcs and nodes and focus on the formal properties of different configurations, and (2) study of social networks, that study the dynamics of relationship between nodes whereas the theories derived from behavioral psychology, e.g., balance theory, exchange theory, social comparison theory, social contagion theory.

Borgatti and Li (2009) argued that supply chain management has both ‘hard’ or technical aspect and ‘soft’ or social aspect, therefore social network analysis can be applied to both resource flows that accompanied by less tangible relations, through several theories ranging from sociology to the study of romantic networks, make the distance between supply chain management and to other branches of management science become closer.

Choi and Kim (2008) Introduced the structural embeddedness and its importance in managing relationship between suppliers. While other social network researches emphasize the interdependency of multilevel social structures, embeddedness perspective focus on individual firm’s behaviour within the context of larger relational structures. Structural embeddedness refers to the state of dependency of a firm on its direct or indirect suppliers, whose performances may impact on the firm’s decisions, actions, and outcomes. Therefore, understanding this perspective will allow buying firms to better evaluate their supplier’s performances and help them to select the right suppliers for long-term partnerships.

Choi and Wu (2009-a) examined the relational dynamics of triadic buyer-supplier-supplier relationships through an existing knowledge: Balance theory from social psychological discipline and structural hole theory from anthropology and sociology. In summary, it is necessary to consider network perspective in understanding the relationships between firms in supply network, and thus network theory becomes the basic theory built for triadic relational dynamics.
Social Balance Theory

One of the prominent network theories of organizational behavior at micro level is Heider’s Balance Theory (Galaskiewicz, 2007). According to Heider’s proposition, individual tends to choose balance state in his/her interpersonal relation as when someone’s behavioural changed from liking to disliking (Khanafiah and Situngkir, 2004). As explained by Khanafiah and Situngkir (2004), balance state will occur when the multiplication of sentiment relations, which is determined by the attitude between actors, is positive, as depicted in Figure 7. Choi and Wu (2009-a) described a balanced triadic relationship based on the literatures of balance theory that it is ‘always has three plus signs or two minus signs and one plus sign, and an unbalanced triadic relationship always has two plus signs and one minus sign or three minus signs’.

![Figure 7. Heider’s pox model](image)

Structural Hole Theory

Understanding the structure in social network is fundamental as an example, teams may obtain different outcomes while having the same composition of member skills depending on the patterns of relationships among the members (Borgatti et al., 2009). Structural holes theory as introduced by Ronald S. Burt in 1992, seeing holes as the weaker connections between two groups in social structure (Burt, R.S, 2002). However, the absence of ties between two groups does not mean that they are unaware of each other’s existence (Burt, R.S., 2002, Choi and Wu, 2009-a).

Burt’s structural holes theory focus on ego, ego’s ties, and the relationships among these ties (Galaskiewicz, 2007). Burt’s theory utilized ego network as shown in Figure 8, which consists of: (a) a focal actor or so-called an ego, (b) the set of actors with any kind of ties to ego or known as alters, (c) and all ties among the alters and ties between the alters and the ego. Structural holes are considered as opportunity to intercede the flow of information and control the activities that bring people together from the opposite of the hole, and thus egos with more structural holes as the one on the left of Figure 8 is deemed to have better performance certain
competitive settings compare to the one on the left (Burt, R.S., 2002, Borgatti et al., 2009).

Choi and Wu (2009-a) posited that buying firm might be a *tertius gauden* in buyer-supplier-supplier triad, which means the third actor who has ability to control other two actors, getting profit from being between other two suppliers by engaging them to collaborate.

![Ego Networks](image)

*Figure 8. Two illustrative ego networks. The one on the left contains many structural holes; the one on the right contains few.*

### 2.5 Relationships in Supplier Network

The study of Interorganizational relationships, in particular between purchasing organizations and their independent suppliers has received a great deal of attention from researchers over the past several years (Araujo et al., 1999; Monczka et al., 1998; Wang et al., 2016). Researchers have made conceptual models in managing and understanding the nature of the relationships between organizations in business market focusing on inter-connected actors, activities, and resources (Snehota and Häkansson, 1995; Cannon and Perreault Jr., 1999). In supply chain management, interorganizational relationships can take place within different level of supply networks (Harland, 1996; Möller et al., 2005; Johnsen et al., 2014). The need of differentiating and classifying the supply network has also arisen as different types of supply network require different managerial approaches (Lamming et al., 2000). Johnsen et al introduced three levels of purchasing and supply chain analysis: (1) Dyadic buyer-supplier relationships, (2) supply chains, (3) and networks. Among these three levels, dyadic buyer-supplier has been the subject of many studies (Araujo et al., 1999; Choi and Wu, 2009(b); Roseira et al., 2010).
2.5.1 Dyadic Buyer-Supplier Relationship

Some literatures defined dyad as the lowest level of relationships and the building block of supply chains and networks in which two companies are linked with some activities with resource ties or actor bonds are formed between two companies (Snehota and Häkansson, 1995; Johnsen et al., 2014). A dyadic buyer-supplier relationship as depicted in Figure 9, is a common network that contains two nodes as buyer and supplier and the link that connects them (Choi et al., 2002). Snehota and Häkansson (1995) argued that relationship in dyads can be conceived as ‘quasi-organization’ and generate a source of value whereas its significance depends on how they manage the relationships.

![Figure 9. Dyadic buyer-supplier model](image)

In buyer-supplier dyads, the relationship involved between two firms could be categorize into cooperative or competitive (Ellram and Edis, 1996; Cannon and Perreault Jr.,1999; Choi et al., 2001, Choi et al., 2002):

- **Cooperative buyer-supplier relationship** is described to have a long-term relationship commitment and shared risks and common goals (Choi and Liker, 1995; Choi et al., 2002; Ellram and Edis, 1996; Ellram and Hendrick, 1995; Paulraj et al., 2008). The relationship is built by trusting behaviors and high level of commitment between two firms, they shared relationship-specific asset and shared meaningful information to solve problem and accomplish mutual goals with improved communication (Cannon and Perreault Jr., 1999; Ellram and Hendrick, 1995; Paulraj et al., 2008; Choi and Wu, 2009-a).

- In **Competitive buyer-supplier relationship**, competition by means of adversarial engagement, in which each firm is only eager to what is the best for them, struggling for the same resources and gains in a win-lose context, it is characterized to have an arm’s length, short term traditional relationship, with lack of involvement due to suspicion and mistrust (Choi and Wu, 2009-b; Ellram and Edis, 1996, Monczka et al., 1998). The decision to adopt competitive relationship is based on economic risks, as
this type of relationship may emerge due to risk related to transaction, appropriation, technology diffusion, and commoditization (Choi et al., 2002).

2.5.2 Triads in Supply Networks

Many scholars have focused their studies of supply chain management in dyad perspective, however, less attention has been paid to triad. In recent literatures, triads have been regarded as smallest unit and fundamental building blocks of a network (Bastl et al., 2013; Choi and Wu, 2009-a; Choi and Wu, 2009-b). According to Wasserman and Faust (1994) Triad is, “a subset of three actors and the (possible) tie(s) among them”. Triad is important in network as it occupies an intermediate level in network analysis, strategically located between dyad and higher-order aggregation (Wasserman and Faust, 1994). Moreover, triad microstructure is implicit in other prominent network constructs (Madhavan et al., 2004). Choi and Wu (2009-c) argued that a triad is the smallest network unit in which how the link affects a link or how a node affects a link can be observed. Therefore, studying triad is essential as starting point of networks study.

Triads can be present in various configuration. Triads in service supply chain are commonly constructed by interaction among buyer, supplier or service provider, and customer (Finne and Holström, 2013; Li and Choi, 2009; Van der Valk and Iwaarden, 2011; Wynstra et al., 2015). Triads in supply networks can occur when: (a) one buyer interacting with two suppliers (Borekci et al., 2015; Choi et al., 2002; Choi and Wu, 2009-a; Choi and Wu, 2009-b; Dubois and Frederiksson, 2008; Wu et al., 2010; Wu and Choi, 2005; Madhavan et al., 2004; Wilhelm, M.M., 2011); (b) when one buyer interacting with its supplier and its customer (Mena et al., 2013); (c) and when one supplier interacting with two buyers (Choi and Kim, 2008). Detailed configurations are listed in Table 1.

The link between suppliers within triad can take place either in the same tier or across different tiers (Bastl et al., 2013). Wynstra et al (2015) distinguished the form and feature of buyer-supplier-customer triads in manufacturing and service supply chain as following:

- **Triads in manufacturing supply chain**, parts supplier is not necessarily interacted with buyer’s customer. Supplier-supplier interaction within triad as in Choi and Wu (2009-a; 2009-b) studies, may or may not take place. Furthermore, their studies of supplier-supplier relationships have focused on upstream and take place in the same tier with a
prescription of how to manage upstream supply networks in order to eventually satisfy customer. Hence, the triad implicitly in relation to the customer, but the customer is not part of the triad.

- **Triads in service supply chain**, the supplier has direct contact with the customer, at least at the level of operational process. Hence, direct contact with customer is a main distinguishing characteristic of this triad. Service triads incorporate the customer as a member of the triad explicitly. Meaning, designing and managing this supply network in order to satisfy customer, in some ways, also involves managing the customer’s input and participation in the co-production of the service itself.

<table>
<thead>
<tr>
<th>Scope</th>
<th>Configuration</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triads in supply network</td>
<td>Buyer-supplier-supplier</td>
<td>• Borecki et al., 2015;</td>
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<td>• Choi et al., 2002;</td>
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<td></td>
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<td>• Choi and Wu, 2009-a; 2009-b;</td>
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<td>• Dubois and Fredriksson, 2008;</td>
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<td>• Madhavan et al., 2004;</td>
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<td>• Wilhelm, M.M., 2011;</td>
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<td></td>
<td>Supplier-buyer-customer</td>
<td>• Mena et al., 2013</td>
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<td>Buyer-supplier-supplier’s supplier</td>
<td>• Rosetti and Choi, 2005</td>
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<td></td>
<td>Buyer-buyer-supplier</td>
<td>• Choi and Kim, 2008</td>
</tr>
<tr>
<td>Triads in service delivery / service outsourcing</td>
<td>Supplier-service provider-consumer</td>
<td>• Finne and Holmström, 2013;</td>
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<td>• Li and Choi, 2009;</td>
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<td>• Van der Valk and Iwaarden, 2011</td>
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<td>Buyer-supplier-customer</td>
<td>• Wynstra et al., 2015</td>
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<td>Buyer-intermediary vendor-supplier</td>
<td>• Wuyts et al., 2004</td>
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<tr>
<td>Triads in logistic industry</td>
<td>Supplier-customer-transport carrier</td>
<td>• Rodrigues et al., 2008</td>
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<td>Seller-3PL carrier-buyer</td>
<td>• Mason et al., 2007</td>
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<td>Triads in service quality</td>
<td>Production-purchasing-sales</td>
<td>• Svensson, G., 2002</td>
</tr>
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</table>

*Table 1. Various configurations of triad from several references*
2.5.3 Triadic Buyer-Supplier-Supplier Relationships

Relationship between suppliers has received more attention among the emerging supply chain management studies (Choi and Wu, 2009-a). A triadic buyer-supplier-supplier relationship can be described as a puzzle that composed by two independent pieces: buyer-supplier relationship and supplier-supplier relationship, as a result, examining the relationship between suppliers should be also taken into accounts the interaction between the buyer and each of the supplier (Choi et al., 2002). In other words, how suppliers interact with each other is affecting the operational performance of the buyer itself (Wu and Choi, 2005).

Choi et al (2002) proposed three archetypes of supplier-supplier relationships: competitive, cooperative, and co-opetitive, while each of the three archetype is differentiated based on its communication pattern, power and control, and its nature. On the previous study carried out by Xu (2017), another archetype included to complement the model, derived from structural-hole state, where there are no relationships occur between two suppliers, or so-called coexistence in supplier-supplier relationship.

**Competitive supplier-supplier relationship**

In competitive buyer-supplier-supplier relationship configuration as seen in Figure 10, both suppliers create a distance without direct lines of communication. However, they know of each other’s existence through information from the buyer or through the media. They exchange limited information with minimal communication occurs. Typically, the buying firm interacts with each supplier independently, then transfer the information to the competing suppliers, served as mediator between them. Both firms may take part in product development projects. Nevertheless, both suppliers do not share any knowledges or resources to jointly solve managerial issues, neither jointly coordinate the operational activities (Choi et al., 2002).

Despite its adversarial nature, the supplier-supplier relationship may benefit the buying firm by adopting dual sourcing policy, allows it to exploit market competitiveness. Moreover, the buying firm may leverage its power over the suppliers while playing the role as intermediary between them (Choi et al., 2002).
Cooperative supplier-supplier relationship

Cooperative buyer-supplier-supplier relationship is illustrated in Figure 11. Choi et al. (2002) pointed out that cooperation in supplier-supplier relationship occurs when both suppliers work together with high of free flow information involved between them. The suppliers may engage in product development projects, exchange ideas, resources, and expertise such as technological know-how, human resources, and production capacity to accomplish mutual goals. Indeed, this relationship requires intensive social interaction between suppliers and tend to occurs over long period of time (Choi et al., 2002). Cooperative relationship between suppliers aims to obtain a mutual win-win situation through sharing of tangible and intangible resources (Borekci et al., 2015). Cooperation between suppliers can positively affect buyer’s performance when it is demonstrated flexibility and synergistic activities (Choi et al., 2002) However, such cooperative relationship may lead to strategic partnership between the parties that may induced a further collaboration in terms of agreed prices, production quantity and quality, resulting an undesired behavior such as collusive which is detrimental for the buyer (Borekci et al., 2015; Choi et al., 2002). Suppliers in monopolistic industries are likely to exhibit cooperative relationships (Wu et al., 2010). This behavior may also result in demand management as well as partitioning the market among the suppliers in order to reduce competition (Choi et al., 2002).
Co-opetitive supplier-supplier relationship

Co-opetitive buyer-supplier-supplier relationship as depicted in Figure 12, is defined as ‘cooperative behavioral actions which two competing suppliers (of a given buyer) engage in’ (Wu et al., 2010). It is happened when both suppliers understand the importance of competition as a self-preservation and survival action, and the importance of cooperation as an attempt to learn and expanding the market. The information exchange in a co-opetitive relationship occurs when there are common interests between competing suppliers (Choi et al., 2002).

Wu et al (2010) measured the supplier-supplier coopetition in their study as the level of cooperative activities between two competing suppliers in terms of information sharing, mutual assistance, and joint operations. This relationship entails direct communication and exchange of materials between the competing suppliers to obtain overall efficiency and competitiveness of both suppliers (Choi et al., 2002).

Co-opetitive relationships can induce optimal gains for both parties (Wu et al., 2010). What makes competing suppliers decided to engage in co-opetitive behavior is because they believe this approach might lead to future collaboration which is more beneficial than having direct confrontational actions which may lead to an act of retaliation (Wu et al., 2010). Furthermore, this behavior leads to increase the resilience of the buyer, suppliers and their triad, showing the highest impact in terms of resilience compare to other archetypes of supplier-supplier relationships (Borekci et al., 2015).
Coexistence in supplier-supplier relationship as explained by Xu (2017) occurs when there are no direct communication and no interaction involved between two suppliers. The buyer maintains its relation with each supplier separately as illustrated in Figure 13, creating a missing link between them. This condition is reflecting a *structural-hole state* in the structural-hole theory that characterized by weaker connections between two parties in social structure (Burt, R.S., 2002).

In a coexistent supplier-supplier relationship means no relationships intertwined between two suppliers, neither competition nor cooperation, might be due to lack of information about the other’s existence or irrelevance of business operations as expressed by two suppliers offering different component to the buyer (Xu, J., 2017).
Chapter 3 – Theoretical Background and Hypothesis

The framework constructed in this research is based on the study of triadic buyer-supplier-supplier relationship in the scope of NPD and its impact on the NPD performance, that was originally developed by Xu (2017) as the intersection of topic supplier involvement in NPD and relationships within supply network. The initial study provides opportunity to expand on the topic in detail in order to obtain better understanding on how supplier-supplier relationship may vary according to buyer’s behavior and the nature of NPD project, and how this relationship affecting the performance of NPD.

Numerous studies have emphasized the importance of integrating supplier in NPD project that will lead to reduction of development lead time and development cost, as well as increasing the product quality and innovation that eventually generate success in NPD (Bonaccorsi and Lipparini, 1994; Clark, K.B, 1989; Clark and Fujimoto, 1991; Handfield et al., 1999; Imai et al., 1985; Petersen et al., 2005; Ragatz et al., 2002; Song and di Benedetto, 2008; Wasti and Liker, 1997). In addition, dyadic relationship between buyer and supplier in the context of NPD has also been discussed by several researchers (Petersen et al., 2005; Van Echtelt et al., 2006; Wynstra and Pierick, 2000). However, the idea of making suppliers collaborate in buyer’s NPD project has not been the topic of literatures that speak about either triadic relationship in supply network nor supplier involvement in NPD. Some scholars have given their interest in observing the dynamics of triadic buyer-supplier-supplier relationships and its implication to buyer’s and supplier’s performances (Choi and Wu, 2009-a; Choi et al., 2002; Wu and Choi, 2005; Wu et al., 2010), but few of them have raised the topic of how triadic relationship may have impact on the buyer’s NPD performance. Indeed, the idea of making suppliers collaborate in NPD is worth to be discussed as referring to social network theory, firms tend to create ties among them by sharing information and do activities together (Galaskiewicz, j., 2011). Moreover, firms with many structural holes among pair of nodes will perform better and might enjoy the profit as tertius gauden by engaging suppliers to collaborate (Borgatti et al., 2009; Choi and Wu, 2009-a). Consequently, it is necessary to complete the missing part and fill in the gap by interpolating the concern of supplier-supplier relationship into the scope of NPD. Therefore, this research attempts to examine the suppliers’ behavior in buyer’s NPD project, more precisely focusing on supplier-supplier collaboration, what influences this relationship
In this section, a framework will be developed based on theoretical findings from literatures. The research will start with the construction of independent variables that affect the decision of buyer in managing its suppliers, then it proceeds to the level of supplier-supplier collaboration during the NPD process and how different level of supplier-supplier collaboration affecting the performance of NPD. Some indicators and measurement metrics were selected to evaluate the outcomes of the buying firm’s NPD whose suppliers are collaborated and involved in the NPD project.

3.1 Level of supplier-supplier collaboration

When suppliers interacted with each other, the relationship intertwined between them could be competitive, cooperative, or co-opetitive (Choi et al., 2002). In competitive supplier-supplier relationship, both suppliers do not share any knowledges or resources to jointly solve managerial issues, and thus, unlikely to effectively engaged in product development project due to its adversarial nature (Choi et al., 2002). In contrary, cooperative or collaborative relationship between suppliers aims to obtain mutual gains by sharing tangible and intangible resources, therefore, this behavior is preferable in NPD project. Moreover, a big company like Toyota has enjoyed sustainable competitive advantage through a ‘dynamic learning capability’ which attained through cooperative relationships between its suppliers (Dyer and Nobeoka, 2000). Therefore, collaborative supplier-supplier relationship is ideally to be intertwined between suppliers during developing new product and expected to have impact on NPD performance.

Many studies explained about the type and level or intensity of supplier integration in buyer’s NPD project (Petersen et al., 2005; Wynstra and Pierick, 2000), but no study focused on identifying the level of cooperation between suppliers in buyer’s NPD project. Therefore, this paper is aimed to evaluate the intensity of collaboration between suppliers that occur in buyer’s NPD project by adopting several studies addressing interfirm collaboration.

Collaboration between firms commonly found in supply chain where two or more independent firms jointly work together to plan and execute supply chain operations, generating greater success rather than work separately (Simatupang and Sridharan, 2002). Supply chain
collaboration can performed vertically with customers or suppliers as when the manufacturer, the distributor, the carrier, and the retailer share their responsibilities, resources and performance information together to serve relatively similar customer, for instance through Vendor Managed Inventory (VMI), Efficient Customer Response (ECR), and Collaborative, Planning, Forecasting, and Replenishment (CPFR), and horizontally with competitors or non-competitors by private information or resources sharing such as joint distribution centers (Barratt, M., 2004; Simatupang and Sridharan, 2002).

Some researchers focus on investigating the nature of collaboration to identify the type and the level or intensity of interorganizational collaboration for management purpose (Adobor, H., 2006; Cousins, P.D., 2002; Cousins, P.D., 2005; Mentzer et al., 2000). Cousins (2002) classify interfirm relationships according to the level of dependency and the level of uncertainty, which result in four distinct relationship management strategies. Adobor (2006) proposed four clusters of interfirm alliances based on their origins and link the context to operational dynamics. Cousins (2005) distinguished three types of collaboration according to the nature of the firm’s strategic directions and the business outcomes that the firm is expected to receive. The classification approaches exerted in these studies mainly focused on the nature of relationship between buyer-supplier. Meanwhile, supplier-supplier relationship does not involve business transactions between them, as a consequence, adapting these models is challenging. In fact, the nature of supplier-supplier collaboration is at the core of our interest. Based on the context of new product co-development, this study inherited the classification of Mentzer et al (2000) who suggested interfirm relationship as a continuum from strategic to operational partnering based upon the orientation of the partners and the degree of implementation of partnering between two independent firms.

**Strategic collaboration** or strategic partnering according to Mentzer et al (2000) is an on-going, long term interfirm relationship aimed for achieving strategic goals by delivering values to customer and generating profitability to partners. The antecedents of a strategic collaboration are interdependence between firms, trust, commitment, organizational compatibility, and top management vision (Mentzer et al., 2000). This collaboration is focused on long-term product redesign and contributes to building up a willing and capable contributes to meet the current and changing future technology, capability needs, and to reach superior service capabilities through joint technology developments and sharing of knowledges and capabilities (Cousins,
Operational collaboration refers to as-needed, shorter-term relationship for obtaining parity with competitors (Mentzer et al., 2000). Firms that engaged in operational collaboration usually focus on business benefits coming from cost reduction, supply base reduction and other tactically focused approaches (Cousins, P.D., 2005). This collaboration is based on sharing information, planning and managing activities in operational areas or in a specific development project, whereas partner is viewed as close associate improving supply chains efficiency and effectiveness in the short term (Cousins, P.D., 2005; Mentzer et al., 2000; Van Echtelt et al., 2006). Collaboration in operational arena is likely to occur when the level of interdependence, trust, commitment, organizational compatibility, and top management vision is low (Cousins, P.D., 2002; Van Echtelt et al., 2006).

Strategic and operational collaboration are distinct according to the degree of implementation (Mentzer et al., 2000) and their nature in terms of: information sharing, information technology utilization, joint objectives, and trust.

- **Information sharing.** Mentzer et al (2000) argued that shared information varies in between strategic and operational interfirm partnering. Partners in strategic partnership practice multilevel information sharing, whereas firms in an operational partnership practice single or limited multilevel information sharing. Wu and Choi (2005) explained the types of information shared between two collaborative suppliers and how they exchange information may vary according to the nature of supplier-supplier relationship and buyer-supplier relationship, whereas suppliers exchange explicit information or operational related information when they interact with each other in short-term technical task, while when suppliers became closely coupled, the exchange of information was not just explicit information but tacit information as well. Tacit knowledge is shared between collaborative firms through discussion, debate or joint problem solving (Ramesh and Tiwana, 1999).

- **Information technology (IT) utilization.** Strategic interfirm collaboration utilizes more various information technology than operational partnering (Mentzer et al. 2000). In strategic partnering, technology used is more standardized and integrated to link the partners, meanwhile operational partnering requires technology for more tactical applications that are limited in scope. Peng et al (2014) conducted studies that the level of collaboration is influenced by the extent to which various NPD IT tools are used by the NPD team. The level
of collaboration increased as the use of product design IT tools such as computer-aided design (CAD), computer-aided process planning (CAPP), and simulation modelling increased. Another IT tools that associated to level of collaboration in NPD is the use of project management software, email groupware and shared part databases that facilitate effective information sharing among NPD teams (Peng et al., 2014).

- **Joint objectives.** Wu and Choi (2005) used descriptors as collaborative, professional, alliance, transactional, arms-length, adversarial and working relationship to capture the characteristics of buyer-supplier relationship and supplier-supplier relationship on their study about buyer-supplier-supplier relationship dynamics. In Alliance and collaborative relationship both partners imply closer relationship such as share the same vision and collaborate to achieve the same business objectives (Wu and Choi, 2005). Partners in strategic collaboration utilize more joint planning and control through a strategic interface team to establish joint objectives and performance measures of the total system, whereas those in operational partnering are more focus on each firm’s performance such as the effects of collaboration on their own operating revenues, expenses, profits, and growth (Mentzer et al., 2000).

- **Trust.** Trust and commitment are fundamental antecedents to strategic collaboration, whereas lower level of these antecedents will lead to operational collaboration orientation (Mentzer et al., 2000). Sako and Helper (1998) pointed out long-term commitment, information exchange, technical assistance, and customer reputation contribute to the creation and subsistence of trust. Sako (1992) classified trust into three categories: (a) contractual trust, or trust that supplier or other party will adhere to fulfil what is written in the contract; (b) competence trust, or trust that other party has the capability to produce what is agreed, (c) goodwill trust, or trust that other party will perform tasks in excess of the agreement as an act to support the relationship’s continuity. Frequent face to face meetings with suppliers will encourage goodwill trust building (Bunduchi, R, 2013). Bunduchi (2013) argued that the existence of goodwill trust is the key variable of the strategic collaboration in NPD as it reduces the incentives for suppliers to behave opportunistically, in this case, buying firm will able to obtain better terms and condition during the negotiation with them instead of with new suppliers.

The aforementioned arguments regarding strategic and operational interfirm collaboration imply that suppliers can collaborate in different levels. Supplier-supplier relationship can
orientate to a strategic or operational collaboration. Hence, the spectrum of supplier-supplier relationships in NPD project is ranging from operational collaboration to strategic collaboration as depicted in Figure 14.

![Figure 14. Level of supplier-supplier collaboration research framework.](image)

### 3.2 Determinants of supplier-supplier collaboration in NPD

Developing new product is basically a complex and difficult task, that characterized by uncertainty and variability (Ferreira, J.C.A., 2009). It requires different expertise in product, process, and technical aspects and accompanied high investment and costly changes along the process continuous, that makes collaboration with other parties, suppliers in particular, is essential (Ferreira, J.C.A., 2009). Many researches exhibited the importance of integrating suppliers in NPD process and the fact that this practice has contributed to many success stories of NPD project (Bonaccorsi and Lipparini, 1994; Clark, K.B, 1989; Clark and Fujimoto, 1991; Handfield et al., 1999; Imai et al., 1985; Petersen et al., 2005; Ragatz et al., 2002; Song and di Benedetto, 2008; Wasti and Liker, 1997). Nevertheless, only few were paid attention on investigating what has led to a collaboration between suppliers in meeting buyer’s needs. These determinants are intended to be investigated in this research.

Literatures have identified that complexity and uncertainty are essential determinants that affect the level of difficulty of an NPD project and affect the performance of NPD (Ahmad et al., 2013; Clark and Fujimoto, 1991; De Brentani, U., 2001; Tatikonda and Rosenthal, 2000). Other variables such as design outsourcing and acceleration in NPD project have been investigated, however, they eventually influence the complexity of the NPD project through the amount of...
design tasks and its interdependence, the number personnel executing new tasks and playing new roles (Swink, M., 1999). Hwang et al. (2012) investigated variables affecting difficulty in NPD project including product feature, project structure, capabilities, and technical risk that have impact on the degree of complexity and uncertainty due to risks of technology, material, vendor, and process newness. For this reason, project complexity and uncertainty have been chosen as variables that are the focus of this study. Complexity and uncertainty in NPD project have to be managed properly as these variables contribute to a poor NPD performance (Ahmad et al., 2012; Schuh et al., 2016-b; Swink, M, 1999; Tatikonda and Rosenthal, 2000).

Tatikonda and Rosenthal (2000) defined complexity as the nature, quantity, and magnitude of organizational subtasks and subtask interactions involved in the project. Other literature argued that complexity as the number of the tasks and their interrelationships in the execution of NPD project. (Ahmad et al., 2013). In this study, the author defines project complexity as the load of the tasks and the interdependence between the tasks that lead to higher level of difficulties in NPD project.

Meanwhile, uncertainty refers to technology novelty as the newness of the technology exerted in the product development process (Tatikonda and Rosenthal, 2000). Uncertainty by other scholar defined as the degree of familiarity firms or users have with a technology or a product (De Brentani, U., 2001). Therefore, author defines project uncertainty as to the level of newness that associated with the risk in NPD project.

Complexity in NPD project itself can lead to significant delay, over budget, and even project failure (Kim and Wilemon, 2003; Schuh et al., 2016-b), and uncertainty is even linked to risk that can lead to late time to market, high cost, and low product quality, whereas new products entail more effort, time, and resources compare to making an improvement to existing products (De Brentani, U., 2001; Tatikonda and Rosenthal, 2000). Firms often face the dilemma of developing new product with high complexity and high technology novelty. High degree of differentiation and complexity are often required in order to develop new product that can survive in a highly competitive market, and even can be the source of competitive advantage (Kim and Wilemon, 2003; 2009). However, in order to achieve differentiation in the competitive market, some firms choose to exert technologies that are new, as competitors may not be able to duplicate the new developed product (Tatikonda and Rosenthal, 2000). Some
literatures asserted that in facing today’s challenging business environment, buyers should give their attention to not only their own direct relationship with suppliers, but also supplier-supplier relationship and thereby, on the whole network (Borekci et al., 2015; Wilhelm, M.M., 2011). This is because the relationship between suppliers would eventually affect buyer’s performances, for instance, conflicting supplier-supplier relationship will prevent the buyer from obtaining the desired products or services from the suppliers, meanwhile the transacting relationship between them will accomplish such desired performances including successful NPD, and increased resilience of the buyer, suppliers, and their triad (Borekci et al., 2015; Wu and Choi, 2005). Therefore, collaboration often becomes a solution in addressing complexity and uncertainty problems in NPD project, as through cooperation, development teams gain knowledge from the learning occurs during the development process (Kim and Wilemon, 2003; Ragatz et al., 2002).

Therefore, the following hypothesis is drawn:

**H1a. Complexity has a direct and positive correlation with strategic supplier-supplier collaboration in buyer’s NPD project.**

Complexity and uncertainty have been a motivation for partnering and early supplier involvement (Campbell and Cooper, 1999; Mikkola and Skjoett-Larsen, 2003). Suppliers to be involved early include suppliers of parts representing high value and complexity and these suppliers either take on a full black box or grey box responsibility (Clark and Fujimoto, 1991). As the uncertainty and complexity increase the difficulty in NPD project and require greater expertise, involving other parties such as engineers from different organization or stakeholders may help to identify and solve the issues earlier, furthermore, supplier integration is more likely to be employed as it leads to significant improvement in cost, quality, and cycle time objectives (Kim and Wilemon, 2009; Ragatz et al., 2002). According Chaudury and Boer (2016) it has been proven that product-process complexity leads to improved firms’ collaborative competence, which results in higher NPD performance than that of their competitors. Song and Di Benedetto (2008) found that the greater the supplier involvement in the radical innovation development project, the better the products’ innovativeness will be. Considering high complexity and high technology newness employed require great expertise, engaging suppliers to collaborate is necessary as it sparks synergy and induces the creation of both explicit and tacit knowledge (Wu et al., 2010).

Therefore, the following hypothesis is drawn:

**H1b. Uncertainty has a direct and negative correlation with strategic supplier-supplier**
collaboration in buyer’s NPD project.

Beside complexity and uncertainty, buyer’s influence also responsible in the formation of collaboration between suppliers in NPD project. Profound study conducted by Wu et al (2010) exhibits that buyers are able to influence the relationship between suppliers, even facilitate how suppliers engage in co-opetition. In this study, buyer’s influence refers to efforts made by buyer with the intention to make its suppliers collaborate in buyer’s NPD project. The evidence shows that when competing suppliers deliver poor performance to the buyer, buyers got motivated and took the initiative to step in and subsequently provoke collaboration between suppliers with the intention to help each other out to resolve operations problem (Wu et al., 2010). This practice is commonly found in Japanese automakers as their supply management strategy (Borekci et al., 2015; Choi and Wu, 2009-a; Wilhelm, M.M., 2011). Toyota has successfully created interconnected network and has enjoyed the advantages of knowledge-sharing derived from it such as increased productivity, creating sustainable competitive advantage through a ‘dynamic learning capability’ with its suppliers (Dyer and Nobeoka, 2000).

Considering the level of collaboration, stronger collaboration between suppliers will be achieved when buyer enforces it and greater sharing of technology information and decision making within the project team will overcome the issues that may arise in high complexity and high uncertainty NPD project (Kim and Wilemon, 2009; Ragatz et al., 2002; Wu et al., 2010). In contrary, some literatures argued that involving strategic partnering supplier in high uncertainty of NPD project demonstrate negative result of NPD performance, as in breakthrough innovation, new supplier relations is required to stimulate the information creation (Primo and Amundson, 2002; Swink, M., 1999). Recent study by Melander and Lakemond (2015) suggested that the governance of NPD collaboration accompanied by high degree of uncertainty should be performed in two different ways: by limiting supplier involvement as well as increasing the level of collaboration with the suppliers. Phillips et al (2006) introduced the strategic dalliance as an approach in managing suppliers under discontinuous innovation project. Strategic dalliance is defined as an involvement in an activity that only last for a very short period. In this way, firm will able to achieve greater flexibility, agility and freedom, enabling it to adapt rapidly to the changing market needs while maintaining long-term relationships with the existing suppliers. Therefore, unlike complexity and buyer’s influence variables, buyer will engage to a short-term collaboration between suppliers when level of uncertainty in NPD project is high.
Therefore, the following hypothesis is drawn:

**H1c. Buyer's influence has a direct and positive correlation with strategic supplier-supplier collaboration in buyer's NPD project.**

![Figure 15. Framework of determinants of supplier-supplier collaboration in NPD.](image)

### 3.3 Measurement metrics of NPD project

Several approaches can be selected to measure the NPD project performance. The metrics that are employed to measure the NPD performance depends on which level or dimension of the NPD project that you want to assess. Measurement metrics that are chosen to assess the NPD project performance in this study is focusing on two different dimensions, namely: (1) Product effectiveness, (2) and process performance. The purpose of assessing both dimensions is to understand the impact of supplier-supplier collaboration in NPD project on the effectiveness of the developed product and on the process performance of the NPD project, that will contribute to financial success of the new developed product and the firm’s business in general (Brown and Eisenhardt, 1995). In this section, the measurement metrics for each dimension will be explain.

**Product effectiveness**

Brown and Eisenhardt (1995) described product effectiveness as a suitability of the product with firm’s competencies and market needs. The authors examined the product effectiveness through its intrinsic values of the product including its unique benefits to the customers, product quality, cost attractiveness, and innovativeness of the product features, whereas excelled in these metrics will lead to product success and superiority. This study focused on assessing
product effectiveness through new developed product quality.

- **Product quality** – some studies defined product quality influencing customer perceptions through two dimensions including *design quality* or the extent to which the product design matches with customer expectation, and *conformance quality* or the ability to produce the product according to the design specification (Clark and Fujimoto, 1991; Jayaram and Narasimhan, 2007). Cairati and Cakilli (2014) added some aspects such as resistance, manufacturability, testability, and reliability as part of the product feature quality. The quality of the interaction among parts is also important for the product made up of a set of interacting and interlocking parts (Bonaccorsi and Lipparini, 1994).

- **Innovativeness** – Increased level of competition, rapid change of technologies, and global market have been the motivation for firms to keep innovating (Griffin, A., 1997). Innovation can be a source of differentiation and a leverage for the developed product to be accepted in the market (Jayaram and Narasimhan, 2007). Innovativeness is one of the common attributes to measure product effectiveness in NPD project as some researchers put their interest on it. Durmusoglu and Barczak (2011) examined how information technology (IT) affects product effectiveness, have focused on four items in measuring the degree of innovativeness, which is *the uniqueness of the new product* in terms of technology, features, and benefits, compared to competitors' offerings and other products introduced by the responding firm. While Salomo et al (2007) relied on the degree of change as a predictor of innovativeness, and measured it through four dimensions of innovativeness, namely: *Internal Resource—Fit, External Resource—Fit, Technology Dimension*, and *Market Dimension*.

**Process performance**

Brown and Eisenhardt (1995) assessed process performance through speed and productivity of the NPD project. Syamil et al (2014) argued that process performance measurement is measuring how effectively product development process at the project level are functioning through three dimensions: *teamwork, team productivity, and engineering change time*, which might be an early warning signal of downstream problems such as in a project’s quality, time, or productivity. Ahn et al (2006) emphasized the importance of measuring knowledge performance apart from business performance in NPD process, as business performance such as profitability refers to the outcome of the exploitative NPD activities, while knowledge performance can be considered as the outcome of exploratory activities, since it measures the
degree of knowledge creation. The creation of knowledge itself is regarded as the core theme of NPD process and contributes to the firm’s sustainable competitive advantage (Ahn et al., 2006). Based on some literatures, several metrics are selected as an indicator to evaluate process performance namely: *time to market, development cost, and sustainability.*

- **Time to market** – is defined as time required from the beginning of concept generation when the firm decides to develop a new product to the production ramp up or the end of product launch when the product is commercially available and being produced in full-scale (Jayaram and Narasimhan, 2007; Syamil et al., 2004). Synonymous terms for this measure in literatures are product development time, speed to market, cycle time, innovation time, and lead time (Jayaram and Narasimhan, 2007). Some studies considered time to market as an important attribute in NPD process success as the shorter NPD process the more profit that firms will obtain from the launch of a new product through increased market acceptance and the more certainty in forecasting customer preference (Choothian et al., 2014; Clark and Fujimoto, 1991; McNally et al., 2011). Many literatures have pointed out that supplier integration can help to reduce the time to market of the new developed product and improve the NPD performance (Bonaccorsi and Lipparini, 1994; Clark, K.B, 1989; Clark and Fujimoto, 1991; Handfield et al., 1999; Imai et al., 1985; Zhang et al., 2017).

- **Development cost** – product development is accompanied by high cost or investment and high risks (Ahn et al., 2006; Handfield et al., 1999). NPD project costs have direct impact on the financial performance of the company as if the cost of the NPD project is very high, it may lead to over budget that affects the price of final product and thus potentially have negative impact on the new product acceptance in the market (Choothian et al., 2014). Brown and Eisenhardt (1995) argued that process performance and financial success of the product is twofold as productive process can generate lower costs and thus lower price that will lead product success. Development cost has been a main metric for NPD project success in many literatures and deemed as one of the major benefits of the involvement of suppliers in NPD project (Bonaccorsi and Lipparini, 1994).

- **Sustainability** – Greater governmental scrutiny and shorter life cycle have pushed firms to be sustainable in today’s competitive market (Gmelin and Seuring, 2014). Moreover, pressure to create greener goods on business is becoming more intense, as firms nowadays have been focusing on improving their sustainability efforts by reducing carbon emission, recycle or reuse, and developing green technologies (Johnsen et al., 2014). At the business
level, sustainability is linked to eco-efficiency and requires all three dimensions of the ‘triple-bottom-line’ to be satisfied simultaneously for a long-term sustainability (Dyllick and Hockerts, 2002). Pujari et al (2003) investigated the integration of NPD and environmental management philosophies to create an environmental new product development (ENPD) for firms in order to be “green and competitive”. The performance of ENPD is measured through an integration of two dimensions: eco-performance and market performance, whereas eco-performance is related to environmental concerns which comprises socio-environmental impacts associated with the product (Pujari et al., 2003).

The metrics employed for sustainability in NPD including: (a) competitive advantage, product differentiation, and new international market creation; (b) environmental image enhancement; (c) environmental and social life-cycle assessment; (d) and life-cycle costing (Gmelin and Seuring, 2014; Pujari et al., 2003; Pujari, D., 2006).

It is important to measure the items separately while assessing the NPD project performance since some studies have discovered the tradeoff between them (Bajaj et al., 2004; Cohen et al., 1996; McNally et al., 2011). Cohen et al (1996) and McNally et al (2011) for example, focused on the relationship between the time to market of the new developed product and other target performance like product quality, in which the result shows that the time performance is correlated to the quality of the product and both have impact on the overall NPD performance. While other finding identified dependency between the lead time and the development cost of the NPD project (Bajaj et al., 2014). However, the focus of this study to understand the impact of supplier-supplier collaboration on the overall NPD performance. Therefore, the hypothesis can be drafted as following:

H2a. Supplier-supplier collaboration has a direct and positive correlation with product effectiveness of the new developed product.

H2b. Supplier-supplier collaboration has a direct and positive correlation with process performance the new developed product.
The framework of NPD project performance indicators from the buyer’s perspective is summarized in Table 2.

<table>
<thead>
<tr>
<th>NPD performance indicators</th>
<th>Descriptive</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product effectiveness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product quality</td>
<td>Measurement of design quality and conformance quality relative to firm’s objectives</td>
<td>Cairati and Cakilli, 2014; Clark and Fujimoto, 1991; Jayaram and Narasimhan, 2007</td>
</tr>
<tr>
<td>Innovativeness</td>
<td>Measurement of the uniqueness of the new developed product in terms of technology, features, and competitive advantage attained relative to firm’s objectives</td>
<td>Durmusoglu and Barczak, 2011; Salomo et al., 2007</td>
</tr>
<tr>
<td><strong>Process performance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to market</td>
<td>Estimation of time required from the beginning of concept generation of NPD until the end of product launch</td>
<td>Jayaram and Narasimhan, 2007; Syamil et al., 2004</td>
</tr>
<tr>
<td>Development cost</td>
<td>Evaluation of the firm’s ability to low cost of developing new product relative to its initial budget</td>
<td>Brown and Eisenhardt, 1995; Choothian et al., 2014</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Evaluation of the firm’s ability to satisfy ‘triple-bottom-line’ of sustainability in the NPD project relative to firm’s objectives</td>
<td>Dyllick and Hockerts, 2002; Gmelin and Seuring, 2014; Pujari et al., 2003; Pujari, D., 2006</td>
</tr>
</tbody>
</table>

*Table 2. NPD project performance indicators framework*
Hence, the complete research framework can be constructed as depicted in Figure 16.
Chapter 4 – Research Methodology

Most literatures that investigated triadic relationships were using theoretical approach and case-study in building and supporting the hypothesis (Choi and Wu, 2009-a; Choi et al., 2002; Wu and Choi, 2005). This research contains address this issue by adopting a survey research methodology to validate hypothesis derived from extant literature and theory with quantitative analysis. A survey that has been exerted in this study aims to address the methodological gap found in existing literatures. Furthermore, survey research is useful to better understand the relevance of the triadic phenomenon and its distribution in a population thoroughly (Forza, C., 2002).

The scope of this survey covers companies from four industries, namely: Automotive, electric domestic appliances, machinery, and packaging goods, across Italy and Indonesia. Measurement instruments developed in this research are including set of questionnaires which adopted from previous literatures with some necessary adjustments, the administration plan, scaling system and rules. A database of companies from selected industries are also built, whereas the data and contact of the companies were taken from Aida, an Italian company information and business intelligence website, and Indonesian manufacturing company directory websites. The survey is distributed to the companies through email generated from LinkedIn, a social network platform for professionals, while the set of questionnaires are created through SurveyMonkey, an online survey software. Before distributing the survey, a pilot testing is conducted to examine the quality and viability of measurement instruments, whereas the detailed procedure will be explained in the later section. In order to increase the number of responses, some actions are taken such as rewarding the respondents by sharing the survey result after the analysis has been completed and sending some reminders to the respondents who have not completed the survey, kindly asking them to complete the survey before the set time.

Survey research is getting more popular as the number of literatures in operations management (OM) utilizing this method has increased over decades. Pinsonneault and Kraemer (1993) argued that survey research is more appropriate than case study when: (a) there is an interest in knowing what, how, and why the phenomenon is happening; (b) control of dependent and independent variables are not desired or not possible, (c) there is a necessity to study a
phenomenon in its natural state, (d) the phenomenon is ongoing or just occurred recently. In contrary, case study is more appropriate when there is a desire to study the relation between context and the phenomenon or when detailed investigation of context and history of the phenomenon are required. Survey for research purpose is different from the surveys in general. According to Pinsonneault and Kraemer (1993), survey research has three distinct characteristics: (1) to produce quantitative description of a phenomenon of the studied population, (2) data collected through structured and predefined questions, (3) the information collected from a sample that designed to able to generalize the findings in population. The purpose of this survey research is to test the hypothesis constructed regarding triadic supply network relationship in a firm’s NPD project.

After conceptualizing the framework, the survey research then designed following the procedure of theory-testing survey research developed by Forza (2002) as depicted in Figure 17 below.

Stage 1: **Type of industry and geographic location definition.** First step is to define the target sample of the survey by selecting which industry and the specific location that the survey is going to be carried out.

Stage 2: **Measurement instrument and administration development.** Developing the measurement instrument consists of several tasks, namely: creating the survey questions and the scaling system, identifying the respondent, and defining the rule of the survey. Once the measurement instrument is set, next step is to determine the plan on how the survey is going to be administered.

Stage 3: **Pilot testing for measurement items and administration viability examination.** After the set of questionnaires and its administration are done, a pilot test then executed. The pilot test or pre-testing is performed to examine whether the measurement instrument and administration of the survey that have been designed are working as planned.
Stage 4: Survey delivery and data collection. In this stage, the final questionnaires as described in Appendix are delivered to companies through their identified respondents in order to collect the data for theory testing.

Stage 5: Data analysis, hypothesis testing, and discussion. Finally, after collecting the data from respondents, a set of statistical tests can be applied and the results then interpreted in the context of hypothesis. The outcomes of hypothesis testing then discussed including some hypothesis that may not have been supported, and thus the theory can be inferred.

4.1 Measurement

Numbers of literatures were reviewed exhaustively to identify items to measure the constructs of interest. Total seven constructs of measurement with multiple items were operationalized, containing three constructs of context variables, supplier-supplier collaboration, NPD project performance, descriptive questions, and self-assessment. Detailed questions items are listed in Appendix.

Project complexity (PC) is measured as the level of complexity in managing the tasks in NPD project, including the load of the task, the difficulty, and interdependence of the tasks. This measurement construct consists of six scale items which are developed from the existing literatures (Ahmad et al., 2013; Novak and Eppinger, 2001). Each of six scale items is measured using 5-point Likert response scale, with 1 as the lowest and 5 as the highest score. The respondents were asked to indicate the extent to which they agree or disagree with the statement of each item with 5-point Likert response scale ranging from ‘strongly disagree’ to ‘strongly agree’.

Project uncertainty (PU) is measured as the level of project newness in terms of product market and technology, process technology, and collaborated suppliers. Four scale items were developed based on the existing literatures (Ahmad et al., 2013; Melander and Lopez-Vega, 2013) which are measured using 3-point Likert response scale. The respondents were asked to choose the statements which most represent the state of the project newness ranging from ‘existing’ to ‘completely new’.

Buyer’s influence (BI) is measured as the level of specific activities carried out by firm as buyer in engaging its suppliers. Five scale items were adapted from Wu et al. (2010) in their paper about supplier-supplier relationship in buyer-supplier-supplier triads. Each of five items is
measured using 5-point Likert response scale, whereas the respondents as buyer were asked to indicate the extent to which they agree or disagree with the statement of each item.

Level of supplier-supplier collaboration (LC) is measured as the level of collaborative behaviors and activities between the buyer’s suppliers in terms of information sharing, joint information technology (IT) utilization, joint objectives, and trust. Nine scale items were formulated and adapted from several literatures (Bunduchi, R., 2013; Mentzer et al., 2000; Sako, M., 1992), and measured using 5-point Likert response scale with instruction following the previous constructs.

The NPD performance (NP) is measured as level of NPD project success in product effectiveness and process performance employing five indicators: (1) product quality, (2) time to market, (3) development cost, (4) Innovativeness, and (5) sustainability. Respondents were asked to rate the success of their NPD project relative to its goal using 5-point Likert response scale.

Descriptive questions were asked in the beginning of questionnaires that also work as qualifying questions. Information about geographic location, company size and revenues can be collected from this construct of measurement. Moreover, some question to qualify the respondents also included and equipped with ‘logic function’ from the online survey cloud-based software. This qualifying or also called as screening questions are commonly used in online survey to disqualify recipients who are not compliant with the phenomenon of interest, in order to obtain appropriate information (Downs et al., 2010). Thanks to the ‘logic function’, some respondents who could not provide relevant information will be disqualified. For instance, companies with less than two suppliers collaborate in their NPD project will be disqualified and thus will not able to proceed to the main questions and skip the questions to the end of questionnaires. Finally, at the end of the questionnaires, the respondents were asked to assess the benefit of making suppliers collaborate in NPD project.

4.2 Data source

Emails are sent to the people who work in the company, who are knowledgeable about the topic in order to get relevant information. Identifying the appropriate respondent is important since reaching too many people may cause incomplete information and increased random or even bias error due to untrusted and unknowledgeable information (Forza, C., 2002). Therefore, the
questionnaires are distributed to people who are dealing with suppliers in NPD project or in general, namely procurement, purchasing, product or project development, and are holding position at upper level such as directors, managers, or coordinators.

The unit of analysis in this study is companies. In order to achieve a relevant result, the survey is delivered to some companies belong to several industries, namely: automotive, electric domestic appliances, machinery, and packaging goods. These chosen industries are manufacturing industries with high supply chain complexity and they are highly responsive to changing customer’s needs and competitor’s strategic moves, and thus a subject to a fierce competition and entail robust integration among the players in the supply chain (Bonaccorsi and Lipparini, 1994; Bozarth et al., 2009). The sample is taken from multiple locations, spreading across two different countries. This is because a sample taken from a limited geographic area would not be as representative as a sample taken from multiple locations (Forza, C., 2002). Particularly, Italy and Indonesia were chosen as the geographic focus of this study in order to better observe any possible phenomenon occurred or any dynamics in a developed and developing country.

4.3 Pilot testing

Once the measurement instrument and the administration has been completed, the questionnaires then undergo a preliminary testing. The term of pilot study refers to a small version of the ‘full-scale’ study or also known as trial run or feasibility study, that is conducted as preparation of the major study, as well as pre-testing a particular research instrument (Teiljlingen and Hundley, 2001). The purposes of pilot testing are the following:

- To examine measurement instrument of the questionnaires,
- To identify the potential practical problems in the survey procedure,
- To evaluate the viability in the administration process of the survey (Forza, C., 2002; Teiljlingen and Hundley, 2001).

In summary, it is important to carry out pilot test in order to make sure what has been designed is working as expected.

Pilot testing should be done by distributing the final questionnaires to the respondent and must resembling the actual survey that will be performed for theory testing (Forza, C., 2002). According to Forza (2002), questionnaires for pilot testing can be submitted to three types of
Chapter 4 – Research Methodology

people, namely: (a) colleagues, (b) industry experts, (c) and target of respondents. In this study, target respondent was chosen as participant of the pilot testing, as it is able to provide feedback on the relevancy of the measures, the difficulty in administration process, or anything that may affect the quality of the survey. Pilot testing was carried out to a firm from packaging industry by distributing the final questionnaires through online survey cloud-based software, asking them to fill the survey and to give some feedback for improving the quality of the survey. Some positive comments were obtained from the respondent, such as the survey questions are relevant with actual condition as well as easy and simple to fill the survey.

The data from pilot study then have to be excluded from the main result. This is to avoid the result from contamination. The risk of contamination may arise where the data from pilot testing are included to the main result or where new data are collected from the same target respondents who participate in pilot testing (Teiljlingen and Hundley, 2001).

4.4 Data collection

The common methods used to collect data in survey research are questionnaires and interviews (Forza, C. 2002). The units for data collection in survey research is usually individuals, regardless the unit of analysis (Pinsonneault and Kraemer, 1993). In this study, the data collection method is questionnaires which distributed through email and utilizing an online survey cloud-based software. Sending questionnaires through email has some advantages such as cost savings, high flexibility for respondent as they can be completed at respondent’s convenience time, and ensure the rule and instructions are followed (Forza, C., 2002).

Collecting response form respondent is a challenging task as companies and respondents are becoming more reluctant to complete the survey these days. This is shown by a decline of response rate through the years from 1975 to 2005 (Baruch and Holtom, 2008). From the studies that published in 2000 and 2005, the average response rate of survey research conducted at the organizational level was 35.7 percent (Baruch and Holtom, 2008). Moreover, a study in 2004 revealed that response rate of survey research distributed by email was observed to have about 10 percentage points smaller difference than survey which distributed by mail (Kaplowitz et al., 2004). Therefore, some actions are taken in order to increase the response rate, as suggested by Forza (2002), such as reward the respondent by sharing the survey result after the analysis has been completed and reduce respondent’s efforts by making the task to be more concise with brief questionnaires and direct link to the online survey software.
Data were collected within two months, from mid of July to early of September 2018. Total 104 companies are reached through email and LinkedIn, with overall 51 companies from Italy and 53 companies from Indonesia. Total of 18 responses were received, with 14 complete responses and 4 incomplete responses. Out of 14 complete responses, 3 responses are from Italian companies, and 11 responses are from Indonesian companies. From 14 responses, one company only involves one supplier during NPD process, and the other one does not involve the supplier at all, therefore, these 2 responses were non-conforming and thus were excluded. Total 12 usable responses were subjected to quantitative analysis. Summary of data collection procedure is depicted in Figure 18.

* Logic applied to exclude companies which collaborate with < 2 suppliers
Chapter 5 – Data Analysis and Result Discussion

This chapter is dedicated to analyze the result of the survey research by exerting a descriptive and quantitative statistic approaches. The author is fully aware of the low number of responses obtained is which makes it less appropriate to perform statistical analysis. However, the analysis performed in this study is to demonstrate what could be done if adequate number of responses are obtained, and to show and discuss about the methodology for future reference. Therefore, this analysis will contribute as preliminary analysis to assess the appropriateness of the framework and the measurement instrument and to test the feasibility of hypothesis testing. Discussion of the empirical result will be presented in this chapter with observations from previous research to corroborate the arguments.

5.1 Descriptive statistics

Total of 14 complete responses obtained from respondent belongs to Italian and Indonesian companies. The number of employees is ranging from 50 to 5500 employees with sales revenues varies as described in Table 3. Graph 1 tells us that more than 90% of companies involved their suppliers during NPD process, including 75% of companies collaborated with more than two suppliers, 14% of companies collaborated with two suppliers and 7% of companies collaborated with only one supplier. The distribution among Italian companies and Indonesian companies depicted in Graph 2 and the distribution among four industries is depicted in Graph 3. Graph 4 and Graph 5 show the timing of supplier involvement which refers to which stage of NPD process that suppliers are integrated by buyer. Data of company which has two or more suppliers involved in NPD then employed for further statistics analysis.

<table>
<thead>
<tr>
<th>Revenues</th>
<th>Number of complete responses</th>
<th>Company without supplier involved in NPD process</th>
<th>Company with 1 supplier involved in NPD process</th>
<th>Company with 2 suppliers involved in NPD process</th>
<th>Company with more than 2 suppliers involved in NPD process</th>
</tr>
</thead>
<tbody>
<tr>
<td>M = Million</td>
<td>B = Billion</td>
<td>ITA</td>
<td>INA</td>
<td>ITA</td>
<td>INA</td>
</tr>
<tr>
<td>&gt; 1B €</td>
<td>1</td>
<td>ITA</td>
<td>INA</td>
<td>ITA</td>
<td>INA</td>
</tr>
<tr>
<td>100M – 1B €</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>50M – 99M €</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1M – 49M €</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&lt; 1M €</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NA</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total number of company</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3. Profile of companies
Chapter 5 – Data Analysis and Result Discussion

Based on the statistics data showed in Graph 1, Graph 2, and Graph 3, majority of companies that responded the survey having collaboration with more than two suppliers in their focal NPD
project. Only one company collaborated with one supplier and one company does not involve its supplier in its NPD process. All companies from automotive industry were observed to have collaboration with more than two suppliers. It is because automotive industry is a large-scale manufacturing that has always been subject to dynamic change and it corroborates arguments on why automotive industry is an ideal setting for studying supplier-supplier relationships (Wilhelm, M.M., 2011). Diverse result has shown in packaging goods industry which will be interesting to test the theoretical generalizability of supplier-supplier relationship for future research. Graph 4 and Graph 5 describe that suppliers are getting involved mostly at the last stages of NPD process, during the product/process service engineering and design, or during prototype build, test, and pilot/ramp-up for operations. Only few companies from automotive and packaging goods industry integrate their supplier at early stage of NPD process. Based on the data from survey, this is most probably due to components that are supplied by suppliers who are integrated in NPD project are critical components, therefore, an early involvement in NPD process is necessary (Clark and Fujimoto, 1991). Despite the timing of involvement, companies nowadays are likely more conscious about involving their suppliers during developing new product. This study then going deeper to understand the company’s intention in engaging its suppliers in NPD project and the impact on NPD project performance.

5.2 Reliability and Construct Validity Analysis

Measuring the quality of the measurement instrument is fundamental before analyzing the data collected. The quality of measurement here refers to the quality of the survey instruments and procedures used to measure the constructs of interest. Carmines and Zeller (1979) emphasized the importance of measuring theoretical constructs prior the analysis as they noted “if the theoretical constructs have no empirical referents, then the empirical tenability of the theory must remain unknown”. It is plausible because unreliable or invalid measurements might lead to incorrect inferences and misleading conclusions (Forza, C., 2002). The quality of the measurement can be evaluated in terms of reliability and validity, whereas validity aims to evaluate the righteousness of measurement towards the concept and reliability aims to evaluate stability and consistency in measurement (Forza, C., 2002). Lack of validity leads to a systematic error or bias, while lack of reliability leads to random error (Carmines and Zeller, 1979).

Reliability denotes dependability, stability, predictability, consistency and accuracy of the measurement and refers to the extent to which measuring procedure generates the same result
There are four most common methods employed for estimating reliability according to Forza (2002), namely:

- Test-retest method,
- Alternative form method,
- Split halves method, and
- Internal consistency method.

This study exerted internal consistency method for measuring reliability with Cronbach’s coefficient alpha since internal consistency is the most prominent method and it is readily calculated from a single administration of a test (Henson, R.K., 2001). It assesses the equivalence, homogeneity, inter-correlation of the items used in a measure, or degree to which the items used in a measure jointly form a set that capable of independently measuring the same construct (Forza, C., 2002; Henson, R.K., 2001). Cronbach’s alpha is also the most common used reliability indicator in OM survey research (Forza, C., 2002). Cronbach’s alpha reliability coefficient normally ranges between 0 and 1, whereas the closer the coefficient is to 1, the greater the reliability of the measures (O’Leary-Kelly and Vokurka, 1998). The agreement on how large is the alpha coefficient should be in order to be considered acceptable is still debatable. However, Carmines and Zeller (1979) recommended the minimum acceptable value of 0.7, while George and Mallory (2003) provide the following rules of thumb:

“_ > 0.9: Excellent, _ > 0.8: Good, _ > 0.7: Acceptable, _ > 0.6: Questionable, _ > 0.5: Poor, and _ < 0.5: Unacceptable”.

What should be noted is high coefficient of alpha indicates good internal consistency of the items in the construct but does not mean that the construct is unidimensional (Gliem and Gliem, 2003). Another analysis is necessary to assess whether the empirical indicators are logically, as well as theoretically, connected to the construct by measuring its unidimensionality and validity (O’Leary-Kelly and Vokurka, 1998). There are two common methods for assessing the unidimensionality of a measure: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (O’Leary-Kelly and Vokurka, 1998). EFA is commonly used to compress a group of empirical indicators into a smaller set of composite factors (latent variables) with minimum loss of information and to identify which empirical indicators are strongly linked to a particular latent variable, while CFA contains inferential statistics that
allows for a stricter and more objective interpretation of unidimensionality than EFA (O’Leary-Kelly and Vokurka, 1998). This study employed EFA to measure the discriminant validity of the construct by comparing the result of factor analysis with the prespecified factors and loadings.

Five multi-item constructs of measurement that have been developed in Likert scale to measure project complexity (PC), project uncertainty (PU), buyer’s influence (BI), level of supplier-supplier collaboration (LC) and NPD performance (NP), were being tested for their reliability using Cronbach’s coefficient alpha and their construct validity using EFA as suggested by previous scholars (Ahmad et al., 2013; Forza, C., 2002), the result is depicted on Table 4. Principal component analysis yielded only one factor for each construct with an eigenvalue greater than one, suggesting that the items represented a single unidimensional construct. Five factors were generated representing unidimensional constructs with all items having loading greater than the recommended minimum of 0,4 (Carmines and Zeller, 1979). Cronbach’s alpha coefficient for all constructs are higher than recommended minimum of 0,7 (Carmines and Zeller, 1979), ranging from “acceptable” to “excellent” (George and Mallery, 2003).

<table>
<thead>
<tr>
<th>Items</th>
<th>Cronbach’s α</th>
<th>Factor loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC</td>
<td>PU</td>
</tr>
<tr>
<td>PC2: Task definition difficulty</td>
<td>0,793</td>
<td>0,789</td>
</tr>
<tr>
<td>PC4: Number of departments involved</td>
<td>0,829</td>
<td>-0,013</td>
</tr>
<tr>
<td>PC5: Coordination difficulty</td>
<td>0,872</td>
<td>0,079</td>
</tr>
<tr>
<td>PU1: Market newness</td>
<td>0,869</td>
<td>0,190</td>
</tr>
<tr>
<td>PU2: Product technology newness</td>
<td>-0,395</td>
<td>0,636</td>
</tr>
<tr>
<td>PU3: Process technology newness</td>
<td>0,146</td>
<td>0,965</td>
</tr>
<tr>
<td>PU5: Supplier newness</td>
<td>0,012</td>
<td>0,810</td>
</tr>
<tr>
<td>LC7: Joint problem solving</td>
<td>0,953</td>
<td>0,306</td>
</tr>
<tr>
<td>LC8: Goodwill trust</td>
<td>-0,066</td>
<td>0,064</td>
</tr>
<tr>
<td>LC9: Competence trust</td>
<td>0,169</td>
<td>0,057</td>
</tr>
<tr>
<td>BI1: Interaction promotion</td>
<td>0,784</td>
<td>-0,027</td>
</tr>
<tr>
<td>BI3: Collaboration promotion</td>
<td>0,303</td>
<td>-0,164</td>
</tr>
<tr>
<td>NP2: Time to market</td>
<td>0,702</td>
<td>0,484</td>
</tr>
<tr>
<td>NP3: Cost performance</td>
<td>0,011</td>
<td>-0,297</td>
</tr>
<tr>
<td>NP4: Innovativeness</td>
<td>-0,051</td>
<td>-0,056</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

a. Rotation converged in 7 iterations.

Table 4. Reliability and construct validity result
A *cross-loading* is observed among factors that indicates a necessary further analysis. A cross-loading item is an item which loads at 0.32 or higher on two or more factors (Costello and Osborne, 2005). To deal with this situation, some “strong” cross-loading items were dropped from the analysis until a uniform factor is obtained (Costello and Osborne, 2005). However, the low number of responses obtained in this study should be taken into accounts as this might be the cause of abnormality found in this analysis.

### 5.3 Multiple linear regression analysis for theory testing

The most common and appropriate tools to be used in OM field are multivariate techniques in which more than two variables are being analyzed simultaneously (Forza, C., 2002). Some multivariate techniques that can be used for theory testing according to Forza (2002) are: Multiple linear regression, Multiple discriminant analysis, Multivariate analysis of variance (MANOVA), Multivariate analysis of covariance (MANCOVA), Canonical correlation, and Structural equation modelling. In this study, multiple linear regression is exerted for theory testing. Multiple linear regression is useful for assessing the strength of the relationship between each of a set of *independent variables* and a single *dependent variable* (Landau and Everitt, 2004). Multiple linear regression is normally used when a single metric dependent variable presumed to be related to one or more metric independent variables, meanwhile, when only a single metric independent is involved, it is generally referred to *simple linear regression* (Forza, C. 2002; Landau and Everitt, 2004). Following is the detailed information about the interpretation of multiple linear regression (Landau and Everitt, 2004):

- The outcome of multiple regression analysis is a set of data for each explanatory variable or so-called as *regression coefficient* ($\beta$),
- its conformity can be judged by calculation of the *multiple correlation coefficient* ($R$) or by the examination of *residual or error* ($\varepsilon$),
- the proportion of variability of the response variable accounted for by explanatory variables is expressed by the value of $R^2$,
- the *significance* of regression coefficient can be judge by Student’s t-statistic.

Three variables of supplier-supplier collaboration in NPD were tested for their relationship toward the level of supplier-supplier collaboration as well as the relationship between the level of supplier-supplier collaboration with NPD performance using multiple linear regression
method to test the hypotheses. Level of collaboration factor with higher Cronbach’s alpha coefficient (LC2) is chosen as variable tested with respect to cross-loading phenomenon (Costello and Osborne, 2005). Pearson correlation was employed for the significance test as the data derived from interval measures (Forza, C., 2002). The descriptive statistics and the multiple linear regression result are presented in Table 5. Statistical results suggest that overall level of collaboration between suppliers is above average (mean = 3.806) and so is the performance of NPD project (mean = 3.667). The data shows relatively high variability with respect to all five measures which is probably because of the low number of responses achieved.

The multiple correlation coefficient (R = 0.904) indicates that there is a strong overall correlation between the dependent variable with all the independent variables and the variability is accounted for 81.8% (R² = 0.818) (Landau and Everitt, 2004). The empirical analysis shows mixed results, where two hypotheses are supported and two hypotheses are not supported. Hypothesis 1 states that the intensity of supplier-supplier collaboration in NPD is higher when the NPD project is more complex (H1a) and when the buyer puts more effort to make its suppliers collaborate (H1c). Vice versa, the intensity of supplier-supplier collaboration in NPD is lower when the uncertainty of NPD project is higher (H1b). The regression coefficient shows significance only for buyer’s influence variable (β = 0.663; p < 0.05). It indicates a positive correlation between buyer’s influence and supplier-supplier collaboration. This suggests that buyer can influence the relational behavior of its suppliers during NPD process. More efforts made by buyer will leads to a more robust supplier-supplier collaboration. Buyer is found to have a strong positive relationship in making suppliers collaborate by providing facilities for suppliers to interact with each other and promoting joint activities between the involved suppliers. Intensity of supplier-supplier collaboration above average indicating the level of supplier-supplier collaboration apt to strategic collaboration.

Hypothesis 2 argues that increase in level of supplier-supplier collaboration in NPD process leads to better NPD performance. This hypothesis is empirically supported as the regression coefficient is significant (β = 0.640; p < 0.05). Analysis for Hypothesis 2 does support a relationship between supplier-supplier collaboration and NPD project performance. The stronger the collaboration between suppliers will generate better performance of NPD project. Supplier-supplier collaboration contributes to a successful NPD projects through joint problem solving, joint planning and mutual trust between suppliers. Joint objectives and commitment
built between suppliers play important role in building a long-term strategic collaboration. This finding also confirms the arguments that the key variable of a strategic collaboration in NPD is the existence of competence trust and goodwill trust (Bunduchi, R., 2013). Therefore, it can be concluded that only Hypothesis 1a and Hypothesis 2 are empirically supported.

Interesting phenomenon found in the coefficient regression of buyer’s influence towards NPD performance which shows significant correlation ($\beta = 0.856; p < 0.001$) in Table 5. It signals that supplier-supplier collaboration mediates positive relationship between buyer’s influence and NPD project performance. In other words, buyer’s intention in collaborating its suppliers indirectly affect the NPD project performance. It points out that buyer can attain positive NPD performance by making its suppliers collaborate during the NPD process.

Pearson’s correlation between supplier-supplier collaboration and each indicator of NPD performance was measured and presented in Table 6. The result shows that supplier-supplier collaboration is significantly correlated with cost performance. Further examination on individual indicator of NPD performance as seen in Table 6 reveals that supplier-supplier collaboration strong and positively associated with cost performance. This finding suggests that lower development cost can be achieved by collaborating the suppliers. Saving can be obtained when accessibility of parts can be considered early on, and thus eliminating rework.
and reducing costs (Clark and Fujimoto, 1991, Ragatz et al., 2002). When a goodwill trust exists between suppliers, it may reduce the incentives for suppliers to behave opportunistically, and thus buying company will be able to obtain better term and condition including the price during negotiation. This finding also corroborates the arguments that cooperative relationship between suppliers provide the opportunity for coordinated activities to reduce suppliers’ upstream purchasing costs, for instance, by implementing consolidated purchasing (Choi et al., 2002).

<table>
<thead>
<tr>
<th>Supplier-supplier collaboration</th>
<th>Product quality</th>
<th>Time to market</th>
<th>Cost performance</th>
<th>Innovativeness</th>
<th>Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.553</td>
<td>0.263</td>
<td>0.601*</td>
<td>-0.072</td>
<td>0.546</td>
</tr>
</tbody>
</table>

Correlation is significant at the 0.05 level (2-tailed).

Table 6. Pearson’s correlation of supplier-supplier collaboration and NPD performance indicators

Overall, by putting all the findings for Hypothesis 1 and Hypothesis 2 together, a big picture is summed up, that successful NPD project can be achieved through collaboration during NPD process, not only between buyer and supplier, but also between different suppliers, creating supplier-supplier collaboration. And this collaboration can be realized when buyer step in and promote interaction and coordination to help each other out to resolve some issues during NPD process, and using the leverage of being tertius gauden in buyer-supplier-supplier triad to gain profits by engaging other two actors to collaborate.
The summary of the analysis result is illustrated in Figure 19 below.

Figure 19. Full framework with analysis result
Chapter 6 – Conclusion

6.1 Managerial insights

This study has pointed out some evidences and has shown some theoretical ideas to explain why company should pay attention on maintaining good relationship not only to their suppliers but also between the suppliers, in particular, during developing new product. It is necessary for company to engage the suppliers that they are working with during NPD process to collaborate with each other and work together for achieving a successful NPD performance. A proactive approach should be employed by company in making its suppliers to collaborate, whereas time and resources should be invested by company to encourage and facilitate its suppliers in joint meetings and activities during NPD process (Wu et al., 2010). By engaging the suppliers in several occasions and involving them solve the issue together, a robust relationship can be intertwined between them and thus can lead to strong commitment and trust (Wu et al., 2010). The presence of goodwill trust between suppliers suggests a strategic supplier-supplier collaboration, and it may reduce the incentives for suppliers to behave opportunistically (Bunduchi, R. 2013). When suppliers collaborate in NPD project, it is not only facilitating problem solving, but also learning and knowledge sharing that enables buying company to increase its innovativeness and capabilities.

This study could be useful as well for managers to understand whether the suppliers engaged in a short-term, operational collaboration or a long-term strategic collaboration. It gives a prescription on how to manage the relationship between suppliers in order to obtain a strategic supplier-supplier collaboration and thus enables managers to exploit the advantage of this relationship in NPD project. This study also provides some descriptive statistics about the situation that is happening in industry nowadays that could be useful for managers in terms of decision making.

6.2 Contributions

This study makes several contributions for providing the fundamental theories in building the concept of buyer-supplier-supplier relationship and drags it to the scope of NPD process, and also for developing the quantitative approach in order to test the consolidated theory in real world. The topic about NPD has been widely discussed in literatures, including its best practices to gain successful NPD performance. At the same time, a shift from dyadic buyer-
supplier relationship to triadic buyer-supplier-supplier relationship perspective in supply chain is growing its popularity among scholars within past decade. Yet, the study of buyer-supplier-supplier relationship within the context of NPD is barely touched by scholars. Literatures are mainly focus on the characteristics and the implication of the relationships in general. Moreover, existing literatures are mostly conceptual and case based. Consequently, this study is intended to fill these gaps, both in literature and in methodology.

This study gathers the evidences from literatures to support the foundation theory of supplier-supplier collaboration. The concept of supplier-supplier collaboration has been introduced in this study by adopting several relevant theories including supply network theory as the underpinning of the theory of triadic relationship in supply network. The determinants of supplier-supplier collaboration in NPD project have been explored, again supported by evidences, to construct the first hypothesis and understand what are the determinants of collaboration between suppliers during NPD process. These determinants have been empirically tested through company survey from four different industries and two different countries. However, the determinants of supplier-supplier collaboration for each industry has not been examined, that could be interesting to explore in future study.

NPD performance with multi-dimensional performance indicators are proposed to measure the impact of supplier-supplier collaboration on NPD project performance. While evidences found that suppliers that engaged in collaboration during NPD project is indeed generating positive outcomes towards NPD project performance. It supports the theory that collaboration between suppliers can contributes success to NPD project performance. However, each NPD performance indicator may link to each other has not been evaluated. The correlation between NPD indicators is necessary to investigate as some literatures have discovered the presence of trade-offs between each NPD performance indicator.

Overall, this study has contributed in interpolating the study of supplier-supplier collaboration in the context of NPD project, that can be a good starter for further in-depth investigation of suppliers’ relationship in NPD process. Additionally, the quantitative approach that has been used as methodology in this study could be useful as a guideline for future research.
6.3 Limitation and opportunity for future research

This paper has main limitation in number of responses collected from survey. This caused high variability of the data and some minor deviations that can lead to bias in analysis. It suggests for a major concern in data collection planning and strategy in order to reach more respondents and collect more data for a better analysis result. By increasing the number of data collected, it is possible to reduce the variability and thus improve the quality of the data. Hence, accuracy and reliability of the measurements can be enhanced and thus analysis for hypothesis testing can be carried out more precisely. More data will also allow more analysis to perform that gives opportunity for researcher to dig more information and findings that are worth to discuss.

In terms of measurement instruments, the questions drafted in the questionnaires were taken from literatures with some necessary modifications. Therefore, some discrepancies were found with respect to the original work. However, the context of measurement indeed different from the previous work that may suggest distinct results.

Another suggestion for future research is related to source of data. In this study, questionnaires were delivered to buying companies only. It recommends future researcher to involved the suppliers as well in the survey. Further examination of supplier-supplier collaboration from supplier’s side is necessary to perform. In this way, researcher will be able to obtain more insights in term of supplier-supplier relationship from the supplier’s side and uncover more findings that can support the study. Moreover, researcher may expand the investigation to higher level in order to understand how the collaboration between suppliers in buyer’s NPD project may benefit them. With the facts of benefit achieved from the perspective of buyer and supplier will make the collaboration more desirable for both actors, therefore, will contribute more for managers in their effort to make suppliers to collaborate.
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BIBLIOGRAPHY


**APPENDIX**

**Appendix A. Original Question Items Used in Survey**

**A1. Descriptive Questions**

Q1. Which country is your company headquarter located?
Q2. What is your company’s turnover of the last fiscal year?
Q3. What is the number of employees of your company?
Q4. Did your company involve the suppliers during the New Product Development (NPD) process?
Q5. How many suppliers were involved in that NPD project?

To answer the questions below, please think about two most relevant suppliers that were involved in the NPD project referred before (namely Supplier A & Supplier B).

Q6. Was the component critical for the developed product?

Following is the stages of the NPD process:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q7. In which stage of NPD process was the supplier involved?

<table>
<thead>
<tr>
<th>Supplier A</th>
<th>Supplier B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2/3/4/5/6</td>
<td>1/2/3/4/5/6</td>
</tr>
</tbody>
</table>

Q8. Please specify how the components supplied by two suppliers were used in the developed products:

- Components used as raw material/parts of the developed product
- Components used as complementary/supporting element of the developed product (eg. packaging)
Please indicate the extent to which you agree or disagree with the following statements about this project, your plant and organization. Measures for Q9 – Q14 and Q19 – Q39 used a 5-point Likert scale. Measures Q15 – Q18 is multiple choice.

**A2. Project Complexity (PC)**

Q9. This project included many tasks.
Q10. It was difficult to define tasks in the beginning of the project.
Q11. The tasks in this project were highly interdependent.
Q12. There were many departments involved with this project.
Q13. It was difficult to coordinate changes during the product development process.
Q14. Overall, this was a relatively complex or difficult project.

**A3. Project Uncertainty (PU)**

Q15. The market for the developed product was:
   1. An existing market that we served.
   2. An existing market, but new to this company
   3. The market did not exist prior to development of this product
Q16. The product technology for this product was:
   1. Available within the company
   2. New to the company, but available from outside
   3. New to the world
Q17. The process technology used to produce this product was:
   1. Similar to technology we had used before
   2. Required major changes in existing manufacturing
   3. Completely new
Q18. The supplier which collaborated during the development of this product was:
   1. Existing suppliers who have collaborated in product development projects with buying firm previously
   2. Existing suppliers but never have collaboration in product development projects before
   3. New suppliers
A4. Level of supplier-supplier collaboration (LC)

Q19. Supplier A and Supplier B interacted with each other directly on regular basis.
Q20. Supplier A and Supplier B shared operational related information (e.g. technical data, material availability, shipping schedule).
Q21. Supplier A and Supplier B shared tacit information and knowledge (e.g. specific know-how, exchanging & negotiating ideas, joint problem solving).
Q22. Supplier A and Supplier B used integrated Information Technology (IT) tools to share required data and files (e.g. synchronous email groupware, cloud-based file sharing).
Q23. Supplier A and Supplier B used integrated product design and project management IT tools to perform routine new product development (NPD) tasks. (e.g. Computer-aided design (CAD), Computer-aided process planning (CAPP), shared parts database, simulation modelling, project management software).
Q24. Supplier A and Supplier B share the same vision & business objectives within this relationship.
Q25. Supplier A and Supplier B advise each other of any potential problems in meeting your company’s needs.
Q26. Supplier A and Supplier B trust each other that no one will behave opportunistically and have commitment to support and continue the relationship instead.
Q27. Supplier A and Supplier B trust each other’s competences, or professional standards, in carrying out the task.

A5. Buyer’s Influence

Q28. We provided occasions (e.g., social settings, meetings, forums and conferences, etc.) where Supplier A and Supplier B can meet and talk in the scope of our NPD process.
Q29. We encouraged Supplier A and Supplier B to work on issues (i.e. quality, delivery, process engineering, etc.) together.
Q30. Our contractual agreements with Supplier A and Supplier B was promoting collaboration between them.
Q31. We encouraged Supplier A and Supplier B to help each other out if they encounter problems during NPD process.
APPENDIX

Q32. We encouraged Supplier A and Supplier B to coordinate their activities without our direct involvement.

A6. New Product Development Performance

Please rate the success of this NPD project in comparison to the initial targets.

Q33. Product Quality
Q34. Time to market
Q35. Cost / Development expenses
Q36. Innovativeness
Q37. Sustainability
### Appendix B. Survey Responses

#### B1. Descriptive Questions Responses

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<th>Q6</th>
<th>Q7</th>
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B1. Project Complexity, Project Uncertainty, Level of Supplier-supplier Collaboration, Buyer’s Influence, and NPD Performance Responses

Measures for Q9 – Q14 and Q19 – Q39 used a 5-point Likert scale. Measures Q15 – Q18 is multiple choice.

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