EXAMINING NEW PRODUCT DEVELOPMENT SPEED IN MANUFACTURING FIRMS IN PENANG: INFLUENCE OF EXTERNAL INTEGRATION AND INTER-ORGANIZATION RELATIONSHIP

By

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ABSTRACT

Ever shortening product life-cycle and intense competition to capture first mover advantage has forced manufacturing firms to continuously improve their new product development (NPD) speed. In today's globalized market, it is not possible to win time-based competition by developing new products by a firm itself. Manufacturing firms need to leverage the technologies, resources and market knowledge held by their suppliers, customers and research institutes to speed up the NPD processes. This research aimed to assess external integration as the predictor for NPD speed. External integration in this research included customer involvement, supplier involvement and third party collaboration. Inter-organization relationship as a mediator for the relationship between external integration and NPD speed was studied. This research applied the quantitative research method with close-ended survey questionnaires. The research population was the manufacturing firms in Penang that engaged in the NPD processes. Thus, the unit of analysis was the organization of the manufacturing firm. Based on the sample of 51 manufacturing firms in Penang, customer involvement and third party collaboration were found positively and negatively predicting inter-organization relationship respectively. Positive relationship between customer involvement and NPD speed was also confirmed. There was no significant relationship between inter-organization relationship and NPD speed as well as between third party collaboration and NPD speed. The mediating role of inter-organization relationship on the relationship between external integration and NPD speed was not significant. This research confirmed third party collaboration as the third dimension of external integration when third party collaboration was correlated to inter-organization relationship. However, when third party collaboration was correlated to NPD speed, the former could not be empirically validated as the third dimension of external integration. This research confirmed the importance of involving customers in the NPD processes to speed up NPD.

Keywords: new product development speed, external integration, customer involvement, third party collaboration and inter-organization relationship.

ABSTRAK

Pemendekan kitaran hayat produk dan persaingan sengit untuk menguasai kelebihan sebagai penggerak yang pertama telah memaksa firma pembuatan untuk mempercepatkan pembangunan produk baharu (PPB) mereka secara berterusan. Dalam pasaran global masa kini, tidak mungkin sesebuah firma mampu mendahului pesaingnya dalam membangunkan produk baharu dengan hanya bergantung kepada keupayaan firma itu sendiri. Firma pembuatan perlu memanfaatkan teknologi, sumber dan pengetahuan pasaran yang dipegang oleh pembekal, pelanggan dan institusi penyelidikan untuk mempercepatkan proses PPB. Kajian ini bertujuan untuk menilai integrasi luaran sebagai peramal bagi kepantasan PPB. Integrasi luaran dalam penyelidikan ini merangkumi penglibatan pelanggan, penglibatan pembekal dan kerjasama pihak ketiga. Hubungan antara organisasi sebagai pengantara bagi hubungan di antara integrasi luaran dengan kepantasan PPB telah diselidiki. Kajian ini menggunakan kaedah penyelidikan kuantitatif melalui penggunaan soal selidik tinjauan pertanyaan tertutup. Populasi penyelidikan ialah firma pembuatan yang terlibat dengan proses PPB di Pulau Pinang . Oleh itu, unit analisis ialah organisasi firma pembuatan. Berdasarkan 51 sampel firma pembuatan di Pulau Pinang, penglibatan pelanggan dan kerjasama pihak ketiga masing-masing didapati menjadi peramal positif dan negatif bagi hubungan antara organisasi. Hubungan positif di antara penglibatan pelanggan dengan kepantasan PPB juga telah disahkan. Tiada hubungan yang signifikan di antara hubungan antara organisasi dengan kepantasan PPB serta hubungan di antara kerjasama pihak ketiga dengan kepantasan PPB. Peranan perantaraan bagi hubungan antara organisasi terhadap hubungan di antara integrasi luaran dengan kepantasan PPB didapati tidak signifikan. Kajian ini mengesahkan bahawa kerjasama pihak ketiga boleh dianggap sebagai dimensi ketiga bagi integrasi luaran apabila kerjasama pihak ketiga dikaitkan dengan hubungan antara organisasi. Namun, apabila dikaitkan dengan kepantasan PPB, kerjasama pihak ketiga tadi tidak dapat disahkan secara empirik sebagai dimensi ketiga bagi integrasi luaran. Kajian ini mengesahkan kepentingan melibatkan pelanggan dalam proses PPB bagi mempercepatkan PPB sesebuah firma.

Kata kunci: kepantasan pembangunan produk baharu, integrasi luaran, penglibatan pelanggan, kerjasama pihak ketiga dan hubungan antara organisasi.

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LIST OF ABBREVIATIONS

DV	Dependent variable
E&E	Electrical and electronic
FMM	Federation of Malaysian manufacturers
IV	Independent variable
Med	Mediating variable
MIDA	Malaysian investment development authority
NPD	New product development
NPI	New product introduction
R&D	Research and development
GERD	Gross domestic expenditure on R&D
KSAO	Knowledge, skills, ability and other attributes
KPI	Key performance indicator
MNC	Multi-national corporation
GDP	Gross domestic product
PPB	Pembangunan produk baharu
PPRN	Public-private research network
SME	Small and medium-sized enterprises

CHAPTER 1

INTRODUCTION

1.0 Introduction

Chapter one begins with introduction of background for this research and explains why this research is important for academia and practitioners in Penang in section 1.1. It also explains the current issues experienced by academia and practitioners. This chapter subsequently explains the current research gaps that this research aims to fill. Based on understanding of research gaps through literature review, analyzing current business environment and collecting feedback from subject matter experts, problem statements of this study are identified and explained in section 1.2. Research questions and research objectives are subsequently developed and presented in section 1.3 and section 1.4 respectively. Next, scope and limitation of this study are listed in section 1.5. Significance of research is then highlighted in section 1.6. Chapter one ends with definition of key terms and explanation of how this thesis is organized in section 1.7 and section 1.8 respectively.

1.1 Background of the study

In the first quarter of 2018, Malaysia's economy registered a healthy growth of 5.4% with service and manufacturing sectors remained as the anchor of economy. As retrieved on the first of June 2018, data from Department of Statistics Malaysia's official website showed that service sector contributed 54.8% to Malaysia's gross domestic product (GDP) followed by 22.8% from manufacturing sector. Compared to the fourth quarter of 2017, manufacturing sector grew 5.3% in the first quarter of 2018, led by electrical, electronic and optical products (Department of Statistics Malaysia,

2018). Malaysia's gross domestic expenditure on research and development (R&D) as a percentage of GDP (GERD/GDP) was valued at 1.30% in 2015 with business enterprise sector (51.95%) being the major contributor, followed by higher learning institutions (28.48%), government agencies and research institutes (19.56%) (Ministry of Science, Technology and Innovation, 2018).

Akoum (2016) reported that R&D, science and technology indicators had been associated with economic development indicators. To inspire more R&D investments in business enterprises, Malaysian government provided support to business enterprises by offering incentives and grants. Malaysian government's emphasis on R&D was also reflected in the 11th Malaysia Plan 2016-2020. As reported in Malaysian Investment Development Authority's (MIDA) official website retrieved on the first of June 2018, Global Competitiveness Report 2016-2017 ranked Malaysia eighth and eleventh out of 148 countries in "company spending on R&D" and "university-industry collaboration in R&D" respectively. Malaysia's National Science, Technology and Innovation Policy targeted to achieve at least 2.0% GERD/GDP by 2020 (MIDA [Malaysian Investment Development Authority], 2018). Recognizing the important role played by manufacturing firm's R&D in generating future economic growth, research in the area of manufacturing firm's R&D was selected for this dissertation.

According to Awwad and Akroush (2016), changing business environment was the most important factor that drove companies to develop new product at increasing speed in order to sustain its competitive advantage. Companies spent significant amount of their revenue on R&D, hoping to stay ahead of competition by developing new products that exceed customer needs and at higher speed than competitors did. Jos and

Ton Van (2012) reported that product life cycle was becoming shorter in many industries due to the influence of fashion trend and more severe global competition. Today's business environment changes continuously due to rapid changes in customer's expectation, new technology proliferation, shorter product life cycle and increasing product varieties. As shown in Figure 1.1, consumer electronic industry had the shortest development cycle time and shortest useful product life span. Which meant consumer electronic industry was the most sensitive industry to being late to market due to their very short product life span. Late to market meant reduced useful product life span and a significant percentage drop in revenue (Shuler, 2011). Shortening product life span led to shorter time to market and time to volume. Which resulted in quicker implementation of targeted quality and productivity (Plewa, 2017). Based on research findings presented above, the scope of this research was refined to focus on new product development (NPD) speed in manufacturing firms only.

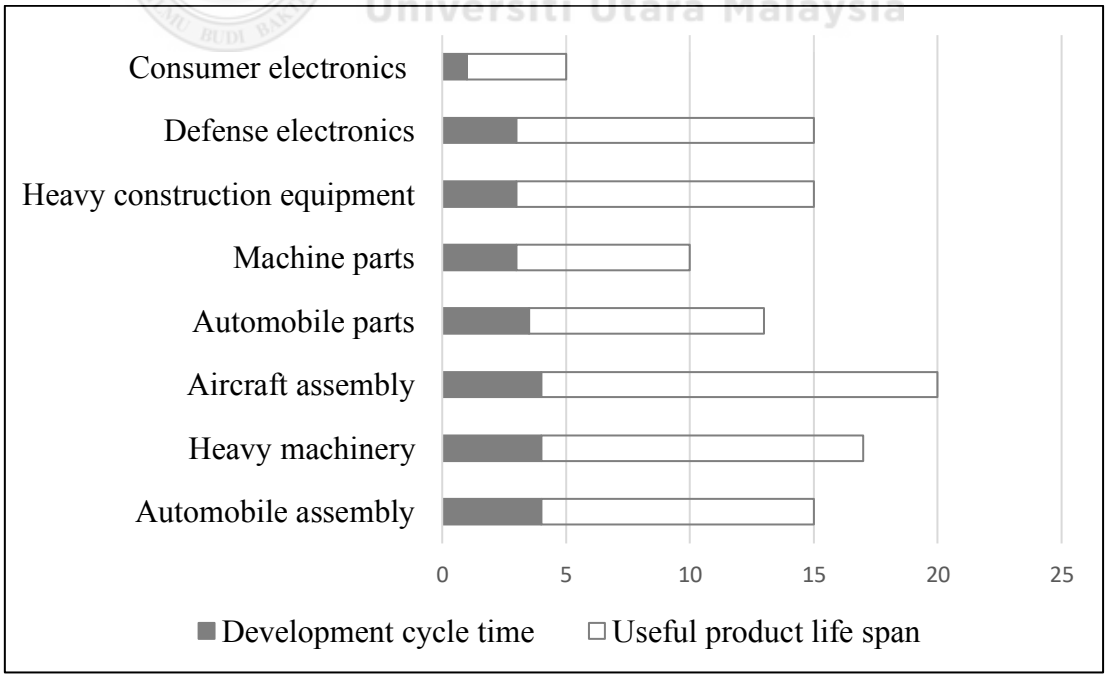

Figure 1. 1
Development cycle time and useful product life span by industry in year
Source: Shuler, 2011

Year	1	2	3	4
First mover firm	Development	Selling in market (revenue generation)		
Follower firm	Development		Selling in market (revenue generation)	

Figure 1. 2
Impact of new product development speed on company's revenue

Figure 1.2 further illustrates this concept schematically. Assuming a scenario of two companies producing a same product and competing in the same market. The product they produce will obsolete from the market by end of year four whereby it will be replaced by a new generation product. The company that launches new product to the market first is the first mover firm while the second company that launches the same product later is the follower firm. First mover firm takes one year to develop the new product and start selling to the market from year two to year four. Follower firm takes two years to develop the same product. Hence, follower firm only able to sell its product from year three to year four. First mover firm with higher NPD speed enjoys first mover advantage and able to generate revenue for longer time. After product launching, follower firm may face another challenge of entering the existing market that first mover firm monopolizes. Existing customers may be used to the design and feature of first mover firm's product as well – consumer inertia. As a result, follower firm may not survive this competition just because of its slower NPD speed. As a result, NPD speed is becoming more critical in the era of time-based competition like today.

Statista (2017) revealed that computing and electronic industry spent the most (23.1% of sales revenue) on R&D, followed by healthcare (22.7%) and automotive (15.5%) industry in 2017. Successful multinational corporations reinvest significant amount of their revenue in R&D every year to innovate and continue staying ahead of highly competitive global competition. Being the leading industry in Malaysia's manufacturing sector, electrical and electronic industry contributed significantly to Malaysia's export (36.6%) and employment (25.3%) in 2016 (MIDA, 2018). Penang contributed 12.8% of Malaysia's overall manufacturing revenue in 2015. It was also the biggest contributor in northern region of Malaysia. Manufacturing sector contributed 44.7% of Penang's commercial activities in 2015 with electrical and electronic industry being the main contributor (MIDA, 2017).

Electrical and electronic (E&E) industry was also the leading industry in overall Malaysia's manufacturing sector. Electronic components, consumer electronics, industrial electronics and electrical products were the four categories of E&E industry in Malaysia (Invest Penang, 2018). Semiconductor industry was part of electronic component sector, which contributed significantly to Penang's manufacturing industry. It had been empirically proven numerous times by previous researchers that high NPD speed contributed to high manufacturing firm's performance (Akroush, 2012; Carbonell & Rodríguez Escudero, 2010; Chen, 2007; Feng & Wang, 2013; Gök & Peker, 2017; Langerak & Hultink, 2005; Lim, Sharkey & Heinrichs, 2006; Schuh, Riesener & Koch, 2017). Therefore, the understanding of factors contributing to high NPD speed was very important for manufacturing firms in Penang in order to stay competitive. However, research on NPD speed in Penang's manufacturing firms was

limited in literature. As a result, the scope of this research was further refined to focus on NPD speed in Penang's manufacturing firms.

NPD speed is the speed of development processes for a new product. Chen (2007) explained that there were many other terms describing NPD speed in literature, namely speed-to-market, time-to-market, innovation speed, cycle time, lead-time and NPD timeliness. It could also be called project time, project duration, time-efficiency, adherence to schedule, time performance and time-based performance. Time to market is the time taken from product idea conception until the product is launched to the market for sales. Time to market is shorter if NPD speed is high. NPD speed is crucial for industries with short product life span or market demands frequent product upgrades.

A number of researchers agreed that NPD speed was a strong predictor for company performance because it enabled faster launching of new products to the market, which in effect catalyzed the growth of company revenue (Akroush, 2012; Carbonell & Rodríguez Escudero, 2010; Langerak & Hultink, 2005; Lim et al., 2006). It was reported that NPD speed significantly influenced market performance directly (Feng & Wang, 2012). Wong, Avenida and Tong (2011) argued that the two items important for manufacturing firms to succeed in a highly competitive business environment were speed of product introduction and on-time launch of new products. Su et al. (2013) revealed that the companies that introduced new technologies to the market faster, enjoyed competitive advantage over its competitors. Dumaine as cited in Feng and Wang (2013) reported that firms with high NPD speed established industry standards and developed technology edges. Advancement in technology and internet caused rapid changes in technology industry. As a result, NPD cycle time reduction

became increasingly important for technology firms to survive in highly competitive business environment (Liu et al., 2012; Saji & Mishra, 2012). Feng and Wang (2013) reported that firms needed to speed up NPD processes in order to maintain profitable growth by continuously introducing new products to the market. This was due to rapid shortening of product life cycle and fast obsolescence of products in the market. In addition, Zao et al. as cited in Feng and Wang (2013), reported that speedier NPD compared to competitors could enhance customer satisfaction and improve customer loyalty.

Wherever possible, product development activities should run concurrently in order to reduce development cycle times (Stark, 2015). If product development activities at each component supplier were managed concurrently, NPD could be significantly sped up. Ever shortening product life-cycle and intense competition to capture first mover advantage forced manufacturing firms to continuously improve their NPD speed. Stalk and Hout (1990) argued that fast NPD was a key component of time-based strategy and was critical to achieve time-based advantage (as cited in Chen, 2007, p. 2). A company could have first-mover advantage or fast follower advantage by having high NPD speed. In order to compete in today's highly competitive business environment, manufacturing firms in Malaysia must know the factors that significantly contribute to high NPD speed. Only with product innovation and high NPD speed, companies in Malaysia will be able to compete globally. Foreign multinational companies will also relocate their R&D division out of Malaysia if their subsidiary in Malaysia cannot innovate and develop new product fast enough compare to their R&D divisions in other countries. Cirera and Sabetti (2016) reported a positive direct relationship between innovation and employment rate. However, it was at a decreasing

rate as firms transition from developing to the technological frontier. This finding was valid in Malaysia context as Malaysia was a developing country.

Due to advantages of being a market leader, market participants in manufacturing industries always compete to develop and introduce first-of-a-kind product to the market first. Gómez-Villanueva and Ramírez-Solís' (2013) finding reinforced the view that first mover firm had advantages over follower firms. For industrial products, once your customer design-in your new product as its component, your competitors will be forced to follow your design in order to win second source business with your customer. However, this is only possible if customer fully owns the product design. Nevertheless, it is always not easy to copy design in manufacturing industry due to protection by patent law and intellectual property (IP) if the first mover firm owns the design's patent exclusively. Besides, switching cost is also high in high technology industries, especially for automotive and medical industries. Al-kwifi, Ahmed and Yammout (2014) revealed that the cost associated with overcoming technology incompatibility of medical technology products was remarkably high, which prevented users from switching to a new supplier. Huan and Hsieh (2012) found that product complexity was a key antecedent to switching cost. Switching cost is also contributed by reliability test, safety test and qualification requirements which are costly and time consuming to complete. There are some basic quality requirements that manufacturing industries need to follow. For consumer products like electronic devices, once a user used to the features and user interfaces of a specific brand, he/she will most likely stick to the same brand in his/her next purchase. Unless, he/she was disappointed by his/her first trial.

For companies that engaged in low cost marketing strategy, NPD speed was more important compared to quality (Le & Hui, 2018). For industries that cost of quality is not too high compare to time to market, management sometimes has to make conscious decision to launch their product first while improving their process yield in parallel, as long as product quality and performance minimally meet customer's specification. LED (Light Emitting Diode) industry for example, manufacturers need to develop new platforms (completely new design) or new proliferations (with components change to upgrade performance or quality) every six or three months respectively in order to compete and gain design-win (customer design in your product into their new product) with key customers. This is in line with some major trade shows or exhibitions that happen every quarter. Trade shows or exhibitions are the places where customers meet their potential suppliers with latest technologies that they are looking for.

NPD speed is an important KPI (key performance indicator) in manufacturing industry. Catic and Sobek (2013) reported that the high level performance indicators commonly used for product development performance were time-to-market, budget, schedule and innovation rates. If one of the many component manufacturers fails to meet the committed development schedule, the market launch of the end product will also be delayed even though all other component manufacturers meet their committed development schedule, especially for companies that use concurrent development approach. As such, good coordination and relationship among key stakeholders are important to manufacturing industry's NPD success. NPD success warrants future growth of a profit making company.

With the above reasons explained, NPD speed was deemed crucial for manufacturing firms' survival, whereby many of them are located in Penang state's free industrial zones. Although NPD speed of a manufacturing firm was proven important to survive global competition, there was still lack of similar research done in Malaysia context. Moreover, Malaysia's economy depended significantly on manufacturing sector. Manufacturing sector contributed 22.8% of Malaysia's 2018 first quarter GDP (Department of Statistics Malaysia, 2018). It is now clear that achieving high NPD speed is important for manufacturing firms in Penang. The next step is to decide which antecedent of NPD speed that this research needs to focus on.

Due to multi-cultural values of Malaysia, the previous findings on the relationship between NPD speed and inter-organization relationship reported by researchers abroad most likely could not be generalized to Malaysia context. Previous studies on the relationship between NPD speed and inter-organization relationship were mainly conducted in Taiwan, Hong Kong, Norway, the United States of America and China (Athaide, Stump & Joshi, 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons, Haugland, Grønhaug & Hammervoll, 2011; Trainor, Krush & Agnihotri, 2013). Organizational culture or national culture might influence inter-organization relationship, depending on which factor dominated. In organizational culture, each organization can be viewed as a separate cultural system. McAdam, Moffett and Peng (2012) reported that non-Chinese conceptions of knowledge sharing could result in misleading approaches being used to promote knowledge sharing in a Chinese organization or firm. Therefore, it is important to empirically validate the effect of inter-organization relationship on NPD speed in Malaysia context. Research gap identified

is the direct relationship between inter-organization relationship and NPD speed, which is later addressed by hypothesis H3 in section 3.2.

NPD activities are extending from an individual firm to the entire supply chain in today's dynamic and uncertain business environment (Hoegl & Wagner; Ren & Hu as cited in Zhang & Yang, 2016). In today's globalized market, it is not possible to win competition by conducting NPD processes by a firm itself. Manufacturing firms need to leverage the technologies, resources and market knowledge own by their external business partners like suppliers, customers and their collaborated third party partners to speed up NPD processes. Third party in this research refers to impartial research institute or university. The key external business partners for manufacturing firms are their customers and suppliers.

Previous studies revealed mixed results on the relationship between NPD speed and customer involvement (Lau, 2011; Wong et al., 2011; Feng & Wang, 2012; Wong & Tong, 2012; Lin & Huang, 2013; Feng, Cai, Zhang & Liu, 2016) as well as between NPD speed and supplier involvement (Danese & Filippini, 2010; Lau, 2011; Feng & Wang, 2012; Tsai, Tsai & Wang, 2012). In addition, previous empirical researches using customer involvement and supplier involvement as independent variables to predict NPD speed in Malaysia context were also limited. Furthermore, mixed results from previous studies warranted a confirmation study, which was still lacking. Previous studies were mainly conducted in countries with very different national culture compared to the multi-cultured Malaysia. A Malaysia specific research to determine the factors that significantly contribute to high NPD speed was required. Therefore,

these research gaps were identified and hypotheses H1a and H1b were created to address these research gaps.

Besides customer and supplier, third party (university or research institute) was increasingly viewed as another important external partner that influenced the success of a company's NPD projects. Although third party collaboration was commonly known by practitioners to play an important role in manufacturing firm's NPD processes, literature on the direct relationship between third party collaboration and NPD speed was still lacking. To close this research gap, hypothesis H1c was created to test the significant direct relationship between third party collaboration and NPD speed in Penang's manufacturing firms.

Customer involvement and supplier involvement were the two dimensions of external integration reported in literature (Chen, 2007; Lau, 2011; Feng & Wang, 2012; Wong & Tong, 2012; Feng et al., 2016). Guimón (2013) reported that collaboration between academia and industry was increasingly regarded as a critical component of efficient national innovation system. Due to the growing focus on third party collaboration in industry and increasing support by the government (MIDA, 2018), this research included third party collaboration as the third dimension of external integration and intended to empirically confirm its predictive effect on NPD speed. The addition of third party collaboration as the third dimension of external integration made this study special and was expected to add knowledge in the field of NPD study. This research gap of not having third party collaboration in external integration was addressed by hypotheses H1, H2 and H4 in section 3.2 whereby external integration

was defined as consisted of three dimensions, namely customer involvement, supplier involvement and third party collaboration.

In order to maximize technology sharing and knowledge flow among customer, supplier and the collaborated third party, inter-organization relationship plays an important role. Lin and Huang (2013) found that customer participation with information sharing had a significant and positive impact on inter-organizational relationship, which in turn positively influenced NPD time efficiency. Cultural influences on inter-organization relationship made the results from previous similar studies conducted abroad difficult to be generalized to Malaysia context (Athaide et al., 2003; Mons et al., 2011; Lin & Huang, 2013; Trainor et al., 2013; Feng & Zhao, 2014). The behavior of cultural exchange between two cultural systems can be very different in different cultures. This complexity is further compounded by the unique multicultural values inherited by Malaysian. Take uncertainty avoidance cultural dimension as an example, a company in a country that scores high in uncertainty avoidance tends to build good relationship with its business partners as priority to avoid ambiguous situation in all aspects of their daily business dealings (Hofstede & Hofstede, 2005). Nevertheless, research on the direct relationships between external integration, customer involvement, supplier involvement and third party collaboration with inter-organization relationship in Malaysia context was limited. This limitation formed research gaps and they were being addressed by hypotheses H2, H2a, H2b and H2c respectively in section 3.2.

The extend of market information sharing and technology sharing as well as project coordination effectiveness between manufacturing firm and its customer, supplier and collaborated third party depends on their mutual trust and inter-organization bonds. Henderson (2014) revealed that trust had a moderating effect in forming and maintaining business relationships as it reduced uncertainty and the perception of risk. Tutore (2013) reported that national culture strictly embedded in the corporate social or environmental behaviors. Due to cultural influence of inter-organization relationship, similar mediating effect of inter-organization relationship in Malaysia's manufacturing firms might be different from the results obtained in other national cultures or regions (Lin & Huang, 2013). Nevertheless, empirical study in this aspect when used customer involvement as independent variable was still lacking in Malaysia context. On the other hand, similar researches using the other two dimensions of external integration, namely supplier involvement and third party collaboration as independent variables were also limited in literature. Previous research findings on the mediating role of inter-organization relationship needed to be validated in Malaysia context as well (Lin & Huang, 2013). All these limitations formed research gaps and hypotheses H4, H4a, H4b and H4c addressed them in section 3.2.

At this stage, it was clear that the antecedents of NPD speed that this research aimed to investigate were external integration, customer involvement, supplier involvement, third party collaboration and inter-organization relationship. Dependent variable for this research was NPD speed. Independent variables being examined in this research included external integration and its three dimensions of customer involvement, supplier involvement and third party collaboration. This study aimed to explore third party collaboration as the third dimension of external integration.

The result of this study would help Penang's manufacturing firms to remain competitive. At the same time, highly competitive MNC's (Multi National Corporation) subsidiaries in Penang would also prevent the holding companies from relocating their subsidiaries to other less costly labor markets around this region like Vietnam, Indonesia, etc. This would directly maintain Malaysia's job opportunities and warrant a sustainable national economic growth. In addition, Bogliacino and Vivarelly (2010) also revealed that R&D expenditures had a job-creating effect.

A better understanding of the effect of customer involvement, supplier involvement and third party collaboration on NPD speed from this study aimed at enhancing Penang manufacturing firms' global competitiveness. A better knowledge about inter-organization relationship would also help firms managing their customers, suppliers and third party collaboration partners' inter-organization bonds better. This was in turn, expected to result in higher NPD speed and subsequently result in higher company performance.

1.2 Problem statement

Manufacturing industry contributed 22.8% of Malaysia's GDP in the first quarter of 2018 with electrical and electronic sector being the main contributor (Department of Statistics Malaysia, 2018). Majority of northern Malaysia's manufacturing firms were located in Penang state. NPD speed had been empirically proven as the key determining factor for manufacturing firm's market and financial performances (Akroush, 2012; Carbonell & Rodríguez Escudero, 2010; Chen, 2007; Feng & Wang, 2013; Gök & Peker, 2017; Langerak & Hultink, 2005; Lim, Sharkey & Heinrichs, 2006; Schuh, Riesener & Koch, 2017).). In spite of its importance, research on manufacturing firm's

NPD speed in Penang was still lacking. This literature gap triggered further investigation of NPD speed in Penang's manufacturing firms by this research.

It was a challenge to generalize similar behavioral studies conducted abroad to Malaysia context due to its unique multicultural values. The following studies were conducted abroad but still lacking in Malaysia context. Firstly, the relationships between customer involvement and supplier involvement with inter-organization relationship (Athaide et al., 2003; Mons et al., 2011; Lin & Huang, 2013: Feng & Zhao, 2014). Secondly, the relationship between inter-organization relationship and NPD speed (Athaide et al., 2003; Mons et al., 2011; Lin & Huang, 2013; Trainor et al., 2013; Feng & Zhao, 2014). Thirdly, the relationship between customer involvement and supplier involvement with NPD speed (Danese & Filippini, 2010; Lau, 2011; Wong et al, 2011; Feng & Wang, 2012; Tsai et al., 2012; Wong & Tong, 2012; Lin & Huang, 2013; Feng et al., 2016). Lastly, the mediating effect of inter-organization relationship on the relationship between customer involvement and NPD speed (Lin & Huang, 2013). Effective intercultural communication was pivotal to maintain good inter-organization relationship (Harvey & Griffith, 2002). Lack of research on the six relationships highlighted above in Malaysia context was identified as research gaps and this research aimed to close these research gaps by empirically testing these six relationships in Malaysia context.

Even though supplier involvement was reported in literature as the second dimension of external integration, research studying the mediating effect of inter-organization relationship on the relationship between supplier involvement and NPD speed was still lacking in literature (Chen, 2007; Lau, 2011; Feng & Wang, 2012; Wong

& Tong, 2012; Feng et al., 2016). This research aimed to close this research gap by exploring the mediating effect of inter-organization relationship on the relationship between supplier involvement and NPD speed in manufacturing firms located in Penang.

It was apparent that university-industry collaboration had become increasingly important and financially supported by governments in the form of grants and incentives. Malaysian government also strongly supported this effort (MIDA, 2018). Nevertheless, research to empirically confirm third party collaboration as another significant dimension of external integration was still lacking. In closing this research gap, this research redefined external integration as consisted of customer involvement, supplier involvement and third party collaboration. This new external integration variable was tested in this research as independent variable predicting NPD speed and inter-organization relationship.

Third party collaboration being tested as independent variable to predict NPD speed as well as inter-organization relationship were limited in literature. Therefore, research gaps were identified for the following relationships. Firstly, the relationship between third party collaboration and inter-organization relationship. Secondly, the relationship between third party collaboration and NPD speed. Lastly, the mediating effect of inter-organization relationship on the relationship between third party collaboration and NPD speed. To close these research gaps, this research targeted to explore the above three relationships in Penang's manufacturing firms with third party collaboration being the independent variable. Table 1.1 summarized the identified research gaps that this research intended to close.

Table 1. 1
Research gaps identified

			Literature availability				This research's aim
IV	**Med**	**DV**	**Worldwide**	**Research gap**	**Malaysia context**	**Research gap**	
EI	-	NPDS	Lacking	Yes	Lacking	Yes	Explore
CI	-	NPDS	Yes	No	Lacking	Yes	Replicate
SI	-	NPDS	Yes	No	Lacking	Yes	Replicate
TPC	-	NPDS	Lacking	Yes	Lacking	Yes	Explore
EI	-	IOR	Lacking	Yes	Lacking	Yes	Explore
CI	-	IOR	Yes	No	Lacking	Yes	Replicate
SI	-	IOR	Yes	No	Lacking	Yes	Replicate
TPC	-	IOR	Lacking	Yes	Lacking	Yes	Explore
IOR	-	NPDS	Yes	No	Lacking	Yes	Replicate
EI	IOR	NPDS	Lacking	Yes	Lacking	Yes	Explore
CI	IOR	NPDS	Yes	No	Lacking	Yes	Replicate
SI	IOR	NPDS	Lacking	Yes	Lacking	Yes	Explore
TPC	IOR	NPDS	Lacking	Yes	Lacking	Yes	Explore

Note: IV = independent variable; Med = mediating variable; DV = dependent variable; EI = external integration; CI = customer involvement; SI = supplier involvement; TPC = third party collaboration; IOR = inter-organization relationship; NPDS = new product development speed.

In summary, total 14 research gaps were identified and listed as following:

Research gap 1: Lack of research verifying third party collaboration as the third dimension of external integration.

Research gap 2: Lack of research investigating the relationship between external integration and new product development speed in Malaysia context.

Research gap 3: Lack of research investigating the relationship between customer involvement and new product development speed in Malaysia context.

Research gap 4: Lack of research investigating the relationship between supplier involvement and new product development speed in Malaysia context.

Research gap 5: Lack of research investigating the relationship between third party collaboration and new product development speed in Malaysia context.

Research gap 6: Lack of research investigating the relationship between external integration and inter-organization relationship in Malaysia context.

Research gap 7: Lack of research investigating the relationship between customer involvement and inter-organization relationship in Malaysia context.

Research gap 8: Lack of research investigating the relationship between supplier involvement and inter-organization relationship in Malaysia context.

Research gap 9: Lack of research investigating the relationship between third party collaboration and inter-organization relationship in Malaysia context.

Research gap 10: Lack of research investigating the relationship between inter-organization relationship and new product development speed in Malaysia context.

Research gap 11: Lack of research investigating the mediating role of inter-organization relationship in the relationship between external integration and new product development speed in Malaysia context.

Research gap 12: Lack of research investigating the mediating role of inter-organization relationship in the relationship between customer involvement and new product development speed in Malaysia context.

Research gap 13: Lack of research investigating the mediating role of inter-organization relationship in the relationship between supplier involvement and new product development speed in Malaysia context.

Research gap 14: Lack of research investigating the mediating role of inter-organization relationship in the relationship between third party collaboration and new product development speed in Malaysia context.

1.3 Research questions

To fill the research gaps identified in section 1.2 above, this study was developed to test a conceptual framework describing the effect of external integration on NPD speed and the mediating effect of inter-organization relationship. The three external integration's dimensions of interest in this study were customer involvement, supplier involvement and third party collaboration. Third party collaboration was an added dimension for external integration based on feedback from practitioners and literature review. Research gap 1 highlighted in section 1.2 was filled by answering Research question 1, Research question 2 and research question 4. If the answer to these three research questions were "Yes", it implied that third party collaboration could be considered as the third dimension of external integration. The remaining 13 research gaps identified in section 1.2 were related to the four research questions listed here. This research specifically addressed four research questions below:

Research question 1: Does external integration (customer involvement, supplier involvement and third party collaboration) relate to new product development speed in Penang's manufacturing firms?

Research question 2: Does external integration (customer involvement, supplier involvement and third party collaboration) relate to inter-organization relationship in Penang's manufacturing firms?

Research question 3: Does inter-organization relationship relate to new product development speed in Penang's manufacturing firms?

Research question 4: Does inter-organization relationship mediate the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and new product development speed in Penang's manufacturing firms?

1.4 Research objectives

The following four research objectives aimed to answer the four research questions identified in section 1.3.

Research objective 1: To examine the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and new product development speed in Penang's manufacturing firms.

The main focus of the study was to empirically examine the significant relationship between customer involvement, supplier involvement and third party collaboration with NPD speed in Penang's manufacturing firms. Customer involvement (Lau, 2011; Wong et al., 2011; Feng & Wang, 2012; Wong & Tong, 2012; Lin & Huang, 2013; Feng, Cai, Zhang & Liu, 2016) and supplier involvement (Danese & Filippini, 2010; Lau, 2011; Feng & Wang, 2012; Tsai, Tsai & Wang, 2012) had been empirically tested abroad as significant predictors for NPD speed. This study aimed to test these relationships in Malaysia context. On the other hand, third party collaboration was added as the third dimension of external integration besides supplier involvement and customer involvement in this study. Hence, this study also aimed to explore the relationship between third party collaboration and new product development speed. In

this research, external integration consisted of customer involvement, supplier involvement and third party collaboration.

Research objective 2: To examine the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and inter-organization relationship in Penang's manufacturing firms.

There were significant relationships reported in literature between customer involvement and supplier involvement with inter-organization relationship (Lin & Huang, 2013; Feng & Zhao, 2014). However, there was lack of study on the relationship between third party collaboration and inter-organization relationship. Third party was increasingly viewed as an important part of an organization's external partner with positive results from their collaboration activities. Research objective 2 was identified to fill this research gap. This study aimed to explore an empirical evidence of third party collaboration as the third dimension of external integration. External integration consisted of customer involvement, supplier involvement and third party collaboration in this research.

Research objective 3: To examine the significant relationship between inter-organization relationship and new product development speed in Penang's manufacturing firms.

Previous research studying the relationship between inter-organization relationship and NPD speed was conducted abroad with different cultural values (Lin & Huang, 2013). Lack of similar research done in Malaysia context prompted this

research. With strong inter-organization bonds among member firms, the understanding of each member firm's technological capability, process knowhow and market information became more apparent. Strong trust and good relationship between firms would facilitate information and technology sharing between firms. This would subsequently result in smooth implementation of product modulation and concurrent development. This in turn resulted in high NPD speed. This research aimed to examine the relationship between inter-organization relationship and NPD speed in Penang's manufacturing firms.

Research objective 4: To examine the mediating effect of inter-organization relationship in the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and new product development speed in Penang's manufacturing firms.

The extend of market information sharing and technology sharing as well as project coordination effectiveness between manufacturing firm and its customer, supplier and collaborated third party depended on their mutual trust and inter-organization bonds. Due to cultural influences of inter-organization relationship, the mediating effect of inter-organization relationship in Penang's manufacturing firms might be different from the previous results obtained in other national cultures or regions (Lin & Huang, 2013). Thus, this research aimed to examine the significant mediating effect of inter-organization relationship in the relationship between customer involvement, supplier involvement and third party collaboration with NPD speed in Penang's manufacturing firms. This study aimed to validate the results reported by Lin and Huang (2013) in Malaysia context when customer involvement was used as

independent variable. Lin and Huang's (2013) finding was based on sample from Taiwan's high technology firms. When supplier involvement or third party collaboration was tested as independent variable, the study could be considered as an exploratory study.

1.5 Scope and limitation of study

The scope of this research focused on NPD speed of manufacturing firms in Penang and its relationship with customer involvement, supplier involvement and third party collaboration. Target population of this study consisted of manufacturing firms in Penang state that engaged in NPD activities. Part of this research validated in Malaysia context the findings from previous similar studies conducted abroad (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al., 2011; Trainor et al., 2013). The aim was to empirically test and confirm that the findings from previous studies conducted in other countries were also applicable in Malaysia context. This study also attempted to explore empirically that third party collaboration was another significant predictor for NPD speed and as the third dimension of external integration.

This study only focused on one of six antecedents of NPD speed reported in literature, namely strategy orientation, project strategy, process-related factors, structure-related factors, team-related factors and environment characteristics (Chen, 2007). This study focused on external integration dimension of structure-related factor. The reason of fine focusing of this research scope was due to mixed results reported in literature for external integration dimension and practical gaps identified in manufacturing firms in Penang. In order to speed up NPD processes, manufacturing

firms needed to leverage resources, knowledge and technologies from its business partners like customers, suppliers, collaborated universities and research institutions.

The samples collected were limited to manufacturing firms in Penang state only. Cultural values in each state of Malaysia might be slightly different, especially between east and west Malaysia. The findings from this study perhaps cannot be generalized but can be replicated to other regions or states of Malaysia. Future research to replicate this study to other five regions of Malaysia was suggested. The findings from this study helped to answer research gaps related to NPD speed of manufacturing firms in Penang. The results cannot be generalized but can be replicated to other economic sectors or industries and other countries. These shortfalls formed limitation of this study.

The scope of third party collaboration in this study covered technical and market knowledge exchange but not on student internship program. Third parties were impartial research institutions or universities either from public or private sector. Hence, third party collaboration in this study excluded internal collaboration with R&D department. Product as defined in this study covered only physical goods but not service goods or training programs.

1.6 Significance of research

This study on NPD speed in Penang's manufacturing firms and its relationships with customer involvement, supplier involvement and third party collaboration, as well as the mediating effect of inter-organization relationship were expected to fill the identified research gaps in section 1.2 and yield significant theoretical, practical and policy implication. It was also confirmed earlier that NPD speed significantly related

to manufacturing firms' performance. With stronger R&D capability, highly competitive MNC's subsidiary in Penang will also prevent the holding companies from relocating their subsidiaries to other less costly labor markets around this region like Vietnam, Indonesia, etc.

The two external partners included in external integration dimension in literature were customer and supplier (Chen, 2007). Recently, third party was increasingly viewed as an organization's important external partner due to positive results from its collaboration activities with industries, coupled with strong government support (Lai, Chen & Yang, 2012; MIDA, 2018). Lau (2011) reported that customer involvement generated demand-side knowledge and capabilities while supplier involvement created supply-side ones. Based on feedback from subject matter experts in the field of NPD, third party collaboration sometimes sparks new approaches and knowledge in developing new product. This was the reason why this research included third party collaboration as the third dimension of external integration. The result of this study would confirm whether third party collaboration was a significant new factor of external integration or not. The finding of this study would also confirm if third party collaboration was a significant positive predictor for NPD speed and inter-organization relationship.

The results of this study will help Penang's manufacturing firms to improve its NPD speed and subsequently continue to remain competitive in today's business environment. The result of this study would also clarify the mixed results of previous studies conducted abroad on the relationship between customer involvement and supplier involvement with NPD speed (Danese & Filippini, 2010; Lau, 2011; Feng et

al., 2016; Feng & Wang, 2012; Lin & Huang, 2013; Tsai et al., 2012; Wong et al., 2011; Wong & Tong, 2012). Besides validating similar research findings from other countries to Malaysia context due to national culture differences, following were two factors that made this study unique. This study added third party collaboration as the third dimension of external integration and tested it as independent variable for its relationship with inter-organization relationship and NPD speed. Secondly, the mediating effect of inter-organization relationship on the relationship between external integration and NPD speed was studied using only one of three dimensions of external integration in previous studies. Previous study conducted by Lin and Huang (2013) only examined the mediating effect of inter-organization relationship on the relationship between customer involvement and NPD performance. NPD speed was one of the three factors for NPD performance as defined by Lin and Huang (2013). This study complemented previous studies by empirically examining the second dimension of external integration, namely supplier involvement. In addition, third party collaboration was also added as the third dimension of external integration in this research.

The findings from this research can be replicated to other regions of Malaysia as well as other countries with different cultural values than Penang. A better understanding of this area of study helps Malaysian policy makers to implement policies that enhance manufacturing firms' NPD speed and subsequently increase manufacturing firms' global competitiveness. With higher NPD speed, local companies can file more patents and IP to sustain their position as first mover. Which will directly generate more future economic growth. This research also highlights the danger of ignoring NPD speed. With slower NPD, manufacturing firms may completely lose their market share due to entry barrier establish by first mover. This research was expected

to add to the existing body of knowledge by providing empirical evidences within the context of Malaysia, particularly Penang state. Empirical confirmation of third party collaboration as the third factor of external integration from this study was hoped to contribute theoretically and practically in the research area of NPD.

1.7 Definition of key terms

The term NPD used throughout this thesis refers to new product development. IV, Med and DV are the abbreviations for independent variable, mediating variable and dependent variable respectively. Independent variables in this study are the three factors of external integration, namely customer involvement, supplier involvement and third party collaboration. Inter-organization relationship and NPD speed are the mediating variable and dependent variable respectively. R&D is the acronym for Research and Development. Product in this research refers to physical goods which are assembled or manufactured in a manufacturing firm but not includes service goods or training programs. New product in this research refers to goods that differ significantly in their characteristics or intended uses from products previously manufactured by the same firm.

New product development speed: NPD speed is the speed of development processes for a new product from a product idea being conceptualized until the new product is launched in the market for sales. Lukas, Menon and Bell (2002) defined new product development speed as the pace of activities between idea conception and product implementation (as cited in Chen, 2007, p. 15).

Customer involvement: Customer involvement in NPD processes refers to new product co-development and information exchange by a company with its customer. A company involves its customer in its NPD processes to gain specific customer requirements and get early feedback on its design. Market information can be directly or indirectly obtained through this communication with customer. Customer involvement was defined in literature as direct participation of customer in the design and development stages of a new product, whereby the customer engaged in problem solving activities and co-develop the final form of the product with the manufacturer (Feng et al., 2010; Brown & Eisenhardt, 1995 as cited in Lau, 2011).

Supplier involvement: Through supplier involvement, a company can have the access to the latest material or component technologies and information held by the supplier. Some companies also co-develop their new product with their component or material suppliers. Supplier involvement was defined as direct participation of supplier during product development processes (Ragatz et al., 1997 as cited in Lau, 2011). Supplier involvement covered mostly joint product design with key suppliers (Fliess & Becker, 2006; Takeisi, 2001 as cited in Lau, 2011).

Third party collaboration: Third party in this research refers to impartial professional entities like university and research institution. In third party collaboration, third party provided manufacturer with advanced technical theories and market knowledge that led to better design and market performance (Lai et al., 2012). Some companies collaborate with third party to get access to researchers' consultation available at third party. The scope of third party collaboration in this study covered technical and market knowledge exchange, but not on student internship program. Third party in this research could be

a research institute from public or private sector. The scope of third party collaboration in this research excluded internal collaboration with R&D department as well.

Inter-organization relationship: Inter-organization relationship referred to connectivity ties between two organizations (Lin & Huang, 2013). In this research, inter-organization relationship referred to the relationship between the company being studied and its business partners like customer, supplier and third party.

1.8 Organization of the thesis

This thesis was organized into five chapters. Chapter one provided background of the research and chapter two summarized critical reviews of literature and theories related to topics of interest in this study. Chapter three described the methodology used in this research. Chapter four summarized the results and discussions of the study. Finally, the thesis was concluded at chapter five with recommendation.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Chapter two is a summary of critical review of literature and theories related to the topic of this research. The literature selected for review in this study was mostly published no longer than ten years from the date of this thesis. Some older literature was also reviewed in search of the original literature that introduced the important concept or theory related to this study. However, for formation of research framework, more recent literature were used as reference. The review summary was presented in the sequence of dependent variable in section 2.2, followed by independent variables in section 2.3 and finally the mediating variables in section 2.4. Dependent variable for this study was NPD speed. Independent variables in this study were customer involvement, supplier involvement and third party collaboration. The mediating variable being assessed in this study was inter-organization relationship. In each variable, the literature review was organized thematically. After critically reviewing each variable, the relationships between the variables were reviewed and summarized in section 2.5 through section 2.8. Research gaps identified through literature review in chapter two formed the basis for research framework creation in section 3.1, with some supporting data from current business environment and feedback from subject matter experts.

2.1 New product development performance

NPD performance consisted of three dimensions, namely NPD efficiency, NPD effectiveness and product innovativeness (Lin & Huang, 2013). NPD time efficiency also referred to as NPD speed. As explained in section 1.1, product life span continued

to reduce globally across all industries (Shuler, 2011). As a result, highly competitive firms reinvested significant amount of their resources in R&D to speed up their NPD processes. In today's highly competitive time-based market, a firm will still fail if it has NPD effectiveness but slow in NPD speed.

2.2 New product development speed

Literature review for NPD speed was started by reviewing the importance of NPD speed, followed by reviewing the predictors found in previous researches for NPD speed.

2.2.1 Importance of new product development speed

NPD speed was vital for a company to survive in a competitive, uncertain, and turbulent market environment (Moreno-Moya & Munuera-Aleman, 2016). Only the company that able to provide the right product to consumer fastest had a competitive edge (Schuh et al., 2017). Therefore, successful firms needed to speed up their NPD processes in order to sustain profitable growth by continuously introducing new products to the market at the highest possible speed (Feng & Wang, 2013). This was due to rapid shortening of product life cycle and fast obsolescence of existing products, while competition intensified (Langerak & Hultink, 2005; Shuler, 2011). Late to market meant reduced useful product life span and a significant percentage drop in revenue (Shuler, 2011). As a result, NPD speed is becoming more critical for firms to stay competitive in today's highly competitive time-based market (Awwad & Akroush, 2016; Jos & Ton Van, 2012).

Gómez-Villanueva and Ramírez-Solís' (2013) finding reinforced the view that first mover firm had advantage over follower firm. First mover firm had the opportunity to define industry standard, which included but not limited to product design, pricing and quality standard. In order to be a first mover firm, firm needed to have speediest NPD compared to its competitors. Dumaine as cited in Feng and Wang (2013) revealed that firm with high NPD speed could establish industry standard and develop technology edges. In addition, Zao et al. as cited in Feng and Wang (2013) also reported that speedier NPD compared to competitors could enhance customer satisfaction and improve customer loyalty. Which in turn resulted in improved market performance directly. This notion was empirically proven by Feng and Wang (2013) that NPD speed significantly improved market performance. On the other hand, customer involvement in NPD could only improve NPD performance provided that the firm had the ability to establish it, specifically through being a market pioneer (Tseng, 2015). In another research, Lim, Sharkey and Heinrichs (2006) reported that faster NPD speed was positively related to export involvement, export success and overall competitive position in international market. In brief, high NPD speed helped market leaders capturing global market through first mover advantage.

The two dimensions of new product competitive advantage, namely new product quality and new product speed had direct effect on new product customer performance and company's financial performance (Akroush, 2012). In an earlier research, Langerak and Hultink (2005) provided an empirical confirmation that NPD speed yielded significant improvement in firm's financial performance. However, a negative direct relationship between innovation and financial performance was also reported. Nevertheless, market performance reversed this negative effect to a positive

total influence through its suppression effect (Gök & Peker, 2017). Being a market leader, firm with high NPD speed enjoyed high financial performance as the bottom line result.

Carbonell and Rodríguez Escudero's (2010) study confirmed the significant positive relationship between innovation speed and new product performance. However, Lin et al. (2012) found that product quality was the dominant factor determining the success of NPD project when firm executed rapid product development strategy. Le and Hui (2018) reported that innovation speed had greater effect on low cost competitive advantage while organizational learning and quality had greater effect on differentiation competitive advantage. As market leader, first mover firm that embarks on rapid product development strategy has the opportunity to define industry standard which includes product design, quality and pricing of the first of the kind product. Hence, they may be able to monopolize market and subsequently enjoy high market and financial performances.

2.2.2 Antecedents of new product development speed

Since the mid-1990s, scholars had been trying to explore the underlying theoretical construct that related to NPD speed from different theoretical perspectives. Chen (2007) did a comprehensive literature review from 1986 to 2007 on NPD speed and summarized six broad categories of antecedents for NPD speed, namely strategy orientation, project strategy, process-related factors, structure-related factors, team-related factors and environment characteristics. Strategy orientation consisted of five factors, namely speed emphasis, innovative culture, top management support, resource availability and strategy synergy. Project strategy was measured by five factors like

product vision, newness, project complexity, team size and sources of technology. The six process-related factors were process formalization, process concurrency, rapid prototyping, advanced tools, team learning and process proficiency. Structure-related factors were internal integration, functional diversity, external integration, decentralization and co-location. Leadership, KSAO, teamwork, team decision and team stability made up team-related factors. KSAO refers to team members' knowledge, skills, ability and other attributes such as experience. Environmental characteristics measured environmental uncertainty, market competitiveness and firm size factors (Chen, 2007).

Despite much theories and conceptual level discussions emphasized their importance, Chen (2007) found that the cumulative effect of strategy orientation, project strategy and environment characteristics failed to fully influence NPD speed significantly. On the other hand, the cumulative effect of process and team-related factors were found significantly influencing NPD speed. Chen (2007) revealed that only nine over 23 significant predictors of NPD speed could be considered salient drivers of NPD speed with mean correlation r values more than 0.3. They consisted of four team-related factors, three process-related factors, one strategy orientation and one product-related factor. These salient drivers of NPD speed were top management support, product vision, process concurrency, fast prototyping, team learning, leadership, KSAO, teamwork and team stability.

Mixed results were reported for structure related factors, Chen (2007) reported that internal integration, external integration and decentralization were significantly influencing NPD speed, but they were not salient drivers for NPD speed with mean

correlation r values less than 0.3. On the other hand, functional diversity was found not significantly related to NPD speed. Chen (2007) suggested future research to investigate the relationship between external integration and NPD speed due to their significant relationship but explained variance in NPD speed by external integration was relatively small. Besides, the mean correlation r value for the relationship between external integration and NPD speed was also low (less than 0.3). This low mean correlation value contradicted with the popular but untested notion by practitioners which held that external integration was necessary to accelerate NPD. External integration consisted of three factors as defined by Chen (2007), namely customer involvement, supplier involvement and external communication. The subsequent literature review focused on external integration and its factors.

Since 2007, many researches on the relationship between customer involvement and NPD were found in literature. Most of the researchers tested customer involvement as independent variable (Feng et al., 2016; Feng & Wang, 2012; Lai et al., 2012; Lau, 2011; Lin & Huang, 2013; Mons et al., 2011; Tsinopoulos & Al-Zu'bi, 2012; Wong et al., 2011; Wong & Tong, 2011; Wong & Tong, 2012; Yang & Zhang, 2018) while some researchers tested customer involvement as mediator for the relationship with NPD (Mons et al., 2011; Wong et al., 2011; Wong & Tong, 2011) as well as moderator (Tih et al., 2016; Tong & Wong, 2012). The relationship between supplier involvement and NPD were found examined by researchers many times since 2007 as well. Supplier involvement was tested as independent variable (Danese & Filippini, 2010; Feng & Wang, 2013; Lai et al., 2012; Lau, 2011; Luo, Mallick & Schroeder, 2010; Minguela-Rata, Fernández-Menéndez & Fossas-Olalla, 2014; Tsai et al., 2012) and moderating factor for the relationship with NPD (Danese & Filippini, 2010). On the other hand,

studies on third party collaboration was found reported in literature as moderating variable (Lai et al., 2012). Customer and supplier involvement being studied together as one factor was also reported in relation to NPD (Lau, 2011), which was studied as independent variable. External integration was also found in literature as independent variable for the relationship with NPD (Chen & Lim, 2011).

Due to mixed results reported in previous studies on the relationship between external integration and NPD speed, a deep dive into literature focusing on the factors of external integration like customer involvement, supplier involvement and third party collaboration was conducted. Literature review for these external integration factors were summarized in 2.3.1, 2.3.2 and 2.3.3 respectively.

2.2.3 Underpinning theory

The five theoretical perspectives related to NPD speed that Chen (2007) summarized were strategy and execution, rational planning, organizational learning, resource-based view and expectancy theory. This research built upon theory of organizational learning. Particularly from external learning perspective, whereby different technology sourcing strategies influenced innovation speed throughout the NPD processes (Kessler et al., 2000). Organizational learning is the underpinning theory of this research.

2.3 External integration

Chen (2007) reported that external integration of structure-related factor consisted of three factors, namely supplier involvement, customer involvement and external communication. External communication emphasized information exchange among team members and organizations. Based on Feng and Wang's (2013) research design

in measuring customer involvement and supplier involvement, customer involvement and supplier involvement included external strategic collaborations as well as information sharing and joint problem solving. The element of external communication had been included in the questionnaire for customer involvement and supplier involvement in this study. For consistency, this research adopted the questionnaire used by Feng and Wang (2013) to measure customer involvement and supplier involvement. As a result, external integration is now consisted of two factors in this research's perspective, namely customer involvement and supplier involvement.

It was a popular but untested notion by practitioners which held that third party collaboration or university-industry collaboration was an important factor contributing to high NPD speed. In view of its importance, this research added third party collaboration as another factor of external integration that predicted NPD speed of manufacturers in Penang state. In the scope of this study, external integration was defined as consisted of customer involvement, supplier involvement and third party collaboration. Therefore, external integration in this research is now consists of three factors instead of two factors mentioned above. Similar to customer involvement and supplier involvement, third party collaboration in this research covered both external communication as well as strategic collaboration with third party. The subsequent literature reviews presented in section 2.3.1, 2.3.2 and 2.3.3 focus on literature review of these three factors of external integration.

2.3.1 Customer involvement

Previous studies broke down customer involvement into two (Lin & Huang, 2013) or three (Cui & Wu, 2016) forms of involvement. In Lin and Huang's (2013) research on customer involvement, they broke down customer involvement into two forms, namely customer participation - information and customer participation - co-developer. However, in Cui and Wu's (2016) research, customer involvement was broken down into three forms, which were customer involvement as an information source, customer involvement as co-developers and customer involvement as innovators. In customer involvement as information source, NPD employees gathered information from customers and applied such information to develop products that met customers' requirements. In customer involvement as co-developer, customer developed new product together with NPD employees (Cui & Wu, 2016). In Feng and Wang's (2013) research, customer involvement focused on collaboration, information sharing and joint problem solving.

Mons et al. (2011) reported that customer involvement in NPD processes could result in exploration and exploitation of new values to and from customer. This new added values included product customization and value co-creation. The ability to draw upon customer knowledge to develop new product had direct positive impact on relationship profitability. On the other hand, Lai, Chen and Yang (2012) revealed that customer involvement improved design performance and market performance simultaneously. The ability to leverage customer's resources and knowledge enable firms to develop a new product that matches customer's need and expectation better. Higher customer satisfaction will thus result in better market performance. Customer involvement was found tested as moderator in literature as well. Tih et al. (2016) found

that the speed of dissemination within NPD team on customer and competing product information had a positive impact on customer involvement. Enhancement of information dissemination could be better achieved with better utilization on information technologies.

Lau (2011) argued that supplier and customer involvements in NPD processes were highly integrated. When manufacturer engaged in supplier involvement, the experiences learned would improve its future engagement with customer in NPD activities and vice versa. Customer involvement generated demand-side knowledge and capabilities while supplier involvement created supply-side ones. Integrating the two activities improved NPD efficiency and effectiveness.

On the hindsight, customer involvement did not happen without resistance. Differences in organization culture between the two firms would resist collaboration. Cao, Huo, Li and Zhao (2015) found that hierarchical culture was negatively related to both internal and customer integration. On the other hand, Eslami and Lakemond (2016) revealed that the two factors that constrained customer's knowledge contribution and timing of customer collaboration were customer's technical capability and the locus of initiative. If customer initiated the collaboration, the tendency of customer contributing knowledge in the product development processes would be higher. If customer posed relevant technical capabilities, the customer would tend to contribute knowledge beyond ideation phase (Eslami & Lakemond, 2016). Similarly, Cui and Wu (2016) also found that impact of customer involvement on product performance was contingent upon the firm's technological capability. The three conditions that unfavorable to suppliers with respect to their ability to benefit from involvement in customer's product

development processes were customer power advantage, remote location relative to that of customer and frequent changes in the customer's purchasing personnel (Barriers to productive supplier involvement, 2015).

2.3.2 Supplier involvement

Supplier involvement as measured in this research focused on information sharing, collaboration and joint problem solving with supplier (Feng & Wang, 2013). Yeniyurt, Henke and Yalcinkaya (2014) revealed that supplier benefited more compared to customer in terms of NPD performance from their new product collaboration relationship. Lam, Chin and Pun (2007) reported that manufacturing firm collaborated with supplier during NPD processes to reduce product development time, cost and improve product design. In addition, involving supplier in NPD processes was also empirically found improving design performance (Lai et al., 2012). In this supplier collaboration processes, supplier's shared-knowledge and technology directly improved design performance of a co-developed product. Danese and Filippini (2010) found in a separate study that product modularity had a direct positive effect on NPD speed. Furthermore, inter-functional integration was found significantly moderating the relationship between product modularity and NPD speed. In product modularity concept, all component suppliers could execute concurrent development among themselves. Good planning and inter-functional as well as inter-organizational integration played a big role in contributing to speedier NPD process.

Each finished product is usually built by integrating several components or modules, which are separately built by different suppliers based on their core competencies. Successful integration and leveraging each supplier's core competency

subsequently result in high NPD speed and success. Danese and Filippini (2010) also reported that supplier involvement reduced NPD time. However, Tsai et al. (2012) argued that managers who supported supplier collaboration by itself and ignored sufficient technological capacity and promotion capacity as well as neglected technological turbulence might fail to achieve their intended NPD performance.

Danese and Filippini (2010) found that supplier involvement in NPD processes enabled a clearly defined interface across product modules to establish accurately. This in turn allowed efficient parallel designing, prototyping and testing of modules concurrently across all suppliers and firm. Concurrent development eventually led to higher NPD speed. Aydin, Cetin and Ozer (2007) reported that product development performance was related to product development cycle time. Product development cycle time was in turn influenced by the following three factors: firm's organizational structure and processes, supplier's organizational structure and processes and structure and processes of buyer-supplier interface.

2.3.3 Third party collaboration

Third party in this research referred to impartial professional entities like university and research institution. Due to their impartiality, university and research institution able to provide manufacturing firm unbiased technical theory and market knowledge. This subsequently resulted in improved product design and market performance. Lai et al. (2012) reported that third party collaboration without relation to market competition enhanced product innovation performance. However, third party collaboration's impact on product innovation performance was weakened when it was done with supplier's involvement. Lynch and O'Toole found that 57% of respondents in their study on

Ireland's manufacturing industry involved third parties in their NPD processes (as cited in Lai et al., 2012, p. 263).

Lassen and Laugen (2017) found that radical innovation output was positively related to internal collaboration (R&D department) and external collaboration (university) but was negatively related to supplier involvement. Belderbos, Carree, Lokshin and Fernández Sastre (2015) revealed that persistent collaboration had a systematically positive effect on innovativeness but all other temporal patterns of collaboration did not significantly improve innovation performance. Jung and Andrew (2014) reported that R&D collaboration with university or research institute could reduce cost, improve profitability and generate spillover benefits. Aristei et al. (2016) found that internal knowledge, appropriability condition and incoming spillover explained a large variation in R&D collaboration propensity of European firms with universities.

Lai et al. (2012) reported that university was an important external resource for companies seeking innovation knowledge. Third party involvement were found to be an important moderator for the relationship between external member involvement and product innovation performance. Aristei, Vecchi and Venturini (2016) reported that larger European firms and those relying on external finance or public R&D funding performed a larger proportion of their research in partnership with university. As for Asia region, Lai et al. (2012) reported that research institutions and universities in Taiwan were required to conduct researches which were relevant to industry to improve competitiveness of Taiwanese industry. Moreover, Cin, Kim and Vonortas (2017) found significant positive effect of public R&D subsidy on both R&D expenditure and

the value added productivity of Korean manufacturing small and medium-sized enterprises (SMEs). Buganza, Colombo and Landoni (2014) found that SMEs engaged in collaboration with university following a progressive model. They started from the easiest collaboration during the testing phase to a more complex collaboration during the research phase. In this manner, SMEs established a trust-based relationship with university.

Malaysian government also encouraged university-industry collaboration. The Global Competitiveness Report 2016-2017 ranked Malaysia 11 out of 148 countries in "university-industry collaboration in R&D" category (MIDA, 2018). University-industry collaboration was seen as a strategic approach to achieve university's mission in entrepreneurial activities and industry's mission to appear as champion in the new era of rapid technology development. However, the challenge was that both parties represent two different organizational cultures; university culture and industry culture (Ramli & Zainol, 2013). Sohn and Kenny as cited in Jung and Andrew (2014) also highlighted the difference in organizational culture in the world of academia and private companies that formed barrier to R&D collaboration in South Korea. Although the importance of university-industry collaboration was recognized by many governments and many efforts had been introduced to improve it, organizational culture difference between university and industry remained as the main challenge. The launching of Public-Private Research Network (PPRN) was one example of Malaysian government's effort to encourage and improve university-industry collaboration in Malaysia. University-industry collaboration was termed as third party collaboration in this research.

On the 24th of February 2015, prime minister of Malaysia launched PPRN as an initiative to promote strategic cooperation between university, industry and government agencies. The objective of PPRN was to create a network that encouraged knowledge sharing in Malaysia, an environment where knowledge and information were collected and diffused from those that had it (University) to those that needed it (industry/SME). PPRN encouraged demand-driven innovation programs for the development of productivity and innovation. The aim of PPRN formation was to benefit or help local industries. PPRN facilitated the link between industry and higher educational institute with the objective to resolve industry's technology related issues. In this relationship, PPRN was the facilitator, industry was the information user and higher educational institute was the information producer. Successful collaborative project between industry and researcher was co-financed by PPRN and the company involved.

2.4 Inter-organization relationship

Lin and Huang (2013) reported in their study that strong inter-organization relationship had a positive impact on NPD efficiency and effectiveness. Nevertheless, inter-organization relationship had a negative influence on product innovativeness. It was argued that when customer involved in NPD processes and started sharing their information, both parties would share their critical information based on trust and reciprocity that originated from strong inter-organization ties. This critical information sharing subsequently resulted in improved NPD efficiency and effectiveness. Danese and Filippini (2010) empirically confirmed that prior relationship history had a significant and positive influence on new product co-development success. Lin and Huang (2013) revealed that strong inter-organization relationship mediated the effect

of customer participation on NPD performance. They measured NPD performance by three dimensions, namely NPD efficiency, NPD effectiveness and product innovativeness. Trust was an important antecedent in supplier relationship as it increased the likelihood of information sharing between organizations. Knowledge integration would happen when buyer and supplier were confident with each other's competency and reputation. When the perceived benefit of knowledge input overweigh the cost of knowledge leakage, limited interaction might take place (Rosell et al., 2014).

Organizational culture was defined by Schein as the pattern of shared behaviors, values and beliefs that provided a foundation to understand the organizational functioning processes and norms of behavior (Schein, 1985 as cited in Harvey & Griffith, 2002). Organizations were themselves cultural systems. Without effective inter cultural communication capabilities, the relationship between inter-organizational partners could not be maintained or effective over time (Harvey & Griffith, 2002). Hence, due to cultural sensitivity of inter-organizational study, the results from previous similar studies conducted in foreign countries could not be generalized to Malaysia's manufacturing firms (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al., 2011; Trainor et al., 2013). For the same reason, sampling plan for this study was limited to Penang state of Malaysia to ensure result consistency. Selection of sample with homogeneous cultural value ensure consistency of survey results.

Biswas and Akroyd (2016) found that involving external collaborative partners in NPD stage-gate meeting improved inter-firm trust and co-development relationship. Through NPD stage-gate meetings, collaborative partners became familiar with each other's processes and developed shared vision and alignment of objectives. Which in

turn improved inter-organization relationship and promoted information sharing among collaborative partners.

2.5 External integration and new product development speed

It was reported in Wong and Tong's (2011) research that R&D-marketing cooperation and customer orientation had a significant influence on new product success. After one year, Wong and Tong (2012) revealed in another report that customer orientation was found to have a significant and positive impact on new product success. Their study revealed that when customer orientation was high, the positive R&D-marketing cooperation-new product success (RMC-NPS) relationship was strengthened. Feng and Wang (2013) revealed that NPD cost and speed significantly influenced market performance directly. The authors also reported that customer involvement was positively associated with cost and speed of NPD but customer involvement and market performance were not significantly correlated (Feng & Wang, 2012). Zhang and Yang (2016) revealed that information technology implementation moderated the relationship between external involvement and speed-to-market of new products.

Product differentiation and customization provided additional values to customer compared to competitors' offerings. To succeed in product differentiation strategy, accesses to market information and knowledge were critical. Involving customer in NPD processes facilitated the access to critical information like confidential market information and specific customer needs. Developing a new product that precisely met customer needs greatly enhanced new product success. NPD speed would also improve by avoiding spending time to develop a product that did not meet customer needs or modifying the product later to meet customer needs. Zhang and

Yang (2016) indicated that new product's speed-to-market significantly and positively mediated the relationship between customer involvement and new product market performance. On the other hand, Le and Hui (2018) reported that NPD speed had greater effect on low cost competitive advantage while organizational learning and quality had greater effect on differentiation competitive advantage.

Luo, Mallick and Schroder (2010) found that the higher the percentage of parts designed and manufactured by suppliers, the lower the collaborative product development project performance. This study revealed that supplier involvement effort was positively associated with collaborative product development project performance, while the manufacturer's internal coordination capability positively moderated the relationship between supplier involvement efforts and collaborative product development performance (Luo, Mallick & Schroder, 2010). Feng and Wang (2013) reported that supplier involvement was positively associated with NPD cost, NPD speed and market performance. Their study concluded that internal and customer involvement enhanced market performance indirectly, whereas supplier involvement improved market performance both directly and indirectly (Feng & Wang, 2012). On the other hand, Danese and Filippini (2010) found that product modularity was positively related to NPD time performance, but supplier involvement and inter-functional integration in NPD were not significantly related to NPD time performance. Their finding did not support the existence of a significant moderating effect of supplier involvement on the product modularity-NPD time performance relationship.

Lai et al. (2012) argued that a company that leveraged supplier's capability to improve its in-house capability could improve its product development cycle time significantly. Technology and electronic manufacturing firms designed their products by modules or separate components. These components were then purchased from their suppliers. All the component suppliers then concurrently designed and built their component based on the specification and drawing provided by customer. By concurrent product development process, overall development cycle time could be significantly reduced. At the same time, each component could be outsourced to the best supplier that specialized in specific technology. Leveraging all component suppliers' core competencies would then result in the creation of high quality new product and shorten NPD cycle time.

Zhang and Yang (2016) found that supplier involvement was less likely to lead to the enhancement of speed-to-market if the firm not able to establish a higher level of information implementation. Zhang, Wang and Gao (2017) reported that supplier involvement might only influence Speed-to-market via information sharing between firm and its suppliers. Zhao, Cavusgil and Cavusgil (2014) revealed that firms tend to perform NPD tasks that they had in-house core competencies. However, they would likely externalize complex tasks to suppliers in order to utilize suppliers' resources to increase NPD speed.

Third party in this study referred to impartial entities like university and research institution. Third party was important contributor for scientific and technological knowledge creation. Lynch and O'Toole (2006) reported that 57% of respondents in their study on Irish manufacturing firms involved third parties in their

NPD processes. Lai et al. (2012) revealed that the reason companies involved third party in their product development processes included customer requirement, acquiring expertise, creating market opportunities and lowering cost, risk and development time. Compared to multinational companies, most of Malaysia's local manufacturing firms did not have enough resources and budget to fund in-house R&D activities by themselves. The launching of PPRN in 2015 in Malaysia helped local manufacturing firms reducing their product development cost significantly. Upon successful project completion, the development cost was shared between PPRN and the collaborated company. Lai et al. (2012) reported that Taiwanese manufacturing firms involved third party to improve product development cycle time. Nevertheless, similar research to study the relationship between external integration and NPD speed was still lacking in Malaysia context.

Petersen et al. as cited in Tsinopoulos and Al-Zu'bi (2012) revealed that customer and supplier collaboration might increase the sense of ownership which in turn might increase the likelihood of market success. Feng and Wang (2013) revealed that NPD speed significantly influenced market performance directly. Lau (2011) reported that customer involvement and supplier involvement were positive predictors for firms' market and financial success. In essence, customer involvement and supplier involvement increased the sense of ownership, which in turn sped up new product launching and subsequently resulted in firm's market and financial success.

Cui and Wu (2017) reported that customer involvement as information source was a better predictor for NPD success compared to customer involvement as co-developer in a more experimental NPD approach. In an experimental NPD approach,

firms emphasized trial and error learning processes. Tsinopoulos and Al-Zu'bi (2012) reported that both lead user and product expert had significant positive impact on NPD speed. However, collaboration with lead user would lead to greater NPD speed than with product expert. Lead user was user that experienced needs unknown to the public and therefore could innovate by finding solutions to those needs. Product expert was external NPD collaborator who had a commercial interest in the development of a new product. Von Hippel as cited in Lin, Tu, Chen and Huang (2013) proposed that lead user or customer who faced specific need in advance of the general market place were key sources of information necessary for innovation. Wang and Li-Yang (2014) argued that successful NPD usually required a firm to have internal resources and capabilities to absorb, assimilate, and reconfigure externally obtained knowledge. External organizational learning from customers who knew best the product requirements led to rapid NPD.

On the other hand, Wong and Tong (2012) reported that when customer orientation was high, the positive RMC-NPS (R&D Marketing Cooperation-New Product Success) relationship was strengthened; conversely, when customer orientation was low, the positive RMC-NPS relationship was weakened. Feng and Wang (2013) also reported that customer and supplier involvements had significant effect on NPD cost and NPD speed. Feng and Wang (2013) found that customer involvement was positively associated with NPD cost and NPD speed, while the relationship between customer involvement and market performance was not significant. On the other hand, supplier involvement was found having positive correlation with cost and speed of NPD and market performance. The study concluded that internal and customer involvement indirectly improved market performance, but supplier involvement both directly and

indirectly improved market performance. Feng et al. (2016) found that market newness had positive and significant moderating effect on the relationship between customer involvement and new product performance, while the moderating effect of technological newness was negative and significant. As listed above, while most literature pointed out that both customer involvement and supplier involvement had significant positive relationship with new product performance, they were affected by external environmental factors like market newness and technological newness.

2.6 External integration and inter-organization relationship

Lin and Huang (2013) demonstrated the significant positive relationship between customer involvement and inter-organization relationship while Feng and Zhao (2014) found inter-organization relationship had significant positive relationship with customer involvement and supplier involvement. Lin and Huang (2013) reported that customer participation as an information resource and co-developer had significant positive impact on inter-organization relationship. Compared to customer participation as information resource, customer participation as co-developer was found having stronger correlation with inter-organization relationship. One year later, Feng and Zhao (2014) found that good relationship with customer improved customer involvement and good relationship with supplier improved supplier involvement. In addition, top management support improved customer involvement but did not improve supplier involvement directly.

Compared to Chinese-controlled firms, the effect of supplier relationship on supplier involvement was stronger in foreign-controlled firms (Feng & Zhao, 2014). Lai et al. (2012) revealed that the relationship between customer involvement and

market performance was significantly moderated by third party involvement. Third-party in this study referred to impartial entities like university and research institution. Although significant relationships had been found in previous researches on the relationship between third party involvement and new product performance (Jung & Andrew, 2014; Lai et al., 2012; Lassen & Laugen, 2017), there was lack of research done to verify the relationship between third party involvement and inter-organization relationship.

When customer, supplier and third party involved in a same project during product development processes, frequent interactions between the team members would take place. These interactions might be in the form of face-to-face meeting, video conferencing or teleconferencing. The most intense interaction could be created if customer organized workshop that involved all component suppliers, the manufacturing firm that assemble the parts and the customer itself. These frequent interactions created mutual trust and reciprocity among the team members. This in turn resulted in the formation of strong inter-organizational bonds between manufacturing firm with its customer, supplier and third party collaboration partner.

2.7 Inter-organization relationship and new product development speed

Lin and Huang (2013) found that inter-organization relationship had a significant positive relationship with NPD's efficiency and effectiveness. In their study, NPD's efficiency was defined as the ability of a project team to reduce development time and cost (Lin & Huang, 2013). Failures and issues encountered during product development processes slowed down project progress. Supplier, customer and third party had different technological competencies and specialized in different process technologies.

Involving supplier, third party or customer sped up problem solving processes because the firm that faced problem no longer constrained by its own limited knowledge to solve problem. When project problem could be resolved timely, NPD timeline would not be affected.

Yang and Zhang (2018) reported that customer focus, customer involvement and communication with customer had significant positive relationship with both financial and nonfinancial performance of NPD. However, Lin and Huang (2013) found in their study that involving customer alone might not result in NPD success. In order to reap maximum NPD result by customer involvement, strong relationship must be built with customer to foster problem solving, co-operation and knowledge sharing by customer. Only after trust was established through healthy inter-organization relationship, efficient flow of information between firms would then happen and subsequently lead to rapid NPD success. Organizations were themselves cultural systems. Without effective intercultural communication capability, the relationship between inter-organization partners could not be maintained or effective over time (Harvey & Griffith, 2002).

2.8 Mediating effect of inter-organization relationship

Lin and Huang (2013) reported that strong inter-organization relationship mediated the effect of both customer participation as an information resource and customer participation as a co-developer on NPD performance. NPD performance was measured by three dimensions, namely efficiency, effectiveness and product innovativeness (Lin & Huang, 2013). On the other hand, similar research using the other two factors of

external integration, namely supplier involvement and third party collaboration as independent variable was still lacking.

2.9 Conclusion

From the literature review presented above, it could be concluded that there were mixed results from previous studies conducted outside Malaysia on the impact of customer involvement, supplier involvement and third party collaboration on NPD speed. Inter-organization relationship was cultural specific. Therefore, the results from previous studies conducted outside Malaysia could not be generalized to Malaysia. Furthermore, researches in the area of NPD speed, customer involvement, supplier involvement, third party collaboration and inter-organization relationship were still lacking in Malaysia context.

Recently, third party is increasingly viewed as an important external partner to improve NPD speed. Many countries' government, including Malaysian government also encouraged, facilitated and provided incentives for university-industry collaboration. However, empirical research to include third party collaboration as another factor of external integration besides customer involvement and supplier involvement was still lacking in the published literature. There was also very limited study to empirically test the relationship between third party collaboration with NPD speed and inter-organization relationship. Study on the mediating effect of inter-organization relationship on the relationship between customer involvement and NPD speed in Malaysia context was also very limited. Similar relational studies using supplier involvement and third party collaboration as independent variables were also lacking. The above limitations in literature were identified as research gaps. The

objective of this research was to empirically test and close these research gaps in literature.

CHAPTER 3

METHODOLOGY

3.0 Introduction

Literature review presented in chapter two provided the foundation to develop research framework and research hypotheses in section 3.1 and section 3.2 respectively. Which in turn, resulted in research design creation in section 3.3. This research used quantitative research method with close-ended survey questionnaire. Research framework was designed based on research gaps identified through critical review of literature. Measurement of variables was explained in section 3.4 and modification of adapted questionnaire was discussed in section 3.4.1. Validity and reliability of the questionnaire were also analyzed and presented in section 3.4.2. Reasons for the measurement of demographic information were discussed in section 3.4.3. Unit of analysis, sampling procedure and data collection procedure were outlined in section 3.5, section 3.6 and section 3.7 respectively. Finally, techniques of data analysis which were used to analyze the collected data were explained in detail in section 3.8.

3.1 Research framework

Research framework in figure 3.1 was designed for this research based on research gaps identified through critical review of literature. Research framework for this study showed the relationships between external integration, inter-organization relationship and NPD speed. External integration consisted of three factors, namely customer involvement, supplier involvement and third party collaboration. In this research, NPD speed was dependent variable, while customer involvement, supplier involvement and third party collaboration were independent variables. This research framework tested

inter-organization relationship as mediating variable in the relationship between customer involvement, supplier involvement and third party collaboration with NPD speed. Fast NPD was a key component of time-based strategy and was critical to achieve time-based advantage (Stalk & Hout, 1990 as cited in Chen, 2007). A company could have first-mover advantage or fast follower advantage by having high NPD speed.

Independent variables: **Mediator:** **Dependent variable:**

External Integration:

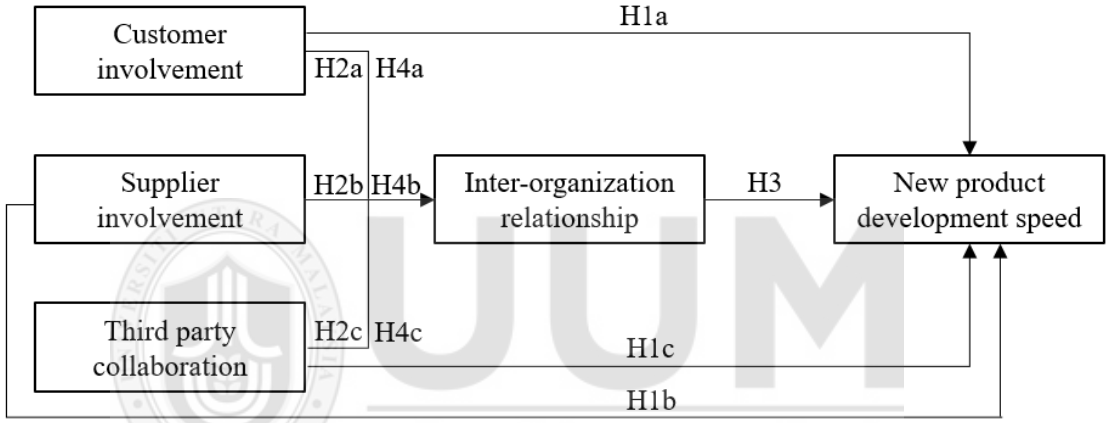

Figure 3. 1
Research framework

Dependent variable (DV): New product development speed

Independent variables (IV): External integration:

- Customer involvement
- Supplier involvement
- Third party collaboration

Mediating variable (Med): Inter-organization relationship

Lin and Huang (2013) demonstrated the significant positive relationship between customer involvement and inter-organization relationship while Feng and Zhao (2014) found inter-organization relationship had significant positive relationship with customer involvement and supplier involvement. Chen (2007) reported that external integration dimension of structure-related factor consisted of three factors, namely customer involvement, supplier involvement and external communication. The questionnaire used in this research to measure customer involvement and supplier involvement were adopted from Feng and Wang (2013). This questionnaire measured customer involvement and supplier involvement as external information and knowledge source as well as external strategic collaborator. Thus, questionnaire used in this research to measure customer involvement and supplier involvement also measured external communication as well. The questionnaire that measured customer information exchange and knowledge source were "we consulted major customers before designing a new product" and "major customers were frequently consulted about the design of the new product". The questionnaire used to measure strategic customer collaboration were "we partnered with major customers for developing new product", "major customers' involvement was essential in the design effort for new product development" and "major customers were involved in our company's continuous improvement programs".

Third party was increasingly viewed as an important part of an organization's external partner with positive results from their collaboration activities and strong government support. However, research on the relationships between third party collaboration with inter-organization relationship and NPD speed were still lacking in

Malaysia context. Third party collaboration was thus added as the third factor of external integration in this research.

Lin and Huang (2013) found that NPD speed was positively impacted by inter-organization relationship. Effective intercultural communication was pivotal in maintaining good inter-organization relationship (Harvey & Griffith, 2002). The findings by Lin and Huang (2013) could not be generalized to Malaysia context due to cultural differences. Hence, this research framework also attempted to validate Lin and Huang's findings in Malaysia context.

Previous studies revealed mixed results on the relationship between NPD speed and the two factors of external integration, namely customer involvement (Feng et al., 2016; Feng & Wang, 2012; Lai et al., 2012; Lau, 2011; Lin & Huang, 2013; Mons et al., 2011; Tsinopoulos & Al-Zu'bi, 2012; Wong et al., 2011; Wong & Tong, 2011; Wong & Tong, 2012; Yang & Zhang, 2018) and supplier involvement (Danese & Filippini, 2010; Feng & Wang, 2012; Lai et al., 2012; Lau, 2011; Luo et al., 2010; Minguela-Rata et al., 2014; Tsai et al., 2012). Feng and Wang (2013) reported that customer involvement and supplier involvement positively associated with NPD speed. Lai et al. (2012) also argued that NPD speed could be significantly improved by leveraging supplier's capability. However, Danese and Filippini (2010) found that supplier involvement in NPD was not significantly related to NPD speed. Although third party was increasingly considered by practitioners as another important external partner that could significantly speed up NPD process, the study on the relationship between third party collaboration and NPD speed was still lacking. Lynch and O'Toole (2006) reported that 57% of respondents in their study on Irish manufacturing firms

involved third parties in their NPD processes. On the other hand, Lai et al. (2012) reported that Taiwanese manufacturing firms involved third party to improve product development cycle time. Therefore, this research framework added third party as another factor of external integration and attempted to confirm the positive relationship between external integration and NPD speed in Penang's manufacturing firms.

Lin and Huang (2013) reported that strong inter-organization relationship mediated the effects of both customer participation as an information resource and customer participation as a co-developer on NPD performance. NPD performance was measured by three dimensions, namely efficiency, effectiveness and product innovativeness. The extend of market information sharing and technology sharing as well as project coordination effectiveness between manufacturing firm and its customer, supplier and collaborated third party depended on their mutual trust and inter-organization bonds. Due to cultural influence of inter-organization relationship, the mediating effect of inter-organization relationship in Malaysia's manufacturing firms might be different from the results obtained in other national cultures or regions. On the other hand, similar research using the other two factors of external integration, namely supplier involvement and third party collaboration as independent variable was also lacking. Hence, this research framework was designed to test the mediating role of inter-organization relationship on the relationship between external integration and NPD speed. External integration in this research framework consisted of three factors, namely customer involvement, supplier involvement and third party collaboration.

3.2 Research hypotheses/propositions development

A research hypothesis is an unproven proposition that tentatively explains certain facts or phenomena. It is a proposition that is empirically testable. It is also an empirical statement concerning the relationship among variables (Zikmund, 2000).

Research hypotheses below were posited based on research objectives presented in section 1.4 and research framework illustrated in section 3.1.

Research hypotheses:

IV-DV

H1: External integration significantly relates to new product development speed in Penang's manufacturing firms.

H1a: Customer involvement positively relates to new product development speed in Penang's manufacturing firms.

H1b: Supplier involvement positively relates to new product development speed in Penang's manufacturing firms.

H1c: Third party collaboration significantly relates to new product development speed in Penang's manufacturing firms.

IV-Med

H2: External integration significantly relates to inter-organization relationship in Penang's manufacturing firms.

H2a: Customer involvement positively relates to inter-organization relationship in Penang's manufacturing firms.

H2b: Supplier involvement positively relates to inter-organization relationship in Penang's manufacturing firms.

H2c: Third party collaboration significantly relates to inter-organization relationship in Penang's manufacturing firms.

Med-DV

H3: Inter-organization relationship significantly relates to new product development speed in Penang's manufacturing firms.

IV-Med-DV

H4: Inter-organization relationship significantly mediates the relationship between external integration and new product development speed in Penang's manufacturing firms.

H4a: Inter-organization relationship significantly mediates the relationship between customer involvement and new product development speed in Penang's manufacturing firms.

H4b: Inter-organization relationship significantly mediates the relationship between supplier involvement and new product development speed in Penang's manufacturing firms.

H4c: Inter-organization relationship significantly mediates the relationship between third party collaboration and new product development speed in Penang's manufacturing firms.

3.3 Research design

The questionnaire being used in this study consisted of six sections. Eleven questions in section one were designed to collect important demographic information for this study. Section one was subdivided into section 1a and 1b for company profile and respondent profile respectively. Section 1a consisted of seven company profile questions and section 1b consisted of four respondent profile questions. The respondents that answered "no" for question seven of section 1a were omitted from data analysis. Question seven of section 1a asked respondents whether the company they worked with engaged in any form of NPD activity or not.

Six questions in section two were used to measure NPD speed. Question one to question three were adapted from Feng and Wang (2013) and question four to question six were adapted from Lin and Huang (2013). Section three measured customer involvement and section four measured supplier involvement. Each section contained five questions. All questions in section three and section four were adapted from Feng and Wang (2013). Third party collaboration was measured in section five that consisted of five questions adapted from Lai et al. (2012).

Section six measured inter-organization relationship between respondent's company and its business partners. Definition for business partners was provided in the questionnaire, which was defined as customers, suppliers and third parties. The six questions being used to measure inter-organization relationship were adapted from Lin and Huang (2013). Section two, three, four, five and six used five-point Likert's scale. Which was adopted from the original questionnaire in literature. Scale one for strongly disagree, scale two for disagree, scale three for neutral, scale four for agree and scale

five for strongly agree. Instead of seven-point Likert's scale, this study employed five-point Likert's scale because it was most recommended by researchers that it would reduce the frustration level of respondents as well as increase response rate and response quality (Babakus & Mangold, 1992; Sachdev & Verma, 2004). The whole questionnaire consisted of 38 questions, which approximately took 20 minutes to complete.

3.4 Measurement of variables/instrumentation

This study was conducted using close-ended survey questionnaire that consisted of 38 easy-to-understand questions or items. Except eleven questions for demographic information collection, the other remaining 27 items were used to measure dependent variable, independent variables and mediating variable. Items in section two, three, four, five and six were either adopted or adapted from previous researchers' published articles (Feng & Wang, 2013; Lai et al., 2012; Lin & Huang, 2013). Original sources of all items in section two, three, four, five and six were summarized in table 3.1. Modification of the adapted questionnaires were explained in section 3.4.1. In the process of modifying the adapted questionnaire, input from five reviewers were taken. The five reviewers' background met this survey's respondent criteria and were qualified to be the respondents for this research. However, these five reviewers were not asked again to answer questionnaire for the final data collection.

Table 3. 1
Original sources of items in section two, three, four, five and six

Variable	No	Original version	Questionnaire authors
New product development speed (Section two)	1	We deliver the new product to market quickly.	Feng & Wang, 2013
	2	We are first in the market in introducing the new product.	
	3	We have time-to-market that lower than industry average.	
	4	We have fast new product development capability.	
	5	Top management was very pleased with the time it took us to bring this product to market.	Lin & Huang, 2013
	6	This product was launched on or ahead of the original schedule.	
	7	This product was completed in less time than what was considered normal and customary for our industry.	
	8	This product was developed and launched faster than a similar product of a major competitor.	

Table 3.1 (Continued)

Variable	No	Original version	Questionnaire authors
Customer involvement (section three)	1	We consulted major customer early in the design efforts for the new product.	Feng & Wang, 2013
	2	We partnered with major customer for developing new product.	
	3	Major customer was an integral part of the design effort for the new product development.	
	4	Major customer was frequently consulted about the design of the new product.	
	5	We have continuous improvement programs that include our major customer.	
Supplier involvement (section four)	1	We consulted major supplier early in the design efforts for the new product.	Feng & Wang, 2013
	2	We partnered with major supplier for developing new product.	
	3	Major supplier was an integral part of the design effort for the new product development.	
	4	Major supplier was frequently consulted about the design of the new product.	
	5	We have continuous improvement programs that include our major supplier.	

Table 3.1 (Continued)

Variable	No	Original version	Questionnaire authors
Third party collaboration (section five)	1	Third parties involved in early stage of product development.	Lai, Chen & Yang, 2012
	2	We use information from Third parties.	
	3	Third parties input for prototype test.	
	4	Product development people meet Third parties people.	
	5	Third parties input for parts design.	
Inter-organization relationship (section six)	1	Our firm feels indebted to customers for what they have done for us.	Lin & Huang, 2013
	2	Our interactions with customers can be defined as "mutually gratifying".	
	3	Maintaining a long-tern relationship with customers is important to us.	
	4	Our business relationship with customers could be described as "cooperative" rather than an "arm's-length" relationship.	
	5	Our firm expects to be interacting with customers far into the future.	
	6	Our firm and customers maintain our relationship with considerable frequency of contact.	

3.4.1 Modification of adapted questionnaire

The adapted questionnaire was modified to suit Malaysia context and made easier for Malaysian respondents to understand. For section two that measured NPD speed, item one and three were omitted after detail discussion with five questionnaire reviewers. The reviewers had concern on the word "quickly" used in item one "We deliver the new product to market quickly". Which was deemed subjective and would likely lead to response error because different respondents might interpret "quickly" differently. Item three "We have time-to-market that is lower than industry average" was omitted after detail discussion with the five reviewers. The same question was asked again in item seven, by replacing time-to-market with NPD cycle time. The reviewers were confused and tried to interpret time-to-market and NPD cycle time differently. According to Chen (2007), time-to-market and NPD cycle time were two of many other terms used for NPD speed in literature. However, respondents for this survey might not be familiar with this technical definition. Industry standard for NPD cycle time was provided in Appendix A of the survey questionnaire, but not time-to-market. Thus, item with time-to-market was omitted instead of the item with NPD cycle time.

Item two was adapted from Feng and Wang (2013). Item two was changed from "We are first in the market in introducing the new product" to "We are first in the market in introducing new product". Item four was adopted from Feng and Wang (2013). After the above modification, Item two and item four were renamed as item one and item two respectively in the final questionnaire for section two. Similarly, item five, six, seven and eight were renamed accordingly to item three, four, five and six respectively.

Continuing section two, item three to item six were adapted from Lin and Huang (2013). Item three was changed from "Top management was very pleased with the time it took us to bring this product to market" to "Our plant managing director was very pleased with the time it took for us to bring new products to the market". Item four was changed from "This product was launched on or ahead of the original schedule" to "New products were launched on or ahead of the original schedule". Item five was changed from "This product was completed in less time than what was considered normal and customary for our industry" to "Our new product development cycle time is shorter than industry average". Item six was changed from "This product was developed and launched faster than a similar product of a major competitor" to "New products were launched to the market faster than our competitors". This item was modified to avoid double-barreled question. Complete development time and launching time for a new product could be different in certain companies. Certain new products could be developed but would not be launched to the market at the same time due to marketing strategy reason. Comparison between the original and adapted version of NPD speed items was summarized in table 3.2.

Table 3. 2
Original and adapted version of new product development speed items

	Original version	Adapted version
1.	We deliver the new product to market quickly.	Omitted – Questionnaire reviewer feedback that "quickly" is subjective and will likely lead to response error. Fortunately, the objective of this item can be accomplished through other items in this section.
2.	We are first in the market in introducing the new product.	We are first in the market in introducing new product.
3.	We have time-to-market that lower than industry average.	Omitted after detail discussion with five questionnaire reviewers.
4.	We have fast new product development capability.	No change – adopted.
5.	Top management was very pleased with the time it took us to bring this product to market.	Our plant managing director was very pleased with the time it took for us to bring new products to the market.
6.	This product was launched on or ahead of the original schedule.	New products were launched on or ahead of the original schedule.
7.	This product was completed in less time than what was considered normal and customary for our industry.	Our new product development cycle time is shorter than industry average.
8.	This product was developed and launched faster than a similar product of a major competitor.	New products were launched to the market faster than our competitors.

For section three that measured customer involvement, namely item one, two, three, four and five were adapted from Feng and Wang (2013). Item one was changed from "We consulted major customer early in the design efforts for the new product" to

"We consulted major customers before designing a new product". Item two was changed from "We partnered with major customer for developing new product" to "We partnered with major customers for developing new product". Item three was changed from "Major customer was an integral part of the design effort for the new product development" to "Major customers' involvement was essential in the design effort for new product development". Item four was changed from "Major customer was frequently consulted about the design of the new product" to "Major customers were frequently consulted about the design of the new product". Item five was changed from "We have continuous improvement programs that include our major customer" to "Major customers were involved in our company's continuous improvement programs". Comparison between the original and adapted version of items used to measure customer involvement was summarized in table 3.3.

Table 3. 3
Original and adapted version of customer involvement items

	Original version	**Adapted version**
1.	We consulted major customer early in the design efforts for the new product.	We consulted major customers before designing a new product.
2.	We partnered with major customer for developing new product.	We partnered with major customers for developing new product.
3.	Major customer was an integral part of the design effort for the new product development.	Major customers' involvement was essential in the design effort for new product development.
4.	Major customer was frequently consulted about the design of the new product.	Major customers were frequently consulted about the design of the new product.

Table 3.3 (Continued)

	Original version	Adapted version
5.	We have continuous improvement programs that include our major customer.	Major customers were involved in our company's continuous improvement programs.

For section four that measured supplier involvement, namely item one, two, three, four and five were adapted from Feng and Wang (2013). Item one was changed from "We consulted major supplier early in the design efforts for the new product" to "We consulted major suppliers early when we designed a new product". Item two was changed from "We partnered with major supplier for developing new product" to "We partnered with major suppliers for developing new product". Item three was changed from "Major supplier was an integral part of the design effort for the new product development" to "Major suppliers' involvement was essential in the design effort for new product development". Item four was changed from "Major supplier was frequently consulted about the design of the new product" to "Major suppliers were frequently consulted about the design of the new product". Item five was changed from "We have continuous improvement programs that include our major supplier" to "Major suppliers were involved in our company's continuous improvement programs". Table 3.4 summarized comparison between the original and adapted version of supplier involvement items.

Table 3. 4
Original and adapted version of supplier involvement items

	Original version	Adapted version
1.	We consulted major supplier early in the design efforts for the new product.	We consulted major suppliers early when we designed a new product.
2.	We partnered with major supplier for developing new product.	We partnered with major suppliers for developing new product.
3.	Major supplier was an integral part of the design effort for the new product development.	Major suppliers' involvement was essential in the design effort for new product development.
4.	Major supplier was frequently consulted about the design of the new product.	Major suppliers were frequently consulted about the design of the new product.
5.	We have continuous improvement programs that include our major supplier.	Major suppliers were involved in our company's continuous improvement programs.

Section five that measured third party collaboration was adapted from Lai et al. (2012). Item one was changed from "Third parties involved in early stage of product development" to "Third party/s was/were involved in early stage of product development". Item two was changed from "We use information from third parties" to "We use market information from third party/s". Item three was changed from "Third parties input for prototype test" to "Third party/s provided input for prototype test". Item four was changed from "Product development people meet third parties people" to "Product development people meet third party/s people regularly". Item five was changed from "Third parties input for parts design" to "Third party/s provided technical input for parts design". Comparison between the original and adapted version of third party collaboration items was summarized in table 3.5.

Table 3. 5
Original and adapted version of third party collaboration items

	Original version	Adapted version
1.	Third parties involved in early stage of product development.	Third party/s was/were involved in early stage of product development.
2.	We use information from third parties.	We use market information from third party/s.
3.	Third parties input for prototype test.	Third party/s provided input for prototype test.
4.	Product development people meet third parties people.	Product development people meet third party/s people regularly.
5.	Third parties input for parts design.	Third party/s provided technical input for parts design.

Section six that measured inter-organization relationship was adapted from Lin and Huang (2013). Item one was changed from "Our firm feels indebted to customers for what they have done for us" to "Our company feels thankful to our business partners for what they have done for us". Item two was changed from 'Our interaction with customers can be defined as "mutually gratifying"' to "Our interactions with business partners are mutually satisfying". Item three was changed from "Maintaining a long-term relationship with customers is important to us" to "Maintaining a long-term relationship with business partners is important to us". Item four was changed from 'Our business relationship with customers could be described as "cooperative" rather than an "arm's-length" relationship' to "We maintain good relationship with our business partners". Item five was changed from "Our firm expects to be interacting with customers far into the future" to "Our company believes in long term relationship with business partners". Item six was changed from "Our firm and customers maintain our relationship with considerable frequency of contact" to "We always keep in touch with

our business partners". Comparison between the original and adapted version of inter-organization relationship items was summarized in table 3.6.

Table 3. 6
Original and adapted version of inter-organization relationship items

	Original version	Adapted version
1.	Our firm feels indebted to customers for what they have done for us.	Our company feels thankful to our business partners for what they have done for us.
2.	Our interactions with customers can be defined as "mutually gratifying".	Our interactions with business partners are mutually satisfying.
3.	Maintaining a long-tern relationship with customers is important to us.	Maintaining a long-term relationship with business partners is important to us.
4.	Our business relationship with customers could be described as "cooperative" rather than an "arm's-length" relationship.	We maintain good relationship with our business partners.
5.	Our firm expects to be interacting with customers far into the future.	Our company believes in long term relationship with business partners.
6.	Our firm and customers maintain our relationship with considerable frequency of contact.	We always keep in touch with our business partners.

3.4.2 Validity and reliability

To ensure validity and reliability of the questionnaire and the data collected, all items used in the questionnaire were either adopted or adapted from previous researchers' published articles (Feng & Wang, 2013; Lai et al., 2012; Lin & Huang, 2013). The sequence of items in each questionnaire section was also fully adopted from previous

researches. Some questionnaire items were modified to suit Malaysia context and made easy for local respondents to understand. Factor analysis was used to check validity and consistency of the questionnaire used. Results of KMO and Bartlett's test for the five variables were verified and reported. Barlett's test was significant if p-value was <0.05 for the tested variables. If Barlett's test was significant, validity and consistency of the questionnaire used to measure the variables were considered adequate if KMO values were more than 0.5 each (Coakes, Steed & Ong, 2009; Tabachnick & Fidell, 2007 as cited in Pallant, 2007). Questionnaire reliability for all the five variables was empirically tested by verifying their Cronbach's alpha values.

3.4.3 Measurement of demographic information

Eleven relevant demographic questions about the manufacturers and respondents were collected to reflect the characteristics of the sampled manufacturers and respondents. The measurements of these demographic information were addressed in section one of the survey questionnaire and discussed in the following section. Section one was subdivided into section 1a for company profile and section 1b for respondent profile.

Item one in section 1a- Years of operation in Penang: This question asked how many years the manufacturer started operation in Penang since it was founded. Older firms tend to have more NPD projects and have more cumulative experience in tracking and improving its NPD speed. In addition to empirically validating this notion, this research also aimed to characterize the firms' extend of external integration and inter-organization relationship in term of years of operation in Penang, using one-way ANOVA. The categories of number of years manufacturer started its operation in Penang were summarized in table 3.7.

Table 3. 7
Years of operation in Penang

Choice	Category
1	< 3 years
2	≥ 3 years to < 5 years
3	≥ 5 years to < 10 years
4	≥ 10 years to < 20 years
5	≥ 20 years

Item two in section 1a - Size of the manufacturer: This question asked the manufacturers how many permanent employees they employed. Production was the key function of a manufacturing firm. For certain small manufacturer, NPD activities might not be done by a dedicated function like R&D department. Manufacturing or engineering department could execute the NPD activities as well. Sometimes, the founder of a small company could be involved as well. The categories of manufacturer's size were summarized in table 3.8. This research aimed to characterize the influence of manufacturer size on NPD speed, external integration and inter-organization relationship by using one-way ANOVA. Size of company had a recognized effect on NPD speed (Lin & Huang, 2013). Thus, this data was also collected as control variable when doing regression analysis for NPD speed.

Table 3. 8
Size of the manufacturer

Choice	Category
1	≤ 50 permanent employees
2	51 – 200 permanent employees
3	201 – 500 permanent employees
4	501 – 1000 permanent employees
5	1001 – 2000 permanent employees
6	≥ 2001 permanent employees

Item three in section 1a - Size of R&D department: This question asked the manufacturers how many permanent employees they employed in R&D department. Additional resources were required to perform NPD activities and it became more apparent when the manufacturer strived to increase its NPD speed. It was expected that the bigger the manufacturer's R&D department, the more NPD projects it would have and with speedier NPD compared to industry average. The categories of manufacturer's R&D department size were summarized in table 3.9. Besides NPD speed, the influence of R&D size was also characterized on external integration and inter-organization relationship by using one-way ANOVA.

Table 3. 9
Size of R&D department

Choice	Category
1	None
2	1 – 5 permanent employees
3	6 – 10 permanent employees
4	11 – 15 permanent employees
5	16 – 20 permanent employees
6	≥ 21 permanent employees

Item four in section 1a – Company origin: This question asked the manufacturer's holding company's country of origin. National culture influenced inter-organization relationship. This question aimed to find answer whether holding company's national culture had any influence on its Penang subsidiary in handling its inter-organization relationship. The categories of manufacturer's company origin were summarized in table 3.10. In addition to inter-organization relationship, this research intended to understand the effect of company origin on NPD speed and external integration based on test of difference by using one-way ANOVA.

Table 3.10
Company origin

Choice	Category
1	Local company
2	American MNC
3	European MNC
4	Japanese MNC
5	Taiwanese, Hong Kong or China MNC
6	Others, please indicate

Item five in section 1a - Type of industry: This question asked the manufacturer's type of industry. Due to differences in product life span, product complexity, quality and safety requirements, every industry had its own industry standard in term of development cycle time. This demographic data was collected to detect differences in NPD speed by industry although the questionnaire had been designed to eliminate this influence by asking respondents to answer NPD speed questions by relative to industry standard but not by absolute NPD cycle time in months or years. The categories of manufacturer's type of industry were summarized in table 3.11. This research also aimed to characterize NPD speed, external integration and inter-organization relationship of manufacturing firms in Penang by different type of industry by using one-way ANOVA.

Table 3.11
Type of industry

Choice	Category
1	Semiconductor/electronic components
2	Equipment and instrumentation
3	Electrical/household appliances
4	Automotive
5	Others, please indicate

Item six in section 1a - Component manufacturer: This question asked respondents whether they were component manufacturers or not. NPD speed was one of the critical factors that determined the success of a component manufacturer. Industrial customers usually outsourced many components of their new product and developed them concurrently with a few suppliers. Any component supplier's delay

would directly delay the customer's new product launching. Component manufacturers or industrial suppliers were expected to have higher NPD speed to stay competitive in the market. Component in this study refers to material, piece part, subassembly or subsystem which was required as input to build a finished product.

Item seven in section 1a - Does your company engage in any form of NPD activity? This question was asked to ensure the respondents were eligible to participate in this survey. If the respondent answered "no" to this question, the data collected from this respondent was omitted for data analysis.

Item one in section 1b - Job title of the respondent: The respondent for this survey should have experience or involve in NPD activities and sufficiently knowledgeable on the processes and outcomes of their company's NPD activities. Nevertheless, the respondent for this survey did not necessarily coming from a specific function like R&D. However, the respondent must be at least at engineer/executive or higher level.

Item two in section 1b – Length of service: In order to reliably answer this questionnaire, the respondent must have sufficient knowledge on his/her company's NPD processes and results. Thus, the respondent selected for this survey preferably had worked for the present company for more than one year.

Item three in section 1b – Respondent's department: Not all companies have R&D department, especially in a small and young company. Although the eligible respondents for this survey were not necessarily coming from R&D department, it was

deemed necessary to verify respondents' department to make sure they were relevant to NPD activities. For example, respondents from logistic or security department should be avoided.

Item four in section 1b – Respondent's gender: Respondent's gender did not affect the result of this survey. This question was for general respondent profile data collection only.

3.5 Unit of analysis

Unit of analysis is at organization level with only one respondent representing each manufacturing firm located in Penang state that engages in any form of NPD activity. Only one respondent was selected from each manufacturing firm to represent the selected manufacturing firm in the population. The respondent selected was an employee that directly involved in his/her company's NPD processes or responsible to the completion of NPD project. The position he/she held in his/her organization was either executive, engineer, manager or higher levels. The selected respondent was presumably well-verse in his/her company's NPD processes and results. The selected respondents were mainly from R&D department that managed or executed NPD projects, like Technical Project Leads, R&D Engineers, Product Development Engineers or Program Managers. They could also be from other R&D equivalent departments or supporting departments that involved in their company's NPD activities or responsible to the completion of NPD projects. Certain small companies do not officially set up an R&D department but the extended function was carried out by other departments like engineering department.

3.6 Sampling procedure

Unit of analysis for this research is at organization level. Therefore, the sample collected must be a manufacturing firm located in Penang state that engaged in any form of NPD activity. These manufacturing firms introduced new product to the general market or to their industrial customers. Federation of Malaysian Manufacturers (FMM) directory did not indicate whether their member companies engaged in any NPD activity or not. Thus, this sample screening was done during data collection process. Respondent criteria were explained to the respondents during first e-mail and phone contact with respondents and reiterated in the questionnaire instruction. Again, item seven in section 1a for company profile asked respondents whether their company engaged in any form of NPD activity that introduced new product or not. If the respondent answered "no" for this question, this respondent was omitted from data analysis. This three-tier screening was done to ensure correct sample was collected for analysis. Only one respondent was selected from each sample manufacturer to represent his/her company. If more than one respondent from a same company answered the questionnaire voluntarily, only the most relevant respondent was used for data analysis. Hierarchy of selection was based on department, position held followed by length of service. For department, priority was given to respondent from R&D department. Respondents at higher organization level and longer length of service were prioritized.

3.6.1 Population

Target population of this research was the manufacturing firms in Penang that engaged in any form of NPD activity that introduced new product to the market or to their industrial customers. Both local companies and foreign multi-national corporations with manufacturing facilities in Penang were included in this study. FMM directory

was chosen as it was the most reliable source of data on manufacturing industry in Malaysia, which was widely referred to by researchers who studied Malaysian manufacturing sector in general (Ahmad Zaidi, 2014).

Malaysia is divided into six main regions, namely the northern region, central region, southern region, east coast, Sabah, and Sarawak. Northern region consists of states like Perlis, Kedah, Penang and Perak. Kuala Lumpur, Selangor and Negeri Sembilan make up the central region of Malaysia. The three states that form the east coast of Malaysia are Kelantan, Terengganu and Pahang. Southern region consists of Malacca and Johore. These six regions have somewhat different cultural value, level of development, history and socio-economy. They are grouped under different Malaysia Economic Corridors. The same states that form the northern region of Malaysia are clustered under Northern Corridor Economic Region (NCER).

To ensure sampling homogeneity, this study focused on manufacturing firms in Penang state only. Although the four states in NCER shared the same economic agenda, their economic composition were fairly different. Referring to Department of Statistics Malaysia's official website as of 12th of June 2018, Penang, Kedah, Perak and Perlis contributed 14.8%, 4.5%, 4.5% and 0.2% share at constant price year 2005 to Malaysia's manufacturing industry respectively in year 2013.

In year 2016, manufacturing sector's contribution in each state's economic activity was 44.6% (Penang), 28.9% (Kedah), 18.5% (Perak) and 8.1% (Perlis) (Department of statistic Malaysia, 2017). Due to disparity in manufacturing sector's contribution to state's economy and cultural differences between Penang and the other

three NCER states, it was decided to further focus this research's population frame to Penang state only. Another reason Penang state was chosen in this study was that majority of electrical and electronic manufacturing firms and their supporting industries were located in Penang state. As explained in the background of this study (section 1.1), electrical and electronic industry had the shortest product development cycle time. Thus, NPD speed was expected to have greater impact on electrical and electronic industry compared to other manufacturing industries in Malaysia.

3.6.2 Sample

The information collected from the sample of limited number of respondents must be able to represent the characteristics of target population under study (Salant & Dillman, 1994). Hence, samples should be taken from the sample frame that was closely related to the target population and provided only the correct and complete number of elements from where the actual samples were drawn (Cooper & Schindler, 2008). Respondents selected were the eligible employees from the manufacturers listed in sample frame. Sample frame of this research was the 288 Penang manufacturing firms listed in the 47th edition of FMM directory (2016). Only one employee was selected to represent each manufacturing firm in this study. As explained in section 3.6, three-tier screening was done to ensure correct respondents were selected for analysis.

3.6.3 Size of sample

For multiple regression analysis, Hair, Anderson, Tatham and Black as cited in Barlett, Kotrlik and Higgins (2001) suggested that the ratio of sample to independent variables should not fall below five. A more conservative ratio of ten sample for each independent variable was reported optimal (Miller & Kunce, 1973; Halinski & Feldt, 1970 as cited

in Barlett et al., 2001). The maximum number of independent variables that this study analyzed using multiple regression was four. Thus, by using the more conservative ratio of ten, sample size of 40 was sufficient. After all the data screening processes explained in chapter 4, the remaining 51 valid samples used for regression analysis was considered sufficient.

Total 288 manufacturing firms in Penang were listed in the 47th edition of FMM directory (2016) that manufactured physical goods themselves, which were considered the sample frame for this study. The scope of physical goods included consumer goods and capital/industry goods. Each of these 288 manufacturers was assigned an identity number from 1 to 288. A randomized sample frame was created by using Minitab 17.3.1 statistical software (refer Appendix B). The following section explained how the data was collected from this randomized sample frame.

3.7 Data collection procedures

Data were collected mainly through mailing or e-mailing of survey questionnaire. This data collection method was chosen because it was lower in cost, better privacy to respondent, wide geographical area coverage and less sensitive to bias due to interviewer's influence. However, mailing method had its own weaknesses like outdated mailing or e-mail addresses, low response rate and little control of what happened after the questionnaires were mailed. To mitigate the problem of outdated mailing address, the manufacturers' address were taken from the latest 47th edition FMM directory published in 2016. Poslaju was used to send the questionnaire together with a stamped return envelope to each respondent. Besides faster and confirmation on

delivery, this premium postal service was chosen to show respondents the importance of this survey.

According to Sekaran (2003), advance notification on the forthcoming survey could increase response rate for mail survey. Advance notification was made using phone call and e-mail. A softcopy of survey questionnaire was also attached to the e-mail when the advance notification was sent to respondents through e-mail. In some cases, the respondent replied e-mail with answered questionnaire attached. For these cases, an appreciation note was sent to each respondent and hard copy survey questionnaire was no longer needed to be mailed to these respondents. This study's data collection procedure could be summarized into four steps below:

i. Advance notice was sent to each respondent through e-mail, followed by phone call to explain the purpose of this survey, respondent's criteria and the estimated delivery date of the upcoming questionnaire hard copy. The selection and sequence of manufacturers to be contacted were based on the randomized sample frame created in section 3.6.3. Survey questionnaire soft copy was also attached in this first e-mail contact. In this phone call, the most eligible respondent from the contacted company was requested from the contact person listed in the 47th edition of FMM directory (2016). At the same time, the contact person was also requested to forward the e-mail to the employee who was most eligible to answer the questionnaire.

ii. If respondent replied e-mail with answered survey questionnaire attached, an appreciation note was sent to this respondent immediately.

iii. A week after the first contact, a personalized cover letter with a questionnaire and a stamped return envelope were mailed to each of the

identified respondent that had not responded through e-mail with answered questionnaire. For some companies within Bayan Lepas Free Industrial Zones, the cover note, questionnaire and stamped return envelope were hand carried to the companies for cost saving reason.

iv. One to two weeks after sending the questionnaire, a follow up call and/or e-mail was done to confirm receipt of the questionnaire by the respondents. Explanation on the questionnaire to the respondent was provided if required. At the same time, the respondents were reminded to complete the questionnaire. In some cases, several reminders were necessary until the due date of the survey.

This research was expected to receive low response rate of around 20%, based on previous study conducted by Ahmad Zaidi (2014) on Malaysian manufacturing firms. Besides the four steps taken above, additional actions below were taken to increase response rate:

i. The questionnaire were sent to a specific respondent's name instead of department name to reduce possibility of bureaucracy in mail handling. Respondent's name was requested from the contact person listed in the 47th edition of FMM directory (2016) during the first phone call. In case the contact person listed in the 47th edition of FMM directory (2016) had left the company, a call to the company's general line was done to request the receptionist to direct the call to the correct responsible person. The criteria of a targeted respondent was clearly defined in the cover note so that the contact person or respondent could forward the e-mail with questionnaire to

another more eligible employee in his/her company if he/she thought he/she was not the most suitable person to answer the questionnaire.

ii. Each question was written short and concise for better interpretation. The questions were modified to suit local context and used commonly used words. All jargons were eliminated and replaced with simple words.

iii. References like industry standard were given in questionnaire's appendix to help respondent answering the questions better. Specific terms used in this study like business partner and third party were explained before asking questions that used these specific terms.

iv. The respondents were assured of data confidentiality. This assurance was clearly stated in the questionnaire's cover letter with Othman Yeop Abdullah Graduate School of Business' (OYAGSB) letter head. This was important because respondents were more willing to respond to a survey that came from a recognized university (Edwards et. al., 2002).

v. The questionnaire was designed with structured close-ended questions with multiple choices and rating response options. Open-ended questions were very demanding for respondent to answer and might lead to lower response rate (Saland & Dillmant, 1994).

vi. The respondents were offered a copy of summary survey result upon request.

vii. Double-barreled questions were corrected to suit this study's context. Double-barreled questions would confuse respondents and cause respondents to stop answering the questionnaire. It became worse if respondent answered the question without fully understood the question.

3.8 Techniques of data analysis

After the data was collected, keyed into IBM SPSS Statistics version 22 software and properly coded, frequency statistic was tabulated for demographic data profiling and variable profiling. From frequency statistic table, missing data from any of the respondents could be easily detected and rectified. Before parametric data analysis could be conducted, normality of the data was tested to ensure the data collected was normal. To ensure consistency of result, two methods of Normality test were conducted. $Z_{skewness}$ and $Z_{Kurtosis}$ were first calculated. If $Z_{skewness}$ and $Z_{Kurtosis}$ for all the five tested variables were within ±3, normality of the data was considered acceptable. To increase the confidence level, Shapiro-Wilk's test of normality was also conducted to assess normality of the data collected. If data was not normal, data transformation was conducted and box plot was plotted to identify outliers. Outliers were then removed to improve normality of the data until acceptable. After outliers were removed and data was normal, test of multi collinearity was conducted to ensure no multi collinearity problem among the tested variables.

After this stage, the data was ready for hypothesis testing using regression analysis. Hypothesis H1, hypothesis H1a, hypothesis H1c and hypothesis H3 were tested using hierarchical regression analysis because the effect of company size needed to be controlled towards NPD speed. Lin and Huang (2013) revealed that size of company had a recognized effect on NPD speed. Hypothesis H2, hypothesis H2a and hypothesis H2c were tested using multiple regression analysis. Nevertheless, hypothesis H1b, hypothesis H2b and hypothesis H4b were not tested due to distribution for supplier involvement was not normal. The relationships being examined in this study were IV-DV, IV-Med and Med-DV. Multi collinearity problem among the

variables was once again verified by checking Tolerance value and VIF value of the coefficients table of regression analyses output.

Mediating effect of inter-organization relationship on the relationship between external integration and NPD speed was tested using Baron and Kenny's (1986) procedure. After completing hypotheses testing above, one-way ANOVA was conducted for test of differences. One-way ANOVA was conducted to test variables differences by the demographic data of interest like type of industry and origin of company.

3.9 Conclusion

This research used quantitative research method with close-ended survey questionnaire. Discussions on how this research was conducted were detailed in this chapter. Mitigation plans to overcome all potential issues related to measurement instrument, sampling procedure, data collection and data analysis procedures were explained and justified in detail. The sample frame of this study was manufacturing firms in Penang listed in the 47th edition of FMM directory (2016). Actual data analysis and interpretation of SPSS output are discussed in next chapter. Table 3.12 below summarizes research gaps identified for each hypothesis and the results obtained from previous researches (Akroush, 2012; Athaide et al., 2003; Carbonell & Rodríguez Escudero, 2010; Chen, 2007; Danese & Filippini, 2010; Feng et al., 2016; Feng & Wang, 2013; Feng & Zhao, 2014; Gök & Peker, 2017; Jung and Andrew, 2014; Lai et al., 2012; Langerak & Hultink, 2005; Lassen & Laugen, 2017; Lau, 2011; Lin & Huang, 2013; Lim et al., 2006; Mons et al., 2011; Schuh et al., 2017; Trainor et al., 2013; Tsai, Tsai & Wang, 2012; Wong et al., 2011; Wong & Tong, 2012).

Table 3.12
Identified research gaps for each hypothesis and previous research's results

Hypotheses	Previous results	Research gaps
IV-DV		
H1: External integration significantly relates to new product development speed in Penang's manufacturing firms.	Significant positive relationship: 1) CI with NPDS - 10 times 2) SI with NPDS - 10 times	1) Lack of similar study in Malaysia 2) TPC and NPDS direct relationship is lacking
H1a: Customer involvement positively relates to new product development speed in Penang's manufacturing firms.	Not significant: 1) CI with NPDS - 2 times 2) SI with NPDS - 2 times	3) Inclusion of TPC as third dimension of EI is lacking
H1b: Supplier involvement positively relates to new product development speed in Penang's manufacturing firms.		
H1c: Third party collaboration significantly relates to new product development speed in Penang's manufacturing firms.		

Table 3.12 (Continued)

Hypotheses	Previous results	Research gaps
IV-Med		
H2: External integration significantly relates to inter-organization relationship in Penang's manufacturing firms. **H2a:** Customer involvement positively relates to inter-organization relationship in Penang's manufacturing firms. **H2b:** Supplier involvement positively relates to inter-organization relationship in Penang's manufacturing firms. **H2c:** Third party collaboration significantly relates to inter-organization relationship in Penang's manufacturing firms.	Significant positive relationship: 1) CI with IOR - 2 times 2) SI with IOR - 1 time	1) Lack of similar study in Malaysia 2) TPC with IOR direct relationship is lacking 3) Inclusion of TPC as third dimension of EI is lacking
Med-DV		
H3: Inter-organization relationship significantly relates to new product development speed in Penang's manufacturing firms.	Significant positive relationship: 1) IOR with NPDS - 5 times Significant negative relationship: 1) IOR with NPDS - 1 time	1) Lack of similar study in Malaysia

Table 3.12 (Continued)

Hypotheses	Previous results	Research gaps
IV-Med-DV		
H4: Inter-organization relationship significantly mediates the relationship between external integration and new product development speed in Penang's manufacturing firms.	Significant relationship: 1) CI - IOR - NPD performance - 2 times	1) Lack of similar study in Malaysia 2) Lack of study using SI and TPC as IV 3) Inclusion of TPC as third dimension of EI is lacking
H4a: Inter-organization relationship significantly mediates the relationship between customer involvement and new product development speed in Penang's manufacturing firms.		
H4b: Inter-organization relationship significantly mediates the relationship between supplier involvement and new product development speed in Penang's manufacturing firms.		
H4c: Inter-organization relationship significantly mediates the relationship between third party collaboration and new product development speed in Penang's manufacturing firms.		

Note: IV = independent variable; Med = mediating variable; DV = dependent variable; EI = external integration; CI = customer involvement; SI = supplier involvement; TPC = third party collaboration; NPDS = new product development speed.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter focuses on the results of data analyses performed. Section 4.1 presents the response rate of this research. Section 4.2 to section 4.7 cover the results of demographic information, goodness of measure, factor analysis, reliability analysis, test of normality, inter-correlations among all studied variables and outlier analysis. Section 4.8 and section 4.9 report the results of all hypotheses tested and test of differences tested respectively. Section 4.10 discusses the results reported in section 4.8 and 4.9. Section 4.11 summarizes all the test results obtained for this research.

4.1 Response rates

Based on rule of thumb of the ratio of ten as explained in section 3.6.3, 51 valid responses used in this study exceeded the minimum sample size requirement of 30 (Barlett et al., 2001). 74% or 213 companies out of 288 companies listed in the 47th edition of FMM directory (2016) were contacted to participate in this research. Response rate is a measure of researcher's success in persuading respondents to return the questionnaire (Babbie, 1990). After 16 weeks of data collection, total 166 responses were collected. Which was equivalent to 78% response rate. All the responses were successfully collected after the eighth follow up. Data collection stopped after four consecutive follow ups in seven consecutive weeks without any further new response.

Table 4. 1
Responses after follow-ups

Responded	**No of company**	**After week**
Before 1 follow up	63	1
After 1 follow up	10	2
After 2 follow up	17	3
After 3 follow up	5	4
After 4 follow up	31	5
After 5 follow up	19	6
After 6 follow up	11	7
After 7 follow up	3	8
After 8 follow up	7	9
After 9 follow up	0	10
After 10 follow up	0	12
After 11 follow up	0	14
After 12 follow up	0	16
Total responses	**166**	

Out of 166 responses collected with completed questionnaire, 85 companies engaged in NPD activities while the remaining 81 companies did not engage in any form of NPD activity in their company. Two responses were omitted due to incomplete questionnaire. Having NPD activity was the prerequisite to qualify as sample for this research. Thus, only 85 responses left as valid sample which was equivalent to 51% of total completed questionnaire. This research was expected to receive low response rate of around 20%, based on previous study conducted by Ahmad Zaidi (2014) on Malaysian manufacturing firms. It is explained in section 4.5.1 and section 4.5.2 that the data collected could only be tested normal after excluding none component manufacturers from the data. As a result, the useful samples had further reduced to 51 companies which were used for hypotheses testing and test of differences after

removing two outliers. These 51 companies yielded 24% response rate and representing 18% of the total sample frame of 288 companies.

There was no record found regarding the list of companies in Penang state that engaged in NPD activities. Based on the ratio tabulated in table 4.2, 51% of the population is estimated to be having NPD activities. Thus, out of 288 companies in the sample frame, it was estimated that only 147 companies engaged in NPD activities.

Table 4. 2
Response breakdown

	No of company	**%**
Sample frame	288	
Total companies approached	213	74%
Responded with NPD activities	85	51%
Responded without NPD activities	81	49%
Total responded (overall response rate)	166	**78%**
Not responded	34	16%
Not reachable	11	5%
Omitted - respond error	2	1%

Note: NPD = new product development speed. The two omitted responses were due to incomplete questionnaire.

4.2 Demographic information

4.2.1 Company profile – overall sample

As summarized in table 4.3, majority of the companies participated in this study started their operation in Penang for at least 20 years (61.2%), followed by at least 10 years to less than 20 years (22.4%) and at least five years to less than 10 years (11.8%). Only

4.8% of the companies started their operation in Penang for less than five years. 2.4% was at least three years to less than five years and 2.4% less than three years. All the samples collected met the sampling requirement of at least one year.

Only 4.7% of the samples collected had company size not more than 50 permanent employees. Majority of the sample companies employed 51 – 200 permanent employees (28.2%) and at least 2001 permanent employees (22.4%). For the company size categories of 201 – 500, 501 – 1000 and 1001 – 2000, their contribution to this study were 18.8%, 14.1% and 11.8% respectively. Majority of the sample companies had more than 50 permanent employees because NPD activities were usually conducted by the bigger companies. One of the prerequisite to participate in this survey was that the company involved must engage in NPD activities.

15.3% of the companies participated in this study did not have an R&D department in their company. Their NPD activities were conducted by other departments like Process Engineering or Equipment Engineering departments. Majority of the samples were collected from the group of 1 – 5 R&D employees (35.3%) and at least 21 R&D employees (34.1%). 10.6% of the companies participated in this study employed 6 – 10 R&D employees. A small portion of the samples collected for this study were coming from the categories of 11 – 15 R&D employees (2.4%) and 16 – 20 R&D employees (2.4%).

This study was mainly participated by local companies (38.8%) and American MNCs (Multi-national Corporation) (36.5%). European MNCs and Japanese MNCs contributed 11.8% and 9.4% respectively to this study. 2.4% and 1.2% of the

respondent companies were Taiwanese, Hong Kong or China MNCs and Singapore companies respectively.

Almost half of the responses collected from this study were from semiconductor or industrial electronic industries (48.2%), followed by industrial equipment or instrumentation industries (15.3%). Almost all the companies from industrial equipment or instrumentation industries were the suppliers for the companies in semiconductor or industrial electronic industries. Electrical or consumer electronic industries contributed 7.1% to this study's total sample. Automotive (9.4%), medical (5.9%) and food (2.4%) industries made up the remaining respondents. Total 62.4% of the responded companies were component manufacturer while the remaining 37.6% were not component manufacturers.

Table 4. 3
Company profile – overall sample

Item		**Frequency**	**Percent**
Years of operation	< 3 years	2	2.4
	≥ 3 years to < 5 years	2	2.4
	≥ 5 years to < 10 years	10	11.8
	≥ 10 years to < 20 years	19	22.4
	≥ 20 years	52	61.2

Table 4.3 (Continued)

Item		Frequency	Percent
Size of company	≤ 50 permanent employees	4	4.7
	51 – 200 permanent employees	24	28.2
	201 – 500 permanent employees	16	18.8
	501 – 1000 permanent employees	12	14.1
	1001 – 2000 permanent employees	10	11.8
	≥ 2001 permanent employees	19	22.4
Size of R&D	None	13	15.3
	1 – 5 employees	30	35.3
	6 – 10 employees	9	10.6
	11 – 15 employees	2	2.4
	16 – 20 employees	2	2.4
	≥ 21 employees	29	34.1
Company origin	Local company	33	38.8
	American MNC	31	36.5
	European MNC	10	11.8
	Japanese MNC	8	9.4
	Taiwanese, Hong Kong or China MNC	2	2.4
	Others (Singapore)	1	1.2

Table 4.3 (Continued)

Item		Frequency	Percent
Type of industry	Semiconductor / industrial electronics	41	48.2
	Electrical / consumer electronics	6	7.1
	Industrial equipment / instrumentation	13	15.3
	Medical	5	5.9
	Automotive	8	9.4
	Food	2	2.4
	Others (E.g. toys and furniture)	10	11.8
Component manufacturer	Yes	53	62.4
	No	32	37.6

4.2.2 Company profile – component manufacturer

It is explained in section 4.5.1 and section 4.5.2 that the data collected could only be tested normal after excluding non-component manufacturers from the data. Thus, further breakdown of company profile was conducted for the 51 component manufacturers, which were used for hypotheses testing and test of difference. Inter dependency among manufacturing firms and their supplier and/or customer are stronger in component manufacturers compared to non-component manufacturers. Thus, the data from non-component manufacturers created noises that caused the overall distribution to be not normal.

Majority of the component manufacturers responded to this survey started their operation in Penang at least 10 years ago. 63.7% of the responded companies had operation in Penang for more than 20 years and 21.6% at least 10 years to 20 years.

Years of operation for the remaining component manufacturers were less than three years (3.9%), at least three years to five years (3.9%) and at least five years to 10 years (7.8%).

Only 3.9% of the component manufacturers had less than 50 permanent employees. 25.5% of the respondent companies had at least 2001 permanent employees. The remaining categories of company size were about equally represented. For the company size categories of 51 – 200, 201 – 500, 501 – 1000 and 1001 – 2000, their contribution to this survey were 17.6%, 19.6%, 17.6% and 15.7% respectively.

Majority of the respondents had big R&D group of at least 21 R&D employees (37.3%), followed by 1 – 5 R&D employees (31.4%). However, 15.7% of the respondents did not has an official R&D department in their companies. The remaining respondents were grouped under 6 – 10 R&D employees (7.8%), 11 – 15 R&D employees (3.9%) and 16 – 20 R&D employees (3.9%).

Most of the component manufacturers participated in this survey were American MNCs (43.1%) and local companies (35.3%). The remaining respondents were Japanese MNCs (9.8%), European MNCs (5.9%), Taiwanese, Hong Kong or China MNCs (3.9%) and Singaporean MNC (2.0%).

Majority of the component manufacturers participated in this survey came from semiconductor or industrial electronic industries (72.5%). The remaining industries participated in this study were automotive (9.8%), industrial equipment or

instrumentation (7.8%) and electrical or consumer electronic industries (2%). Table 4.4 below summarizes the company profile for component manufacturers.

Table 4. 4
Company profile – component manufacturer

Variable		**Frequency**	**Percent**
Years of operation	< 3 years	2	3.9
	≥ 3 years to < 5 years	2	3.9
	≥ 5 years to < 10 years	4	7.8
	≥ 10 years to < 20 years	11	21.6
	≥ 20 years	32	62.7
Size of company	≤ 50 permanent employees	2	3.9
	51 – 200 permanent employees	9	17.6
	201 – 500 permanent employees	10	19.6
	501 – 1000 permanent employees	9	17.6
	1001 – 2000 permanent employees	8	15.7
	≥ 2001 permanent employees	13	25.5
Size of R&D	None	8	15.7
	1 – 5 employees	16	31.4
	6 – 10 employees	4	7.8
	11 – 15 employees	2	3.9
	16 – 20 employees	2	3.9
	≥ 21 employees	19	37.3

Table 4.4 (Continued)

Variable		Frequency	Percent
Company origin	Local company	18	35.3
	American MNC	22	43.1
	European MNC	3	5.9
	Japanese MNC	5	9.8
	Taiwanese, Hong Kong or China MNC	2	3.9
	Others – Sing7apore	1	2.0
Type of industry	Semiconductor / industrial electronics	37	72.5
	Electrical / consumer electronics	1	2.0
	Industrial equipment / instrumentation	4	7.8
	Automotive	5	9.8
	Others (E.g. toys and furniture)	4	7.8

4.2.3 Respondent profile – overall sample

All the respondents that answered the survey questionnaire were having at least one year working experience in their existing companies and at least an executive/engineer or higher. 81.2% of the respondents worked in R&D (40.0%), Engineering (30.6%) and Quality (10.6%) department. Employees from these three departments were most suitable for this study as they were the direct contact persons to customer, supplier or third party in manufacturing firms. The two respondents from Purchasing, Commodity or Sourcing department were technical sourcing managers who deal extensively with suppliers and R&D to source for new technologies, components and materials. The three respondents from Sales and Marketing department were technical marketing

managers or application managers who deal with customer on the technical expect of the product. The three respondents from Production and Planning department were R&D or NPI planners who support R&D builds by planning with customer on demand side and with supplier on supply side. The R&D builds managed by these planners were unreleased products or prototypes. There were eight plant managers participating in this survey. They were owners of the company and they oversee every activity in their company. Therefore, all these respondents qualified to participate in this survey. As for gender split, the respondents were predominantly male (85.9%) but not important for this survey. Table 4.5 summarizes the respondent profile for the overall sample of this study.

Table 4. 5
Respondent profile – overall sample

Item		**Frequency**	**Percent**
Job title	Executive or engineers	15	17.6
	Lower level manager (section head, principle/staff engineer)	50	58.8
	Middle level manager (senior manager, department manager)	10	11.8
	Senior level manager (CEO, general manager and managing director)	10	11.8

Table 4.5 (Continued)

Item		Frequency	Percent
Length of	1	3	3.5
service (year/s)	2	4	4.7
	3	8	9.4
	4	6	7.1
	5	11	12.9
	6	9	10.6
	7	6	7.1
	8	2	2.4
	9	6	7.1
	10	10	11.8
	11	6	7.1
	12	2	2.4
	13	2	2.4
	15	3	3.5
	16	1	1.2
	18	1	1.2
	19	1	1.2
	26	1	1.2
	28	2	2.4
	36	1	1.2

Table 4.5 (Continued)

Item		Frequency	Percent
Department	R&D, PD, NPI or Project management	34	40.0
	Process or Manufacturing Engineering	26	30.6
	Purchasing, Commodity or Sourcing	2	2.4
	Quality	9	10.6
	Sales and Marketing	3	3.5
	Production and Planning	3	3.5
	Plant manager	8	9.4
Gender	Male	73	85.9
	Female	12	14.1

4.2.4 Respondent profile – component manufacturer

All the respondents that answered the survey questionnaire for component manufacturers were having at least one year working experience in their existing companies and at least an executive/engineer or higher. 80.4% of the respondents worked in R&D (43.1%), Engineering (25.5%) and Quality (11.8%) department. Employees from these three departments were most suitable for this study as they were the direct contact persons to customer, supplier or third party in manufacturing firms. The respondent from Purchasing, Commodity or Sourcing department was a technical sourcing manager who deal extensively with suppliers and R&D to source for new technologies, components and materials. The two respondents from Sales and Marketing department were technical marketing managers or application managers who deal with customer on the technical expect of the product. The two respondents

from Production and Planning department were R&D or NPI planners who support R&D builds by planning with customer on demand side and with supplier on supply side. The R&D builds managed by these planners were unreleased products or prototypes. There were five plant managers participating in this survey. They were owners of the company and they oversee every activity in their company. Therefore, all these respondents qualified to participate in this survey. For component manufacturers, male respondents answered 86.3% of the questionnaires. However, it would not affect the outcome of this survey. Table 4.6 summarizes the respondent profile for component manufacturers.

Table 4. 6
Respondent profile – component manufacturer

Variable		**Frequency**	**Percent**
Job title	Executive or engineers	9	17.6
	Lower level manager (section head, principle / staff engineer)	27	52.9
	Middle level manager (Senior manager, department manager)	10	19.6
	Senior level manager (CEO, General Manager and Managing director)	5	9.8

Table 4.6 (Continued)

Variable		Frequency	Percent
Length of	1	2	3.9
service (year/s)	2	4	7.8
	3	5	9.8
	4	3	5.9
	5	6	11.8
	6	3	5.9
	7	4	7.8
	8	1	2.0
	9	5	9.8
	10	3	5.9
	11	4	7.8
	12	2	3.9
	13	1	2.0
	15	3	5.9
	18	1	2.0
	19	1	2.0
	26	1	2.0
	28	2	3.9

Table 4.6 (Continued)

Variable		Frequency	Percent
Department	R&D, PD, NPI or Project management	22	43.1
	Process or Manufacturing Engineering	13	25.5
	Purchasing, Commodity or Sourcing	1	2.0
	Quality	6	11.8
	Sales and Marketing	2	3.9
	Production and Planning	2	3.9
	Plant manager	5	9.8
Gender	Male	44	86.3
	Female	7	13.7

4.3 Goodness of measure

4.3.1 Factor analysis: External integration and inter-organization relationship

A factor analysis using principal components method followed by a Varimax rotation was undertaken on the 15-item scale measuring external integration (customer involvement, supplier involvement and third party collaboration) and 6-item scale measuring inter-organization relationship. Both external integration as independent variable and inter-organization relationship as mediating variable were analyzed together. The 15-item scale measuring external integration consisted of three sets of 5-item scale, each measuring customer involvement, supplier involvement and third party collaboration respectively.

An examination of the correlation matrix indicated that a considerable number of Pearson correlation coefficients exceeded 0.3, so the matrix was suitable for factoring. Bartlett's test of sphericity was significant (p-value less than 0.05) and the

Kaiser-Meyer-Olkin measure of sampling adequacy was 0.701 which was greater than the minimum requirement of 0.6 (Coakes, Steed & Ong, 2009).

Five factors emerged with eigenvalues greater than 1.0, explaining a total of 66.56% of variance. All items loaded above 0.50 on the appropriate factors were selected from the analysis. Factor one comprised five customer involvement (CI) items with factor loadings ranging from 0.65 to 0.79. Factor two contained four supplier involvement (SI) items with factor loadings ranging from 0.66 to 0.81. Factor three consisted of five third party collaboration (TPC) items with factor loadings ranging from 0.76 to 0.87. Factor four included six inter-organization relationship (IOR) items with factor loadings ranging from 0.63 to 0.79. Factor five only had one supplier involvement (SI) item with factor loading 0.87, which was item SI5. In the subsequent factor analysis, item SI5 was considered to be excluded because factor five contained less than two items per factor.

Except item IOR5, all the other twenty (20) items displayed communality extraction values more than 0.5, ranging from 0.518 to 0.798. Although item IOR5 had the lowest communality extraction value of 0.407, it had factor loading of 0.63 and a low cross loading of 0.06. Which resulted in high delta of 0.58 between its factor loading and cross loading. As a result, it was decided to maintain item IOR5 for the subsequent factor analysis. Inspection on the anti-image correlation matrix revealed that all the measures of sampling adequacy were well above the acceptable level of 0.5 (Coakes et al., 2009), except SI5 which was 0.402. All the measures of sampling adequacy ranged from 0.508 to 0.866. Thus, the decision to remove SI5 in the subsequent factor analysis was justified.

Table 4. 7
Rotated factors and factor loadings of external integration and inter-organization relationship

Items	Factors				
	1	2	3	4	5
CI1 - We consulted major customers before designing a new product.	**.78**	.26	-.01	.11	.02
CI2 - We partnered with major customers for developing new product.	**.79**	-.01	.14	.07	.26
CI3 - Major customers' involvement was essential in the design effort for new product development.	**.65**	-.01	.27	.14	.02
CI4 - Major customers were frequently consulted about the design of the new product.	**.72**	.24	.05	-.03	-.01
CI5 - Major customers were involved in our company's continuous improvement programs.	**.68**	.06	-.18	.14	-.09
SI1 - We consulted major suppliers early when we designed a new product.	.21	**.74**	-.07	.19	-.10
SI2 - We partnered with major suppliers for developing new product.	.07	**.66**	-.02	.26	.35
SI3 - Major suppliers' involvement was essential in the design effort for new product development.	.28	**.79**	.00	.07	-.17
SI4 - Major suppliers were frequently consulted about the design of the new product.	-.03	**.81**	.10	-.01	.24

Table 4.7 (Continued)

Items	Factors				
	1	2	3	4	5
SI5 - Major suppliers were involved in our company's continuous improvement programs.	.14	.12	.04	.06	**.87**
TPC1 - Third party/s was/were involved in early stage of product development.	.06	.00	**.87**	-.09	-.13
TPC2 - We use market information from third party/s.	-.14	.08	**.76**	-.14	.19
TPC3 - Third party/s provided input for prototype test.	.00	.00	**.84**	-.08	-.10
TPC4 - Product development people meet third party/s people regularly.	.07	-.03	**.87**	-.02	.13
TPC5 - Third party/s provided technical input for parts design.	.24	-.03	**.81**	.04	-.01
IOR1 - Our company feels thankful to our business partners for what they have done for us.	.20	.10	-.25	**.73**	.14
IOR2 - Our interactions with business partners are mutually satisfying.	.12	.04	-.35	**.75**	.13
IOR3 - Maintaining a long-term relationship with business partners is important to us.	.25	.03	-.04	**.68**	-.30
IOR4 - We maintain good relationship with our business partners.	.15	.11	.23	**.66**	-.30
IOR5 - Our company believes in long term relationship with business partners.	.03	.04	.04	**.63**	.06
IOR6 - We always keep in touch with our business partners.	-.16	.20	-.06	**.79**	.18

Table 4.7 (Continued)

Items	Factors				
	1	2	3	4	5
Eigenvalue	2.10	1.96	4.63	1.96	1.26
Percentage of Variance	9.98	9.31	22.04	9.31	6.00
KMO Measure of Sampling adequacy = 0.701					
Bartlett's Test of Sphericity Approx. Chi Square = 896.257; df = 210; Sig = .000					

Note: N = 85. Underlined loadings indicate inclusion of that items into the factor.

The above factor analysis was repeated after excluding SI5. An examination of the correlation matrix indicated that a considerable number of correlations exceeded 0.3, so the matrix was suitable for factoring. Bartlett's test of sphericity was significant (p-value less than 0.05) and the Kaiser-Meyer-Olkin measure of sampling adequacy improved from 0.701 to 0.720 after removing SI5. Inspection on the anti-image correlation matrix revealed that all the measures of sampling adequacy were well above the acceptable level of 0.5 (Coakes et al., 2009), ranging from 0.509 to 0.872.

Four factors emerged with eigenvalues greater than 1.0, explaining a total of 63% of variance. All items loaded above 0.50 on the appropriate factors were selected from the analysis. Factor one comprised five customer involvement (CI) items with factor loadings ranging from 0.65 to 0.78. Factor two contained four supplier involvement (SI) items with factor loadings ranging from 0.71 to 0.84. Factor three consisted of five third party collaboration (TPC) items with factor loadings ranging from 0.77 to 0.87. Factor four included six inter-organization relationship (IOR) items with factor loadings ranging from 0.63 to 0.77. Except item IOR5, all the other 19 items displayed communality extraction values more than 0.5, ranging from 0.514 to 0.776.

Although item IOR5 had the lowest communality extraction value of 0.404, it had factor loading of 0.63 and a low cross loading of 0.06. Which resulted in high delta of 0.58 between its factor loading and cross loading. As a result, it was decided to maintain item IOR5 for the subsequent data analysis.

Table 4. 8
Rotated factors and factor loadings of external integration and inter-organization relationship – Repeated after removing SI5

Items	**Factors**			
	1	**2**	**3**	**4**
CI1 - We consulted major customers before designing a new product.	**.78**	.25	-.02	.12
CI2 - We partnered with major customers for developing new product.	**.77**	.04	.14	.08
CI3 - Major customers' involvement was essential in the design effort for new product development.	**.65**	.00	.27	.15
CI4 - Major customers were frequently consulted about the design of the new product.	**.73**	.24	.05	-.02
CI5 - Major customers were involved in our company's continuous improvement programs.	**.68**	.04	-.19	.15
SI1 - We consulted major suppliers early when we designed a new product.	.22	**.71**	-.07	.18
SI2 - We partnered with major suppliers for developing new product.	.06	**.71**	-.02	.24
SI3 - Major suppliers' involvement was essential in the design effort for new product development.	.30	**.73**	.00	.06
SI4 - Major suppliers were frequently consulted about the design of the new product.	-.03	**.84**	.10	-.03

Table 4.8 (Continued)

Items	Factors			
	1	2	3	4
TPC1 - Third party/s was/were involved in early stage of product development.	.07	-.03	**.87**	-.08
TPC2 - We use market information from third party/s.	-.15	.11	**.77**	-.14
TPC3 - Third party/s provided input for prototype test.	.01	-.02	**.84**	-.07
TPC4 - Product development people meet third party/s people regularly.	.07	.00	**.87**	-.02
TPC5 - Third party/s provided technical input for parts design.	.24	-.03	**.81**	.05
IOR1 - Our company feels thankful to our business partners for what they have done for us.	.18	.16	-.26	**.72**
IOR2 - Our interactions with business partners are mutually satisfying.	.11	.09	-.36	**.74**
IOR3 - Maintaining a long-term relationship with business partners is important to us.	.26	-.03	-.05	**.69**
IOR4 - We maintain good relationship with our business partners.	.16	.06	.22	**.67**
IOR5 - Our company believes in long term relationship with business partners.	.02	.06	.03	**.63**
IOR6 - We always keep in touch with our business partners.	-.18	.25	-.06	**.77**

Table 4.8 (Continued)

Items	Factors			
	1	2	3	4
Eigenvalue	2.09	1.90	4.59	4.02
% of Variance	10.44	9.51	22.95	20.10
Kaiser-Meyer-Olkin = 0.720				
Bartlett's Test of Sphericity Approx. Chi Square = 857.134; df = 190; Sig = .000				

Note: N = 85. Underlined loadings indicate inclusion of that items into the factor.

4.3.2 Factor analysis: New product development speed

A factor analysis using principal components method followed by a Varimax rotation was undertaken on the 6-item scale measuring NPD speed. An examination of the correlation matrix indicated that a considerable number of correlations exceeded 0.3, so the matrix was suitable for factoring. Bartlett's test of sphericity was significant (p-value less than 0.05) and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.879 which was greater than the minimum requirement of 0.6 (Coakes et al., 2009). All six items displayed communality extraction values more than 0.5, ranging from 0.519 to 0.742. Inspection on the anti-image correlation matrix revealed that all the measures of sampling adequacy were well above the acceptable level of 0.5 (Coakes et al., 2009), ranging from 0.863 to 0.900. Only one factor emerged with eigenvalue greater than 1.0, explaining a total of 67.74% of variance.

4.4 Reliability analysis

After all the items being factored accordingly, Cronbach's alpha reliability analysis was performed. The main purpose of this analysis was to ensure consistency and accuracy among items extracted in the earlier factor analysis. The important statistical values in

Cronbach's alpha reliability analysis included scale mean, variance if item were deleted from the scale and Cronbach's alpha if item were deleted from the scale. Summary of the Cronbach's alpha reliability analysis is tabulated in table 4.9 below.

Table 4. 9
Cronbach's alpha values for all the studied variables

Variables	**Cronbach's alpha**	**Number of item deleted**
Independent variable:		
Customer involvement: CI1, CI2, CI3, CI4 and CI5.	0.80	None
Supplier involvement: SI1, SI2, SI3 and SI4.	0.78	None
Third party collaboration: TPC1, TPC2, TPC3, TPC4 and TPC5.	0.90	None
Mediating variable:		
Inter-organization relationship: IOR1, IOR2, IOR3, IOR4, IOR5 and IOR6.	0.81	None
Dependent variable:		
New product development speed: NPDS1, NPDS2, NPDS3, NPDS4, NPDS5 and NPDS6.	0.90	None

Cronbach's alpha values for all the variables were higher than 0.70, ranging from 0.78 to 0.90. The high value of Cronbach's alpha meant that the items used in each variable were appropriate and reliable. Cronbach's alpha value slightly decreased or maintained when any item in variable customer involvement was deleted. Thus, all five items in customer involvement CI1, CI2, CI3, CI4 and CI5 were maintained. Supplier involvement's Cronbach's alpha value also slightly reduced if any of the four items in variable supplier involvement was deleted. Hence, all four items in supplier

involvement SI1, SI2, SI3 and SI4 were kept. Third party collaboration's Cronbach's alpha value slightly decreased when any of item TPC1, TPC3, TPC4 or TPC5 was deleted. On the other hand, Third party collaboration's Cronbach's alpha value only increased by 0.004 if item TPC2 was deleted. As a result, all items in variable third party collaboration were maintained.

For mediating variable inter-organization relationship, its Cronbach's alpha value slightly reduced if any of its six items was deleted. Therefore, inter-organization relationship variable remained consisted of six items. For dependent variable new product development speed, it's Cronbach's alpha value slightly decreased if any of item NPDS1, NPDS2, NPDS4, NPDS5 or NPDS6 was deleted. If item NPDS3 was deleted, new product development speed's Cronbach's alpha value remained unchanged. As a result, NPD speed variable remained comprising six items.

4.5 Test of normality

Skewness and kurtosis refer to the shape of the distribution. Skewness value provides an indication of the symmetry of the distribution. Kurtosis, on the other hand, provides information about the 'peakedness' of the distribution (Pallant, 2007). The distributions for customer involvement, supplier involvement and NPD speed were negatively skewed, while the distribution for third party collaboration and inter-organization relationship were positively skewed. From kurtosis statistic, the distributions for customer involvement, supplier involvement and NPD speed were peaked while the distributions for third party collaboration and inter-organization relationship were flatter. Zskewness and Zkurtosis for all variables were within +3 and -3, except

Zkurtosis for supplier involvement which was high at 5.465. Supplier involvement's distribution had a sharp peak at mean value of 4.01.

Table 4. 10
Skewness and Kurtosis of variables

	Skewness		Kurtosis	
Variables	**Statistic**	**Std Error**	**Statistic**	**Std Error**
Customer involvement	-0.736	0.261	2.817	0.517
Supplier involvement	-1.541	0.261	5.465	0.517
Third party collaboration	0.112	0.261	-1.002	0.517
Inter-organization relationship	0.504	0.261	-0.755	0.517
New product development speed	-0.331	0.261	0.017	0.517

Shapiro-Wilk statistic was used in test of normality due to sample size less than one hundred (Coakes et al., 2009). The sample size used in this study was 85 manufacturing firms. Data normality for all the variables analyzed could not be assumed due to their significant levels were less than 0.05 as shown in table 4.11. Without further data transformation, the existing data could not be used for further parametric data analysis. As shown in table 4.10, supplier involvement displayed an extreme level of skewness and kurtosis. Therefore, a natural logarithmic transformation was conducted before assessing the variables' normality again.

Table 4. 11
Test of normality

Variables	Shapiro-Wilk		
	Statistic	df	Sig.
Customer involvement	0.922	85	0.000
Supplier involvement	0.772	85	0.000
Third party collaboration	0.961	85	0.012
Inter-organization relationship	0.912	85	0.000
New product development speed	0.955	85	0.005

4.5.1 Test of normality – Natural logarithmic transformation

The above test of normality was repeated after all the variables were subjected to natural logarithmic transformation. After natural logarithmic transformation, all variables' Zskewness worsened except for variable Ln Inter-organization relationship, whereby its Zskewness improved slightly from 0.504 to 0.384. Likewise, all variables' Zkurtosis also worsened except for variable Ln third party collaboration, whereby its Zkurtosis improved slightly from -1.002 to -0.915. Based on Shapiro-Wilk statistic, all variables were significantly not normal after natural logarithmic transformation. In fact, the significant levels were also worsen compared to before natural logarithmic transformation. Therefore, it could be concluded that natural logarithmic transformation did not help in improving variable normality in this study.

Table 4. 12
Skewness and Kurtosis of variables – Natural logarithmic transformation

	Skewness		Kurtosis	
Variables	**Statistic**	**Std Error**	**Statistic**	**Std Error**
Ln Customer involvement	-1.607	0.261	6.774	0.517
Ln Supplier involvement	-2.401	0.261	8.962	0.517
Ln Third party collaboration	-0.261	0.261	-0.915	0.517
Ln Inter-organization relationship	0.384	0.261	-0.827	0.517
Ln New product development speed	-0.833	0.261	0.420	0.517

Table 4. 13
Test of normality – Natural logarithmic transformation

Variables	**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**
Ln Customer involvement	0.868	85	0.000
Ln Supplier involvement	0.703	85	0.000
Ln Third party collaboration	0.958	85	0.007
Ln Inter-organization relationship	0.920	85	0.000
Ln New product development speed	0.923	85	0.000

4.5.2 Test of normality – by group of component manufacturer

Based on several inputs from experienced industry experts, component manufacturers and non-component manufacturers managed their external business partners differently and they did not value inter-organization relationship equally. NPD timeline for a

component manufacturer was highly dependent on the speed of NPD by its suppliers as well as the specification and expectation defined by its customer. On the other hand, most of non-component manufacturers defined their own products' specification. However, the level of dependency on external business partners also depended on other factors like type of industry and size of the company. As a result, the variables' distributions for component manufacturers were expected to be more consistent compared to non-component manufacturers. Therefore, the tendency of getting a normal distribution in a small sample size study was expected to be higher for component manufacturers group. These experienced industry experts were the same five reviewers that helped reviewing the questionnaire in section 3.4.

Normality of the variables were hence assessed by group of component manufacturer. There were two groups of manufacturing firms by this category, either a component manufacturer or a non-component manufacturer. In addition to the similar normality test conducted above, component manufacturer was entered in the factor list dialogue box. The sample of this study consisted of 53 component manufacturers and 32 non component manufacturers.

Table 4. 14
Skewness and Kurtosis of variables – by group of component manufacturer

Variables	Component manufacturer	Skewness		Kurtosis	
		Statistic	Std error	Statistic	Std error
Customer involvement	Yes	0.152	0.327	0.212	0.644
	No	-0.827	0.414	1.945	0.809
Supplier involvement	Yes	-0.250	0.327	1.711	0.644
	No	-1.564	0.414	3.545	0.809
Third party collaboration	Yes	0.217	0.327	-0.510	0.644
	No	0.056	0.414	-1.533	0.809
Inter-organization relationship	Yes	0.247	0.327	-0.721	0.644
	No	1.000	0.414	-0.197	0.809
New product development speed	Yes	-0.321	0.327	0.327	0.644
	No	-0.125	0.414	-0.368	0.809

Except supplier involvement, Zskewness and Zkurtosis for all variables in component manufacturer group were within the range of -1 to +1. Although Zkurtosis for supplier involvement in component manufacturer group was higher than 1 at 1.711, it was still lower than the Zkurtosis for supplier involvement in non-component manufacturer group which was at 3.545. As shown in table 4.15, all variables in component manufacturer group were normal, except supplier involvement variable was still significantly not normal. After natural logarithmic transformation of the component manufacturer group of supplier involvement variable, similar normality test was conducted. Result of Shapiro-Wilk statistic showed that both component manufacturer and non-component manufacturer remained significantly not normal post-natural logarithmic transformation of supplier involvement variable. Besides, Zskewness and Zkurtosis for both component manufacturer and non-component

manufacturer were also worsen after natural logarithmic transformation. Therefore, the subsequent parametric analysis could not be conducted using supplier involvement variable. Supplier involvement variable could not be used for hypotheses testing because data normality was one of the assumptions underpinning the use of regression (Coakes et al., 2009). Unfortunately, the three dimensions of external integration had to be reduced to only two dimensions in this research, which were customer involvement and third party collaboration.

Table 4. 15
Test of normality – by group of component manufacturer

Variables	**Component manufacturer**	**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**
Customer involvement	Yes	0.959	53	0.068
	No	0.896	32	0.005
Supplier involvement	Yes	0.849	53	0.000
	No	0.737	32	0.000
Third party collaboration	Yes	0.967	53	0.152
	No	0.902	32	0.007
Inter-organization relationship	Yes	0.957	53	0.054
	No	0.779	32	0.000
New product development speed	Yes	0.962	53	0.089
	No	0.952	32	0.166

Besides component manufacturer grouping, the other groupings of sample were also assessed to check normality of the variables by each group. The other groupings that had been assessed including years of operation, size of company, size of R&D, company origin and type of industry. These other groupings did not improve normality

of the data collected for this research. As such, grouping by component manufacturer was considered the best grouping that could be used to enhance distribution normality.

4.6 Descriptive statistics and inter-correlations among all studied variables

Table 4.16 showed descriptive statistics, Cronbach's alpha values and inter-correlations among all the studied variables for component manufacturers. All studied variables showed good reliability coefficient (>0.7) of 0.80, 0.78, 0.90, 0.81 and 0.90 for customer involvement, supplier involvement, third party collaboration, inter-organization relationship and NPD speed respectively. It revealed a high internal consistency of all the studied variables, especially for third party collaboration and NPD speed with Cronbach's alpha value of 0.90. The inter-correlations among independent variables were low with Pearson correlation coefficient ranging from 0.06 to 0.18, with average Pearson r of 0.13. Which meant there was only 1.7% of overlap present in the independent variables' matrix. It also showed that there was high independence among the three independent variables. Therefore, there was no multi-collinearity issue existed in this study. According to Cohen (1988), the strength of correlations were categorized as small (r = 0.10 to 0.29), medium (r = 0.30 to 0.49) and large (r = 0.50 to 1.00).

Significant correlations were found between inter-organization relationship with customer involvement (r = 0.24, p-value 0.042), supplier involvement (r = 0.32, p-value 0.009) and third party collaboration (r = -0.311, p-value 0.012). On the correlation with NPD speed, the significant correlations were found with customer involvement (r = 0.244, p-value 0.039) and supplier involvement (r = 0.233, p-value 0.047). Nevertheless, the correlation between NPD speed and third party collaboration (r = 0.065, p-value 0.322) as well as between NPD speed and inter-organization

relationship (r = 0.188, p-value 0.089) were found not significant. The correlation strength among all the significant correlations were ranging from small to medium strength.

Table 4. 16
Descriptive statistics, Cronbach's alphas and zero-order correlations of all the studied variables

Item	CI	SI	TPC	IOR	NPDS
Independent variables:					
Customer involvement (CI)	0.80				
Supplier involvement (SI)	0.18	0.78			
Third party collaboration (TPC)	0.13	0.06	0.90		
Mediating variable:					
Inter-organization relationship (IOR)	0.24*	0.32**	-0.31*	0.81	
Dependent variable:					
New product development speed (NPDS)	0.24*	0.23*	0.06	0.19	0.90
Mean	3.98	4.05	3.06	4.34	3.54
Standard deviation	0.33	0.31	0.66	0.33	0.56

Notes: *p<0.05; **p<0.01; Values in the greyed diagonal cells are Cronbach's alpha values; Values in the other cells are Pearson correlation coefficient.

4.7 Outlier analysis – Casewise diagnostics

Outliers in the original data were detected and deleted to reduce bias results while testing the hypotheses. Outlier in the data matrix was detected by using Casewise diagnostics, where the standard deviation was set at ±2.5. Table 4.17 summarized the results of Casewise diagnostics among the studied variables, namely customer

involvement, third party collaboration, inter-organization relationship and NPD speed. There was no outlier detected using Casewise diagnostics while assessing the relationship between external integration (customer involvement and third party collaboration) and inter-organization relationship as well as the relationship between inter-organization relationship and NPD speed. For the relationship between external integration (customer involvement and third party collaboration) and NPD speed, there were two outliers detected by using Casewise diagnostics. The two outliers detected were coming from respondent ID 5 and 32. After removing these two outliers from the dataset, mean values for customer involvement, third party collaboration, inter-organization relationship and NPD speed were calculated and replaced with the existing mean values for the above four variables. An updated descriptive statistics for the four variables after removing outlier ID 5 and 32 was tabulated in table 4.18. Only after this step, the data was considered clean and correct for further hypotheses testing.

Table 4. 17
Outlier analysis: among the studied variables

Independent variable	**Dependent variable**	**Outlier cases detected**	**Number of outlier cases deleted**
Customer involvement	Inter-organization relationship	No outlier case detected	
Third party collaboration	New product development speed	5 and 32	2
Inter-organization relationship	New product development speed	No outlier case detected	

Table 4. 18
Descriptive statistics after removing outliers

Item	CI	TPC	IOR	NPDS
Mean	3.98	3.07	4.35	3.56
Standard deviation	0.33	0.67	0.34	0.53

4.8 Results for hypotheses testing

Hypotheses H1, H1a, H1b and H1c stated that external integration, customer involvement, supplier involvement and third party collaboration significantly related to NPD speed respectively. Hypotheses H2, H2a, H2b and H2c postulated that external integration, customer involvement, supplier involvement and third party collaboration significantly related to inter-organization relationship respectively in Penang's manufacturing firms. In hypothesis H3, it was hypothesized that inter-organization relationship significantly related to new product development speed in Penang's manufacturing firms. Hypotheses H4, H4a, H4b and H4c were designed to investigate if inter-organization relationship significantly mediated the relationship between external integration, customer involvement, supplier involvement and third party collaboration with NPD speed respectively.

Collinearity diagnostic was used to double check presence of multicollinearity in the data. Data was confirmed free from multicollinearity problem if VIF was less than 10 and TOL was more than 0.1 (Pallant, 2007). Table 4.19 summarized the collinearity statistics for all the studied variables. All variables met the VIF and TOL criteria mentioned above. Therefore, it was confirmed that the data used in this research was free from multicollinearity problem. Plot for homoscedasticity was also verified

for all variables. The plots were all widely spread. Thus, there was no heteroscedasticity indication in the data.

Table 4. 19
Collinearity statistics for all studied variables

Independent variable	**TOL**	**VIF**	**TOL**	**VIF**
Customer involvement	0.983	1.018	0.983	1.018
Third party collaboration	0.983	1.018	0.983	1.018
Inter-organization relationship	NA	NA	1.000	1.000
Dependent variable	**Inter-organization relationship**		**New product development speed**	

To make sure the data used was independent of error, Durbin Watson test of independence of error was conducted and its results were summarized in table 4.20. The data was considered independent of error if its Durbin Watson value was within the range of 1.5 to 2.5. Durbin Watson values for this study's data ranged from 1.848 to 2.350. Therefore, it was concluded that the data used in this study was independent of error.

Table 4. 20
Independence of error – Durbin Watson

Dependent variable	**Independent variable**	**Durbin Watson**
Inter-organization relationship	Customer involvement Third party collaboration	2.350
New product development speed	Inter-organization relationship	1.918
New product development speed	Customer involvement Third party collaboration	1.848

4.8.1 Test for hypotheses H1, H1a, H1b and H1c – Hierarchical multiple regression analysis

H1: External integration significantly relates to new product development speed in Penang's manufacturing firms.

H1a: Customer involvement positively relates to new product development speed in Penang's manufacturing firms.

H1b: Supplier involvement positively relates to new product development speed in Penang's manufacturing firms.

H1c: Third party collaboration significantly relates to new product development speed in Penang's manufacturing firms.

Hierarchical multiple regression analysis was conducted to examine the relationship between external integration and NPD speed whereby external integration consisted of two dimensions, namely customer involvement and third party collaboration. Size of company had a recognized effect on NPD speed (Lin & Huang, 2013). Therefore, size of company was entered as control variable (control the effect towards dependent variable) in block one. In block two, independent variables customer involvement and third party collaboration were entered in linear regression to check for their predictive power on NPD speed.

Durbin Watson value of 1.908 was within the range of 1.5 to 2.5, VIF values were less than 10 and Tolerance values were more than 0.1. The model was tested not significant with Sig. F Change value 0.066 (>0.05) that customer involvement and third party collaboration only made a unique contribution of 10.5% to the variance of NPD

speed. Table 4.21 summarized the results of hierarchical multiple regression analysis for dependent variable NPD speed.

Table 4. 21
Hierarchical multiple regression analysis: Test for H1, H1a and H1c

Model	Variables	Beta	Sig. t	R^2	ΔR^2	ΔF	ΔF Sig.
1	Size	0.199	0.161	0.040	0.040	2.027	0.161
2	Size	0.237	0.089	0.145	0.105	2.883	0.066
	CI	0.306	**0.030**				
	TPC	0.080	0.564				

Note: Dependent variable is new product development speed. Size is size of company, CI is customer involvement and TPC is third party collaboration.

In this hierarchical multiple regression model, third part collaboration did not significantly predict NPD speed. However, the relationship between customer involvement and NPD speed was significant with p-value of 0.030. Customer involvement was positively related to NPD speed. Therefore, hypothesis H1a was supported but hypothesis H1c was not supported. Which meant there was no significant relationship between third party collaboration and NPD speed. However, there was a significant relationship between customer involvement and NPD speed. As a result, hypothesis H1 was partially supported. Manufacturing firms that promoted customer involvement in their NPD processes tend to have higher NPD speed compared to their competitors or industry average.

4.8.2 Test for hypotheses H2, H2a, H2b and H2c – Multiple regression analysis

H2: External integration significantly relates to inter-organization relationship in Penang's manufacturing firms.

H2a: Customer involvement positively relates to inter-organization relationship in Penang's manufacturing firms.

H2b: Supplier involvement positively relates to inter-organization relationship in Penang's manufacturing firms.

H2c: Third party collaboration significantly relates to inter-organization relationship in Penang's manufacturing firms.

Multiple regression analysis was conducted to assess the relationship between customer involvement and third party collaboration with inter-organization relationship. Customer involvement and third party collaboration were the two dimensions of external integration in this research. Due to data normality issue in supplier involvement variable, only customer involvement and third party collaboration variables were included as independent variables for this multiple regression analysis. Hence, hypothesis H2b was not tested. 15.6% of variance in inter-organization relationship was explained by independent variables customer involvement and third party collaboration. The model was tested significant with F (5.607, 2) and p-value 0.006. Thus, hypothesis H2 was fully supported. Table 4.22 summarized the results of multiple regression analysis for dependent variable inter-organization relationship. The relationships between customer involvement and inter-organization relationship as well as between third party collaboration and inter-organization relationship were significant with their p-values less than 0.05. Hence, hypotheses H2a and H2c were supported.

Table 4. 22
Multiple regression analysis: Test for H2, H2a and H2c

Variables	Beta	t-value	p-value	R^2
Customer involvement	0.303	2.314	**0.025**	0.156
Third party collaboration	-0.355	-2.705	**0.009**	

Note: Dependent variable is inter-organization relationship.

The following predictive equation was derived from this study, which explained the relationship between inter-organization relationship with customer involvement and third party collaboration.

$$IOR = 3.7 + 0.3CI - 0.2TPC + e$$

In conclusion, hypotheses H2a and H2c were supported that there were significant relationships between customer involvement and inter-organization relationship as well as between third party collaboration and inter-organization relationship. In addition, this result also empirically confirmed the significant relationship between external integration and inter-organization relationship as postulated by hypothesis H2, whereby external integration consisted of customer involvement and third party collaboration in this research. Manufacturing firms that encouraged higher customer involvement but discouraged third party involvement in their NPD activities tend to have better inter-organization relationship with their business partners.

4.8.3 Test for hypothesis H3 – Hierarchical regression analysis

H3: Inter-organization relationship significantly relates to new product development speed in Penang's manufacturing firms.

Hierarchical regression analysis was performed to examine the relationship between inter-organization relationship and NPD speed. Lin and Huang (2013) reported that size of company had a recognized effect on NPD speed. Therefore, size of company was entered as control variable (control the effect towards dependent variable) in block one. In block two, independent variable inter-organization relationship was entered in linear regression to check for its predictive power on NPD speed. Durbin Watson value of 1.938 was within the range of 1.5 to 2.5, VIF value of 1.018 was less than 10 and Tolerance value of 0.983 was more than 0.1. The model was tested not significant with Sig. F Change value 0.379 (>0.05) that inter-organization relationship only made a unique contribution of 1.6% to the variance of NPD speed. Table 4.23 summarized the results of hierarchical regression analysis for dependent variable NPD speed.

Table 4. 23
Hierarchical regression analysis: Test for H3

Model	Variables	Beta	Sig. t	R^2	ΔR^2	ΔF	ΔF Sig.
1	Size	0.199	0.161	0.040	0.040	2.027	0.161
2	Size	0.183	0.203	0.055	0.016	0.788	0.379
	IOR	0.126	0.379				

Note: Dependent variable = new product development speed; Size = size of company.

Hypothesis H3 was not supported. Which meant there was no significant relationship between inter-organization relationship and NPD speed.

4.8.4 Test for hypotheses H4, H4a, H4b and H4c

H4: Inter-organization relationship significantly mediates the relationship between external integration and new product development speed in Penang's manufacturing firms.

H4a: Inter-organization relationship significantly mediates the relationship between customer involvement and new product development speed in Penang's manufacturing firms.

H4b: Inter-organization relationship significantly mediates the relationship between supplier involvement and new product development speed in Penang's manufacturing firms.

H4c: Inter-organization relationship significantly mediates the relationship between third party collaboration and new product development speed in Penang's manufacturing firms.

Based on Baron and Kenny's (1986) procedure, inter-organization relationship will fully mediate the effect of external integration (customer involvement, supplier involvement and third party collaboration) on NPD speed if the following conditions (a) to (d) are satisfied through three regression steps below:

Step 1: External integration predicting NPD speed.

Step 2: External integration predicting inter-organization relationship.

Step 3: External integration and inter-organization relationship predicting NPD speed.

Condition (a): External integration significantly predicts NPD speed.

Condition (b): External integration significantly predicts inter-organization relationship.

Condition (c): Inter-organization relationship significantly predicts NPD speed. With external integration as control variable.

Condition (d): The power of external integration to predict NPD speed becomes non-significant after controlling for inter-organization relationship.

- If beta becomes non-significant → fully mediating.
- If beta still significant, but reduce in value → partially mediating.
- If beta value and significant level exactly the same → no mediating effect.
- If beta still significant and increase in value → no mediating effect.

Table 4. 24
Baron and Kenny's procedure: Test for H4

Step	DV	IV	Beta	Sig. t	Condition
1	NPDS	CI	0.306	**0.030**	Fulfilled
		TPC	0.080	0.564	Not fulfilled
2	IOR	CI	0.303	**0.025**	Fulfilled
		TPC	-0.355	**0.009**	Fulfilled
3	NPDS	CI	0.280	0.060	-
		TPC	0.107	0.470	-
		IOR	0.082	0.595	**Not fulfilled**

Note: DV = dependent variable; IV = independent variable; NPDS = new product development speed; CI = customer involvement; TPC = third party collaboration; IOR = inter-organization relationship

Result from hypothesis H1 test (step 1) confirmed that third party collaboration did not significantly predict NPD speed. However, customer involvement significantly predicted NPD speed. Therefore, customer involvement as independent variable fulfilled condition (a) but third party collaboration as independent variable did not fulfill condition (a). Result from hypothesis H2 tests (step 2) confirmed that condition (b) was fulfilled, whereby customer involvement and third party collaboration

significantly predicted inter-organization relationship. However, condition (c) was not fulfilled in step 3, whereby inter-organization relationship did not significantly predict NPD speed when external integration was entered as control variable. As a result, based on Baron and Kenny's (1986) procedure, inter-organization relationship was confirmed not a significant mediator for the relationship between external integration and NPD speed, between customer involvement and NPD speed as well as for the relationship between third party collaboration and NPD speed. Based on Baron and Kenny's (1986) procedure, hypothesis H4, hypothesis H4a and hypothesis H4c were not supported because Baron and Kenny's condition (c) was not met (inter-organization relationship did not significantly predict NPD speed). Hypothesis H4b was not tested due to distribution not normal for supplier involvement variable.

4.9 Results for test of difference – One-way ANOVA

The two assumptions that must be met before conducting one-way ANOVA were population normality and homogeneity (Coakes et al., 2009). As reported in section 4.5 for test of normality, only the sample group of component manufacturers were tested normal. Thus, test of difference using one-way ANOVA in this section was conducted on component manufacturers only. In addition, independent variable supplier involvement was also tested not normal within component manufacturers group. Thus, supplier involvement was excluded from the test of difference.

4.9.1 New product development speed differences by company profile

As shown in table 4.25, Levene test for homogeneity of variances for all the five company profiles, namely years of operation, size of company, size of R&D, company origin and type of industry were not significant (p-value > 0.05). Thus, the population

variances for each group of every company profile listed in table 4.25 were approximately equal. Variances were assumed equal if p-value in Levene test was more than 0.05 (Coakes et al., 2009; Pallant, 2007). Therefore, the two assumptions of population normality and homogeneity of variances were met before conducting one-way ANOVA.

Table 4. 25
Test for homogeneity of variances – New product development speed

Company profile	Levene statistic	df1	df2	Sig.
Years of operation	0.712	4	46	0.588
Size of company	0.845	5	45	0.525
Size of R&D	0.513	5	45	0.765
Company origin	2.312	4	45	0.072
Type of industry	2.630	3	46	0.061

Test result showed that NPD speed for all groups of years of operation were not significantly different, F(4, 46) = 0.221, p-value 0.925. There was also no significant difference in NPD speed for different sizes of company with F(5, 45) = 0.939, p-value 0.465. Similar finding was observed on size of R&D. Different sizes of R&D department did not significantly influence the manufacturing firms' NPD speed, F(5,45) = 0.629, p-value 0.679. No significant difference in NPD speed for different type of industry as well, F(3,46) = 1.171, p-value 0.336.

Table 4. 26
One-way ANOVA – New product development speed

Company profile	F	p-value	Result
Years of operation	0.221	0.925	No difference
Size of company	0.939	0.465	No difference
Size of R&D	0.629	0.679	No difference
Company origin	3.214	0.014	Difference
Type of industry	1.171	0.336	No difference

NPD speed was different across different company origin, F(4,45) = 3.214, p-value 0.014. American MNCs had the fastest NPD speed (mean value 3.85), followed by European MNCs (mean value 3.67), Taiwanese, Hong Kong or China MNCs (mean value 3.42), local companies (mean value 3.32) and Japanese MNCs (mean value 3.20). Mean values of NPD speed for different company origin were in the following descending order: American MNCs > European MNCs > Taiwanese, Hong Kong or China MNCs > local company > Japanese MNCs.

Shuler (2011) reported that electrical and electronic industry had the shortest development cycle time and shortest useful product life span. Which meant electrical and electronic industry were the most sensitive industry to being late to the market, due to their very short product life span. Late to market could be translated to reduced useful product life span and a significant percentage drop in potential revenue. Nevertheless, table 4.26 showed that there was no significant NPD speed difference for different types of industry. The questionnaire for NPD speed was designed to get respondents to rate their companies' NPD speed comparing to their own industry instead of the whole manufacturing sector. For example, the respondents were asked to rate their companies'

NPD cycle time by comparing to industry average instead of providing an absolute cycle time value. Product development cycle time industry average for nine major industries was provided in questionnaire's appendix A for respondent's reference. Therefore, the data collected for NPD speed in this research had been successfully normalized to industry type. NPD cycle time for different industry types as provided in questionnaire's appendix A were in the following ascending order: semiconductor and industrial electronics < electrical and consumer electronics < defense electronics = heavy construction equipment = machine parts < automobile parts < aircraft assembly = heavy machinery = automobile assembly.

4.9.2 Customer involvement differences by company profile

Except size of company, Levene test for homogeneity of variances for the remaining four company profiles, namely years of operation, size of R&D, company origin and type of industry were not significant (p-value > 0.05). Hence, the population variances for each category of company size could not be assumed equal. As a result, one-way ANOVA test for customer involvement by size of company could not be performed due to homogeneity of variances criteria not met. The population variances for each group of the remaining four company profiles listed in table 4.27 were approximately equal. In conclusion, years of operation, size of R&D, company origin and type of industry could proceed for one-way ANOVA as they had met homogeneity of variances criteria.

Table 4. 27
Test for homogeneity of variances – Customer involvement

Company profile	Levene statistic	df1	df2	Sig.
Years of operation	0.193	4	46	0.941
Size of company	2.668	5	45	0.034
Size of R&D	2.400	5	45	0.052
Company origin	1.288	4	45	0.289
Type of industry	0.546	3	46	0.653

One-way ANOVA results revealed that there was no customer involvement difference in terms of years of operation [F(4,46) = 2.439, p-value 0.06], size of R&D [F(5,45) = 0.199, p-value 0.961], company origin [F(4,45) = 1.203, p-value 0.323] or type of industry [F(3,46) = 0.512, p-value 0.727].

Table 4. 28
One-way ANOVA – Customer involvement

Company profile	F	p-value	Result
Years of operation	2.439	0.060	No difference
Size of company	1.757	0.141	Variance not homogeneous
Size of R&D	0.199	0.961	No difference
Company origin	1.203	0.323	No difference
Type of industry	0.512	0.727	No difference

4.9.3 Third party collaboration differences by company profile

Levene test for homogeneity of variances for years of operation, company origin and type of industry were not significant (p-value > 0.05). Hence, the population variances for each group of years of operation, company origin and type of industry were approximately equal. Therefore, years of operation, company origin and type of

industry met homogeneity of variances criteria to proceed One-way ANOVA test. On the other hand, Levene test for homogeneity of variances for size of company and size of R&D were significant with p-value of 0.028 and 0.020 respectively. As a result, one-way ANOVA test for third party collaboration by size of company and size of R&D could not be performed due to homogeneity of variances criteria not met.

Table 4. 29
Test for homogeneity of variances – Third party collaboration

Company profile	Levene statistic	df1	df2	Sig.
Years of operation	1.075	4	46	0.380
Size of company	2.793	5	45	0.028
Size of R&D	2.997	5	45	0.020
Company origin	1.049	4	45	0.393
Type of industry	0.755	3	46	0.525

Based on test results tabulated in table 4.30, third party collaboration for all the groups of years of operation and company origin were not significantly different with F(4,46) = 0.722, p-value 0.581 and F(4,45) = 1.105, p-value 0.371 respectively. Thus, third party collaboration of a component manufacturer did not depend on years of operation and company of origin. However, third party collaboration differed in different types of industry that the component manufacturer participated in.

Third party collaboration in different types of industry was significantly different with F(3,46) = 5.04, p-value 0.002. Semiconductor or industrial electronic industry (mean value 3.108) showed significantly higher third party collaboration compared to other industries, followed by automotive industry with mean value 2.700.

Lastly, electrical or consumer electronics and industrial equipment or instrumentation industries had similar interest in third party collaboration with similar mean value of 2.400. Descending order of third party collaboration among different types of industry was semiconductor or industrial electronics > automotive > electrical or consumer electronics = industrial equipment or instrumentation.

Table 4. 30
One-way ANOVA – Third party collaboration

Company profile	F	p-value	Result
Years of operation	0.722	0.581	No difference
Size of company	1.003	0.427	Variance not homogeneous
Size of R&D	0.470	0.797	Variance not homogeneous
Company origin	1.105	0.371	No difference
Type of industry	5.040	0.002	Difference

4.9.4 Inter-organization relationship differences by company profile

Levene test for homogeneity of variances for years of operation was significant with p-value 0.012. Hence, population variances for different years of operation categories were not equal and could not proceed for one-way ANOVA test. The remaining four types of company profiles met homogeneity of variances requirement with p-value more > 0.05. P-value for size of company, size of R&D, company origin and type of industry were 0.417, 0.906, 0.144 and 0.731 respectively.

Table 4. 31
Test for Homogeneity of Variances – Inter-organization Relationship

Company profile	Levene statistic	df1	df2	Sig.
Years of operation	3.651	4	46	0.012
Size of company	1.021	5	45	0.417
Size of R&D	0.308	5	45	0.906
Company origin	1.805	4	45	0.144
Type of industry	0.432	3	46	0.731

One-way ANOVA test result confirmed that there was no significant difference in different categories of size of company, size of R&D, company origin and type of industry with F(5,45) = 1.651 p-value 0.166, F(5,45) = 0.582 p-value 0.714, F(4,45) = 0.519 p-value 0.760 and F(3,46) = 2.314, p-value 0.072 respectively.

Table 4. 32
One-way ANOVA – Inter-organization relationship

Company profile	F	p-value	Result
Years of operation	0.268	0.897	Variance not homogeneous
Size of company	1.651	0.166	No difference
Size of R&D	0.582	0.714	No difference
Company origin	0.519	0.760	No difference
Type of industry	2.314	0.072	No difference

4.10 Discussion on test results

4.10.1 Discussion on the results for hypotheses testing

The relationship between customer involvement and NPD speed was tested twelve times in previous researches (Feng et al., 2016; Feng & Wang, 2013; Lai et al., 2012; Lau, 2011; Lin & Huang, 2013; Mons et al., 2011; Tsinopoulos & Al-Zu'bi, 2012;

Wong et al., 2011; Wong & Tong, 2011; Wong & Tong, 2012; Yang & Zhang, 2018). Out of twelve tests, ten tests resulted in significant positive relationship between customer involvement and NPD speed. Whereas, the remaining two tests found no significant relationship between customer involvement and NPD speed. This study's result supported 83% of previous researches' finding on the relationship between customer involvement and NPD speed. Manufacturing firms that involved customer in their NPD processes tend to had higher NPD speed compared to their competitors or industry average. Information exchange and co-development with customers enable manufacturing firms to focus on what really important to customer and do not waste time developing something not valued by customers. This process effectively reduces time wasted on none value-added activities. Hence, it positively impacts NPD speed. For the same reason explained above, hypothesis H1b test for direct relationship between supplier involvement and NPD speed was not done due to the data collected for supplier involvement variable was not normally distributed and failed to fulfil the prerequisite requirement for regression analysis. Besides significant positive relationship between supplier involvement and NPD speed reported in previous researches (Feng & Wang, 2013; Lai et al., 2012), correlation between the two variables was also significant in this study. As reported in table 4.16, Pearson correlation r value was 0.23 (p-value 0.047) for the correlation between supplier involvement and NPD speed in this research.

Result of hypothesis H1c test revealed that there was no significant direct relationship between third party collaboration and NPD speed. This result suggested that third party collaboration could not be added as the third dimension of external integration when it was correlated with NPD speed. Majority (72.5%) of the companies

participated in this research were coming from semiconductor and industrial electronic industry. Results of interviews with participating companies from semiconductor industry revealed that the technology owned by the manufacturing firms themselves were much advanced than what they could possibly get from third party in Malaysia. They also couldn't find local research institutions that conducted research in the area that matched the technologies they were looking for to develop their new products. Therefore, there were no incentive for manufacturing firms to share information and collaborate with third party for their critical projects in Malaysia. As a result, even though there was a collaboration program with third party, there was no real impact to the outcome of its product development activities – NPD speed.

Results from test of hypothesis H2, hypothesis H2a and hypothesis H2c revealed that there was a significant relationship between external integration and inter-organization relationship. External integration in this test consisted of customer involvement and third party collaboration. External information exchange and collaboration on product development activities affect inter-organization relationship with business partners. Manufacturing firms that encourage higher level of customer involvement but with limited third party collaboration in their NPD activities tend to have better inter-organization relationship with their business partners. Customer and third party involvement in this research covered project information exchange and new product co-development arrangement. This result supported two previous research findings that good relationship with customers increased the degree of customer involvement (Lin & Huang, 2013; Feng & Zhao, 2014). The result of this hypotheses test also closed research gap 6, research gap 7 and research gap 9 highlighted in section 1.2.

To recall, Lai et al. (2012) reported that third party involvement had a moderating effect on the relationship between customer involvement and market performance. However, there was lack of research finding in literature on the direct relationship between third party collaboration and inter-organization relationship. In this research, third party collaboration had been statistically confirmed as a significant predictor for inter-organization relationship. Therefore, it was empirically confirmed that third party collaboration could be considered as the third dimension of external integration, in addition to customer involvement and supplier involvement when third party collaboration was correlated to inter-organization relationship. This result closed research gap 1 raised in section 1.2.

This research found that limiting direct involvement of third party in a manufacturing firm's NPD activities led to better inter-organization relationship between the manufacturing firm and its business partners which include customer, supplier and third party. Before starting a technical project, manufacturing firm usually signs non-disclosure agreement with its related business partners. Inter-organization relationship with customer will be negatively affected if customer found out that the manufacturing firm also collaborated with third party for the same project. This result closed the research gap identified in section 1.2 whereby there was lack of literature on the direct relationship between third party collaboration and inter-organization relationship.

Previous research reported that supplier involvement was a significant positive predictor for inter-organization relationship (Feng & Zhao, 2014). Furthermore, correlation between supplier involvement and inter-organization relationship was tested

significant with medium strength (r = 0.32 and p-value 0.009) as reported in section 4.6 table 4.16. According to Cohen (1988), the strengths of correlations were categorized as small (r = 0.10 to 0.29), medium (r = 0.30 to 0.49) and large (r = 0.50 to 1.00). Unfortunately, supplier involvement was omitted from this research's hypothesis testing (H2b) due to the data collected for supplier involvement variable was not normal. One of the prerequisite for multiple regression analysis was that the data used must be normal. Limitation on this part of the research will be discussed in detail in section 5.4 for limitation and recommendation for future research.

As reported in section 4.8.3, hypothesis H3 was not supported. Which indicated that there was no significant relationship between inter-organization relationship and NPD speed for component manufacturers in Penang. There were mixed results from previous researches on the relationship between inter-organization relationship and NPD speed (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al., 2011; Trainor et al., 2013). Inter-organization relationship was tested five times as significant positive predictor for NPD speed and one time as significant negative predictor for NPD speed. For example, one previous research on Taiwanese high-tech firms found that strong inter-organizational relationships had a positive influence on efficiency of NPD (Lin & Huang, 2013).

The level of dependency on inter-organization relationship for organization success is affected by its national culture. Uncertainty avoidance is the cultural dimension that most relevant to inter-organization relationship. Based on Henderson's (2014) finding, trust and good business relationships reduced uncertainty and the perception of risk. Business partners fostered strong inter-organization relationship to

avoid ambiguous situation in all aspects of their daily business dealings. Malaysia scored 36 points and Taiwan scored 69 points in uncertainty avoidance index (Hofstede & Hofstede, 2005). This cultural gap explained why hypothesis H3 was not supported in this study and supported in previous studies conducted in Taiwan. In Taiwan, manufacturing firms with higher inter-organization relationship tend to achieve higher NPD speed as they were more aligned with the commonly accepted values in the same national culture. In contract, inter-organization relationship was not an important factor determining the success of an organization in Malaysia. Due to its relatively lower uncertainty avoidance index, a business entity in Malaysia did not feel unsecure even though it did not know its business partner well or did not have a strong inter-organization relationship with its business partners. This explained why inter-organization relationship was not a significant predictor for NPD speed in Malaysia. In conclusion, the results from previous researches conducted in different national culture could not be applied in Malaysia context.

As reported in section 4.8.4, inter-organization relationship was tested not significantly mediating the relationship between external integration (customer involvement and third party collaboration) and NPD speed. The finding by Lin and Huang (2013) that strong inter-organization relationship mediated the relationship between customer involvement and NPD performance could not be generalized to Malaysia context. The samples collected by Lin and Huang (2013) were from Taiwan's high-tech firms. Big gaps in national cultural values (uncertainty avoidance dimension in particular) between Taiwan and Malaysia could be the reason for this result difference. Malaysia scored 36 points and Taiwan scored 69 points in uncertainty avoidance index (Hofstede & Hofstede, 2005). Countries with high uncertainty

avoidance index valued more information exchange, collaboration and good relationship among business partners to avoid ambiguous situation throughout the whole product development processes. Malaysia scored low in uncertainty avoidance index. Hence, inter-organization relationship did not show any significant mediating effect on the relationship between external integration and NPD speed. External integration tested in this research consisted of customer involvement (H4a) and third party collaboration (H4c). Supplier involvement (H4b) was omitted due to data normality issue. It was reported in section 4.9.4 that there was no significant difference in inter-organization relationship for different country of origin. Hence, for manufacturing firms operating in Malaysia, Malaysia national culture dominated country of origin's cultural influence in terms of uncertainty avoidance cultural dimension.

4.10.2 Discussion on the results for test of difference

Based on one-way ANOVA, NPD speed was tested significantly different by different company origins. Similarly, third party collaboration was tested significantly different by different type of industries. However, customer involvement and inter-organization relationship were tested not significantly different by any category of company profile collected in the survey.

4.10.2.1 New product development speed

As reported in section 4.9.1, mean values of NPD speed for different company origins were in the following descending order: American MNCs > European MNCs > Taiwanese, Hong Kong or China MNCs > local companies > Japanese MNCs. Braunscheidel and Suresh (2018) reported that hierarchical culture in organization

negatively impacted internal and external integration. In American culture, superiors generally gave leeway to subordinates to make day-to-day project decision. On the other hand, Japanese culture appeared to have more respect for authority. Comparing to their American counterparts, Japanese managers made slower and conservative but lesser error decision (Hashimoto, 2010, Dec 15). These differences resulted in more bureaucracy and slower decision making process in Japanese MNCs which led to slower NPD speed in Japanese MNCs compared to American MNCs. Cao, Huo, Li and Zhao (2015) found that hierarchical culture was negatively related to both internal and customer integration. The combination of Braunscheidel and Suresh's (2018) finding, Cao et al.'s (2015) finding and this study's hypothesis H1a result indirectly formed the explanation why Japanese MNCs had slower NPD speed compared to others. Result of hypothesis H1a in this research confirmed that customer involvement significantly predicted higher NPD speed. Lower customer involvement in Japanese MNCs due to their higher hierarchical culture led to lower performance in NPD speed. Mean customer involvement for Japanese and American MNCs in this research were 3.84 and 4.05 respectively.

4.10.2.2 Third party collaboration

As reported in section 4.9.3, the descending order of third party collaboration among different types of industry were semiconductor or industrial electronics > automotive > electrical or consumer electronics and industrial equipment or instrumentation. Industrial equipment or instrumentations were generally designed and custom made for a specific customer. They were typically designed and built according to the purchase spec provided by customer. As a result, the product requirements were predefined by the customer and less likely to be influenced by third party. In addition, customer would

also restrict their supplier from disclosing their component design to third party. Thus, custom made products like industrial equipment or instrumentation tend to have lesser degree of third party collaboration.

On the other hand, semiconductor or industrial electronic component manufacturers designed and produced part of or the complete product for multiple customers. Some of these semiconductor components were considered as commodity component or had become off the shelve products. Thus, third party collaboration provided more value to their NPD processes and was less restricted by their customer because the manufacturer usually owned the design itself. However, there was no incentive for manufacturing firms to collaborate with third party if they could not learn much from third party, especially for high technology firms. Which they usually owned state of the art technology.

4.11 Conclusion

Based on test results of hypotheses testing summarized in table 4.33 below, customer involvement and third party collaboration practiced by manufacturing firms in Penang could significantly predict their inter-organization relationship with business partners. Involvement of customer in NPD activities significantly strengthened the relationship with their business partners. In contrast, involving third party in NPD activities significantly weakened their relationship with business partners.

The other relationships which were tested not significant were the relationship between inter-organization relationship and NPD speed as well as the relationship between third party collaboration and NPD speed. This study also found that inter-

organization relationship was not a significant mediating factor for the relationship between external integration and NPD speed for manufacturing firms in Penang. External integration in this study covered customer involvement and third party collaboration.

Table 4. 33
Summary of hypotheses testing

Hypotheses	Relationship	Test result
H1	EI- NPDS	Partially supported
H1a	CI - NPDS	Supported
H1b	SI - NPDS	Not tested (Data not normal)
H1c	TPC - NPDS	Not supported
H2	EI - IOR	Fully supported
H2a	CI - IOR	Supported
H2b	SI - IOR	Not tested (Data not normal)
H2c	TPR - IOR	Supported
H3	IOR - NPDS	Not supported
H4	EI - IOR - NPDS	Not supported
H4a	CI - IOR - NPDS	Not supported
H4b	SI - IOR - NPDS	Not tested (Data not normal)
H4c	TPC - IOR - NPDS	Not supported

Note: IOR = inter-organization relationship; NPDS = new product development speed; EI = external integration; CI = customer involvement; SI = supplier involvement; TPR = third party collaboration.

One-way ANOVA results revealed that origin of company could significantly influence the company's NPD speed in descending order of American MNCs, European MNCs, Taiwanese, Hong Kong or China MNCs, local companies, Japanese MNCs and

Singapore MNCs. Different industries engaged third party in their NPD activities differently. Semiconductor or industrial electronic industry collaborated with third party the most, followed by automotive, electrical or consumer electronics and industrial equipment or instrumentation industry.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Introduction

This chapter brings to a conclusion and provides recommendation for future improvement. Section 5.1 provides an overview of this research and addresses the four research questions captured in section 1.3, which are aligned with the proposed hypotheses. Section 5.2 highlights the significance of this research's findings. Section 5.3 underlines the implications of this research, which includes theoretical, practical and policy implications of the research. Section 5.4 presents the limitation of this research and provides recommendation for future research. Lastly, section 5.5 concludes the research.

5.1 Overview of the research

Chapter one explained the importance of this research and justified why the identified research gaps needed to be addressed urgently. It had been proven empirically that NPD speed was crucial to survive time-based competition and many industries were moving towards the direction of time-based competition as product life cycles were shortening due to fashion trend (Awwad & Akroush, 2016; Jos & Ton Van, 2012). Therefore, a full understanding of the underlying factors contributing to high NPD speed would enable managers focusing their resources on the areas that accelerate their NPD processes and subsequently maximizing company performance. Due to research gaps identified in literature and popular questions from practitioner, this research aimed to close the research gaps concerning the relationships between NPD speed, inter-organization relationship and external integration.

Chapter two summarized and synthesized critical reviews of past literature on NPD speed, external integration and inter-organization relationship as well as their inter-relationships. External integration in this research covered customer involvement, supplier involvement and third party collaboration. This research built upon theory of organizational learning. Particularly from external learning perspective, whereby different technology sourcing strategies influenced innovation speed throughout the NPD processes (Kessler et al., 2000). Organizational learning is the underpinning theory of this research. Research gaps were identified in Malaysia context when customer involvement, supplier involvement and inter-organization relationship were tested as independent variable to predict NPD speed. Research gap was also found concerning the mediating role of inter-organization relationship in the relationship between supplier involvement and NPD speed. Inclusion of third party collaboration as the third dimension of external integration made this research special.

Chapter three highlighted the research framework of this research. This research used quantitative research method with close-ended survey questionnaire. All the 27 measurement items used to measure customer involvement, supplier involvement, third party collaboration, inter-organization relationship and NPD speed were validated scales adapted from published literature (Feng & Wang, 2013; Lai et al., 2012; Lin & Huang, 2013). Unit of analysis was at organization level, which was manufacturing firm. Only one respondent was used from each manufacturing firm located in Penang state that engaged in NPD activities. Out of 288 manufacturing firms listed in the 47th edition of FMM directory (2016), a total of 213 manufacturing firms were approached and questionnaire distributed. Hierarchical multiple regression was used to test hypotheses H1, H1a and H1c. Multiple regression analysis was used to test hypotheses

H2, H2a and H2c. Hypothesis H3 was tested using hierarchical regression analysis. Hypothesis H4, H4a and H4c were examined based on Baron and Kenny's (1986) procedure. Finally, test of difference was performed by using One-way ANOVA.

Chapter four presented the test results and discussed the empirical findings in detail. Total 166 completed questionnaire were received after eight follow up with the participating firms, which took nine weeks to complete. 78% overall response rate was achieved in this survey. After normality test and outlier removal, the data from 51 manufacturing firms were used for hypotheses testing and test of differences. As a result of the analysis, hypotheses H1a, H2, H2a and H2c were supported whereas hypothesis H1 was partially supported. However, hypotheses H3, H1c, H4, H4a and H4c were not supported. Unfortunately, hypotheses tests involving variable supplier involvement were not done due to data normality issue. Hence, hypotheses H1b, H2b and H4b were not done. Summary of the hypothesized relationships and their empirical findings were highlighted in line with the 4 research questions associated with this research as follows:

Research question 1: Does external integration (customer involvement, supplier involvement and third party collaboration) relate to new product development speed in Penang's manufacturing firms?

Research hypothesis H1, H1a, H1b and H1c below was created to address research question 1 above.

H1: External integration significantly relates to new product development speed in Penang's manufacturing firms.

H1a: Customer involvement positively relates to new product development speed in Penang's manufacturing firms.

H1b: Supplier involvement positively relates to new product development speed in Penang's manufacturing firms.

H1c: Third party collaboration significantly relates to new product development speed in Penang's manufacturing firms.

Hypothesis H1b was not tested due to data normality issue for supplier involvement variable. Hypothesis H1a was supported and this result revealed that customer involvement was a significant positive predictor for NPD speed in Penang's manufacturing firms. 10% of variance in NPD speed was explained by customer involvement. Hypothesis H1c was not supported. Therefore, hypothesis H1 was only partially supported.

Research question 2: Does external integration (customer involvement, supplier involvement and third party collaboration) relate to inter-organization relationship in Penang's manufacturing firms?

In order to address research question two, this research hypothesized that external integration significantly relates to inter-organization relationship in Penang's manufacturing firms (H2). In this research, external integration consisted of customer involvement, supplier involvement and third party collaboration. Due to data normality issue, supplier involvement was omitted from this hypothesis test. Thus, only customer involvement and third party collaboration were added as independent variables in multiple regression analysis. This empirical finding revealed that external integration

significantly related to inter-organization relationship in Penang's manufacturing firms, whereby 15.6% of variance in inter-organization relationship could be explained by external integration which consisted of customer involvement and third party collaboration. Therefore, hypothesis H2 was fully supported.

Hypothesis H2a stated that customer involvement positively relates to inter-organization relationship in Penang's manufacturing firms. Result of hypothesis H2a test confirmed that customer involvement was significantly and positively related to inter-organization relationship in Penang's manufacturing firms. Which agreed with Lin and Huang's (2013) finding. This result implied that involving customer in NPD activities improved manufacturing firm's inter-organization relationship with its business partners like suppliers, customers and third party research institutions or universities. This finding concluded that hypothesis H2a was supported.

Hypothesis H2b stated that supplier involvement positively relates to inter-organization relationship in Penang's manufacturing firms. One of the prerequisite to perform regression analysis was that the data used must be normal (Coakes et al., 2009). As mentioned above, the data collected for supplier involvement was not normal. Thus, test of hypothesis H2b could not be proceeded. Hypothesis H2c stated that third party collaboration significantly relates to inter-organization relationship in Penang's manufacturing firms. Result of hypothesis H2c test confirmed that third party collaboration was significantly and negatively related to inter-organization relationship in Penang's manufacturing firms. This result revealed that collaboration with university or research institute weaken inter-organization relationship with other business partners. During collaboration, technical information exchange between the two collaborated

parties was inevitable. Therefore, it was normal for the other business partners to suspect their technical information or knowhow had been shared with third party if there was a collaboration activity going on. Hypothesis H2c was thus supported and this finding revealed that third party collaboration was empirically confirmed as the third dimension of external integration when it was correlated with inter-organization relationship.

Research question 3: Does inter-organization relationship relate to new product development speed in Penang's manufacturing firms?

Hypothesis H3 was postulated as following: Inter-organization relationship significantly relates to new product development speed in Penang's manufacturing firms. Result of hypothesis H3 test using hierarchical regression analysis revealed that inter-organization relationship did not significantly relate to NPD speed in Penang's manufacturing firms. Thus, hypothesis H3 was not supported. This result did not agree with the finding by Lin and Huang (2013) whereby there was significant positive relationship between inter-organization relationship and NPD speed for Taiwan's high technology firms. This result difference could be explained from the perspective of cultural value differences between the two countries, particularly in terms of uncertainty avoidance cultural dimension. Detail discussion on this result was presented in section 4.10.1.

Research question 4: Does inter-organization relationship mediate the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and new product development speed in Penang's manufacturing firms?

In order to address research question four, this study hypothesized that inter-organization relationship significantly mediates the relationship between external integration and NPD speed in Penang's manufacturing firms (hypothesis H4). External integration in this study included customer involvement, supplier involvement and third party collaboration. The corresponding hypotheses postulated to address these three factors of external integration individually were as following:

H4a: Inter-organization relationship significantly mediates the relationship between customer involvement and new product development speed in Penang's manufacturing firms.

H4b: Inter-organization relationship significantly mediates the relationship between supplier involvement and new product development speed in Penang's manufacturing firms.

H4c: Inter-organization relationship significantly mediates the relationship between third party collaboration and new product development speed in Penang's manufacturing firms.

Based on Baron and Kenny's (1986) procedure, inter-organization relationship was not a significant mediator for the relationship between external integration and NPD speed. As a result, hypotheses H4, H4a and H4c were not supported. Hypothesis

H4b was not tested due to data normality issue encountered for supplier involvement variable.

Table 5.1 below provides all the hypothesized relationships between NPD speed, inter-organization relationship and external integration in accordance to the 4 research questions stated in section 1.3. The main shortfall of this research was the missing results related to supplier involvement variable. Its absent also directly impact the result of all the other tests concerning the relationship between NPD speed and external integration.

Table 5. 1
Overview of research questions and hypothesized relationships between new product development speed, inter-organization relationship and external integration

Research questions and hypothesized relationships	**Supported / not supported**
Research question 1:	
Does external integration (customer involvement, supplier involvement and third party collaboration) relate to new product development speed in Penang's manufacturing firms?	
H1: External integration significantly relates to new product development speed in Penang's manufacturing firms.	Partially supported
H1a: Customer involvement positively relates to new product development speed in Penang's manufacturing firms.	Supported
H1b: Supplier involvement positively relates to new product development speed in Penang's manufacturing firms.	Not tested (Data not normal)

Table 5. 1 (Continued)

Research questions and hypothesized relationships	**Supported / not supported**
H1c: Third party collaboration significantly relates to new product development speed in Penang's manufacturing firms.	Not supported
Research question 2:	
Does external integration (customer involvement, supplier involvement and third party collaboration) relate to inter-organization relationship in Penang's manufacturing firms?	
H2: External integration significantly relates to inter-organization relationship in Penang's manufacturing firms.	Fully supported
H2a: Customer involvement positively relates to inter-organization relationship in Penang's manufacturing firms.	Supported
H2b: Supplier involvement positively relates to inter-organization relationship in Penang's manufacturing firms.	Not tested (Data not normal)
H2c: Third party collaboration significantly relates to inter-organization relationship in Penang's manufacturing firms.	Supported
Research question 3:	
Does inter-organization relationship relate to new product development speed in Penang's manufacturing firms?	
H3: Inter-organization relationship significantly relates to new product development speed in Penang's manufacturing firms.	Not supported

Table 5. 1 (Continued)

Research questions and hypothesized relationships	**Supported / not supported**
Research question 4:	
Does inter-organization relationship mediate the relationship between external integration (customer involvement, supplier involvement and third party collaboration) and new product development speed in Penang's manufacturing firms?	
H4: Inter-organization relationship significantly mediates the relationship between external integration and new product development speed in Penang's manufacturing firms.	Not supported
H4a: Inter-organization relationship significantly mediates the relationship between customer involvement and new product development speed in Penang's manufacturing firms.	Not supported
H4b: Inter-organization relationship significantly mediates the relationship between supplier involvement and new product development speed in Penang's manufacturing firms.	Not tested (Data not normal)
H4c: Inter-organization relationship significantly mediates the relationship between third party collaboration and new product development speed in Penang's manufacturing firms.	Not supported

5.2 Significance of the findings

This research confirmed that customer involvement was a significant positive predictor for NPD speed and inter-organization relationship in Malaysia context. On the exploratory part of this research, it was found that third party collaboration could be included as the third dimension of external integration when it was correlated to inter-

organization relationship. Third party collaboration was tested significant and negatively related to inter-organization relationship.

5.3 Implications of the study

5.3.1 Theoretical implications

The outcome of this research presented a new perspective on the research area of NPD speed, specifically for component manufacturers in Penang state. The result of this study added another empirical evidence that customer involvement was a positive predictor for NPD speed in Malaysia context. In addition, this study also added another empirical finding in literature that customer involvement was positively related to inter-organization relationship in Malaysia context. However, this study confirmed negative relationship between third party collaboration and inter-organization relationship.

For the exploratory part of this research, it was found that third party collaboration could be considered as the third dimension of external integration when third party collaboration was correlated to inter-organization relationship. However, when third party collaboration was correlated to NPD speed, the finding of this research revealed that third party collaboration could not be considered as the third dimension of external integration. Therefore, external integration of external organization learning theory remain consisted of two dimensions. Which were customer involvement and supplier involvement from NPD perspective. This mixed results warranted future research with bigger sample size to validate the findings, especially for all tests related to supplier involvement variable. All hypotheses (H1b, H2b and H4b) related to supplier involvement were not tested due to data normality problem. The use of second-generation statistical software like PLS is suggested for future research.

5.3.2 Practical implications

The findings from this research suggest that R&D managers in Penang's manufacturing firms can deprioritize inter-organization relationship in their pursuit of improving their companies' NPD speed. They should instead put more resources or find ways to increase customer involvement in their NPD activities in order to accelerate their NPD speed. Limiting the direct involvement of third party in a manufacturing firm's NPD activities may help improving inter-organization relationship with its business partners. Relationship with business partners can be improved by involving customer in NPD activities. Nevertheless, good or bad inter-organization relationship with business partners does not influence the speed of NPD activities. When direct customer involves in a development project, the project requirements and direction become clearer. Hence, other business partners become more confident with the project and start building trust and relationship with the firm.

A manufacturing firm with high NPD speed shall protect its invention by using patent law or IP to sustain its position as first mover. The direct implication of stronger NPD speed in manufacturing firms is higher future economic growth for Malaysia. With stronger R&D capability, highly competitive MNCs' subsidiary in Penang will also prevent the holding companies from relocating their subsidiaries to other less costly labor markets around this region like Vietnam, Indonesia, etc. Which directly help sustaining Malaysia's employment rate. This result agreed with Cirera and Sabetti's (2016) finding that strong R&D capability generates employment opportunities.

This research found that American MNCs typically had significantly speedier NPD compared to manufacturing firms from other countries of origin. During talent source, human resource managers can help their company by looking for talented candidates from American MNCs to fill the positions that directly involve in the company's NPD activities if NPD speed is the key success factor.

Collaboration with third party should be treated confidential and this relationship should not be made known to other business partners that work on the same project. Relationship with other business partners may be negatively affected if they know that the manufacturing firm that they work with collaborates with third party. When presenting company's profile to customer, third party collaboration shouldn't be mentioned as it is not considered a strength in customer's perspective. It may unnecessarily make customer worry about the potential treat of technological information leakage.

5.3.3 Policy implications

The finding of this research suggested that third party collaboration does not significantly contribute to NPD speed. Based on feedback from practitioners, there is currently very limited research conducted by local universities or research institutes that matches industry demand. Besides encouraging industry-university collaboration, government should allocate more grant to support and facilitate researches in the area that matches industry requirement. There is no value of collaboration with third party if manufacturing firm cannot benefit from it, at least from the perspective of manufacturing firm. This supply and demand matching can be best facilitated by PPRN.

The result of this research revealed that third party collaboration weaken inter-organization relationship with other business partners. Which implied the worry of technical information sharing by business partner to third party. Related authority should convince industry that the technical information shared during collaboration with third party would be treated with utmost confidentiality to avoid information leakage to competitors. The technical information or knowhow that had been shared with third party would only stay with third party and would not be shared with another business entity during their consultation or collaboration. To regain confidence in Malaysia's industry, policy makers can encourage industry to start from the easiest collaboration during the testing phase to a more complex collaboration during the research phase. In this manner, industry will establish a trust-based relationship with university during the testing phase (Buganza et al., 2014).

American MNCs' NPD speed was the highest among all countries of origin. To make Malaysia the preferred location of choice to set-up R&D center, Malaysia government may encourage more foreign direct investment from American MNCs, followed by European MNCs. These companies will directly train local engineers and managers to be more competitive in terms of developing new product at higher speed. More tax reliefs and R&D grants can be considered to attract these investors.

5.4 Limitation and recommendation for future research

Due to data normality issue, only fifty one component manufacturers remained as useful data for hypotheses testing and test of difference after outlier removal. This study's sample was limited to component manufacturers in Penang state of Malaysia that developed new product internally. Service providers and manufacturers that does

not conduct any NPD activity were excluded from this research. This limited sample size formed limitation of this research. Future research is suggested to increase sample size by expanding the target population to include other states with strong manufacturing sector. Selangor is suggested as the first choice follow by Johor. Selangor and Johor contributed 28.9% and 12.6% to Malaysia's manufacturing sector respectively in 2016 (Department of statistics Malaysia, 2017).

Hypothesis H1b was not tested whereby supplier involvement was used as independent variable due to data not normal even after data transformation and excluding non-component manufacturers from the dataset. Data normality is one of the assumptions underpinning the use of regression (Coakes et al., 2009). There were many empirical evidences reported in literature for the relationship between supplier involvement and NPD speed (Danese & Filippini, 2010; Lau, 2011; Feng & Wang, 2013; Tsai, Tsai & Wang, 2012). Majority of these previous studies found significant positive relationship between supplier involvement and NPD speed. Therefore, future research on the relationship between external integration and NPD speed was suggested to include supplier involvement as one of the key dimensions for external integration. Future research was also suggested to test hypothesis H1b again with supplier involvement as independent variable. For small sample analysis similar to this survey, future research is suggested to use second-generation statistical software like PLS for data analysis.

Supplier involvement was excluded in this study because the data could not be transformed to normal even after excluding non-component manufacturers. Data normality is one of the assumptions underpinning the use of regression (Coakes et al.,

2009). Only 15.6% of variance in inter-organization relationship could be explained by customer involvement and third party collaboration. Feng and Zhao (2014) reported that relationship with supplier significantly increased the degree of supplier involvement. Therefore, the percentage of variance in inter-organization relationship that can be explained by external integration is expected to improve if supplier involvement is included in the analysis. In addition, result from section 4.6 also revealed that supplier involvement was significantly correlated with inter-organization relationship with significant p-value <0.01. Future research is suggested to test hypothesis H2b again with supplier involvement included as independent variable and use second-generation statistical software like PLS to test the relationship.

Mediating effect of inter-organization relationship on the relationship between supplier involvement and NPD speed was not tested for hypothesis H4b because supplier involvement's data distribution was tested not normal. One of the main research objective of this study was to explore the mediating effect of inter-organization relationship on the relationship between supplier involvement and NPD speed. Based on previous research findings, there were significant relationships between supplier involvement and inter-organization relationship (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al., 2011), between inter-organization relationship and NPD speed (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al, 2011; Trainor et al., 2013), as well as between supplier involvement and NPD speed (Feng & Wang, 2013; Lau, 2011; Tsai, Tsai & Wang, 2012). These previous findings had satisfied the three conditions in Baron and Kenny's (1986) procedure for mediator testing. Therefore, it is strongly suggested to repeat this test in Malaysia

context with bigger sample size, aiming to pass normality test to enable hypothesis H4b testing.

In the effort of exploring third party collaboration as the third dimension of external integration, mixed results were obtained. This research confirmed that third party collaboration could be considered as the third dimension of external integration when third party collaboration was correlated to inter-organization relationship. However, when third party collaboration was correlated to NPD speed, third party collaboration was found not a significant third dimension of external integration. Future research is suggested to investigate and understand these mixed results.

Future research to replicate this research to other four economic regions in Peninsular Malaysia is suggested. These four regions are Northern, Central, Southern and East Cost of Malaysia. In addition, it is suggested to characterize and compare the results of these four economic regions. The result of this research revealed that American MNCs were significantly better compared to Japanese MNCs in terms of NPD speed. Future research is suggested to characterize the differences between American and Japanese MNCs in terms of working culture, organization structure, business model, etc., which lead to higher NPD speed in American MNCs. Future research to examine the influence of national culture versus organizational culture on NPD speed is suggested as well.

5.5 Conclusion

Hypotheses H1a, H2, H2a and H2c were supported while hypotheses H1c, H3, H4, H4a and H4c were not supported. On the other hand, hypothesis H1 was partially supported. However, Hypotheses H1b, H2b and H4b were not tested due to data for supplier involvement was tested not normal. Agreed to previous research findings, customer involvement was tested a significant positive predictor for NPD speed (Feng, Cai, Zhang & Liu, 2016; Feng & Wang, 2013; Lau, 2011; Lin & Huang, 2013; Wong et al., 2011; Wong & Tong, 2012) and inter-organization relationship (Athaide et al., 2003; Feng & Zhao, 2014; Lin & Huang, 2013; Mons et al, 2011).

Third party collaboration as predictor for NPD speed was explored in this study. Result showed that third party collaboration was not a significant predictor for NPD speed, specifically for Penang's component manufacturers. Third party collaboration failed to be included as the third dimension of external integration based on its relationship with NPD speed. However, third party collaboration could be considered as the third dimension of external integration when it was correlated to inter-organization relationship. Investigation to understand this mixed results is suggested. The main shortfall for this study was exclusion of supplier involvement as independent variable due to data normality issue. Future research suggestions are mainly focusing on repeating the hypotheses tests in this research that related to supplier involvement, namely H1b, H2b and H4b.

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APPENDICES

Appendix A: Questionnaire

UNIVERSITI UTARA MALAYSIA
Othman Yeop Abdullah Graduate School of Business (OYAGSB)
Sintok, Kedah.

SURVEY QUESTIONAIRE

TOPIC: The effect of external integration on new product development speed in Penang's manufacturing firms: Inter-organization relationship as mediator

Dear Participants,

Thank you for taking the time to participate in this study on New Product Development (NPD). We would appreciate it very much if you could answer all the questions / statements carefully. The information given by you will influence the accuracy and the success in this study. It will take approximately 20 minutes to complete this questionnaire that consists of total 38 questions.

All answers will be treated with strict confidentiality and will be used for the purpose of this study only. If you want to receive the findings of the study, please give us your details (name, e-mail and contact number). I am happy to give you a summary of the findings of this study.

Thank you for your cooperation.

Yours sincerely,

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As respondent, you must be an executive, engineer or higher level in a manufacturing firm in Penang that involves in new product development processes. Otherwise, kindly help to forward this survey questionnaire to your friends or colleagues that meet the above criteria.

SECTION 1: DEMOGRAPHIC INFORMATION

The following questions are meant for analysis purpose only. Kindly answer by marking a tick (√) (if you use hard copy) or click (if you use soft copy) on ☐, whichever applicable.

Section 1a: Company profile (Information about the company you work with)

1. Years of operation in Penang:
   - ☐ < 3 years
   - ☐ ≥ 3 years to < 5 years
   - ☐ ≥ 5 years to < 10 years
   - ☐ ≥ 10 years to < 20 years
   - ☐ ≥ 20 years

2. Size of the company you work with:
   - ☐ ≤ 50 permanent employees
   - ☐ 51 – 200 permanent employees
   - ☐ 201 – 500 permanent employees
   - ☐ 501 – 1000 permanent employees
   - ☐ 1001 – 2000 permanent employees
   - ☐ ≥ 2001 permanent employees

3 Number of permanent employee in your company's R&D* department:
   - ☐ None
   - ☐ 1 – 5 employees
   - ☐ 6 – 10 employees
   - ☐ 11 – 15 employees
   - ☐ 16 – 20 employees
   - ☐ ≥ 21 employees

   Note*: R&D – Research and Development

4. Company origin:
   - ☐ Local company
   - ☐ American MNC*
   - ☐ European MNC
   - ☐ Japanese MNC
   - ☐ Taiwanese, Hong Kong or China MNC
   - ☐ Others, please indicate: _____

   Note*: MNC – Multi-national corporation

5. Type of industry your company in:
   - ☐ Semiconductor / industrial electronics
   - ☐ Electrical / consumer electronics
   - ☐ Industrial equipment / instrumentation
   - ☐ Medical
   - ☐ Automotive
   - ☐ Food
   - ☐ Others, please indicate: _____

6. Is your company a component* manufacturer?
   - ☐ Yes, my company's products will be further processed or assembled by our customer.
   - ☐ No, we are not a component manufacturer.

   Note*: Component refers to material, piece part, subassembly or subsystem which is required as input to build a finished product.

7. Does your company engage in any form of new product development activity that introduce new product to the market or to your industrial customers?
   ☐ Yes ☐ No

Section 1b: Respondent profile (Information about yourself)

1. Your current job title in the company you work with:
   _____

2. Length of service in your present company: _____year/s.

3. Which department do you belong to? _____

4. Your gender:
   ☐ Male ☐ Female

SECTION 2: NEW PRODUCT DEVELOPMENT SPEED This section measures **new product development speed** of your company. Please mark a tick (✓) (if you use hard copy) or click (if you use soft copy) on ☐that best describes your company.		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	We are first in the market in introducing new product	☐	☐	☐	☐	☐
2	We have fast new product development capability	☐	☐	☐	☐	☐
3	Our plant managing director was very pleased with the time it took for us to bring new products to the market	☐	☐	☐	☐	☐
4	New products were launched on or ahead of the original schedule	☐	☐	☐	☐	☐
5	Our new product development cycle time is shorter than industry average Note: refer Appendix A for cycle time industry average	☐	☐	☐	☐	☐
6	New products were launched to the market faster than our major competitors	☐	☐	☐	☐	☐

SECTION 3: CUSTOMER INVOLVEMENT This section measures the degree of **customer involvement** during new product development process in your company. Please mark a tick (✓) (if you use hard copy) or click (if you use soft copy) on ☐that best describes your company		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	We consulted major customers before designing a new product	☐	☐	☐	☐	☐
2	We partnered with major customers for developing new product	☐	☐	☐	☐	☐
3	Major customers' involvement was essential in the design effort for new product development.	☐	☐	☐	☐	☐
4	Major customers were frequently consulted about the design of the new product	☐	☐	☐	☐	☐
5	Major customers were involved in our company's continuous improvement programs	☐	☐	☐	☐	☐

SECTION 4: SUPPLIER INVOLVEMENT This section measures the degree of **supplier involvement** during new product development process in your company. Please mark a tick (✓) (if you use hard copy) or click (if you use soft copy) on ☐that best describes your company		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	We consulted major suppliers early when we designed a new product	☐	☐	☐	☐	☐
2	We partnered with major suppliers for developing new product.	☐	☐	☐	☐	☐
3	Major suppliers' involvement was essential in the design effort for new product development.	☐	☐	☐	☐	☐
4	Major suppliers were frequently consulted about the design of the new product.	☐	☐	☐	☐	☐
5	Major suppliers were involved in our company's continuous improvement programs	☐	☐	☐	☐	☐

SECTION 5: THIRD PARTY COLLABORATION This section measures the degree of **third party collaboration** during new product development process in your company. Please mark a tick (✓) (if you use hard copy) or click (if you use soft copy) on ☐that best describes your company. *Third party/s in this study refers to at least one impartial professional entities like universities and research institutions.*		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	Third party/s was/were involved in early stage of product development	☐	☐	☐	☐	☐
2	We use market information from Third party/s	☐	☐	☐	☐	☐
3	Third party/s provided input for prototype test	☐	☐	☐	☐	☐
4	Product development people meet Third party/s people regularly	☐	☐	☐	☐	☐
5	Third party/s provided technical input for parts design	☐	☐	☐	☐	☐

SECTION 6: INTER-ORGANIZATION RELATIONSHIP This section measures **inter-organization relationships** between your company and its business partners. Please mark a tick (√) (if you use hard copy) or click (if you use soft copy) on ☐ that best describes your company. *Business partners refer to customers, suppliers and Third party/s.*		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	Our company feels thankful to our business partners for what they have done for us	☐	☐	☐	☐	☐
2	Our interactions with business partners are mutually satisfying	☐	☐	☐	☐	☐
3	Maintaining a long-term relationship with business partners is important to us	☐	☐	☐	☐	☐
4	We maintain good relationship with our business partners	☐	☐	☐	☐	☐
5	Our company believes in long term relationship with business partners	☐	☐	☐	☐	☐
6	We always keep in touch with our business partners	☐	☐	☐	☐	☐

APPENDIX

Appendix A: Product development cycle time industry average for section 2, question 5

Industry	**Product development cycle time**
Semiconductor and industrial electronics	9 months
Electrical and consumer electronics	1 year
Defense electronics	3 years
Heavy construction equipment	3 years
Machine parts	3 years
Automobile parts	3.5 year
Aircraft assembly	4 years
Heavy machinery	4 years
Automobile assembly	4 years

Source: Shuler, K. (2011)

Note: Please take note that information in the above table is for your reference only and may not include your industry. Please feel free to use your own data if you have more recent data or more accurate data for your specific industry.

All responses are completely confidential

Thank you for your time and cooperation!

Appendix B: Randomized sample frame

Sample frame ID							
276	146	45	66	141	239	252	112
88	59	256	164	8	125	138	9
218	32	175	80	130	214	258	100
206	82	113	165	171	237	257	37
91	232	280	199	228	230	70	183
178	267	54	157	36	198	160	275
284	14	185	271	181	23	193	40
72	189	83	129	176	264	202	16
2	122	133	123	71	64	156	
246	102	12	187	60	30	234	
269	103	46	260	231	204	147	
4	266	89	105	78	273	180	
241	148	210	24	245	92	77	
203	285	197	38	76	250	278	
51	139	222	216	75	145	173	
213	132	223	135	238	151	63	
233	177	13	34	179	10	55	
281	53	43	207	19	152	121	
101	1	81	172	253	288	136	
31	251	47	143	110	67	7	
200	149	235	242	127	85	196	
194	279	154	192	93	226	150	
108	48	99	104	109	68	118	
208	17	240	128	211	29	137	
277	111	25	26	243	286	188	
259	166	35	5	224	86	262	
161	170	227	21	155	27	186	
65	106	98	84	94	217	114	
249	49	96	33	201	254	229	
115	134	163	41	184	265	28	
58	270	162	219	18	11	44	
62	215	169	221	131	95	22	
97	56	212	87	42	247	282	
39	116	73	174	126	268	182	
158	159	120	195	220	168	140	
274	153	272	236	255	6	244	
119	69	124	191	61	167	74	
287	225	190	57	248	3	52	
50	117	107	79	15	283	142	
263	90	261	20	209	144	205	

Note: This random sampling frame was generated by using Minitab 17.3.1 statistical software

Appendix C: SPSS output

Appendix C. 1: Factor analysis – External integration and inter-organization relationship

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.720
Bartlett's Test of Sphericity	Approx. Chi-Square	857.134
	df	190
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.590	22.952	22.952	4.590	22.952	22.952	3.866	19.332	19.332
2	4.020	20.098	43.051	4.020	20.098	43.051	3.194	15.969	35.300
3	2.089	10.443	53.494	2.089	10.443	53.494	3.028	15.141	50.441
4	1.901	9.507	63.001	1.901	9.507	63.001	2.512	12.560	63.001
5	.983	4.915	67.916						
6	.826	4.130	72.045						
7	.793	3.963	76.008						
8	.739	3.693	79.702						
9	.645	3.225	82.926						
10	.614	3.070	85.996						
11	.479	2.393	88.390						
12	.434	2.168	90.558						
13	.384	1.922	92.479						
14	.331	1.656	94.136						
15	.313	1.563	95.698						
16	.242	1.209	96.908						
17	.231	1.156	98.064						
18	.140	.701	98.765						
19	.127	.634	99.398						
20	.120	.602	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
CI1	-.018	.119	.784	.255
CI2	.140	.079	.774	.035
CI3	.267	.149	.649	.003
CI4	.045	-.024	.727	.237
CI5	-.186	.147	.681	.041
SI1	-.075	.183	.223	.714
SI2	-.024	.242	.056	.713
SI3	.003	.063	.297	.733
SI4	.103	-.033	-.027	.845
TPC1	.874	-.077	.069	-.030
TPC2	.766	-.144	-.148	.113
TPC3	.841	-.072	.006	-.022
TPC4	.873	-.018	.071	-.002
TPC5	.809	.052	.242	-.035
IOR1	-.255	.719	.178	.159
IOR2	-.356	.744	.105	.087
IOR3	-.045	.690	.261	-.034
IOR4	.221	.673	.164	.055
IOR5	.031	.632	.022	.058
IOR6	-.061	.774	-.180	.253

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Appendix C. 2: Factor analysis – New product development speed

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.879
Bartlett's Test of Sphericity	Approx. Chi-Square	301.483
	df	15
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.065	67.745	67.745	4.065	67.745	67.745
2	.632	10.534	78.279			
3	.487	8.115	86.394			
4	.320	5.325	91.719			
5	.276	4.594	96.313			
6	.221	3.687	100.000			

Extraction Method: Principal Component Analysis.

Appendix C. 3: Reliability analysis

Customer involvement:

Reliability Statistics

Cronbach's Alpha	N of Items
.797	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CI1	15.67	2.890	.659	.732
CI2	15.74	2.813	.660	.731
CI3	15.74	3.385	.525	.776
CI4	15.71	3.115	.603	.752
CI5	16.20	2.900	.487	.798

Supplier involvement:

Reliability Statistics

Cronbach's Alpha	N of Items
.783	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
SI1	12.01	1.750	.585	.732
SI2	11.93	1.685	.557	.748
SI3	12.00	1.738	.618	.716
SI4	12.13	1.662	.600	.724

Third party collaboration:

Reliability Statistics

Cronbach's Alpha	N of Items
.896	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
TPC1	12.20	9.233	.793	.864
TPC2	11.86	9.194	.641	.900
TPC3	12.20	9.257	.753	.872
TPC4	12.42	8.842	.817	.857
TPC5	12.45	9.560	.740	.875

Inter-organization relationship:

Reliability Statistics

Cronbach's Alpha	N of Items
.812	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
IOR1	21.62	3.238	.627	.774
IOR2	21.65	3.183	.647	.769
IOR3	21.41	3.055	.580	.781
IOR4	21.45	3.107	.523	.796
IOR5	21.40	3.219	.473	.806
IOR6	21.53	3.085	.628	.771

New product development speed:

Reliability Statistics

Cronbach's Alpha	N of Items
.903	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
NPDS1	17.33	9.533	.755	.883
NPDS2	17.13	10.304	.707	.890
NPDS3	17.09	10.562	.613	.903
NPDS4	17.24	10.230	.783	.880
NPDS5	17.42	9.580	.782	.878
NPDS6	17.49	9.777	.779	.879

Appendix C. 4: Test of normality – by group of component manufacturer

Tests of Normality

	Component manufacturer	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CI	Yes	.180	53	.000	.959	53	.068
	No	.260	32	.000	.896	32	.005
SI	Yes	.289	53	.000	.849	53	.000
	No	.389	32	.000	.737	32	.000
TPC	Yes	.126	53	.035	.967	53	.152
	No	.146	32	.080	.902	32	.007
IOR	Yes	.154	53	.003	.957	53	.054
	No	.333	32	.000	.779	32	.000
NPDS	Yes	.120	53	.055	.962	53	.089
	No	.129	32	.193	.952	32	.166

a. Lilliefors Significance Correction

Appendix C. 5: Hierarchical multiple regression analysis – test for H1

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.199[a]	.040	.020	.52569	.040	2.027	1	49	.161	
2	.380[b]	.145	.090	.50658	.105	2.883	2	47	.066	1.908

a. Predictors: (Constant), Size

b. Predictors: (Constant), Size, CI, TPC

c. Dependent Variable: NPDS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.560	1	.560	2.027	.161[b]
	Residual	13.541	49	.276		
	Total	14.101	50			
2	Regression	2.040	3	.680	2.650	.060[c]
	Residual	12.061	47	.257		
	Total	14.101	50			

a. Dependent Variable: NPDS

b. Predictors: (Constant), Size

c. Predictors: (Constant), Size, CI, TPC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.290	.203		16.233	.000		
	Size	.067	.047	.199	1.424	.161	1.000	1.000
2	(Constant)	1.115	.927		1.203	.235		
	Size	.080	.046	.237	1.737	.089	.979	1.021
	CI	.485	.216	.306	2.241	.030	.977	1.024
	TPC	.063	.109	.080	.581	.564	.970	1.031

a. Dependent Variable: NPDS

Appendix C. 6: Multiple regression analysis – test for H2

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.435[a]	.189	.156	.30974	.189	5.607	2	48	.006	2.350

a. Predictors: (Constant), TPC, CI

b. Dependent Variable: IOR

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.076	2	.538	5.607	.006[b]
	Residual	4.605	48	.096		
	Total	5.681	50			

a. Dependent Variable: IOR

b. Predictors: (Constant), TPC, CI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.688	.539		6.842	.000		
	CI	.305	.132	.303	2.314	.025	.983	1.018
	TPC	-.180	.066	-.355	-2.705	.009	.983	1.018

a. Dependent Variable: IOR

Appendix C. 7: Hierarchical regression analysis – test for H3

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.199[a]	.040	.020	.52569	.040	2.027	1	49	.161	
2	.235[b]	.055	.016	.52684	.016	.788	1	48	.379	1.938

a. Predictors: (Constant), Size

b. Predictors: (Constant), Size, IOR

c. Dependent Variable: NPDS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.560	1	.560	2.027	.161[b]
	Residual	13.541	49	.276		
	Total	14.101	50			
2	Regression	.779	2	.389	1.403	.256[c]
	Residual	13.323	48	.278		
	Total	14.101	50			

a. Dependent Variable: NPDS

b. Predictors: (Constant), Size

c. Predictors: (Constant), Size, IOR

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.290	.203		16.233	.000		
	Size	.067	.047	.199	1.424	.161	1.000	1.000
2	(Constant)	2.452	.966		2.537	.014		
	Size	.062	.048	.183	1.291	.203	.983	1.018
	IOR	.198	.223	.126	.887	.379	.983	1.018

a. Dependent Variable: NPDS

Appendix C. 8: Step 3 for Baron and Kenny's procedure – test for H4

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.199[a]	.040	.020	.52569	.040	2.027	1	49	.161	
2	.387[b]	.150	.076	.51047	.110	1.989	3	46	.129	1.965

a. Predictors: (Constant), Size

b. Predictors: (Constant), Size, CI, TPC, IOR

c. Dependent Variable: NPDS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.560	1	.560	2.027	.161[b]
	Residual	13.541	49	.276		
	Total	14.101	50			
2	Regression	2.115	4	.529	2.029	.106[c]
	Residual	11.987	46	.261		
	Total	14.101	50			

a. Dependent Variable: NPDS

b. Predictors: (Constant), Size

c. Predictors: (Constant), Size, CI, TPC, IOR

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.290	.203		16.233	.000		
	Size	.067	.047	.199	1.424	.161	1.000	1.000
2	(Constant)	.662	1.261		.525	.602		
	Size	.077	.047	.227	1.639	.108	.963	1.039
	CI	.444	.231	.280	1.927	.060	.872	1.146
	TPC	.086	.118	.107	.728	.470	.850	1.177
	IOR	.129	.240	.082	.536	.595	.797	1.255

a. Dependent Variable: NPDS