OPEN INNOVATION ADOPTION : THE ROLE OF TECHNOLOGY EXPLORATION, TECHNOLOGY EXPLOITATION AND TRUST AMONG SMEs AND HELICES IN TRIPLE HELIX MODEL

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UNIVERSITI UTARA MALAYSIA

SEPTEMBER 2017

OPEN INNOVATION ADOPTION :THE ROLE OF TECHNOLOGY EXPLORATION, TECHNOLOGY EXPLOITATION AND TRUST AMONG SMEs AND HELICES IN TRIPLE HELIX MODEL

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Thesis Submitted to
Othman Yeop Abdullah Graduate School of Business,
Universiti Utara Malaysia,
in Fulfillment of the Requirement for the Degree of Doctor of Philosopy

Pusat Pengajian Pengurusan Perniagaan
(School of Business Management)

Kolej Perniagaan
(College of Business)

Universiti Utara Malaysia

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Program Pengajian *(Programme of Study)*	:	**Doctor of Philosophy**

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ABSTRACT

Nowadays, it is almost impossible for businesses to craft competitive edges by pulling all in-house resources and capabilities alone. Innovation now demands a critical uplifting of a new dimension widely known as “open innovation”. Open innovation has been a main research focus and has mainly been targeted to large organizations where it have been proven to increase the organizations performance. As knowledge no longer resides within one particular industry alone, previous scholars have underlined the importance of embracing open innovation to SMEs to transform innovation processes. This study was constructed with the intention to look at the placement of open innovation among SMEs, specifically in the Malaysian triple-helix context. This study is developed to a threfold perspectives. Perspective I investigates the relationships of technology exploration, exploitation towards open innovation adoption and to investigate the mediating influence of trust on technology exploration and exploitation towards open innovation adoption. Perspective II investigates the success factors and challenges for the organizations to achieve the difficulty levels of the constructs in the light of open innovation; while Perspective III profiles the organizations based on the constructs involved. A total of 72 Malaysian SMEs involved in a triple helix project were involved in this study. The data collection was gathered through a likert-scale instrument. Two major analyses were used. The Structural Equation Modeling (SEM) and the Rasch Measurement were used to achieve the targeted perspectives. Result from Perspective I shows that technology exploration is significantly related to open innovation adoption and trust has also been proven to have a significant mediating relationship between technology exploration and open innovation adoption. Conversely, technology exploitation has proven insignificant relationship with open innovation adoption and has therefore resulted to trust having a non-significant mediating effect to the relationship of technology exploitation and open innovation adoption. Perspective II resulted to the division between success factors and challenges items while Perspective III indicated six distinct organizations profiles. Discussions of the study are based on latent characteristics shared by respective group. The findings of this study will assist SMEs; government; research bodies; industry players; and policy makers to understand what motivates SMEs to adopt open innovation in the light of their ability level in dealing with various difficulties in technology exploration, exploitation and trust towards triple helices.

Keywords: open innovation, triple helix, open innovation adoption, technology exploration, technology exploitation and trust.

ABSTRAK

Pada masa kini, adalah mustahil untuk perniagaan menghadapi persaingan dengan hanya menggunakan sumber-sumber dalaman dan keupayaan sahaja. Inovasi kini menuntut satu dimensi baru dikenali sebagai "inovasi terbuka". Inovasi terbuka telah menjadi satu bidang tumpuan utama dan telah dikaji di kebanyakan organisasi-organisasi besar dimana ia membuktikan peningkatan dalam prestasi syarikat. Oleh kerana ilmu tidak lagi terbatas di dalam ruang lingkup satu industri sahaja, para penyelidik telah menggariskan kepentingan mengguna pakai model inovasi terbuka di kalangan PKS bagi tujuan mengubah proses inovasi. Kajian ini dilakukan untuk melihat penerimaan ke atas inovasi terbuka dalam konteks PKS dan secara spesifiknya di dalam konteks *'triple helix'* di Malaysia. Kajian ini dibahagikan kepada tiga perspektif yang berbeza. Perspektif I untuk mengkaji hubungan teknologi eksplorasi, teknologi eksploitasi terhadap penggunaan inovasi terbuka dan untuk mengkaji kesan perantara amanah ke atas teknologi eksplorasi, teknologi ekploitasi dan teknologi eksplotasi terhadap penggunaan inovasi terbuka. Perspektif II adalah untuk mengkaji faktor-faktor kejayaan dan cabaran-cabaran organisasi dalam mencapai halangan terhadap konstruk-konstruk yang terlibat, manakala Perspektif III adalah untuk membentuk profil orgnisasi-orgnisasi berdasarkan konstruk-kontruk tersebut. Sejumlah 72 PKS Malaysia telah terlibat di dalam projek *'triple helix'* telah terlibat di dalam kajian ini. Data dikumpul menggunakan instrumen skala-likert. Dua analisis utama telah digunakan. Pertama, Structural Equation Modeling (SEM) dan Rasch telah diterjemahkan untuk mencapai perspektif-perspektif yang dibentuk. Keputusan Perpespektif I telah menunjukkan bahawa teknologi eksplorasi mempunyai hubungan signifikan dengan penggunaan inovasi terbuka dan amanah juga telah membuktikan hubungan perantara yang signifikan bagi hubungan teknologi eksplorasi dan penggunaan inovasi terbuka. Walaubagaimanapun, teknologi eksploitasi menunjukkan tiada hubungan yang signifikan diantara penggunaan inovasi terbuka dan oleh itu, amanah juga didapati tidak signifikan di dalam menjadi perantara diantara teknologi eksploitasi dan penggunaan inovasi terbuka. Perspektif II membawa kepada pembahagian diantara faktor-faktor kejayaan dan cabaran-cabaran berdasarkan item-item manakala Perspektif III menunjukkan terdapat enam profil organisasi yang berbeza. Perbincangan kajian ini adalah berdasarkan kepada ciri-ciri terpendam yang dikongsi setiap kumpulan. Penemuan kajian ini akan membantu PKS, kerajaan, badan-badan penyelidikan, pemain industri, dan pembuat polisi untuk memahami faktor-faktor yang dapat memotivasikan PKS untuk menggunakan inovasi terbuka berteraskan aras keupayaan mereka dalam menangani pelbagai kepayahan di dalam teknologi eksplorasi, teknologi eksploitasi dan amanah terhadap *'triple helices'*.

Kata kunci: inovasi terbuka, *triple helix*, penggunaan inovasi terbuka, eksplorasi teknologi, eksploitasi teknologi dan amanah.

ACKNOWLEDGEMENT

In the name of Allah, the Most Merciful and the Eternity for His blessings and mercy. *Selawat* and *Salam* are always delivered to the last prophet, Muhammad s.a.w who has guided his followers to the rightness.

First and foremost, I would like to convey my heartiest gratitude to my supervisors Prof Dr Rushami Zien Yusoff, Prof Madya Dr Thi Lip Sam and Dr Rohaizah binti Saad for the unconditional support and guide that has transitioned me through this PhD journey. Thank you for the opportunities given and I can assure that the lessons and advices has indeed enlightened and motivate me and will always be the most valuable experience I have had in my entire life.

This very special note is also dedicated to my beloved parents *Ayah* & *Ma; Tam, Abah & Mak* for their continuous prayers and love that has shielded me throughout this beautiful endeavor. The appreciation is also meant to all my friends and families, near and far, for being a strong support system that has always been where and when they are needed. I pray for Allah to grant all of you the *doas* that you have been asking for.

Last but not least, to my better half, Junaidi Abdul Ghani and my beautiful souls Nur Dinie Junaidi, Aniq Zakwan Junaidi and Nur Dalia Junaidi, I dedicate this thesis to all of you as the sign of love and the prove of courage that we have shared throughout my PhD years. You are my armors that have pulled me through the thick and thin and have never stopped believing in me and for that I thank you.

"In the End, It Won't Be How You Walked in The Sun - But How You Handled the Storm – That Will Determine Your Success"

~Yasmin Mogahed~

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AIM	Malaysian Innovation Agency
CTT	Classical Test Theory
GTP	Government Transformation Programmed
ICT	Information Communication Technology
IDT	Innovation Diffusion Theory
IP	Intellectual Property
IRT	ItemResponse Theory
MLSCF	Malaysian Life Sciences Capital Fund
MNSQ	MeanSquare
MOA	Memorandum of Agreement
MTDC	Malaysian Technology Development Corporation
MTT	Modern Test Theory
NEM	New Economic Model
NKEA	National Key Economic Areas
OIA	Open Innovation Adoption
PLS	Partial Least Square
R&D	Research and Development
SEM	Structural Equation Modeling
SET	Social Exchange Theory
SME	Small Medium Enterprises
OIA	Open Innovation Adoption

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The increasing globalization of business activities, the revolution of research and development (R&D) and the fast-moving technological changes have intensified the competition among business players across and within countries stipulating for continuous technological knowledge enrichment. In today's business world, it is almost impossible for businesses to craft competitive edges by pulling all in-house resources and capabilities (Abulrub & Lee, 2012). The call for a more open collaborative network model is intensifying; demanding for a stronger technology and transparent platforms. As innovation becomes a major strategic ingredient to a country economic stability and balance social welfare (Ghili, Shams, & Tavana, 2011; Rahman & Ramos, 2013) companies' innovation activities demanded critical uplifting which requires a new dimension of strategy widely known as "open innovation".

The term which has been proposed as a new paradigm for the management of innovation (Gassmann, 2006; Huff, Möslein, & Reichwald, 2013) is defined as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively.' (West, Vanhaverbeke & Chesbrough, 2006). The concept emphasizes on the sharing of knowledge across organization and industry players (Abouzeedan & Hedner, 2012) to commercialize innovation output through acquiring and leveraging both, the internal and external ideas and technologies (S. Brunswicker & Van de Vrande, 2014; Naqshbandi & Kaur, 2011a; West & Bogers, 2013). From the business point of view, organizations are urge to have a more open business models that will be able to mount a lot of useful ideas available externally. The open innovation concept, which is now being adopted across multi disciplines such as business, economics, sociology etc., can be understood from the business perspective as activities of collaborating with external partners be it suppliers, customers, universities, research institute, government, major industry players etc. with the drive to keep ahead of other industry players in the complex global competition. In other words, the gist of the concept is not about how successful each of these collaborating partners performs independently, but rather how well the innovation activities are successfully crafted and adopted throughout the innovation process as a whole.

Open innovation has earned increasing attention in scientific research, but so far it has mainly been analyzed in large, high-tech multinational enterprises (MNEs) and has mainly focused on in-depth interviews and case studies (Hossain, 2013; Kirschbaum, 2005; van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009). While the growing attention is largely focused to big organizations, which mainly focus on very specific industries and on specific issues (Henry W. Chesbrough, 2002; Laursen & Salter, 2006) rather than the full open innovation model, nevertheless few studies have revealed the growing needs for open innovation to be researched from the context of smaller organizations such as small-and medium-sized enterprises (SMEs) (S. Brunswicker & Van de Vrande, 2014; Gassmann, Enkel, & Chesbrough, 2010; Henkel, 2006; Hossain, 2013; S. Lee, Park, Yoon, & Park, 2010a; Parida, Westerberg, & Frishammar, 2012; Hakikur Rahman & Ramos, 2013; van de Vrande et al., 2009).

The study focuses on collaborative innovation activities and highlights on the trust relations between SMEs and the three major actors of what is known as the “Triple Helix” concept, namely the university; government and industries (Henry Etzkowitz & Leydesdorff, 2000). The concept was first introduced by Etzkowitz and Leydersdorff in 1995, where they put forward the idea of a ‘triadic relationship between university-industry-government’ and designate the activities between three important helices (actors) as interdependent, relatively equal and has it’s own circle which at the same time can be overlapped with other actors by taking the role of the others (H Etzkowitz & Leydesdorff, 1997; Henry Etzkowitz, 2002; Tahrima & Jaegal, 2013) to suit the knowledge society era. Specifically, from the knowledge perspective, Triple Helix is interpreted as the ‘spiral model of innovation which is able to capture multiple reciprocal linkages at different stages of the capitalization of knowledge’ (M. Saad & Zawdie, 2011).

Collaboration projects often entail very high-specific investments and are normally prone to other issues such as uncertainty on future requisite (Gaur, Mukherjee, Gaur, & Schmid, 2012; Patzelt & Shepherd, 2008). The increasing demand for successful collaboration have placed the topic and field to be a crucial area to be frequently researched. In another manner, uncertainties are often related to the issues of risk and trust, which are explained in various perspectives (Camerer, 2003; Linell & Marková, 2013; Tileag, 2013; Twyman, Harvey, & Harries, 2008; Westergren & Holmström, 2012). Therefore, it can be well observed that the readiness of partners to engage in collaborative activities will depend upon the propensity to take risk and to trust their partners.

Business uncertainties are also associated to the limitation of low level of absorptive capacity, policy and financial constraints, human resources, as well as other management challenges that weaken the economic of scales (Jang, Lee, & Yoon, 2016; Saguy, 2011; van de Vrande et al., 2009)which has been said to be the disputes for SMEs to adopt open innovation despite the worldwide acceptance of the model (Hakikur Rahman & Ramos, 2013). Notwithstanding the formal enforcement mechanisms such as the memorandum of agreement (MOA), which stands as collateral understanding between parties, it may still signal distrust and encourage opportunistic behavior (Blomqvist, Hurmelinna, & Seppänen, 2005; Dyer & Chu, 2003). Because of the limitations of formal enforcement, organizational scholars have suggested that informal mechanisms such as trust are necessary to smooth the whole sharing process between collaborative partners (Abu El-Ella, John, & Andreas, 2015; Fleming & Waguespack, 2007; R. Gulati & Nickerson, 2008).

The advancement of technology has make innovation becomes even more competitive. Chesbrough (2003), used the term *disruptive innovation* to explain social changes that come alongside inventions from rapid innovation. Disruptive innovation according to Chesbrough brought along major challenges such as those that come together with the technological breakthrough, which in most of the time is unpredictable. The advancement of technology such as crowdsourcing, social media, and web applications has created a paradigm shift for innovation to move towards a more open platform such as open innovation. As open innovation reflects the purposive of inflow and outflow of knowledge (West, Vanhaverbeke, & Chesbrough, 2006), it is therefore important to look at the movements of the outside-in and inside-out flow of knowledge that is denoted as "technology exploration" and "technology exploitation" (van de Vrande et al., 2009).

1.2 Overview of Open Innovation in Malaysia

In the case of Malaysia, companies are urged to adopt open innovation model as it can lead to the creation of more investment opportunities and will become an important tool to stimulate the economic growth. When speaking to Bernama News in 2012, Dr Roger Wyse, Director of Malaysian Life Sciences Capital Fund (MLSCF) highlighted that open innovation is a paradigm that has overtake the organic innovation methods and is necessary for companies to remain competitive and will serve as a good ground for Malaysia to take off to the next phase in the economic development (BERNAMA, 2012). In another interview with Bernama News (2013), Datuk Abdul Wahab Abdullah, the President and Chief Executive Officer of MIMOS, the National R&D Centre in Information Communication Technology (ICT) of Malaysia, highlighted that open innovation is a good platform for Malaysian ICT companies as more homegrown ICT products can be exploited and explored rather than relying to foreign technologies which are normally limited and hinders local companies to innovate further. This can also helps reduce the government spending to 60 per cent for the ICT projects handled under MIMOS Malaysia (BERNAMA, 2013).

Majority of high-tech SMEs in Malaysia are said to have suffered a major issue in making use of technological knowledge gathered internally and externally to help create unique business values of their own products. Malaysian companies are still relying highly to the foreign technologies and selling it out as off-the-shelf products to the local market. SME Corporation proposed two solutions to overcome this dependencies and foster innovation by creating business value. Among others, Malaysian SMEs are encouraged to invest in its own strength and capabilities by providing business solutions that comes from full knowledge of the existing market needs and gaps through their internal R&D. The other proposition was too scout for external resources for in-house value creation and this can be done through licensing agreement to ensure the knowledge, technology, know-how and skills are transferred fairly for the betterment of the organization involved (Kwei, 2017).

The government of Malaysia targets an increase of 4% of the annual growth against the existing of 2.3% on the back of good support from the SMEs in order to achieve the status of high-income developed nation (The Star, 2015). In doing so, the Malaysian government is determined in apportioning supporting resources to assist in the development of Malaysian SMEs. In order to unlock the innovation potentials and boost the domestic, regional, and global competitive advantage among the Malaysian SMEs, the Malaysian government, in its Tenth Malaysia Plan, underlines five initiatives to assist the target.

Among it are reducing the regulatory costs; building capacities and capabilities; enhancing financing and the support systems needed by the SMEs; and nurturing and supporting the creation of entrepreneurial culture (EPU, 2010).

The Malaysian government has also established other support programs, institutions and agencies such as SME Bank, SMECORP etc., to provide guidance, promotion, production efficiency, R&D activities, and product development (Ahmad & Seet, 2009). This is also true to technology showcases and exhibitions, where multiple of events have been conducted to increase the awareness of IP and the importance of bilateral agreements between collaborating parties (Kwei, 2017).

SMEs in Malaysia represents 97% of the total Malaysian business establishments, contributing to 65% of total employment and nearly 18% of Malaysia's export (The World Bank, 2016). From the light of the country's GDP , SMEs in Malaysia have proven a significant contribution to the country GDP with the rise from 32.2% in 2010 to 36.3% in 2015. However, the reported marginal growth for SMEs productivity is said to be low (Figure 1.1) due to the fact that SMEs are being "input-driven rather than productivity-led" and in order to step forward, SMEs are encourage to shift their labor productivity from being highly "labor-intensive to knowledge and innovation-based economic activities" (SME Corporation Berhad, 2015) and as Malaysia targets to boost the SME's GDP contribution to 41% by 2020, the major element of Malaysia's Master plan will still be focusing on innovation and technology adoption (The World Bank, 2016).

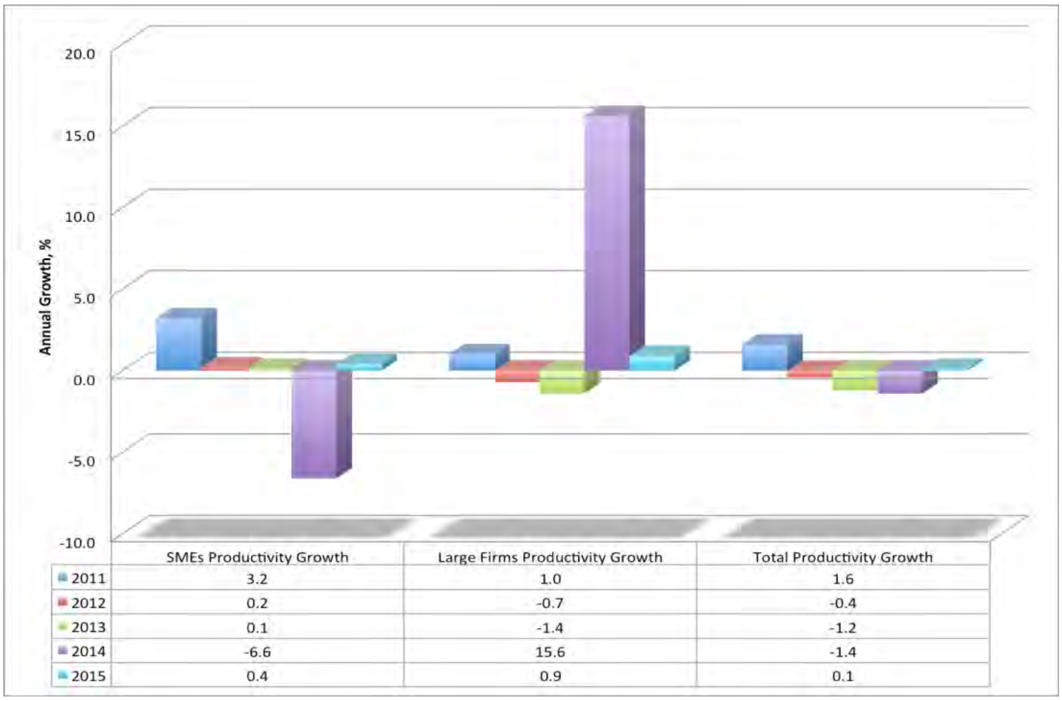

Figure 1. 1
Productivity Growth by Firm Size, %
Source: Department of Statistics Malaysia, 2015

Despite, the government efforts through huge amount of programs and projects targeted to various levels of SMEs, evidence from recent studies estimated that the failure rate of Malaysian SMEs is approximately around 60% (Ahmad & Seet, 2009; N. A. Rahman, Yaacob, & Radzi, 2016). The failures are said to be due to financial, management and marketing obstacles, which calls for a more comprehensive frameworks to explain SME's challenges and to address the structural issues (EPU, 2010), in order to remain competitive in the market. In another similar study by Hashim (2012) and Zulkifli-Muhammad, Char, Yasoa, & Hassan, (2010), SMEs in Malaysia are said to suffer lack of knowledge with regards to marketing issues such as the needed techniques, branding, customer loyalty and are also having problems with business network issues such as possessing good contacts with others local and international enterprises. This is also supporter by another study by Shah Alam, Ali, & Mohd. Jani (2012), which points to the fact that SMEs in Malaysia suffer social barriers, which hinders the competitive advantage and loose out in terms of opportunities. Hence, it is utterly crucial for SMEs to find ways to overcome these obstacles through engagement with external parties via collaborative network projects to complement and supplement their internal activities and to create a bridge with the external environment (Faems, Janssens, Madhok, & Van Looy, 2008).

With the Government Transformation Programmed (GTP) and the New Economic Model (NEM) introduced in the 10th Malaysia Plan (10MP), the government is bringing to the fore, the agenda of increasing more foreign direct investment (FDI), especially into SMEs. The agenda was further strengthened in the 11th Malaysia Plan (11MP), where the focus is mainly on productivity, innovation, entrepreneurship and inclusiveness. In a presentation during Commonwealth Association For Public Administration and Management (CAPAM) Biennial Conference (October, 2014), Secretary General of Ministry of Science, Technology & Innovation, Malaysia, Dato' Sri Dr. Noorul Ainul Mohd Nur, highlighted three issues and challenges affecting the adoption of open innovation in Malaysia. The issues include the transformation towards an open innovation culture; weak measures on open innovation performance; and making sense on the importance of the ecosystem values (MOSTI, 2014).

Moreover, the circle in innovation initiatives introduced by the government has also resulted to multiple initiatives and programs such as the National Key Economic Areas (NKEA) that are sustained and inclusive which embeds triple helix model directly and indirectly. Datuk Seri Panglima Dr Maximus Ongkili, the former minister of Science, Technology and Innovation, in his speech during The 10th Triple Helix International Conference in 2012 highlighted on the benefit of working together through the open platform to accelerate the innovation rate among the ASEAN countries to further enhanced and ultimately lead to economic prosperity.

Having said all the above, the major aim of this study is to identify and describe the level of open innovation adoption among the SMEs through its relation with technology exploration and technology exploitation. The focus of study will be among the SMEs in Malaysia, which has been, or currently involve in collaborative programs involving university, industry and government, or best known as the Triple Helix project in Malaysia. With the use of Innovation Diffusion Theory (IDT) by Everett Rogers, the study began with the attempt to investigate the drives of SMEs in Malaysia to shift towards open innovation platforms. The study too, would like to look at the perceived management challenges and success factors in ensuring effective implementation of technological activities that will ensure open innovation adoption. Furthermore, as collaborative relationships entail trust issues, this study evaluates the involvement of trust as a mediating construct that will encourage the adoption of open innovation in Malaysia.

Based on the background mentioned above, the following section will elaborate further on the problem statements related to the open innovation adoption measures for SMEs participating in Triple Helix projects.

1.3 Problem Statement

Being one of the upper-middle income countries in the world, Malaysia has been an innovation high flyer since 2011 in the Global Innovation Index (GII). However, despite a good ranking score in the GII in comparison to the GDP, the country is ranked low at 72nd place in 2014, and witnessed a dropped from the ranking of 53rd in 2013 (Rasiah & Yap, 2015). The declining performance according to the Global Innovation Index Report 2015, is due to the poor knowledge-based innovation activities where Malaysia is said to be lacking of knowledge-based workers, innovation linkages, as well as knowledge and technology outputs. Nevertheless, the nation is still determine to transform the country towards becoming a high-status income nation by 2020, and in the light of innovation, the government has introduce various initiatives to ensure the economic transformation of the country is to be driven by the innovation and productivity.

Through the establishment of Malaysian Innovation Agency (AIM), the country envision to bring forward an innovation eco-system that will contribute to the wealth creation through the stimulation of knowledge, technology and innovation in Malaysia (National Innovation Agency, 2017). In 2015, AIM has established six approaches to serve as the foundation for future growth to ensure Malaysia remain competitive and relevant in the changing economic environment. Among those are to facilitate the industry-academia collaboration. The target of this approach is to increase the number of commercial-ready intellectual properties (IP) from the industries and SMEs in particular via the collaboration activities between the government, society, university, and industry to promote and nurture a successful open innovation culture (National Innovation Agency, 2015). Therefore, a solid and structured framework needs to be established to provide a reliable and flexible support to adapt to the rapidly changing market forces and overcome unforeseeable obstacles .

Having said, the study choose to discuss the related issues from three viewpoints, namely the theoretical gaps, the managerial (practical) gaps and the methodological gaps.

1.3.1 Theoretical Gaps

Open innovation is still relatively new and not yet a straightforward concept and although the study in the area is expanding exponentially, empirical research is highly needed to better understand the technological exchange activities (Verbano & Venturini, 2013), which constitute open innovation (Hossain, 2013; Huizingh, 2011). Discussions with regards to open innovation have gained enormous attention from both the academic researchers and industrial experts. Although open innovation has been an important subject in the innovation management research, its theoretical framework has been relatively under researched (Ahn, Minshall, & Mortara, 2013). Evidence from previous researches in open innovation, have focused on understanding what are the drivers for business organization to shift their innovation directions towards an open innovation platform (Bigliardi, Dormio, & Galati, 2012; Burcharth, Knudsen, & Søndergaard, 2014; Chesbrough & Crowther, 2006; Chiaroni, Chiesa, & Frattini, 2012; Gassmann et al., 2010; Huizingh, 2011; Petroni, Venturini, & Verbano, 2012; Savitskaya & Ihrig, 2012; van de Vrande et al., 2009; Verbano & Venturini, 2013; West et al., 2006). Despite the wide adoption of open innovation across the globe, the notion of what open innovation means, the scope and the uniqueness of the term is still greatly debated (Dahlander & Gann, 2010; Hossain, 2013) and this adds to a challenge in building a more rational and consensus understanding (Huizingh, 2012) which calls for a development of open innovation model that integrate theories together (Lichtenthaler & Lichtenthaler, 2009).

In the light of technology and open innovation, it is necessary to see how technology exists as an important aspect in open innovation. Chesbrough (2003), in his book entitled "Open Innovation: The New Imperative For Creating and Profiting from Technology" imposed how technology breakthrough had shaped social practices demanding business organizations to change the way they innovate and learn from the widespread of knowledge and ideas across many industries in order to gain competitive advantage. Enkel, Gassmann, & Chesbrough (2009), suggested that studies in open innovation can contribute theoretically to the field of open innovation by either the school of thought, actors, or processes. According to Chesbrough (2003), there are at least two types of open innovation: (1) *outside-in*; and (2) *inside-out*. The *outside-in* is where organizations bring in external flow of ideas, knowledge and technology into their organization for the benefit of their product and services. This according to Chesbrough (2003), is where the company shifts the innovation strategy from monopolizing the source of its innovation to welcoming external contributions.

Conversely, the *inside-out* type of open innovation happens when organization opens up some of their internal ideas, knowledge and technology to be used by other organizations. This openness concept is referred by Chesbrough as a strategy of monopolizing the full capacity of company's own innovation and creating wealth through it. Enkel et al., (2009) add another dimension to open innovation type, which is a combination of outside-in, and inside-out processes and termed it the (3) *coupled process.* This process is explained as a co-creation between organizations and other external partners through alliances join ventures and cooperation, in which the participating partners jointly develop and commercialize innovations. Similarly, Dahlander and Gann (2010), use the dimension of *inbound* versus *outbound* open innovation and pecuniary versus non-pecuniary to point on the meaning of purposive in-flows and out-flows of knowledge that accelerate the internal innovation process as highlighted by Chesbrough (Chesbrough & Crowther, 2006; West et al., 2006).

Another comparable perspective is by Lichtenthaler and Lichtenthaler, (2009), which characterize the open innovation process according to the knowledge process of *knowledge exploration, knowledge retention* and *knowledge exploitation*, which according to the study can be performed internally or externally. Vrande et al., (2009), utilize the term *technology exploitation* to reflect technological capabilities outside the organization boundaries; and *technology exploration* to relate to technological activities that capture and take advantage from external sources of knowledge. Hossain (2013), for instance, suggested that technology transfer (outward and inward) is an important aspect in open innovation as it develops useful technology-related knowledge but is still an unexplored area, which demands future research. There are also evidence that points to prior open innovation research which has focused on the inbound dimension (exploration), whereas the outbound dimension (exploitation) has been relatively neglected (Lichtenthaler, 2009, 2011). The study by (V. Lazzarotti, Manzini, & Pellegrini, 2011) suggested that future research should look deeper into these openness context (technology exploration and technology exploitation) of open innovation and try to search on the intermediate models that drives the innovation process and the performance of open innovation.

Another view to consider is by looking from another angle that empirically explains *exploration* and *exploitation*, which have been introduced by March (1991), in the organizational learning theory which has been widely used in a lot of research especially those involving organizational learning and technological innovation (Li, Vanhaverbeke, & Schoenmakers, 2008). Through an extensive literature review, the study found that although various definition and findings on *exploration* and *exploitation* were developed since their introduction, a common understanding that can be derived from all the research is that *exploitation* refers to the further development of the existing knowledge (internally) and that *exploration* means the search for new knowledge (externally), technology, competencies, markets or relations. This is in line with open innovation view where organization make use of "purposive in-flow and out-flow of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006).

From the view of triple helix, it has been proven that empirically, the study of triple helix has been widely used in innovation literatures. A study by Ranga and Etzkowitz (2013), for instance, holds to view that triple helix systems is an analytical construct that is able to synthesize the key feature of the three helices interactions through the activities of knowledge, innovation generation, diffusion and use; and is able to be absorbed into an 'innovation system' format and advance the innovation system theory and practice. Likewise, (Costello, Donnellan, Gleeson, & Rochford, 2007), put forward arguments on the need to extent the innovation-development process highlighted in the innovation diffusion theory (IDT) by (Rogers, 1995, 2010). The study argued that to shift to open-innovation, within the context of triple helix environment, the innovation-development process must be updated to clearly explain the functions of each helices exist in the triple helix boundaries.

Innovation, inherently is a risky process, and collaborating with external partners whom needs and wants varies among each other throughout the innovation process will add further complications which requires a mechanism of control. This study will highlight the weightage of trust as an important factor in relation to open innovation. Although, there has been an exponentially rich study on trust across broad field and sciences, trust in the light of open innovation is still scarce. There has been a substantial body of evidence from previous research that try relating trust as an important component to open innovation (Ciesielska & Iskoujina, 2012; Dovey, 2009; Fawcett, Jones, & Fawcett, 2012; Graser & Jansson, 2005; Grudzewski, Hejduk, & Sankowska, 2008; Lin, 2011; Olkkonen, Tikkanen, & Alajoutsijärvi, 2000; Ratnasingam, 2013; Westergren & Holmström, 2012).

Theoretically, trust has been proven to be a key factor, which formulates the performance in business transaction (TÓTH, 2013). From the social sciences' perspective, trust has been placed and documented as an important factor that mediates many aspects of human behavior (Camerer, 2003; Linell & Marková, 2013; Tileag, 2013; Twyman et al., 2008). Graser & Jansson (2005), and Grudzewski et al., (2008), places trust as an important aspect that needs to be measured to rationalize the collaborative performance. TÓTH (2013), in his study highlights trust as having a positive significant role with networking activity and innovation while Lin (2012), proves that various types of trust along with innovation attributes have significant affects on the adoption of mobile banking. Ciesielska and Iskoujina (2012), in their study, denote trust as a key success factor in open innovation and suggested that empirical investigations of trust need to be analyzed at different levels to formulate different solutions to trust related problems. Similarly, Ratnasingam (2013), proposed further investigation on the placement of trust within the firm's innovation process in order to understand the impact of trust on the quality of the interactions between the collaborative partners and how it impacts on the innovation activities as a whole.

In the 2015 Edelman Trust Barometer Survey (Edelman, 2015), a new formula for a trusted business innovation is formulated. The formula counts the combination and engagement of factors relating discovery, benefit and integrity. The survey confirms a direct correlation between the trust level in a country and the willingness to adopt innovation and further argued that more independent research needs to be conducted to increase the level of trust for organization to embrace innovations. The same survey also show evidence that a transparent set of actions will increase trust and for organization to implement technology changes.

The evidence from past literatures highlighting on trust makes it viable for trust to be studied as a mediating factor to formulate its relation to open innovation adoption empirically. Hence, it is the objective of this study to investigate the effect of trust as a mediating variable towards between technology exploration and exploitation and the level of open innovation adoption.

Mainly, open innovation has been analyzed under large organization settings such as multi national enterprises (MNEs) compared to small and medium-sized companies (SMEs) and is now utterly crucial to be studied (Hossain, 2013; S. Lee et al., 2010a; Lichtenthaler, 2008; van de Vrande et al., 2009; Vanhaverbeke, W., Vermeersch & De Zutter, 2012). In the context of business competition, SMEs is in the critical situation to fit to the sharp pre requisites and demands with constrained resources in-hand (Hakikur Rahman & Ramos, 2010; TÓTH, 2013).

Research on open innovation in SMEs has received much less attention. Vrande et al. (2009), Lee et al. (2010), and Kathan, Matzler, Hautz, & Hutter (2014), are among some studies, which have stressed the point that the current research on open innovation in SMEs is still very limited and is not yet revealing the creative use of open innovation that many innovating SMEs around the globe are implementing. As Rahman and Ramos (2010), stated that considering open innovation for SME development is still new and understudied, it requires an extension of study and must be strategically developed through qualitative and quantitative synthesis on available resources, including conceptual approaches, strategy approaches, business models and business practices. Correspondingly, Vanhaverbeke, Vermeersch and De Zutter (2012), explain the importance of SMEs to collaborate with external partners to innovate successfully and suggest open innovation to be studied by integrating different management disciplines in order to understand the complexity of open innovation in SMEs.

In summary, the evidences from the past literatures as explained above, has make it viable for this study to feel the theoretical gaps from the perspective of SMEs at large that will enrich and contribute to the open innovation study in particular.

1.3.2 Managerial Gaps

Traditionally, SMEs relied on internal ability and resources to be innovative and to sustain competitive advantage. However, the average success rate of these innovative efforts tends to be much lower than desirable due to high level of risk, complexity and uncertainties (Parida et al., 2012). Scholars and policymakers have underlined the importance of collaboration between SMEs and other organizations in an open innovation model, in order to promote innovation processes (H. Chesbrough, 2010; Rahman & Ramos, 2010, 2014). In order to collaborate in open innovation environment, trust must exist among the collaborative partners (triple helices) (Graser & Jansson, 2005; Grudzewski et al., 2008). In order to trust is to have faith in the honesty, integrity, reliability, and competence of another (Ciesielska & Iskoujina, 2012; Lin, 2012; Ratnasingam, 2013).

Therefore, the ability to adopt open innovation among SMEs in Malaysia needs to be measured to understand the trend towards the adoption of open innovation. In the innovation economy, knowledge can no longer resides within the walls of one particular industry alone (Choudhary, Harding, Camarinha-Matos, Lenny Koh, & Tiwari, 2013). It is dispersed among members of organizations, businesses, competitors, universities, government agencies, research institutes etc. Open innovation is the mechanism for collecting and structuring this knowledge, leading to the identification of new opportunities that can generate wealth or remove the obstacles facing the firm. Thus, to leverage the best out of the open innovation practices, the relationship between the open innovations practices and the level of trust among SMEs towards triple helix must be measured.

In the nutshell, the study in particular intend to address the managerial gaps as explained above from various angles. For instance, as trust become one of the most important ingredients in successful relationship building (B.-Å. Lundvall, 2007; Sharp & Ave, 2012), be it within the organization or across sectors and helices, it is necessary to look at the level of trust among SMEs towards triple helix. Furthermore, to ensure SMEs perceived adoption of open innovation as important and critical, it is important to look at their ability in achieving the items (difficulties) associated with the adoption of open innovation. This must include their ability to perform the level of difficulties in trust to further understand their relationship with the level of open innovation adoptions (Daellenbach & Davernport, 2004; Godoy & Amandi, 2012; B.-Å. Lundvall, 2007; Sharp & Ave, 2012).

1.3.3 Methodological Gaps

In the past years, since its introduction, the study of open innovation have been subjugated by qualitative studies, represented by in-depth interviews, and case studies that are descriptive in nature (Hossain, 2013; Huizingh, 2012). In a report by Lappeenranta University of Technology (2013), on the development of indicators for open innovation, a systematic review of open innovation studies published in ISI Web of Knowledge, EBSCOhost or SciVerse Scopus from the year 2003 to 2013 were tabled.

The report looks at patterns and the methods used in the studies of open innovation where since its introduction in 2003, initial studies tend to focus on conceptualization and theory building using in-depth studies, which mainly focused on success stories and early adopters (Chesbrough & Crowther, 2006; Huizingh, 2012; Huston & Sakkab, 2006). The next phase, which began around 2007, shows the use of qualitative methods based on interviews and multi-case comparison. It is from 2009 onwards that quantitative methods started to take place when open innovation concept has evolved and become matured. It is through that phase that the quantitative indicators (Hurmelinna-Laukkanen & Puumalainen, 2007; Lichtenthaler & Ernst, 2008; Lichtenthaler, 2008; Un, Cuervo-Cazurra, & Asakawa, 2010) and large scale measurement surveys were launched (Belussi, Sammarra, & Rita Sedita, 2008; Hwang, Kim, & Kim, 2009; Laursen & Salter, 2006; Teirlinck & Spithoven, 2008).

Due to this limitedness and lack of empirical study in open innovation, future research on open innovation should be more of quantitative in nature and potentially be applied more often in order to generalize research outcome and allow more hypotheses pertaining to open innovation be tested (Vrande et al., 2009).

This is in line with Babbie (2010), and Fowler (2009), where quantitative technique through survey methods can be considered as the best option to generalize findings. Similarly, Salzberger (1999), argued that the quality and significance of empirical findings are based and depended on the quality and the properties of the measurement theory. Most of the common analysis technique are either using statistical modeling to estimate the relationship between variables, or descriptive analysis by adopting dimensionality reduction methods like Factor Analysis (FA), or Principal Component Analysis (Battisti, Nicolini, & Salini, 2010; R. Saad, 2012) which is in line with the classical test theory.

The classical test theory (CTT), has become a predominant measurement paradigm in social sciences research. A CTT underlying assumption is, each person has a *true score*, (T) , and that it would be obtained with the condition of no errors in measurement. CTT also looks at the relationship between *observed score* (X), *true score* (T) and *error* (E) in the population (Salzberger, 1999). The relations between these scores will explain the quality of the test score and have added to the formalization of reliability in terms of internal consistency and checks of unidimensionality (Tor, 2009).

Conversely, as mentioned by Wright (1977) and as highlighted in CTT framework, the issues in linearizing raw scores are not attended properly and it is considered as test-dependent. In the context where Likert Scale (Nunnally & Bernstein, 1994) data is analyzed. It has been argued that CTT methods are inappropriate due to the fact that it assumes interval or even ratio measurement (Thorpe & Favia, 2012). As explained by Bond and Fox (2013), "the relative value of each response category across all items is treated as being the same, and the unit increases across the rating scale are given equal value". In addition, likert scales, to some researchers, may be seen as representing at best nominal or categorical measurement, but Linacre (2005), argued that it should not be treated as continuous as they do not have the origins or units of measurement even though they are viewed as involving ordinal measurement (Thorpe & Favia, 2012).

Due to that, a Modern Test Theory (MTT) was introduced based on the work of Thurstone (1917). MTT is represented through the Item Response Theory (IRT) and Rasch measurement (Benjamin D Wright, 1977). In IRT, items and respondents attributes can be presented on the same scale (common scale), known as logit (Yu, 2013). Even though the underlying philosophy between IRT and Rasch are different in the sense that IRT is said to be descriptive in nature as it aims to fit the model to the data; and Rasch, on the hand, is vice versa, where it is prescriptive in nature and fits the data to the model, but, both are still learned as having advantages over CTT (Yu, 2013). A study by Magno

(2009), for instance, identifies issues in the CTT such as the concern with the calibration of item difficulties, sample dependence of coefficient measures and the estimates of measurement error, which are addressed in IRT. The test under this theory is based on a set of items, and the assessment of the tested subject ability, which depends on two factors: (1) the subject's relative ability; and (2) the item's intrinsic difficulty.

Rasch measurement is a unique approach of mathematical modeling, which is based upon a latent trait and accomplishes additive conjoint measurement where the word *conjoint* refers to the probabilistic measurement of persons or respondents and the items on the same scale (Granger, 2008). Rasch measurement is prescriptive in nature and is able to eliminate errors associated with CTT as it perfectly fits the data to the model (Yu, 2013). Furthermore, Rasch builds estimates of true intervals of item difficulty and person ability by developing linear measures (Granger, 2008). The advantage of IRT is the ability to provide information through the psychometric characteristics of the individual assessment items (Mohd Asaad, 2012) and in the case of innovation studies, a need to develop a psychometrical valid scale to evaluate the organizations' overall innovation capability is still inadequate (M. N. A. Rahman, Doroodian, Kamarulzaman, & Muhamad, 2015).

Therefore, this study will focus to look at the adoption of open innovation through its actual performance, degree of collaboration intensity, and the innovation process. Specifically, the study intends to look at the ability of SMEs in adopting open innovation through the level of technology exploration and technology exploitation implementation (difficulties), as well as to look at the mediating effect of the different level of trust (difficulties) with the level of open innovation adoption. In doing so, the analysis for the study will be twofold. One being the Rasch model of measurement and second, the Structural Equation Modeling (SEM).

1.4 Research Questions

Given the issues stated in the problem statements, this research will seek to identify the open innovation adoption among the SMEs involved in the triple helix projects in Malaysia by answering the following research questions:

RQ1: Is there any relationship between technology exploration and open innovation adoption?

RQ2: Is there any relationship between technology exploitation and open innovation adoption?

RQ3: Is there any relationship between technology exploration and trust?

RQ4: Is there any relationship between technology exploitation and trust?

RQ5: Is there any relationship between trust and open innovation adoption?

RQ6: Is there any mediating effect of trust on technology exploration and open innovation adoption?

RQ7: Is there any mediating effect of trust on technology exploitation and open innovation adoption?

RQ8: What are the success factors and challenges for organizations to achieve technology exploration?

RQ9: What are the success factors and challenges for organizations to achieve technology exploitation?

RQ10: What are the success factors and challenges for organizations to achieve trust?

RQ11: How can organizations be profiled to understand the potential values of open innovation adoption that can be explain from the perspective of technology exploration, exploitation and trust.

1.5 Research Objectives

To achieve the objectives, this study is divided into three specific perspectives. The first perspective (Perspective I) is to investigate the relationship between technology exploration, exploitation and its influence towards open innovation adoption among SMEs and to investigate the mediating relationship of trust on technology exploration and exploitation towards open innovation adoption. The second perspective (Perspective II) is to investigate the success factors and challenges for organizations to achieve the difficulty levels of technology exploration, exploitation, and trust in the light of open innovation and triple helix. Finally, the third perspective (Perspective III) is to profile the organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust.

Specifically, the research aim to fulfill the following objectives:

RO1: To investigate the degree of relationship between technology exploration and open innovation adoption.

RO2: To investigate the degree of relationship between technology exploitation and open innovation adoption.

RO3: To investigate the degree of relationship exists between technology exploration and trust.

RO4: To investigate the degree of relationship exists between technology exploitation and trust.

RO5: To investigate the degree of relationship exists between trust and open innovation adoption.

RO6: To investigate any mediating relationship of trust on technology exploration and open innovation adoption.

RO7: To investigate any mediating relationship of trust on technology exploitation and open innovation adoption.

RO8: To investigate success factors and challenges for organizations to achieve technology exploration.

RO9: To investigate success factors and challenges for organizations to achieve technology exploitation.

RO10: To investigate success factors and challenges for organizations to achieve trust.

RO11: To profile organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust.

In summary the study will be developed based on the research questions and objectives through the three perspectives as tabled in Table 1.1 below.

Table 1. 1
Research Questions and Research Objectives

	Research Questions		**Research Objectives**	**Perspectives**
RQ1.	Is there any relationship between technology exploration and open innovation adoption?	RO1.	To investigate the degree of relationship between technology exploration and open innovation adoption.	
RQ2.	Is there any relationship between technology exploitation and open innovation adoption?	RO2.	To investigate the degree of relationship between technology exploitation and open innovation adoption.	Perspective I
RQ3.	Is there any relationship between technology exploration and trust?	RO3.	To investigate the degree of relationship exists between technology exploration and trust.	
RQ4.	Is there any relationship between technology exploitation and trust?	RO4.	To investigate the degree of relationship exists between technology exploitation	

	Research Questions		Research Objectives	Perspectives
			and trust.	
RQ5.	Is there any relationship between trust and open innovation adoption?	RO5.	To investigate the degree of relationship exists between trust and open innovation adoption.	
RQ6.	Is there any mediating effect of trust on technology exploration and open innovation adoption?	RO6.	To investigate any mediating relationship of trust on technology exploration and open innovation adoption.	
RQ7.	Is there any mediating effect of trust on technology exploitation and open innovation adoption?	RO7.	To investigate any mediating relationship of trust on technology exploitation and open innovation adoption.	
RQ8.	What are the success factors and challenges for organizations to achieve technology exploration?	RO8.	To investigate success factors and challenges for organizations to achieve technology exploration.	Perspective II
RQ9.	What are the success factors and challenges for organizations to achieve technology exploitation?	RO9.	To investigate success factors and challenges for organizations to achieve technology exploitation.	
RQ10.	What are the success factors and challenges for organizations to achieve trust?	RO10.	To investigate success factors and challenges for organizations to achieve trust.	
RQ11.	How can organizations be profiled to understand the potential values of open innovation adoption that can be explain from the perspective of technology exploration, exploitation and trust.	RO11.	To profile organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust.	Perspective III

1.6 Significance of Study

In general, this study will provide explanation of the open innovation adoption at large and how it fits the SMEs in Malaysia from the context of technology exploration, exploitation and trust towards Triple Helix players. As such, through a systematic research methodology, this study is expected to contribute specifically to the theory, methodology and managerial knowledge enrichment in the study of open innovation.

1.6.1 Theoretical Significance

Theoretically, the study will extend and integrate a few theories from several areas or research related to open innovation studies. It is expected that the result of this study will be able to draw on and contribute to scholarly literatures that examine open innovation from the context of technological activities practices among SMEs. This research will develop the technological, social, political and economic reasons for a renewed attention to the adoption of new innovation models such as open innovation. The result from this study will also contribute in understanding the conceptualization of the role of trust between the SMEs and the helices in open innovation adoption.

1.6.2 Managerial Significance

The study in this nature may also prove significant outputs in helping to understand what are the drives of Malaysian SMEs to adopt open innovation and understand the challenges as well as success factors faced by the organization in implementing technological activities (technology exploration and exploitation) to explain open innovation adoption in Malaysia. Alongside with it, the study intends to study the trust believes, that each SMEs has towards the collaboration helices from the Tripe Helix. The result of this study is expected to be useful to the SMEs at large, national policy makers, innovation practitioners, SMEs governing bodies, triple helices (university-government-industry) and all collaborative parties undertaking any triple helix or collaboration projects. The government of Malaysia will benefit from an understanding about the open innovation system, which is a network of collaborative environment by nature. It is expected that through this study, the government through their agencies will be able to shift their practices to better meet the needs of the SMEs and the collaborating bodies in order to boost the technological activities pertaining to open innovation practices in Malaysia.

1.6.3 Methodological Significance

The data collected from this study will be analyzed using two major analyses to meet the major objective of the study which is to look at the placement of open innovation in the context of small medium enterprises (SME) specifically in the Malaysian triple helix context. First being the Rasch measurement model as a research tool, based on Item Response Theory (IRT), which will serve as the appropriate theory to explain the ability of the respondents in achieving the variance in item difficulties in the constructs involved. Prior to the major analyses, the validity and reliability checked will also be performed to the data according to the IRT perspective. The data were then analyzed to fulfill the perspectives that has been set.

The Rasch model, is a model that follows a small sets of assumptions, which among others are that each and every respondents involved is characterized, by their ability and the level of difficulties that can be expressed by numbers along a continuum line (Bond & Fox, 2015). Previous research in open innovation has attempted to find answers as to what are the drives for business organization to shift their innovation directions towards an open innovation platform. Yet the understanding of the current level of open innovation is yet to be explained from the level of the respondents' difficulties in achieving each of the items involved The result from this study will help to anticipate and explain the study objective, which is to examine the level of open innovation adoption among SMEs in collaborative network settings (triple helix). This will extend the research application process particularly in the existing innovation research studies.

The second major analysis used is Scrutural Equation Modelling (SEM) which will measure the relationship between the construct chosen. In particular, the testing of hypotheses were conducted by imputing Rasch data to test the association between the constructs. This is in conjuction to to the suggestions made by Bond & Fox (2015).

1.7 Scope of Study

The study focuses on hi-tech SMEs, who are involved in the Triple Helix projects govern by one of the government agency. The selection of the companies is based on its participation in a Triple Helix project, which involves collaboration activities with the three institutional spheres namely, the universities or research bodies; the government through it's departments or agencies; and industries, which represents larger business organizations that has the capacity to assist smaller organizations to become a better market player.

The project entails 6 government funding's which has been established since the 7th Malaysian Plan. The funding was initiated with the aim to assist local companies to better develop their technology content and create commercial value for their products, while at the same time expand the capacity, capability and competitiveness (MTDC, 2014, 2017).

This study uses the survey method, where a sample of small and medium enterprises were selected from the population of companies under the funding's of the said Triple Helix project. Questionnaire was developed based on the items from the construct involved and is used as a primary instrument to obtain data from the identified respondents. As the unit of analysis for this study is organization, the instruments were then sent to Managing Directors, Chief Executive Officers (CEOs), top-management and executive level of the firms, which in particular are those that are able to describe the technology process of the company as well as the experience dealing with the three helices under the lights of the Triple Helix they are involved in.

1.8 Definition of Key Terms

Operational definition of a variable is referred as the statement that points out specific dimensions and elements through which a concept will become measurable, and is normally done by looking at the behavioral dimensions, facets, or properties of the concept (Sekaran, 2012). The following section puts forth the operational definitions and key terms of relevant construct variables used in this study. These terms are further explained in Chapter 2.

1.8.1 Open Innovation

The word innovation alone bring forward the meaning of an interactive process which involves multidimensional of organizational factors which are implemented through stages of innovation process in producing innovation outcomes such as knowledge and technology management, idea generation, idea development and commercialization of products and services. Open innovation, on the other hand is referred by Chesbrough (2003) as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively". This bring forward the understanding of open innovation as a term to refer to a business paradigm which makes use of external ideas as well as internal ideas, and internal and external path to market, in line with the advancement of technology in-place.

For the purpose of this study, open innovation will be referred as the interactive process of innovation, which is implemented via various stages involving knowledge derived from technological activities inside and outside the organizations. This includes idea generation, idea development and commercialization of products and services, achieved through collaborating with various partners by mutually sharing risk and benefit collaboratively.

1.8.2 Triple Helix

The concept of Triple Helix as introduced by Etzkowitz and Leydesdorff (1995) refers to a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. The model focuses on the highly potential relationship between the bodies of university-industry-government as one of relatively equal, yet interdependent, institutional spheres. This study refers to Triple Helix as the collaborative projects developed by the government and involves major players such as the government themselves through various ministries, departments or agencies; the academia and research bodies such as the universities, Research and Development (R&Ds) bodies; and the industry players.

1.8.3 Open Innovation Adoption

This study operationalizes open innovation adoption as the actual implementation of open innovation in an organization which will be measured based on the degree of collaboration intensity (V. Lazzarotti et al., 2011). In precise, the intensity of collaboration will be accounted through open innovation performance (Bengtsson et al., 2015; Lakemond, Bengtsson, Laursen, & Tell, 2016; V. Lazzarotti et al., 2011), the IP protections (Hertzfeld, Link, & Vonortas, 2006; Laursen & Salter, 2014; V. Lazzarotti et al., 2011; Manzini & Lazzarotti, 2015) and the innovation process (Doroodian, Nizam, Rahman, Kamarulzaman, & Muhamad, 2014; V. Lazzarotti et al., 2011; V. Lazzarotti, Manzini, & Pellegrini, 2015; M. N. A. Rahman et al., 2015; West & Bogers, 2013; Zhang & Luo, 2013).

1.8.4 Technology Exploration

Technology exploration, in the context of this study will be reffered to as the inbound (inside-out) activities between SMEs involved in a particular triple helix projects and the collaborating partners from the universities as a research bodies that assist in R&D activities and technology transfer; government through the triple helix governing bodies or agencies that provides supports in term of financial aid and commercialization channels; and industries that assist in the marketing activities and prospects. Five major dimensions as suggested by Vrande et. al. (2009) will be used, for the reason that the dimensions has been well accepted and used several times in previous studies related to SMEs and open innovation (Huizingh, 2011; S. Lee, Park, Yoon, & Park, 2010b; Lichtenthaler, 2010b; Rangus & Drnovšek, 2013; Verreynne & Kastelle, 2012; West & Bogers, 2013).

1.8.5 Technology Exploitation

Technology exploitation will be referred to as the outbound activities between SMEs involved in a particular triple helix projects and the collaborating partners from the universities as a research bodies that assist in R&D activities and technology transfer; government through the triple helix governing bodies or agencies that provides supports in term of financial aid and commercialization channels; and industries that assist in the marketing activities and prospects. The activities involved adopt three major categories as suggested by Vrande et. al. (2009) with the intention of enhancing and expanding the existing technological capabilities from within the organization to external boundaries outside the organizations. In details, the activity involves venturing, outward licensing of intellectual property (IP), and the employee involvement (non-R&D workers) throughout the organization innovation process.

1.8.6 Trust

This study operationalized trust, as the positive experienced of the SMEs derived from their willingness to be vulnerable to the actions of others when dealing with the three triple helix players namely the university, government, and the industry throughout the project with the expectation that their collaborating partners will perform positive actions that will boost their level of open innovation activities. In details, the study denotes trust as part of the innovation activity that points to the willingness of SME (the firm) to be vulnerable to the actions of triple helix helices (the agents the firm interacts with) based on the expectation that the helices (the firm's agents) will perform a particular action important to the SMEs (the firm), irrespective of the ability to monitor or control that other party (Mayer, Davis, & Schoorman, 1995). There are three dimensions to support trust in the context of this study. Based on the trust positions by the studies of (M. K. O. Lee, Turban, Matthew, & Lee, 2001; Mayer et al., 1995; Schoorman, Mayer, Davis, & Davis, 2007; Zadjabbarp, 2009).

1.9 Organization of Thesis

The thesis is structured into six chapters and organized according to the research process employed in this study:

Chapter One: Introduction. This chapter introduces and outlines the important contents and terms that are relevant to the research topic and the entire research process in the light of open innovation adoption, technology exploration, exploitation and trust. The specific contents are: background of the study, overview of open innovation (Malaysian context), problem statement from the theoretical, practical, and methodological gaps, research questions, research objectives, significance of the study from theoretical, practical, and methodological perspectives, scope of study, definition of the thesis and organization of the study.

Chapter Two: Review of the Literature. This chapter begins with the discussion of the evolution of open innovation, technology exploration, exploitation, and trust. It then continues with the explanation of underpinning theories, which are related to this study. As the study deploys two major analysis to meet the research objectives, the discussion of the measurement theories are also included in this chapter.

Chapter Three: Conceptual Framework. This particular chapter is structured to discuss some important concepts that are related to the development of the conceptual framework for this research. This chapter begins with the overview of the related literature, before the explanation of the conceptual framework. It will then be followed by the development of testable statements to meet the requirements to achieve the correlations research objectives.

Chapter Four: Research Methodology. This chapter will describe the methodological process, used to answer the research questions for the study. This among others include the research design, sampling frame and method used, data collection methods, instrument development for each constructs and dimensions involved, data analysis methods and the instruments validity process involved.

Chapter Five: Data Analysis and Perspective I Findings. This chapter will present the important findings and results of analysis for the first perspective (perspective I) of the research objectives developed for the study. The results are organized and explain in the manner that the research objectives and research questions are underlined. Prior to the discussion of results, the details on the process of validity and reliability for each construct are discussed thoroughly. This involves both the Rasch and the SEM-PLS methods to confirm that the data is fit to the model being tested.

Chapter Six: Perspective II and Perspective III Findings. This chapter will discuss the findings for Perspective II and III. In detail, the success factors and challenges based on item divisons will be tabled and deliberated for Pespective II and the discussion of the organization profiling will be shown based on the person (organization) maeasures for Perspective III.

Chapter Seven: Conclusions and Recommendations. This final chapter provides the detailed discussions on the research findings. This includes the comparisons and the support materials taken by previous similar studies. The discussion and conclusion will be arranged according to the research objectives of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review related to open innovation and all significant findings from previous research related to the proposed study. The fundamental element of this study is the notion that the levels of technology exploration and exploitation as well as the trust between the collaborating helices influence the open innovation adoption among the small medium enterprises' in Malaysia.

Firstly, Section 2.2 covers the definition and evolution of open innovation that begins by understanding the initial concept of innovation. Section 2.3 will gives some overview of open innovation studies that exist in relation to triple helix. In Section 2.4 will then discuss the issues of open innovation studies with regards to small and medium enterprises (SME) and section 2.5, will continue to relate open innovation issues in the context of Malaysia. Section 2.6 will look into previous studies of open innovation in the light of adoption. The section will also present the dimensions chosen to explain the adoption of open innovation in the context of this study. Section 2.7 and 2.8, will discuss technology exploration and exploitation and their relatedness to open innovation studies. This will then be followed by section 2.9, whre the concept of trust will be elaborated and Section 2.10, where all the related underpinning theories, used in the study, will be discussed.

2.2 Definition and the Evolution of Open Innovation

Open innovation is a paradigm that explains a new dimension of innovation. Closed innovation on the contrary, has always been the way most industries have been operating and as some may refer open innovation as the 21st Century phenomenon, it is therefore necessary to begin by looking at the historical development of innovation, in order to understand the novelty of the of open innovation concept and the challenges it yields.

Joseph Schumpeter first drew the term innovation in his book translated as "Theory of Economic Development" (1934), in which, he defined innovation as the new combinations that "are economically more viable than the old way of doing things". Since then, various innovation perspectives have emerged, as a result from globalization, technology, market demands, economical change and a lot more. Innovation, on one hand, is still referred to productive resources and is addressed to reflect new ideas, devices or processes created by individuals who over time, engage with others within institutional context (Van De Ven, 1986), and is seen as something original and current that penetrates or break-into the market or society. Innovation may be technological or organizational in nature and it may be new to the world, or just new to the industry or the business concerned (Manley & Kajewski, 2011).

In the light of competitive advantage, innovation can be understood as the creation, improvement and implementation of a new product, process, service, or organizational change aiming to increase efficiency, effectiveness or competition (H.W. Chesbrough, 2003). Innovation links to the creativity and the creation of unique ideas, and involves processes for taking those innovative ideas and turning them into reality through invention, research and new product development. The study of innovation has spurred encompassing a rich body of knowledge such as science, technology, economy, business and a lot more. As innovation becomes a key factor in business and organization, researchers in the context of innovation are targeted towards improving and providing better means and tools to business activities at various different phases of the process (West et al., 2006).

In the vigorous business environment where innovation is on the fast changing lane in congruence with products, technologies, customers and competitors, firms must rely on other means to produce and market their services and products. Thus, as open innovation becoming one of the most frequently discussed concepts in innovation management (Chiaroni et al., 2011; Huizingh, 2011), it is important to understand the connotation of "Open Innovation".

The "open innovation" term, signifies an innovation shift (H.W. Chesbrough, 2003; Gassmann, 2006), which concerns "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively" (Henry William Chesbrough et al., 2006). The concept has been debated tremendously in innovation management as well as in multiple other disciplines such as business, economics and sociology and has since captures the interest of both academic and practitioners. Scholars have acclaimed that the activities which were highlighted in the open innovation process (H.W. Chesbrough, 2003) have long been adopted by many companies over the decades; making it clear that the root of open innovation is very tied up to the history (Dahlander & Gann, 2010; Huizingh, 2011).

Lichtenthaler (2011), defined open innovation in the context of knowledge management, in which he refers open innovation as a 'systematically performing knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process'. Henry Chesbrough, further strengthen the paradigm of open innovation since he termed it in 2003 as "a distributed innovation process that relies on a purposively managed knowledge flows across organizational boundaries, using pecuniary and nonpecuniary mechanisms in line with the organization business model to guide and motivate knowledge sharing" (Henry W Chesbrough, 2017).

In the business context, open innovation can be understood by the activities of collaborating with external partners, be it the suppliers, customers, universities, government or major industry players and involves innovation activities such as knowledge sharing (Abouzeedan & Hedner, 2012); technology exploration and exploitation (Hoang & Rothaermel, 2010; Kane & Alavi, 2007; Lichtenthaler, 2010b; Stettner, Aharonson, & Amburgey, 2014), commercialization etc.

The realm of open innovation lays on two facets namely *"outside-in process"* and *"inside-out process"* where both aspects respectively explained the nature of open innovation. "Outside in" denotes the aspects of bring in the ideas and technologies from outside into the organization's own innovation process, whereas the "inside out" is a process out bringing out the un- and under-utilized ideas and technologies (Henry Chesbrough, 2011), from within the organization to external parties to be taken and combined into their innovation process.

(Perkmann & Walsh, 2007), through their study analyzed the flow and characteristics of collaborative efforts between universities and industries via the open innovation perspective in which they identified on the existence of differences between the issues across the industries and the academic evidence. (Gassmann et al., 2010), further add, *"Coupled process"* to reflect another dimension to open innovation which combines the "outside-in" and "inside-out processes". The study further adds, *"Coupled process"* to reflect another dimension to open innovation which combines the "outside-in" and "inside-out processes".

A few other studies in open innovation has move along the same line to explain open innovation in various modes and division. Dahlander and Gann (2010), for instance, use the dimension of *inbound* and *outbound* open innovation and pecuniary versus non-pecuniary to point on the meaning of purposive in-flows and out-flows of knowledge that accelerate the internal innovation process as highlighted by Chesbrough (Henry William Chesbrough et al., 2006; Chesbrough & Crowther, 2006). Comparatively, Vrande et al., (2009) measures open innovation activities via two distinct technological activities and termed it as *technology exploitation* to reflect technological capabilities outside the organization boundaries; and *technology exploration* to relate to technological activities that capture and take advantage from external sources of knowledge. Similarly, another study by Lichtenhaler and Lichtenhaler (2009), characterized open innovation process according to the knowledge process of *knowledge* *exploration, knowledge retention* and *knowledge exploitation*, which according to the study can be performed internally or externally. Studies have also attempted to explain the knowledge inflows and outflows, as defined by Chesbrough (2003), as a separate concept to understand the degree that affected the open innovation the most. One example to quote is the evidence that points to prior open innovation research, which has focused on the inbound dimension (exploration), whereas the outbound dimension (exploitation) has been relatively neglected (Lichtenthaler, 2009; Lichtenhaler, 2011).

2.2.1 Closed Innovation vs. Open Innovation

Closed innovations come about innovation activities that happened within the boundaries of an organization where it is conducted by the internal strength of employees, developed own new technologies and make use of the internal research and development (R&D) capabilities for their own products internally (Lichtenthaler, 2011). Competition among companies are based on the notion that companies must depend on the internal resources, and that the possession to the highly reliable resources, will depend on the number of smart and knowledge workers employed, technology and intellectual property in control, how and what and when to market.

Henry Chesbrough, in his book entitled "Open Innovation: The New Imperative For Creating and Profiting from Technology" (2006), explained that the closed innovation paradigm has eroded due a few reasons. He named the increased mobility of skilled workers; the expansion of venture capital; the external options for unused technologies; and the increased availability of highly capable outsourcing partners.

Chesbrough further explained that open innovation model call upon collaboration effort with customers, partners and other stakeholders that will benefit the organization innovation process. Under the open innovation model, companies must take advantage over the wealth of knowledge, which is extensively available outside the organization boundaries, and, in situations that does not jeopardize the organization, companies can gain profit through their own internal knowledge by sharing it with external parties. This is possible, according to Chesbrough with the emergence of Internet technology and web applications that allows crowdsourcing and inter-connectedness between large group of people such as the social media, blogs, wikis and others.

The table below illustrates the difference between the closed and open innovation as highlighted by Chesbrough (2003).

Table 2. 1
Contrasting Principles of Closed and Open Innovation

Closed Innovation Principles	**Open Innovation Principles**
Most of the smart people in our field work for us	Not all the smart people work for us, so owe must find and tap into the knowledge and expertise of bright individuals outside our company
To profit from R&D, we must discover, develop and ship ourselves	External R&D can create significant value; internal R&D is needed to claim some portion of that value
If we discover it, we will get it to market first	We don't have to originate the research in order to profit from it

Closed Innovation Principles	Open Innovation Principles
If we are the 1st to commercialize we will win	Building a better business model is better than getting to market first
If we create the most and the best ideas in the industry, we will win	If we make the best use of internal and external ideas, we will win
We should control our intellectual property (IP) so that our competitors don't profit from our ideas	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model

Source: Chesbrough, (2003)

Although some would argue that innovation in reality is almost never a choice and deciding between the two concept of innovation is almost impossible bearing the fact that innovation is a complex process of its own and innovation decision have to be tied up to the innovation objectives where in most cases it requires a blend between the two models. Therefore, comparing between the two, it can be understood that the open innovation paradigms are more convoluted and demands the management and organization to strategize the activities to expand beyond the traditional R&D department.

2.3 Open Innovation and Triple Helix

Triple Helix has been introduced (Henry Etzkowitz & Leydesdorff, 1995), as a model for studying the knowledge-based economies. Since the last two decades, research in triple helix has spurs across various countries and has been used to craft operational strategies for regional developments (Leydesdorff, 2012; Luna & Tirado, 2008; Sørensen & Hu, 2014; Wang & Shapira, 2012). The underlying philosophy in triple helix is that the economic strength lies in a prominent role of university, industry and government in producing useful knowledge for the betterment of the society and institution. The model has become an important contribution in shedding the lights for the shift from the industrial oriented economy to a knowledge-based economy.

The triple helix model orchestrates three basic elements, which firstly, underlines a more prominent role for the university in innovation, and can bee seen as equivalent to the role of industry and government in a knowledge–based society. Secondly, triple helix serves as a movement toward collaborative relationships among the three major helices (institutional spheres), where, the outcome from this element points to the fact that innovation policy has to be an outcome of interaction rather than a prescription from government; and the final element is that each institutional sphere may perform new roles, "takes the role of the other", while at the same time maintain their respective function (Henry Etzkowitz, 2008).

The model is claimed to function in an interactive manner, in which, as organizations' technological level increases, they tend to move closer to an 'academic model' (H. Etzkowitz, 2003), where they engage in knowledge sharing and higher level of training. Each and every helix is bound to contribute creatively to the natural innovation dynamics, referred as creative destruction by Schumpeter (Schubert, 2013), and regenerate creativity through the synergy from the intersections between the three institutional spheres of university, industry and government.

Another study by (Leydesdorff & Zawdie, 2010), exemplify that triple helix perspective has enriched the conceptual and empirical dimension of innovation studies and has contributed in expanding the innovation related theories as a systematic phenomenon which, in return, improve the innovation performance, practices and policies at various levels.

2.4 Open innovation and SME

Innovation at large has various effects on SMEs, which among others are evolutionary economics, institutional economics, new regional economics, the economics of learning and the economics of innovation (B. Å. Lundvall, 2010). Since SMEs have dominant impact on national economies, their innovative potential should not be neglected. The inclusion of various open contexts technology is not only becoming trends but also important resources to ensure successful innovation among SMEs. Rahman and Ramos (2014), mentioned how SMEs have been found to be more adaptable to open innovation with a significant contribution on targeting issues and perspectives in relation to their development, such as product, process and service innovation. This according to them leads to an increase competition, demanding customers, knowledge acquisition, and better positioning in the market (de Jong & Vermeulen, 2006; Lemola & Lievonen, 2008).

Open innovation spreads various prospects and opportunities for SMEs as the nature of open innovation itself prioritizes "joint efforts from in-house capabilities and possible outsourcing or combination of several input paths during the product or service development" (Hakikur Rahman & Ramos, 2010). Chesbrough (2010), highlighted on some of the benefits for SMEs through open innovation world, where smaller markets that are of less importance to large firms, provide specialized technological support to others including large companies, can easily enter into a growing market with innovative business model, partner with other dominant businesses and platforms of large companies, and remain in a niche where large firms have lesser interest. There has also been evidence that although large organization involvement in open innovation activities are higher, SMEs' intensity in open innovation activities are greater in comparison to large companies (Spithoven, Vanhaverbeke, & Roijakkers, 2013). The study also find that SMEs will benefit from open innovation especially on the the introduction of new product.

In the light of business practitioners, open innovation has been implemented in hundreds of companies incorporating into their respective business models and innovation processes. Among the big names with strong open innovation efforts are GE, LEGO, General Mills, Philips, P&G, Unilever, Shell, Nokia and an ongoing list. From the scholars' point of view, although the study of open innovation has tremendously being researched in various platforms and fields of knowledge, so far being it has mainly been centered to large, high-tech multinational enterprises (MNEs), which mainly focused on in-depth interviews and case studies (H.W. Chesbrough, 2003; Hossain, 2013; Kirschbaum, 2005; van de Vrande et al., 2009). Few studies have demonstrated the existence of open innovation in smaller organizations such as small-and medium-sized enterprises (SMEs) (Gassmann et al., 2010; Henkel, 2006; S. Lee et al., 2010a; Parida et al., 2012; H. Rahman & Ramos, 2012), which mainly focus on very specific industries and on specific issues rather than the full open innovation model (Henry W. Chesbrough, 2002; Laursen & Salter, 2006), and therefore, the needs to study the concept to fit the SMEs' pattern is utterly crucial (Hossain, 2013; van de Vrande et al., 2009).

2.5 Open Innovation Issues In Malaysia

Open innovation in Asia is still a tough call as there is not that much activity in Asia (Lindegaard, 2011), and Malaysia, in particular, has been listed as among the five top open innovation countries in Asia. Lindergaard further highlights that Malaysia stands out as being an Asian country with the biggest potential to become the open innovation hub in the region due to several factors. Among mentioned are the universities in Malaysia, encourage research on open innovation practices; and has held most renowned conferences. Malaysia has also become the choice of most Asian service providers as their headquarters; small and medium sized companies team-up in clusters and innovate together with the bigger companies locally in Malaysia and globally. Malaysia is also believed to have the highest number of knowledge workers with high proficiency in English; and supported by a well developed infrastructure with excellent logistic and information technology (IT) platforms which according to Lindegaard (2011), provide a balance between the Western and Asian business requirement to collaborate.

Through the Tenth Malaysia Plan (10MP), Malaysia has put innovation and R&D activities as an important agenda to drive the organization and economic development of the country. The blend between innovation and R&D activities will be a catalyst for the vision to transform Malaysia into a high-income nation.

Based on the tier in the National Innovation Policy and Innovation Malaysia (2010), the government needs to commercialize intellectual capital available at universities and research institutes. The government are proposed to leverage on available technologies and ICT platform for the gathering, disseminating and sharing of knowledge to encourage the generation of economic and education (IPPTN, 2010). The same article review the fact that knowledge no longer resides between the internal walls, and need to be collected and structured from every players involved in order to identify new opportunities that can generate wealth, and therefore call upon Malaysia to accept and adopt open innovation through collaboration of triple helix of interaction between industry, academia, and the government.

In a similar study, Naqshbandi and Kaur, (2011) highlight that Malaysia, since its independence, has developed economically in vast areas but is still lacking the formula to compete and be in-lined with other high income countries. Quoting from a report by PEMANDU (2011), the study points to the fact that Malaysia is still at lagging behind other countries in terms of low-cost production and high-value markets. The study further suggest that open innovation could be the breakthrough for a developing nation like Malaysia to move towards an advanced economy.

Collaboration, as how open innovation entails, expands more than just memorandum of understandings (MOUs) and memorandums of agreements (MOAs) (Chong, Abas, & Voon, 2013). (C. A. Lee, 2012), in his study, highlighted on the Malaysian National Higher Education Strategic Plan (NHESP), through collaborative efforts, intends to achieve ten prominent R&D

centers of excellence (COE) by the year 2015, in order to transform the Malaysian Higher Education. This collaborative effort will lead the industry to form strategic alliances with universities and other partners to be able to leverage from each and every resource on a win-win strategy basis (C. A. Lee, 2012; Nordin, 2010), and in order to adapt to the desired stage of a highly-income nation, it is the right time to for Malaysian companies to shift towards highly value-added and knowledge intensive activities through collaborative efforts. Hence, the position of the triple helix in research and innovation is utterly crucial to be explained to develop better understanding (IPPTN, 2010).

Further, (Razak & Saad, 2011), provide evidence that links between the three key helices has existed in Malaysia. The links, which comes in, various projects achieved through training programs, R&D activities, incubators, technology transfers, commercialization etc., and can be seen as the initiatives by the government through two measures (IPPTN, 2010). The first measure indicates providing public funding to encourage research between university and industry and the second measure calls upon the strengthening role of business units residing in universities to promote interactions with industries. One good example of this is the development of University-Industry Collaboration Unit (UIC) (Chong et al., 2013; IPPTN, 2010; C. A. Lee, 2012), USAINS Sendirian Berhad by Univesiti Sains Malaysia; Technology Incubation Centre by Malaysian Technology and Development Centre (MTDC) and many more.

However, despite the various efforts by the government, the success of these efforts lies in the challenge to tackle various issues in line. Saad (2004), asserted the need for effective governance, and Razak and Saad (2011), further include technological and human resource factors; issues pertaining to government and universities' policies, procedures and processes; commercializtiaon issues; relationship between the sphers; work cultures;and intellectual property (IP) issues. Voon, Yilin, Yee, Mei and Choo, (2008), similarly, found that sources of motivation such as innovative products, technology, competent human resource, lead time; government support; and apprehension to innovation have positive relationship to competitive advantage for and motivates SMEs to collaborate strategically with universities and help them to compete in the global market.

When highlighting the relationship challenges, Razak and Saad (2011), claimed that misperceptions clouding the communication between the three spheres has often been associated with the failure to acheive the desired outcome. SMEs and MNCs senior managers have often perceive universities as an 'ivory towers' and being 'too theoretical' and not having the 'sufficient practical knowledge' to tackle the real-time issues.

Another important barrier that has been highlighted in Razak and Saad (2011), is the lacking of IP guidelines in Malaysia, which has hammered the collaborative efforts as parties does not reach the win-win agreement due to the lack of awareness.

2.6 Open Innovation Adoption

The open innovation literatures has attempted to explain open innovation in terms of the models that is being chosen, highlighting on various types as explained above (Abouzeedan & Hedner, 2012; S. Brunswicker & Van de Vrande, 2014; Henry Chesbrough, 2012b; H.W. Chesbrough, 2003; Henry William Chesbrough et al., 2006; Dahlander & Gann, 2010; Hoang & Rothaermel, 2010; Kane & Alavi, 2007; V. Lazzarotti, Manzini, Nosella, & Pellegrini, 2015; Lichtenthaler, 2010a; Stettner et al., 2014). Most of the literatures agree to one thing in common and that is the open innovation is a primary focus of the current business era to drive firms' innovation performance to the desired level.

2.6.1 Open Innovation Performance

Chesbrough in his most recent article in 2017, affirmed that open innovation since his introduction of the term 14 years ago have shown significant relations to business innovation performances (Henry W Chesbrough, 2017). From one perspective, previous research has attempted to look at open innovation through the relationship between the different model of open innovation performances and other factors to understand the acceptance of the different model of OI among companies (V. Lazzarotti et al., 2011).

This study in particular, would like to focus on open innovation adoption and in order to measure the adoption, the study focus to measure the degree of SME's openness which was discussed in the study of Laursen and Salter (2006), and

Lazzarotti et al. (2011). In Laursen and Salter's (2006), companies who are open to external sources of knowledge are said to have a higher innovative performance and the degree of openness according to the study, is measured through the depth and the breadth of the external knowledge search and channels, which can be reflected, by the numbers and the variety of collaboration partners. Additionally, the study of Lazzarotti et al. (2011) which was conducted with the objective to relate the open innovation models to innovative performance and has contributed to the measurement of the innovative performances in which they extended from the study of (Garcia & Calantone, 2002), found that open innovation models increases the innovative performance. The level of innovativeness and its relation to open innovation performances has also been a central area of studies in open innovation literatures (Dahlander & Gann, 2010; Laursen & Salter, 2006; Lazzarotti Raffaella Manzini Luisa Pellegrini et al., 2010). Laursen and Salter, (2006), relates to the ability of innovative organizations to strategise their innovative activities leads to a better innovation performance. The study further added that external sources of innovative practices have a positive effect on the degree of organization openness in which it opens the opportunity to access a wide area of ideas and knowledge (Laursen & Salter, 2006).

In the light of SMEs, open innovation has been among the central study to understand whether or not the models of open innovation fit in the context of SMEs. A study by Rahman and Ramos (2014), put forward the promising benefits of open innovation where joint-efforts from the inbound and outbound activities helps boost SME's innovation performance through its competition, demanding customers, knowledge acquisition, and better positioning in the market (de Jong & Vermeulen, 2006; Lemola & Lievonen, 2008). Alternatively, Chesbrough (2010) put forward the advantage that can be leverage by SMEs in open innovation where smaller companies will benefit from the smaller markets that is not within the interest of large companies.

2.6.2 IP Management

In another perspective, one of the strength of open innovation in comparison to the closed innovation is from the view of intellectual property (IP) management. In a closed environment, internal IP management has become a challenge to organizations as companies are to control their IPs to ensure that it will not be exploited by the competitors (H.W. Chesbrough, 2003). In an open innovation mode however, IP management is an integral part of knowledge sourcing that serve as one of the pillars of open innovation adoption as it enables companies to collaborate and coordinate effectively with partners (Henry Chesbrough, 2012a; Hertzfeld et al., 2006; Laursen & Salter, 2014). The study of Laursen and Salter (2014), for instance, emphasized that one form of formal IP mechanism may lead to another complimentary form of IPs such as trademarks. Meanwhile, a few other studies are in line with the view that IP management is a challenge when implementing open innovation among companies (Alexy, Criscuolo, & Salter, 2009; Henry Chesbrough, 2012b; Laursen & Salter, 2014; V. Lazzarotti, Manzini, Nosella, et al., 2015; Lichtenthaler, 2010b) . IPs need to be protected and the issue of IP protection has been brought forward by Chesbrough since the introduction of the term "open innovation" (Henry Chesbrough & Brunswicke, 2013; H.W. Chesbrough, 2003).

The ability for companies to have in place some level of IP protection mechanism will ensure the companies' willingness to engage in a risky as well as dynamic R&D and innovation project investment (Laursen & Salter, 2014). However, in the case of SMEs, careful attentions need to be given when measuring the impact of IP protection mechanism as previous literatures has well underlined the limitations of SMEs from their point of characteristics and abilities such as their low systematic R&D procedures and high dependency to external partners (Doroodian, Nizam, Rahman, Kamarulzaman, & Muhamad, 2014; H. Rahman & Ramos, 2012; N. A. Rahman, Yaacob, & Radzi, 2016; Spithoven, Vanhaverbeke, & Roijakkers, 2013). SMEs tend be lacking behind in term of patenting the knowledge assets due to their financial constraints (Holgersson, 2012; V. Lazzarotti et al., 2011; V. Lazzarotti, Manzini, & Pellegrini, 2015) which accounts for a different measurement settings than large organizations (Spithoven et al., 2013). The study by Spithoven et al. (2013), claimed that OI practices have an important role in several dimensions (search strategies, external R&D, research collaboration and IP protection mechanism) which in return affect the innovative performance of the organizations and as the IP protection involves high financial commitment, the study concluded that SMEs tend to engage for other formal protection mechanism and "strategic appropriability mechanism".

2.6.3 Innovation Process

Another dimension used to measure open innovation adoption in the context of the study is to measure the openness involved in the various innovation stages. Openness in the innovation process has been mentioned as early as 2004 in the study of Gassman and Enkel where they began reviewing the future of open innovation. The study suggested that open innovation has brought changes within the company's innovation paradigm where the changes are reflected from the innovation process that has been transformed into a "semi-permeable membrane" that allows a more transparent flows between the internal innovation process and the external environment (Gassmann & Enkel, 2004). The key to leverage the change is the successful blend between the external knowledge sources and the internal knowledge base. Additionally, (Gassmann, O., Enkel, E., & Chesbrough, 2010), emphasized how SMEs can take advantage of open innovation by opening their innovation process such as external technology commercialization.

Openness in the innovation process has also been argued from the context of the type and the number of partners involved throughout the innovation process (R. Lazzarotti & Manzini, 2009) in which, the study claimed that the number of partners plays an important role in determining the level of openness in the innovation process. Lazzarotti et al. (2011), further emphasized the importance of measuring the degree of openness in a company that can be translated into what the study termed as "the innovation phase variety" to understand how a company adopt open innovation (V. Lazzarotti et al., 2011). In the light of innovation, the continuous innovation process has become an important element to be measured in order to ensure the sustainability of the overall innovation performance (M. N. A. Rahman et al., 2015). In a study, Doroodian et al., (2014), argued that there are limited number of research that measures the innovation activities involved in transforming the inputs to the outputs. Most of the existing studies have mainly focused to look at the output or the input through financial or non-financial means. The study suggested that there are at least four dimensions that should be included when measuring the innovation activities/processes which includes the knowledge and technology management; idea management; project development and commercialization capabilities (Doroodian et al., 2014). Open innovation on the other hand, is highly reliant to the ability of companies in managing the flows of knowledge coming from various collaborators and partners. West and Bogers, (2013), described three important knowledge flows that can best described the open innovation process, which among others are the 1) obtaining of knowledge; 2) integrating of knowledge; and 3) commercialization of knowledge and the interaction between the organization and the collaborating partners.

As for this study, the adoption of open innovation focuses on the actual implementation of open innovation in an organization and is measured through the degree of collaboration intensity (V. Lazzarotti et al., 2011). In details, the intensity of collaboration is measured through the open innovation performance (Bengtsson et al., 2015; Lakemond et al., 2016; V. Lazzarotti et al., 2011), the IP protections (Stefan & Bengtsson, 2016) and the innovation process (Doroodian et al., 2014) with the emphasize on the collaborative effort and the synergy between SMEs and the triple helices (university-government-industries).

2.7 Technology Exploration

Technology exploration activities, which allow business organizations to search for available technologies, ideas and knowledge in the current market, outside the organization boundaries, require business organizations to create and maintain external networks and connections. Through formal and informal ties within the network counterparts, organizations acquire the desired knowledge to succeed from the external parties. Alliances, for instance between formal collaborative efforts like R&D collaborations and between non-competing firms, are among the strategies that can be taken into measures for companies who wish to take advantage and participate in the technological era (Pangarkar & Wu, 2013).

This study will make use of five activities as highlighted by van de Vrande et al. (2009), which are the customer involvement; external networking, external participation; outsourcing of research and development (R&D) functions; and inward intellectual property (IP) licensing.

2.7.1 Customer Involvement

Customer involvement is one important mechanism, which have been proven by the open innovation studies, to have an important relation to the internal innovation processes (Gassmann, 2006). Ciesielska and Iskoujina (2012), brought forward how promoting the socialization activities among online communities is important in order to enable knowledge sharing activities. The study by Von Hippel (2005), for instance, identifies that customers are not passive adopters of innovations, but rather, they have the power to potentially develop their own innovations. This believes is important as these potentials customers may serve as beneficial ideas that can be imitated and followed by organizations. The spectrum of knowledge that could be spurred from the customer involvement activities may varied from "upgrading the current machines, equipment and software to better satisfy process needs, and because producers fail to provide an adequate supply" (Von Hippel, 2005). Further, according to Chesbrough (2003), organizations should make use of their customers' ideas to analyze the market demands and trends. It is through the customers that business organizations are able to learn and draw profitable patterns and formulas from the customers' experience with the existing products and services offered.

2.7.2 External Participation

Chesbrough (2003), highlights on the importance of organizations in open innovation context, to externally acquire intellectual property (IP), including the licensing of patents, copyrights or trademarks, which according to Chesbrough, is a "necessity to fuel one's business model and to speed up and nurture internal research engines". Although, there are evidence that claimed external participation is only practiced by a small group in SMEs (van de Vrande et al., 2009), while Rangus and Drnovsek (2013), found that external participation are more often practiced in service firms, it is still necessary to put it together with the other technology exploration activities as internal and external knowledge acquisition is found to interact with each other through out the innovation process.

2.7.3 Outsourcing R&D

Enterprises may also outsource R&D activities to acquire external knowledge. At the heart of the open paradigm is the assumption that enterprises cannot conduct all R&D activities by themselves, but instead have to capitalize on external knowledge, which can be licensed or bought (Gassmann, 2006). Technical service providers such as engineering firms and high-tech institutions have also become more important in the innovation process. In the open model it is considered fully legitimate to bring key knowledge development outside the organizational boundary (Prencipe, 2000).

2.7.4 Inward IP Licensing

Further, technology exploration can also be referred to inward IP licensing. It denotes the activity of "buying or using intellectual property, such as patents, copyrights or trademarks, of other organizations to benefit from external knowledge" (van de Vrande et al., 2009). Chesbrough and Crowther (2006), suggested that this activity can be considered as a faster and cheaper way to hunt for supplementary technology outside the firm. Among the activities involving inward IP licensing relates to setting a more systematic and formal manner to hunt for external technology (Chesbrough & Crowther, 2006).

2.7.5 External Networking

External networking is defined as "drawing on or collaborating with external network partners to support innovation processes, for example for external knowledge or human capital" (van de Vrande et al., 2009). As highlighted by Laursen and Salter (2006), being open requires organization to reach ideas from the outside of the organization's boundaries and takes chances to exploit from the new opportunities. In open innovation, ideas can be acquired from "individual inventors, high tech start-ups, academic institutions, and spin-offs of large firms " (H.W. Chesbrough, 2003). In order to benefit from external knowledge, organizations may interpret external networking into various activities such as consultancies and cooperation ties with potential competitors in market (Maula, Keil, & Salmenkaita, 2006; Tether & Tajar, 2008).

2.8 Technology Exploitation

Competitiveness in the long run calls for organization to constantly responds to the global market needs and strategies their competencies to conform to the changing business environment. Ability of organization to leverage from the latest and advanced technology, with competitive pricing to customers in comparison to other players in the same industry will ensure a stronger business viability and longer sustainability (Levinthal & March, 1993; March et al., 1992; Speckbacher, Neumann, & Hoffmann, 2014; Williamson & Markides, 1994).

In the case of Malaysia, serious efforts in IP commercialization, for instance, has been an integral focus of the government since the Sixth Malaysia Plan (Govindaraju, Ghapar, & Pandiyan, 2009). The government has since, emphasized on the function of public R&D to help companies to exploit and commercialize the research and technology products (Othman, Haiyat, & Kohar, 2014).

It can be understood that for business organizations aiming to leverage from the internal knowledge, they may well absorb in various practices. In this paper, three activities related to technology exploitation will be distinguished: venturing, outward licensing of intellectual property (IP), and the involvement of non-R&D workers in innovation initiatives (Gassmann, 2006).

2.8.1 Venturing

Venturing is defined here as the starting up of new organizations based on the knowledge gathered within the organization. The potential of venturing strategies is regarded as being huge and beneficial (H.W. Chesbrough, 2003). Making use of the example from a success story of Xerox, where venturing strategy has brought success to the business. By venturing, the smaller companies or projects are pulled together and is governed and supported by the parent organization.

Intellectual Properties (IP) play a crucial role in open innovation as a result of the in and outflows of knowledge (Arora, Fosfuri, & Gambardella, 2001; H.W. Chesbrough, 2003; Lichtenthaler & Ernst, 2007). In the Tenth Malaysia Plan, for instance, the government of Malaysia has given the mandate to Innovation Malaysia Unit, to generate the IPs and help to commercialize the R&D outputs through a better IPs' management (EPU, 2010).

2.8.2 Outward IP Licensing

Out-licensing of intellectual property (IP) allows business organizations to take advantage over their internal developed IPs, by selling it to other firms that might find it as profitable to their organizations. According to Aurora et. al., (2002), firms opting to out-licensed their IP are normally driven by the "anticipated revenues and profit-dissipation effects". For instance, it may come in the forms of licensing payments. However, an important note highlighted by the same study, is that the organizations might risk competition with the licensees when the IPs are used to compete in the same market. Hence, in order to upsurge the strategic advantage from the out-licensing (IPPTN, 2010; Lichtenthaler & Ernst, 2008; van de Vrande et al., 2009), it is important for the firms utilizing this approach to take a center stage and built a reputation as a knowledge provider among the other players in the market.

Othman, Hayat and Kohar (2014), further confirm, that the study on technology commercialize products (patents, IP, copyrights) within the emerging country has been limited due to limited resources, knowledge bases and expertise. The study stands to the point the reason behind the poor performance of university-industry technology commercialization exists due to several gaps between the important stakeholders in the collaborative effort, which are, the university, the scientist, the industry, the government and the industry.

2.8.3 Employee Involvement

For organization to benefit from its' internal knowledge is to capitalize on the initiatives and knowledge of current employees, including those who are not employed at the internal R&D department. Several case studies illustrate those informal ties of employees with employees of other organizations are crucial to understand how new products are created and commercialized (Chesbrough et al., 2006b). A number of practitioners and scientists endorse the view that innovation by individual employees is a means to foster organizational success (Tushman & O'Reilly, 2013; van de Vrande et al., 2009).

Employee involvements are often being related to the enrichment of knowledge sharing activities (Bartol & Srivastava, 2002). Trust, on the other hand facilitates knowledge sharing (Bakker, Leenders, Gabbay, Kratzer, & Engelen, 2006; Bulu & Yildirim, 2008; Collins & Smith, 2006; Jarvenpaa & Leidner, 1999; Wasko & Faraj, 2005).

Another study by Chesbrough (2013), highlighted on the evidence that although the measurements of the existing open innovation practices are still highly debated by the major industry players, satisfaction among large firms on the open innovation performances is positively correlated with the support by the top management.

This can be further supported by Gassman et al. (2010), when they study the future of open innovation and underline various perspectives to view pass, current and future trends in the literature. Highlighting from some past literature, the study expose the importance of building trust, generating new knowledge and dealing with low reciprocity commitment among team members to ensure successful open innovation performance.

Comparatively, Bababola and Omobowale (2012), through a case study of micro-entrepreneur in Nigeria, posits that the constant interaction between the owner and their employees have contributed to the atmosphere of trust which in return allow them to innovate and provide better service to their customer.

2.9 Trust

Innovation is a concept that has never been inseparable with risk. The dynamic open innovation models which entails collaborating with external partners whom needs and wants varies among each other, will add further complications which demands means of control. (Nonaka, 1994), mentioned that, to succeed in an uncertainty economic environment, the key is to have a winning formula is to manage knowledge. Innovation signifies the utilization of knowledge in order to create something new (Babalola & Omobowale, 2012). Within SMEs, for instance, knowledge is aptly created, shared, transferred, and applied through people rather then through information technology-based mechanism (Zhou, Tan, & Uhlaner, 2007).

Trust is viewed as an effective approach to solve control issues (Ma, He, Shuai, & Wang, 2010), which brings along mutual benefits among the collaborative parties under the boundaries of reciprocity and conditional cooperation. Having said that, open innovation in one hand, is an activity that is highly dependent on collaborative efforts which directly, denotes that trust is a vital ingredient for success.

Trust by definition as referred to Mayer et. al (1995), is the “willingness of one party to be vulnerable to the actions of another party in favor for a certain actions”. In open innovation, where activities involves building successful networks among partners, the quality of the economic relationship (Olkkonen et al., 2000), and between participating firms is an important agenda. The study by (Bart Nooteboom, Berger, & Noorderhaven, 1997), refers trust as an intangible asset, which shapes the future cooperation and makes it much easier and to benefit from the shared resources and knowledge with collaborative partners, trust must be managed efficiently (Bart Nooteboom, 2006). (Gambetta, 2000), defined trust as the general conditions under which it becomes very relevant for cooperation. Focusing on trust, to some researchers is more effective than other means of collaboration as it can be considered a less costly alternative (Bart Nooteboom et al., 1997; Zaheer, McEvily, & Perrone, 1998). Blomqvist, Hurmelinna, and Seppänen (2005), in a similar reference, points to trust as ‘crucial role for the composition of collaborations that are characterized by uncertainty and risk’.

When companies engaged with external partners for various innovation reasons, partners with innovation issues try to find formulas from the other partners who is seen and percept as being capable to assist in the problem solving. Studies by (Graser & Jansson, 2005) and Grudzewski et al. (2008), place trust as an important aspect that needs to be measured to rationalize the collaborative performance. Krishnan, Martin, and Noorderhaven (2006), in their study proves that trust has an important relationship to performance and that uncertainty moderates the performance results. (Dovey, 2009), denotes the relationship between experiences and trust and conclude that failure to learn from experience destroys trust.

The study of trust in open innovation, alliance strategies and collaborative networks can further be analyzed by the characteristics of trust. (Lin, 2011), uses the concept of knowledge-based trust in reference to perceived competence, benevolence and integrity, together with the innovation attributes in which the study proves to have significant affects to the adoption of mobile banking. Further, (Ciesielska & Iskoujina, 2012), characterizes trust as political trust and expert trust. Political trust is defined as the "trust towards the organization that its declarations and presentations will be followed by coherent actions" and expert trust is referred to as trust given to a person who is believed to be "professionally capable of providing quality solutions for given or taken tasks". The study, which focuses on the on-line communities of collaborators, claims that both trust are equally important for business organizations switching from the closed innovation paradigm towards open innovation.

In another perspective, (Ratnasingam, 2013), highlighted on the importance of three types of trust namely competence, predictability and goodwill trust that she relates has significant relationship throughout the innovation process. This study will make use of the three types of trust mentioned by, (Ratnasingam, 2013), and evaluate the effect of these various types of trust to the relationship between technology exploitation and technology exploration on the level of open innovation adoption.

2.9.1 Competence Trust

Competence trust according to (Ratnasingam, 2013), is the trust to the other partner's capability judged from their knowledge, expertise and everything related to the expectation. It is also refers as the firm's trust in the other party's ability, qualifications, infrastructure, talents skills, knowledge and expertise to provide the partners with the expected services, information and knowledge. This concept is also supported by (Ettlinger, 2003), who refers to the same type of trust as emotive or capacity trust. In addition to the work of (Ettlinger, 2003), (Şengün, 2010), interprets competence trust as the capability of the trustee to obtain a certain result, ranging from the creation of an initial idea to exhibiting competencies in problem solving to identification with an "other" inter-firm relationship where trust is manifested from an individual to a group, thereby honoring their expectation of behavior and intent by others.

Ibrahim and Ribbers (2009), when studying the impacts of trust towards inter-organizational system, found that competence trust is positively related to the use of human knowledge resources which is related to inter linkage of business processes and organizational domain knowledge resources. This means that when one partner percepts the other partners as having the desired knowledge required, they are expected to learn and practice more from the knowledge they gathered.

2.9.2 Credibility Trust

Credibility trust, according to (Ratnasingam, 2013), is a predictability trust which is based on the familiarity of the foundation that focus on the stakeholders characteristics based on the experiences with the other party. It is related to the dependency to the other partner's constancy in the quality of performance and services provided which is integral for the expectation assurance to the future performance and act as a 'bonding' agent between respective collaborative parties in a particular project (Costa e Silva, Bradley, & Sousa, 2012; Ratnasingam, 2013). Maskell and Malmberg (1999), in their study, refer to predictability trust as actors who initiate dyadic relationships based on former interactions. (Brattström, Löfsten, & Richtnér, 2012), suggest that systematic processes and structures that exist among business relationships decrease variation thereby creating credibility and fostering trust. Further, Haynes (2009), quoting from Maskell (2000), highlights that credibility trust is not to be avoided as over time, it encourages cooperation; satisfaction and commitment, which will then lead to the goodwill, trust or mostly referred to as benevolence trust.

Credibility trust is related to the experience. (Murphy, 2002), suggests that creative innovations – those initiated by independent actions of employees or business are positively related to experiential or micro level versions of trust. Likewise, Dovey (2009), suggests that trust as in "predictability trust" is built over time, as organizational practices (management behaviors, incentive systems, promotional schemes, etc.) are progressively experienced reliably. Credibility trust is the firm's reliance on the other partner's integrity in the consistency throughout the actions, based from its' prior experience, and permits the stakeholder to make predictions and develop expectations with regards to future services (Ratnasingam, 2013).

2.9.3 Benevolence Trust

Ratnasingham (2013), uses the term *goodwill trust* in exchange to benevolence trust, which, according to Ratnasingam, is based on an emphatic affective foundation that focuses on an institutionalized relationship. Mayer et al., (1995), refers benevolence as the extent in which one party, is perceived to want to do good, having a vested emotional interest (Khairul Shazi, 2014), and showing care and concerns in helping the other counter parts.

Benevolence suggests that partner is somehow affectively attached with another partner, and that one party will have the interest of another party at heart, which will in turn, motivates them to be involved successfully in the collaboration activities. Benevolence trust which is also referred to as relationship trust explain itself by referring to the firm's effort to seek support from the other partner who are percept as being honest, caring and displays benevolence criteria. This is in line with a few other studies such as (Williams, 2007), who highlighted the importance of building a genuine trust through emotion management among cooperating individuals and Meng (2012), who emphasizes on the lack of relationship trust among 'project partners' could deteriorate the performance and desired outcome.

This type of trust relies on the care, concern, honesty, and benevolence shown by the other party. When expectations of reliability and dependability are met, trust moves to affective foundations illustrating emotional bonds such as care and concern. Similarly, benevolence trust is also referred to as personal trust, which is, ‘a feeling among individual actors based upon former experiences and mutual confidence’ (Skytt & Winther, 2011).

Ratnasingam (2013), further stresses that benevolence trust is dependent on both competence trust and credibility trust, and it encourages both parties to share information and knowledge, cooperate, coordinate, create strong ties (bonding) and show commitment. Therefore, benevolence trust is deemed important as it function as a bonding or the building of connectors to persons outside one’s primary community.

2.10 The Underpinning Theories

A theory is said to be an explanation of the observed regularities (Bryman & Bell, 2011). Quoting from Merton (1968), Bryman and Bell agrees to the notion that a theory offers an indication to researchers as to how they might guide or influence the collection of empirical evidence. Hair, Black, Babin, and Anderson (2010), further explains that a theory provides a consistence and comprehensive explanation of a phenomena being studied. Through a guided underpinning theories, it helps researcher to understand the entire relationship among constructs and explains how the constructs affect one another (Zainal Abidin, 2013).

The study seeks to understand the nature of adoption to innovation and therefore will make use of the Innovation Diffusion Theory (IDT) by Rogers (1995). IDT will serve as the major theory to the development of the conceptual framework of the study. Based on the literature review presented, the study will add two additional supporting theories, which are the Organizational Learning Theory (OLT) by Argote & Miron-Spektor (2011), and March (1991); and Social Exchange Theory (SET) by Homans (1961). In detail, the OLT will explain the exploration and exploitation in light of the knowledge learning. The SET, on the other hand, will explain the construct of trust as the mediating variable in the framework.

2.10.1 Innovation Diffusion Theory

Diffusion is a term that has been defined by many researchers in multi-disciplines of sciences. It refers to "the process by which innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2010). The theory of diffusion has been used by many information system researchers to examine diffusion of information technology innovation (Atwell, Schulte, & Westphal, 2009; Bradford & Florin, 2003; Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004; Taylor & Todd, 1995; Valente, 2996; Young, 2006). A number of previous studies have investigated various situations in which a new set of technological activities has been used and showed varied degrees of successful outcome.

Rogers (1995, 2010), explains theory of diffusion as the processes by which the patterns of adoption are described, explained and assists to understand whether or how new invention and implementation of technology is successfully used. This theory has also been implemented to examine a variety of factors that are claimed to determine the sources of information and communication channels of technology throughout the Internet (Carlo, Lyytinen, & Rose, 2012; Xu & Quaddus, 2012). It was until, 1971, that Rogers developed what is called the innovation-decision process (Rogers, 1995, 2010) which describes the process as decision made and passed by individuals based on: (1) first knowledge of an innovation; (2) forming an attitude toward the innovation; (3) a decision to adopt or reject; (4) implementation of the new idea; and (5) confirmation of this decision. Rogers further suggests that each of these innovation-decision processes can be investigated individually.

This theory in particular is suitable to be used in this study as it intends to investigate the level of adoption of a new paradigm to innovation, referred to as *open innovation*. This study argues that basically open innovation has been practiced in the organization through collaborative activities between the organization and external parties, which may be from the government, industries, universities, R&D bodies etc. Hence, the study will look at the implementation process as suggested by the theory. Rogers refer implementation in IDT as an action, which occurs when an individual (or other decision-making unit) puts an innovation to use (Rogers, 1995, 2010). Specifically the study intends to investigate the implementation of open innovation though various items (difficulties) to understand how best it can be confirmed and implemented as an innovation strategy that will contribute to the desired innovation performance.

2.10.2 Organizational Learning Theory

Interest in the field of organizational learning has been mounting since the 1970s, most notably from the work of Argyris and Schon, in 1978 (Crossan, 2003). The reason behind the growing interest is the fact that in an economy where knowledge takes the center stage in bringing wealth and promising competitive advantage, companies are opted to manage knowledge that resides in various forms all around the organization (Kirwan, 2013). The underlying philosophies behind the OLT are said to be best described in two dimensions (B. Yang, 2004). The first dimensions deals with the purpose of learning and the second dimension indicate the focus of learning. The theory suggest that the primary purpose of learning is to enhance personal growth and develop human potential, while the focus of learning indicates how individuals and organization should put attention to the process and implications.

March (1991), further added that the exploration and exploitation effect the way organization learns, in which he argued that the effects of learning can be realized in the changes of the performance distribution; and that it will at the end improve organizations' competitive advantage. He explains exploration as knowledge activities, which includes search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation. Exploitation, on the contrary, is activities, which involves refinement, choice, production, efficiency, selection, implementation, and execution. Although he argued that both exploration and exploitation competes which each other due to scarce resources, one important highlights in the study by March (1991), is when he stresses that the balance between the exploration and exploitation is a primary factor for prosperity and system survival.

In order to tailor suite to the conceptual framework developed and the objective of the research, the study looks further to the OLT expanded by Argote and Miron-Spektor (2011), where according to the framework, organizational experience must be theorized to interact with the organizational context for the purpose of knowledge creation. The novelty of experience in this version of OLT takes the definition of exploration and exploitation and has been termed by March (1991). The relevance of this theory is portrayed by the fact that it explains the ongoing learning cycle that happened through task performance experience, which is then converted into knowledge. The knowledge will then flows out of the organization into the environment and will then changes the organizations' context, which will affects the future learning. This loop according to Argote and Miron-Spektor (2011), will takes place at various levels in the organizations, whether it is individual, group, organizational and interorganizational.

Based on the evidence above, OLT is considered an appropriate theory to explain the learning process that takes place within the technology exploration and exploitation.

2.10.3 Social Exchange Theory

Social exchange theory (SET) has been among the most influential theory in social psychological and sociological perspective that explains social change and stability as a process of negotiated exchanges between parties and for understanding workplace behavior. As early as 1920s, with the contribution from the early writings of Homans (1962), Blau (1964), and (R. M. Emerson, 1972), the theory has been able to bridge various disciplines such as anthropology, social psychology, and sociology (Cropanzano & Mitchell, 2005). Homans (1962), emphasize on the individual behavior of actors when interacting with one another. Blau, (1964) contributes to the development of SET by enriching the concept of *social exchange relationships, which* discussed the interpersonal connections between humans and parties involved. One important argument of Blau is that social exchange is the only means that can produce the personal obligations, gratitude and trust; and not the economic exchange. Blau (1964) and Holmes (1981) refers to trust as an identifying outcome of a favorable social exchange and in order to understand exchange, one need to understand what constitutes trust. Emerson (1972), then developed the psychological basis on the work of Blau and Homans; in which he placed the concept of power and its relation to the social structure. Power, according to Emerson (1962), denotes a function of the dependence of one actor to another. It is in the study of Emerson (1972), that trust, liking, commitment as an emergent outcomes of successful exchange relations are being theorized.

Emerson (1972) also highlighted that although different views of social exchange have emerged, theorists agree that social exchange involves a series of interactions that generate obligations (Emerson, 2008). Within SET, these interactions are usually seen as interdependent and contingent on the actions of another person (Blau, 1964). SET also emphasizes that these interdependent transactions have the potential to generate high-quality relationships.

SET views exchange as a social behavior that may result in both economic and social outcomes (Jay, Wittmann, & Spekman, 2001), and has generally been used to analyzed human interactions with the marketpl1ce, where it is best used to describe satisfaction as being an outcome when people receive fair returns for their expenditure. Chibucos, Leite, and Weis, (2004), explains SET from a few important underlying assumptions within the theory. Firstly, SET believes that humans are generally rational and engage in the calculation of costs and benefits in social exchange. This notion is reflected in situation where decision-making needs to be made.

The other assumption is that those engaged in interactions are rationally seeking to maximize the profits and benefits to be gained from the situation they are in. Further, SET believes that the exchange processes that benefits the individuals, will lead to shape the social interactions. Another important philosophy of SET is that relationships evolve over time into trusting, loyal and, mutual commitments (Cropanzano & Mitchell, 2005), and to do so, the parties involved, must be able to be bounded by certain *rules* of exchange. The rules of exchange are referred to as *reciprocity rule* and *negotiated rule;* will then develop a 'normative definition" to the situation they are engaged in; and this means that rules and norms of exchange are the "guidelines" that govern the exchange process commitments.

Therefore, it is noted that trust as being the outcome of exchange output between parties in communication context needs to be study and explained through the support of this theory.

2.11 The Measurement Theories

This section seeks to justify the adoption of Rasch measurement framework and models for the measurement of organization's ability in implementing the items related to technology exploration and exploitation, its' relation to the difference level of trust and to the open innovation adoption by reviewing the measurement issues in social science with regard to open innovation.

Measurement in the social sciences is aim at establishing a linear ordering among objects such as persons (subjects), items and performances. Antal (2003), argues that despite a large collection of methods, which have been developed in behavioral sciences to define and measure a large spectrums of variables, one still does not know what to measure. He argued that it is the measurement process itself that explained the measured variable and not what the variable is meant to be. He provided an example of measuring an intelligence of a person, where results is based on the intelligence test measures, defined on that very test and does not justify to explain the intelligence 'true' definition.

Stevens (1946), proposed a new definition for measurement in social science, in which he points to the measurement as 'the assignment of numbers to objects or events according to some rule'. Notably, there are some contradicting views that argue they should be no difference between measurement in the social sciences and the physical sciences, which implies that social scientists should strive to meet the necessary criteria for measurement as their counterparts in the physical sciences.

One important view to consider is the arithmetic operations, which are performed during the data collection, are based on numerical labels of counts, scores and ranks, which according to Wright (1997b) can be deceptive. Wright (1997b) also points to 'entity ambiguity', which can be understood as uncertainty to what is being counted in the raw data collected using ordered response categories such as 'always/usually/sometimes/never' or strongly disagree/disagree/agree/strongly agree'. These approach is also known as Likert scale items, introduced by Nunnally and Bernstein (1994). These raw data are merely observations (R. Saad, 2012), and they are used as an indicator for possible measures. In addition, likert scales are seen as representing at best the nominal or categorical measurement (Thorpe & Favia, 2012). An important point to ponder is, whether there is a direct correspondence between the raw data that have been collected, and the intended attribute or latent trait.

Wright (1997a), further argued that categorical and ordinal scales are not linear, and that they are inconsistent as they are biased against extreme scores. Saad (2011), quoting from Berenson, Levine, and Krehbiel (2011), forward the notion that the ordinal scaling is a relatively weak representative of measurement because the scale does not account for the amount of the differences between the categories. The study further added that ordinal scales data implies to display the spectrum of categories represented as "greater,"

”better,” or “more preferred” rather than the degree of how much. Adding to the justification, Preece (2002), infers that parametric statistical tools, such as analyses of variance and covariance, multiple regressions and factor analysis, are not feasible for ordinal data.

Hence, treating raw data from Likert-type response scales as interval scales and proceeding with parametric statistical analysis risks invalid and misleading inferences.

2.11.1 Classical Test Theory (CTT)

For many decades, CTT or interchangeably referred to as Rational Test Theory, has been dominating the test theory (Antal, 2003; Mohd Asaad, 2012). In this theory, a total score is taken, which is the sum of item responses and serve as a basis to indicate item and person statistics such as the location of a person, internal consistency, Cronbach’s α, reliability, correlation etc. The formula is represented as

$$X = T + E \qquad (2.1)$$

The formula explains the underlying assumption of CTT where each person has a *true score*, (T), and the *true score* will be obtained with the condition of no errors in the measurement. Additionally, CTT postulates the relationship between *observed score* (X), *true score* (T) and *error* (E) in the population (Salzberger, 1999).

Tor (2009), further explains that relationship between these scores will justify the quality of the test score and will then contribute to the formalization of reliability in terms of internal consistency and checks of unidimensionality. However, a few issues are seen as pertinent in the light of the traditional test theory or CTT. Firstly, issues of linearizing raw scores is not addressed (Andrich, 2004; Wright, 1997a; Wright, 1997b) and; secondly the results of CTT is test-dependent (Hambleton & Jones, 1993).

2.11.2 Item Response Theory (IRT)

Modern test theory (MTT) was originated from Thurstone (1927), when he described the achievement and attitude measurement in his article entitled *"A Law of Comparative Judgment".* It is in this book that Thurstone introduced a probabilistic model to reflect the connections between responses of a person to an item. It combines the two modes of Modern Test Theory (MTT) (Andrich, 2004), which are; the Item Response Theory (IRT), and the Rasch Model (Wright & Stone, 1979).

The theory can first be understood by dichotomous responses, before it is generalized to presents more than two ordered categories. An interesting point to consider is, in Thurstone's (1927) book, he represented populations rather than individuals. However, when a study seeks to answer issues on efficiency, the concern is immediately channeled to the parameterization of individuals (Andrich, 1978). Within IRT, the model is used to describe the data, and therefore requires the tested models to fit to the data. This is a traditional statistical paradigm of searching for a model to interpret the collected data (Andrich, 2004). One advantage of IRT is that it is able to provide information that allows a researcher to improve the reliability of the estimated situation, which can achieved through the psychometric characteristics of the individual assessment items (Mohd Asaad, 2012).

2.11.2.1 Rasch Model

Rasch measurement is a unique approach of mathematical modeling, which is based upon a latent trait and accomplishes additive conjoint measurement where the word *conjoint* refers to the probabilistic measurement of persons or respondents and the items on the same scale (Granger, 2008). Rasch measurement is prescriptive in nature and is able to eliminate errors associated with CTT as it perfectly fits the data to the model (Yu, 2013). Furthermore, Rasch builds estimates of true intervals of item difficulty and person ability by developing linear measures (Granger, 2008).

Even though the underlying philosophy between IRT and Rasch are different in the sense that IRT is said to be descriptive in nature as it aims to fit the model to the data; and Rasch, on the hand, is vice versa, where it is prescriptive in nature and fits the data to the model, but, both are still learned as having advantages over CTT (Yu, 2013). In other words, IRT is based on a different rationale from mere description of data; rather it is based on the requirement of invariance. Thus, the IRT model is not used merely to describe data, but as a criterion for data and a model to which data should fit.

The Rasch Model is based on a measurement philosophy or paradigm, with a concern to establish a basis for items and as a whole to meet a set of prior requirements of invariance. These prior requirements of invariance are established in the form of a statistical model used as a means of quality control and for scaling of items (Bond & Fox, 2013). This is in contrast to most common alternative approaches in measurement, including other IRT models where statistical models serve to describe the item and data. In the traditional approach, the statistical model must fit the data generated by the scale and items. If it is not the case, then better or more complicated statistical model with more parameters should be sought. In contrast, in the Rasch paradigm, where the model serves as a criterion, when the data do not fit the model, data are reconsidered pertaining to the construct, the questions/items, item format and administration. This paradigm of having data fit the model is consistent with Kuhn's analysis of the foundation of measurement in science (Andrich, 2004).

It can be conclude that, the Rasch model and its specifications are not meant to replace conventional statistical analysis in examining relationships between constructs or variables, but rather it is a complementary model, that serves as an alternative tool for statistical analysis that requires interval-level measurements.

Therefore, as the study intends to look at the ability of SMEs in adopting open innovation through the level of technology exploitation and technology exploration implementation (difficulties), as well as to look at the mediating effect of the different level of trust (difficulties) with the level of open innovation adoption, the Rasch model of measurement is deemed to be the appropriate technique for data analysis.

2.12 Chapter Conclusion

This chapter reviews the literatures on open innovation, and tries to draw the connection between the issues surroundings the concept in general, its relation to the technology, the Malaysian perspective, SMEs, and triple helix in particular, along with the view of some measurement concerns. As open innovation is still relatively new and is not yet a straightforward concept, the need to better understand the relationship between technology exploration (inbound) technology exploitation (outbound) towards open innovation are higly needed. Another integral contribution of this study is from the light of trust. Trust has been highlighted as a key success factor in open innovation and has been suggested that empirical investigations need to be analyzed at different levels of innovation process. So far, only a small number of previous literature are able to elaborate on the behaviors required to build the desired trust for collaborative innovation. Therefore, this study seeks to investigate trust in the lights of collaboration between SMEs and the helices from the triple helix model. Previous research has led to validate the importance of putting together all the related theories, measurement and model in the research design, instrument development and data analysis. The fundamental underpinning theories relating to the development of the conceptual framework are also discussed.

CHAPTER 3

CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

3.1 Introduction

This chapter establishes a conceptual framework and discusses theoretical issues related to understanding researcher's judgment of technology exploration, technology exploitation and the role of trust towards the adoption of open innovation. Accordingly, this chapter will discuss the findings of previous studies in technology exploration, technology exploitation, trust and its relation to open innovation adoption.

3.2 An Overview Of Literature

Over the years open innovation has developed into a highly debated topic. Since it's first introduction by Professor Henry Chesbrough in 2003, it has develop tremendously as a business model that explains the transformation of the innovation concept in which internal innovation activities lead to internally develop products and services that is then distributed by the firm (Henry Chesbrough, 2012b; Henry Chesbrough & Brunswicke, 2013; Chesbrough & Crowther, 2006; Dahlander & Gann, 2010; Gassmann et al., 2010). However, a large number of open innovation studies are mainly focused on large companies with less emphasize on SMEs (Ahn et al., 2013; Hossain, 2013; S. Lee et al., 2010a; Hakikur Rahman & Ramos, 2010; van de Vrande et al., 2009).

Kim and Park (2010), for instance, analyze the effects of open innovation practices among the SMEs in Korea. The study relates open innovation performance and its relation to “external idea sourcing; external knowledge sourcing; and external R&D”. The study concludes that the external R&D activity has a positive relationship with innovative performance. Further, the study finds that the external knowledge sourcing is not related to innovation performance; and the external idea sourcing is negatively related to SMEs innovation performance. This study serves as one of the important highlights in the study of open innovation among the SMEs. One reason is due to the fact that it contributes to the scarcity of open innovation studies from smaller firms' context; and the study proves that despite larger firms benefit from the three practices, it is not the case for smaller firms. The study concludes that further research on how open innovation fits the SMEs model needs to be conducted urgently; to prove the same findings as to what works and learned from the larger organization may not be readily transferable to the smaller context.

3.3 Conceptual Framework

As highlighted by Kumar (2011), a conceptual framework serves as a ground and foundation, which stems the theoretical structure that will explain the relationship between the variables developed as the basis of the research problem. Based on the literature review discussed in Chapter 2, Figure 3.1 illustrates the theoretical association for this study.

This study intends to develop a conceptual framework based on two independent variables, one mediating variable and one dependent variable. The independent variables are technology exploitation and technology exploration. The mediating variable is trust and the dependent variable for the framework is the open innovation process.

In this study, trust mediates the relationship between technology exploitation and technology exploration and open innovation process. The mediating variable is created when a third variable or construct intervenes between two other related constructs (Hair et al., 2010). According to the source, most application of mediation is to explain why a relationship between two constructs exists and this will assist in elucidating the influence of independent variable on dependent variable.

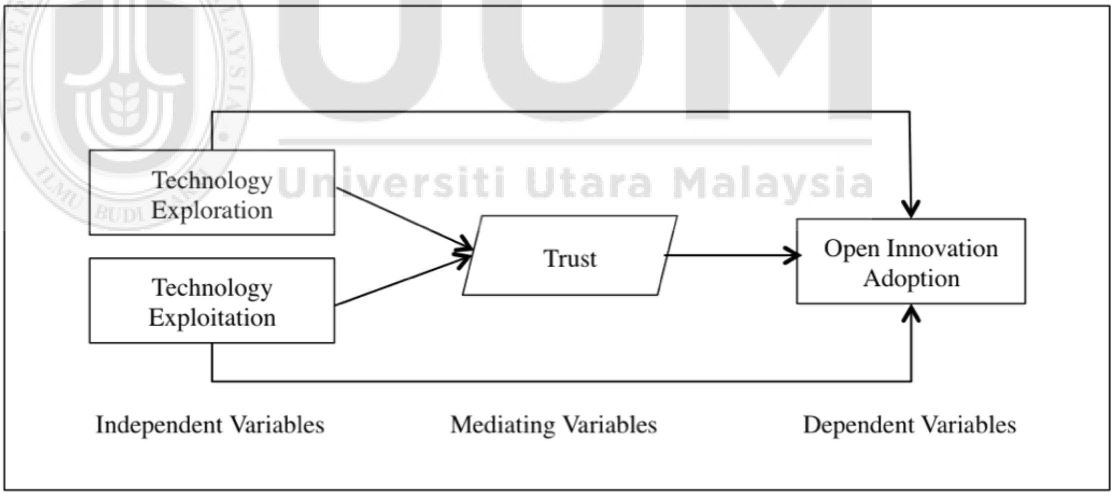

Figure 3. 1
Conceptual Framework of the Study

Based on the above conceptual framework, there are seven relationships that can be emphasized. These relationships are listed as follows:

i. The relationship between technology exploration and open innovation adoption.
ii. The relationship between technology exploitation and open innovation

adoption.

iii. The relationship between technology exploration and trust.

iv. The relationship between technology exploitation and trust.

v. The relationships between trust and open innovation adoption.

vi. The mediating of trust towards the relationship between technology exploration and open innovation adoption.

vii. The mediating of trust towards the relationship between technology exploitation and open innovation adoption.

3.4 Hypothesis Development

Hypothesis refers to assumptions or an idea about phenomenon, relationship or situation, which become basis of an inquiry (Kumar, 2011). It is a form of testable statement from a relational basis between two or more variables (Sekaran, 2011). Accordingly, this section describes the development of testable statement to examine the relationship between the independent variables, mediating and dependent variable. Testable statement is put forward based on the theoretical framework, findings and arguments revealed from previous studies and the item response theory. The following discussions are listed as below.

3.4.1 The Relationship Between Technology Exploration And Open Innovation Adoption

Technology exploration is the outside-in movements of knowledge, ideas and technology into their organization for the benefit of their product and services (H.W. Chesbrough, 2003; Lichtenthaler, 2008; van de Vrande et al., 2009).

Vrande et al. (2009), underlined various ways in which business organizations can raise their technological knowledge platforms (Chesbrough & Crowther, 2006) through external sources. The study named customers, employees and other firms as the most common sources of new ideas together with some technological activities such as venture capital, outsourcing of R&D and external IP licensing.

It is argued that by decreasing the R&D barriers an accelerating the involvement of customers into the product development and commercialization process, organizations will be able to highly leverage what is referred to as user-initiated innovation (Gault, 2012; Mooty & Kedia, 2014). Vrande ET. al (2009) also highlights the involvement of employees in uplifting the innovative performance through open innovation strategy and has been agreed by a few other scholars in the closed or open innovation context (J. S. Chen & Tsou, 2012; R. Y. Y. Hung, Lien, Yang, Wu, & Kuo, 2012; Reed, Storrud-Barnes, & Jessup, 2012).

Given the aforementioned information, this study develop another testable statement which describe the relationship as:

H1: There is relationship between technology exploration and open innovation adoption.

3.4.2 The Relationship Between Technology Exploitation And Open Innovation Adoption.

Technology exploitation signifies technological activities of the organization leveraging and disseminating their internal knowledge and ideas to the outside world. Internal technologies can be commercialized in various ways. In light of the competitive gains, many industries are strategizing a winning formula through technologies value creation activities. Business organizations can implement various strategies through external pathways, such as creating out new ventures, and the licensing of intellectual property (IP) to external parties (H.W. Chesbrough, 2003; van de Vrande et al., 2009). Under today's challenging economic conditions, successful technological exploitation activities may strongly contribute to sustaining superior performance and competitive advantage by capturing value from a firm's technologies (Arora et al., 2002; Teece, Pisano, & Shuen, 1997). Among others, companies are now licensing out their internal technologies to other firms (Lichtenthaler, 2010b). Lichtenhaler (2010, 2007) highlighted the importance of an integrated approach to strategic technology exploitation planning which will most likely gain further importance in the future alongside with the trends towards open innovation.

Understanding the causal relationships between technological exploitation capabilities and open innovation adoption is a very interesting avenue to deepen and broaden our understanding of open innovation (Vrande, Vanhaverbeke, & Gassmann, 2010).

Therefore, as this study aims to investigate the level of technology exploitation activities that lead to open innovation adoption, the testable statement is develop as follows:

H2: There is relationship between technology exploitation and open innovation adoption.

3.4.3 The Relationship Between Technology Exploration And Trust

Studies that relate technology exploration to trust from the open innovation perspective is still understudy; making it viable to look at evidence from the organizational learning context (Levinthal & March, 1993; Vera & Crossan, 2004), and from the innovation literature (J. H. Lee, Lee, & Lee, 2003). As mentioned earlier, there has been some evidence to relate technological activities with trust (J. N. Lee, Huynh, & Hirschheim, 2008; Thatcher, McKnight, Baker, Arsal, & Roberts, 2011; Ulhøi, Neergaard, & Bjerregaard, 2012).

Therefore, this study propose the following testable statement:

H3: There is relationship between technology exploration and trust.

3.4.4 The Relationship Between Technology Exploitation And Trust

As much as technology exploration, the association between technology exploitation and trust from the open innovation perspective is also still at it's infancy stage. Companies are increasingly collaborating in their technological activities and trust is one of the central aspects in the exchange relationship (Ranjay Gulati, 1995; B Nooteboom, 2013), and collaborative performance (Fawcett et al., 2012; Guo, Zhang, & Thalmann, 2014; C. A. Lee, 2012). A study by Lee (2012), reveals that all respondents advocate the importance of trust in ensuring a sustainable collaborative relationship. The study further argue that trust needs to be build and this is very much true when describing the relationship of trust in the context of open innovation which is highly reliance on the success of collaborative activities throughout the dynamic innovation process.

Although there has been very limited studies relating technology exploitation in context of open innovation and trust relationship, a few studies have attempted to demonstrate the relationship between technological activities and trust (Benner & Tushman, 2003; J. N. Lee et al., 2008; Thatcher et al., 2011; Ulhøi et al., 2012).

When describing the relationship between technology exploitation and trust, it is probably appropriate to first look at the concept of exploitation from the organizational learning perspective (Levinthal & March, 1993; Vera & Crossan, 2004), and from the innovation literature (Lee, Lee, & Lee, 2008). Organizational learning according to Fiol and Lyles (1985), is a process that involves 'improving actions as a result of reflection on new knowledge and understanding'. To *exploit* according to Levinthal and March (1993), means to include activities such as "refinement, choice, production, efficiency, selection, implementation and execution".

The trait-off is said as being short-term, immediate with certain benefits. *Exploitative learning* involves the organization's learning on how best they can use existing knowledge that regards to the organizational experiences (Gebauer, Worch, & Truffer, 2012; N. Kim & Atuahene-Gima, 2010). In the light of innovation literature, *exploitative innovation* is referred to as incremental innovations designs that meet the needs of existing customers or market, offering refined products or services, improved established designs, and increase efficiency of existing distribution channels (Jansen, Van Den Bosch, & Volberda, 2006). In other words, exploitation refers to the tendency of an organization to invest attention and its resources to refine and extend its existing knowledge, skills and processes.

Chiang and Hung (2010), stressed that the different ways of acquiring external knowledge (exploitative or exploratory) will shaped the way organization learn, and found exploitative learning is positively related to incremental innovation performance.

In a study by Nielsen and Gudergan (2012), found that trust is positively related to exploitation fit and *'fit'* in the study, denotes the congruent relationship between organizations and its surrounding, strategy structure or processes. Vrande et al., (2009), listed the strategies of venturing, the licensing of intellectual property (IP) to external parties; and employee involvements (H.W. Chesbrough, 2003; van de Vrande et al., 2009).

Thus, based on these literatures, the testable statement to investigate the relationship of technology exploitation and trust is as follows:

H4: There is relationship between technology exploitation and trust.

3.4.5 The Relationship Between Trust And Open Innovation Adoption

Innovation in any forms or manner is a dynamic process that reflects a continuous, evolving and mastered management (Doroodian et al., 2014). This statement indicates that in order to remain competitive, an effective innovation management must be in place. In doing so, patterns must be drawn theoretically and practically to help understand what is the right measures that needs to be in place to describe the innovation evolution.

Innovation entails uncertainty, and uncertainty is inherent in every level of innovation process (Jalonen, 2011), which makes it an undeniable factor to be ignored. In open innovation where knowledge flows internally and externally and formal and informal collaborative activities become the backbone of the innovation process, a measure of reducing the uncertainties becomes a central attention to organizations and academic researchers.

From the perspective of open innovation studies, there has been a substantial body of evidence from previous research that try to relate trust as an important component to open innovation (Ciesielska & Iskoujina, 2012; Dovey, 2009; Fawcett et al., 2012; Graser & Jansson, 2005; Grudzewski et al., 2008; Lin, 2011; Olkkonen et al., 2000; Ratnasingam, 2013; Westergren & Holmström, 2012).

In a study by Ciesielska and Iskoujina (2012), trust has been proven as an important success factor in open innovation. Similarly, a study by Thatcher et al., (2022), proves trust as having an important role in shaping the behavior towards intention to explore technologically.

Given the above evidences and arguments to support the relationship between trust and open innovation adoption this study proposed the following testable statements:

H5: There is relationship between trust and adoption of open innovation.

3.4.6 The Mediating Of Trust Towards The Relationship Between Technology Exploration And Open Innovation Adoption

Although there have been limited studies to explain the relationship between technological activities and trust, there are still evidence to relate exploitation and exploration activities in innovation process to conflicts, distrust, conformity, which in turn, decrease the innovation (Benner & Tushman, 2003). This study propose that the adoption of open innovation among the SMEs in the triple helix model, can only be implemented (increase or decrease or improve or not) with the existence of technology exploitation and exploration, only when trust could be generated between the SMEs and the triple helix players.

The study by Msanjila and Afsarmanesh (2011), found that trust is crucial to be properly managed to ensure a continuous mediating effect for successful collaboration. In another study by Ciesielska and Iskoujina (2012), trust has been proven as an important success factor in open innovation and similarly, a study by Thatcher et al., (2012), proves trust as having an important role in shaping the behavior towards intention to explore technologically.

Therefore, this study argues that trust mediates the relationship between technology exploration, technology exploitation and adoption of open innovation.

H6: Trust mediates the relationship between technology exploration and adoption of open innovation.

3.4.7 The Mediating Of Trust Towards The Relationship Between Technology Exploitation And Open Innovation Adoption

When discussing the mediating effect of trust to technology exploitation, little evidence is found in past research to understand how trust can mediate the relationship between technology exploitation and open innovation adoption. However, as mentioned, there is still evidence to relate exploitation and exploration activities in innovation process to conflicts, distrust, conformity, which in turn, decrease the innovation (Benner & Tushman, 2003). This study is still relevant to technology exploitation as it propose that the adoption of open innovation among the SMEs in the triple helix model, can only be implemented (increase or decrease or improve or not) with the existence of technology exploitation and exploration, only when trust could be generated between the SMEs and the triple helix players.

Therefore, this study put forward the argument that trust mediates the relationship between technology exploitation and adoption of open innovation.

H7: Trust mediates the relationship between technology exploitation and adoption of open innovation.

3.5 Chapter Conclusion

This chapter puts in place the conceptual research framework of the study. There are four major components depicted in the framework and each of the components was discussed extensively to establish the five direct relationships (between independent variables and dependent variable) and two indirect relationship (between mediating variable and dependent variable). Seven testable statements were developed with regards to the level of open innovation adoption. The following chapter will discuss on the methodology proposed for the study, which will cover the research design, sampling, development of questionnaires, and method of analysis.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This chapter will justify the research methodology of the study and will be explained under four major sections. Section 4.2 states the overview of the research design using the adoption of Rasch measurement techniques and will then be followed by Section 4.3 on the discussion of the samplings procedures, and Section 4.4 that will explain the data collection method. The subsequent section addresses the data collection strategy. The final section will put forward the explanation on the instrument development process.

4.2 Research Design

A unified research project is the one that is able to blend together the important elements of the research purpose, questions, approaches and methods (Thomas, 2009). This study uses a quantitative research methodology approach and uses a descriptive study approach through hypothesis testing of the testable relationships between the variables. This study also adopts Rasch measurement techniques for the data analysis using a software package of Winsteps 3.9.1.

The main objective of this study is to investigate the level of technology exploitation and technology exploration implementation that may influence the level of open innovation adoption among SMEs in Malaysia. This study also attempts to investigate the mediating relationship of trust on technology exploitation and technology exploration and open innovation adoption. In order to ensure that the research targets are met, this study employs several methods such as the probability sampling, discussions with various parties such as SMEs' owner, representatives from the government agencies and research bodies and academicians. An extensive literature review from previous studies was conducted to identify and strengthen the gaps and issues highlighted to ensure the suitability of the study. This is important to guarantee that the study is able to contribute to the desired body of knowledge and justified its findings to fit to the issues discussed theoretically, methodologically and practically.

Hence, this study intends to contribute empirically to the innovation management study in general and open innovation literature in specific. Practically, this study is expected to assist in the understanding of the level of open innovation adoption in Malaysia with the emphasized towards small medium enterprises. As this study chooses to use Rasch analysis techniques, it is expected that the result is able to explain the level of abilities among respondents to achieve the difficulties (items) associated with technology exploitation, technology exploration, trust and the level of open innovation adoption.

In details, two independent variables were chosen. Items are grouped according to their relatedness to the two independent variables. The two independent variables are the technology exploitation and technology exploration. As the study also attempts to investigate the role of trust in the relationship between technology exploration and technology exploitation and the open innovation adoption, trust is chosen as a mediating variable and the study intends to investigate any difference in the level of open innovation adoption with the different level of technology exploitation and technology exploration implementation and the different level of trust.

4.2.1 Time Dimension of Study

This study propose to use a cross sectional design. Cross-sectional studies, just like the longitudinal type of studies, make use of data relating to large numbers of individuals or group. A cross-sectional study is a study that is carried out at one time point or over a short period of time and is usually conducted to estimate the prevalence of the outcome of interest for a given population (K. A. Levin, 2006; Thomas, 2009). The reason for choosing cross sectional design is in line with the majority of innovation studies conducted in the past (Gunday, Ulusoy, Kilic, & Alpkan, 2011; Prajogo & Ahmed, 2006; Saad, 2022; Zainal Abidin, 2013).

4.2.2 Research Design Strategies

Data for this study will be collected via survey method. A survey method was employed because this study strongly believes that survey research is best adapted to obtain population's characteristics, personal and social facts, beliefs, attitudes, opinions or needs (Kerlinger, 1972; Zikmund, Babin, Carr, & Griffin, 2010). Through the techniques, the study will be able to provide both practical and conceptual advantages to perceptual and attitudinal type of research (R. Saad, 2012).

4.2.3 Unit of Analysis

Unit of analysis refers to the major entity analyze by the research (Sekaran, 2011); a type of unit a researcher uses when measuring the variables (Neuman, 2006). The unit of analysis chose for this study is organization. In details, this study focuses on small and medium enterprises (SMEs) in Malaysia. The target respondents will be SMEs involved in triple helix projects, which denote the concept of a relationship between university-industry-government (Etzkowitz & Leydesdorff, 1995). Target respondents will be those who are at managerial level. The reason behind are due to the fact that the managerial group will be needed to answer an in-depth questionnaire and is believed to have the desired knowledge, skills and experience and is responsible for the direct and indirect decision making pertaining to innovation activities of their organization and those involving the collaboration with external parties.

4.3 Sampling Frame and Method

Sampling is the process of selecting the sufficient number of respondents from the population to allow a study of the sample and to understand the properties associated or the characteristics that would make it possible for the study to be generalized (Sekaran, 2011). The target population for this study are SMEs which is currently involve in a triple helix project, where the triple helix project in this context, refers to collaborative projects between the there helices of university-industry-government (Etzkowitz & Leydesdorff, 1995).

The study employs probability sampling where each and every members of the population have equal chance of being included in the sample (Thomas, 2009; Zikmund et al., 2010). Simple random sampling is used as the technique to allow statistical methods to be used to analyze the data. This technique is considered most appropriate as it is said to be fair and unbiased random selection (Zikmund et al., 2010). In particular, one project has been identified. The chosen project is a special initiative organized by the Malaysian government and spearheaded by the Ministry of Education in collaboration with a Malaysian government-linked agency spearheaded by selected research universities together with the other counterparts' such as government agents, industries, solution providers etc. The project is developed to assist local companies to share innovation, knowledge sharing and technological advancements. The aim of this special project is to solve specific issues faced by companies in relation to the application of technology. This special project, which gets an allocation of RM50 million by the Malaysian government, is referred to as an ecosystem, which is triple helix in nature and knowledge-friendly. It is through this special initiative, that knowledge will be produced, assimilate, and distributed to companies wanting to upgrade their technologies and business models.

The population frame were derived from the agency database and a finalized total of 105 SMEs have participated actively in the said project. Following the guideline table by Krejcie and Morgan (1970), the sample size needed to represent the population is 86 companies (Sekaran, 2011).

4.4 Data Collection

Data collection is an important aspect in research. In accurate data collection may impact data analysis and lead to invalid results (Sekaran, 2011). There are several methods of data collection that can be chosen such as self-administered questionnaire, e-mail surveys, face-to-face interview or telephone interviews (Sekaran, 2011; William G Zikmund et al., 2010).

This study makes use of self-administered questionnaire as the main technique for data collection following the benefits highlighted by Sekaran (2011), in which he highlighted a few advantages of opting this method. Firstly, the technique is less expensive, less time-consuming, and requires less human and financial means in compariosn to other methods. Secondly, the platform provide respondents with greater anonyminity which leads to a greater chance of getting a better and accurate information. Questionnaires were sent personally via mail and email to the respondents prior to the interview and it will be distributed together with the cover letter stating the purpose of the data collection. A follow-up will then be made via telephones to set for an appointment date for a face-to-face meet ups. The study will also take advantage over any gatherings set by the triple helix committee as a platform for the face-to-face meetings.

4.5 Development of Instruments

The instruments developed for this study are based from the related literatures based from previous studies. The approach used to build the instruments is as reflected within the conceptual framework developed earlier based on the global perspective of literatures related to the open innovation adoption studies. Items selected are gathered and arranged in questionnaire form of manner. The instruments are divided into four sections as follows:

Section A: Companies' background information.

Section B: Questions with regards to technology exploitation and technology exploration activities in the organization.

Section C: Questions associated to trust existence in light of the relationship with each helix of the triple helix associates (university/government/industry).

Section D: Questions that reflect the perception of respondents on the adoption of open innovation through the innovation process exist in the organization. In order to ensure reliability and validity of the survey, the development process of the questionnaire, the scale-items and the wordings were developed and prepared in accordance to the guidelines proposed by Kaplan and Saccuzzo (2012). Among the guidelines is to avoid vague wordings, double-barreled questions, negative words, jargons and too technical wordings. The questions were structured in a closed-ended manner to ensure that each respondent is able to understand the objectives and aims of the questions (Sekaran, 2011).

The questionnaires are made available in both English and Bahasa Malaysia by taking into account the spectrum of targeted respondents and to avoid misconceptions of the terms used throughout the questionnaire. The survey questions were designed based on previous literatures pertaining to open innovation, technology exploration, technology exploitation and trust. Furthermore, discussions with triple helix associates, which comes from the universities, industries or the government agencies as well as the SMEs themselves, were conducted to ensure the format and structure of the sentences to the questions are appropriate.

4.5.1 Operational Definition of Constructs

Operationalization of definitions for constructs used in a particular context of study is another important step that needs to be taken by researchers. It is to ensure that all parties involved in the research developed a consensus understanding of what the research is all about. This is especially important to the targeted respondents to avoid different views of the area being studied, which can cause conflicting results at the end of the research. Operational definition is also referred as measurement of concept (Bryman & Bell, 2011) which involves selecting an indicator or set of indicators that will represent a concept, definitions, dimensions, facets, properties, elements and measures (Sekaran, 2011; Sekaran & Bougie, 2009) . Operationalization can also be understood as a process of "descending the ladder" and transforming the broad idea to the specific, quantifiable concept (De Vaus, 2002).

Explained below are the operational definitions of all the constructs involved in the light of the study. The concepts are derived based on the literature reviews explained in Chapter 2 and visualized in the conceptual framework in Chapter 3, which involves the dependent variable of open innovation adoption, the mediating variable of trust, and the independent variables of technology exploration and technology exploitation.

The questionnaire developed for this study makes use of a 5-point Likert scale technique where the choice of answers ranges from *very low* to *very high* to obtain answers from respondents. Although empirically, there is no evidence to point on a precise best categorical number that works for all rating scales (Bond & Fox, 2015), the choice of 5-point Likert scale is with the reason that it is a simple and pleasing way of gauging specific opinion from respondents besides a practical and familiar survey format (R. Saad, 2012; Sekaran, 2011). This is also in line with the long established guidelines that an appropriate number of Likert scale categories should lie between seven ± two (between five and nine) (Dawes, 2008; Lissitz & Green, 1975; Malhotra, 2006).

4.5.1.1 Dependent Variable - Open Innovation Adoption

Robertson (1971) refers adoption of innovation as "the acceptance and the continued use of an innovation. Alternatively, Rogers in 1962, sees adoption as "a decision to continue full-scale use of innovation" (Rogers, 1995, 2010). Open innovation, on the other hand, is seen as an alternative model to the traditional innovation (Naqshbandi & Kaur, 2011a), and is highly reliance on inter-organizational collaborative efforts and networks to embody external ideas from various sources or sell internal ideas to outside parties benefiting from it.

This study operationalizes open innovation adoption as the actual implementation of open innovation in an organization. In detail, this study supports the five-steps process (knowledge-persuasion-decision-implementation-confirmation), underlined in the innovation-decision process theory incorporated in the diffusion of innovation theory (DOI) (Rogers, 1995, 2010), which is a major theory that serves as a basis to this study.

In precise, the study focuses on the level of implementation, which occurs when an organization put an innovation into actual use (Rogers, 1995, 2010). In other words, the study intends to investigate the implementation of open innovation though various items (difficulties) to understand how best it can be confirmed and implemented as an innovation strategy that will contribute to the desired innovation performance.

Therefore, open innovation adoption in this study focuses on the actual implementation of open innovation in an organization which will be measured based on the degree of collaboration intensity (V. Lazzarotti et al., 2011). The intensity of collaboration will be will be measured through open innovation performance (Bengtsson et al., 2015; Lakemond et al., 2016; V. Lazzarotti et al., 2011), the IP protections (Hertzfeld et al., 2006; Laursen & Salter, 2014; Manzini & Lazzarotti, 2015; Stefan & Bengtsson, 2016) and the innovation process (Doroodian et al., 2014; V. Lazzarotti, Manzini, & Pellegrini, 2015; West & Bogers, 2013; Zhang & Luo, 2013) with the emphasize on the collaborative effort and the synergy between SMEs and all triple helix parties ranging from the academic and research institutions, the government and the industries.

Based on these scholarly literature reviews, 15 items for measuring open innovation adoption were chosen and is further tabulated in Table 4.1 below. A rating scale of 1 to 5 which represents the attitude and perception from *very low* to *very high* is developed to reflect the ability of organizations towards the items being asked.

Table 4. 1
Measurement of Open Innovation Adoption

No.	Dimensions / Items	Related Source
SATISFACTION		
1.	The extent to which your collaboration with external partners helps your company to reduce innovation risk.	Bengtsson et al., 2015; Lakemond et al., 2016; V. Lazzarotti et al., 2011
2.	The extent to which your collaboration with external partners helps your company to reduce new product/process development cost	
3.	The extent to which your collaboration with external partners helps your company to reduce time to market	
4.	The extent to which your collaboration with external partners helps your company to introduce new or significantly improved process of producing your products and services	
5.	The extent to which your collaboration with external partners helps your company to open new markets	
INNOVATION PROCESS		
6.	To what extent does your company collaborated with external partners in the following innovation phase:	Doroodian et al., 2014; V. Lazzarotti, Manzini, & Pellegrini, 2015; Rahman et al., 2015; West & Bogers, 2013; V. Lazzarotti et al., 2011
	a. The knowledge and technology development process?	
	b. The experimentation process?	
	c. The idea development process?	
	d. The commercialization process?	

No.	Dimensions / Items	Related Source
IP PROTECTION		
7.	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects?	Laursen & Salter, 2014; Manzini & Lazzarotti, 2015; Hertzfeld, Link and Vonortas, 2006; Stefan & Bengtsson, 2016 Miozzo, Desyllas, Lee, & Miles, 2016
	a. Patents	
	b. Designs	
	c. Trademarks	
	d. Copyrights	
	e. Non disclosure agreements and other contractual agreements	
	f. Join development agreements	

4.5.1.2 Independent Variable 1 - Technology Exploration Construct and Dimensions

Technology exploration signifies technological activities that capture and take advantage from external sources of knowledge. In detail, technology exploration enables organization to accumulate new knowledge, ideas and useful technologies from the outside which involves interactions with external actors (Sabine Brunswicker & Vanhaverbeke, 2015; Cosh & Zhang, 2012; Huizingh, 2011; Lichtenthaler, 2009; Rangus & Drnovšek, 2013; van de Vrande et al., 2009).

From the perspective of the current study, technology exploration will be reffered to as the inbound (inside-out) activities between SMEs involved in a particular triple helix projects and the collaborating partners from the 1) universities as a research bodies that assist in R&D activities and technology transfer; 2) government through the triple helix governing bodies or agencies that provides supports in term of financial aid and commercialization channels; and 3) industries that assist in the marketing activities and prospects. Five major dimensions as suggested by Vrande et. al. (2009) will be used, for the reason that the dimensions has been well accepted and used several times in previous studies related to SMEs and open innovation (Sabine Brunswicker & Vanhaverbeke, 2015; Huizingh, 2011; Lichtenthaler, 2009; Rangus & Drnovšek, 2013; van de Vrande et al., 2009).

Therefore, the dimensions and items used for technology exploration in this study will be adopting the study by Vrande et al., (2009). The details of each dimensions are as tabled in Table 4.2 as follows.

Table 4. 2
Dimensions of Technology Exploration

Dimensions	**Definition**
Customer Involvement	Company's engagement with customers in the innovation process, which among others are obtaining important information pertaining product or market, training, product evaluation, product development based on customers suggestion etc.
External Participation	Company's participation with external parties outside the organization through strategic alliances, willingness to invest in desired technology or beneficial knowledge should it be proven valuable.
Outsourcing R&D	Companies willingness to invest in external R&D labs such as universities, agencies or research bodies or purchase creative works of others, informal engagement with researchers or university interns
Inward IP Licensing	Willingness to purchase IPs such as patents, copyrights, trademarks and others from outside the organization should the IPs be proven profitable
External Networking	Company's engagement to invest in external network of business partners that is willing to collaborate and support the innovation process.

(Source: Vrande et al, 2009)

A total of 35 items were selected from various literatures to measure technology exploration and will be further explained according to the dimensions of the construct.

A rating scale of 1 to 5, which represents the attitude and perception from very low to very high, is developed to reflect the ability of organizations towards the items being asked.

i. Customer Involvement

Customer involvement has been one of the important aspects when describing innovation performance. There has been sound evidence from the literatures that tries to explain the strength of customer involvement in innovation process (Arnold, Erner, Möckel, & Schläffer, 2010; Laursen & Salter, 2006; Vaisnore & Petraite, 2011; van de Vrande et al., 2009; Von Hippel, 2005). Vrande et al., (2009), stated that organizations gain benefits from their customers through ideas and innovations by proactive market research. Customers may assist in providing necessary tools to experiment the new developed product in comparison to the existing ones in the market or through ideas to help produce products which is based from the customers' design and needs or even sharing ideas and knowledge by providing evaluation and feedback from the general product development (van de Vrande et al., 2009).

Table 4. 3
Questions Used in Customer Involvement

No.	Questions	Related Source
1.	Extent to which your company obtain important product/market information from our customers rather than internal sources (internal search).	Isobe et al., (2004)
2.	Extent to which your customers are usually involved in the process of new product/service development.	Rangus & Drnovšek, (2013)
3.	Extent to which your company engage with your customers in training sessions (as a trainee).	Kappelman, (1995)
4.	Extent to which your company engage with your customers in training or instructing others (as trainer).	Kappelman, (1995)
5.	Extent to which your company engage with your customers in evaluating your product/services.	Rangus & Drnovšek, (2013)
6.	Extent to which your company usually developed new product/service in light of customer wishes and suggestions.	Rangus & Drnovšek, (2013)
7.	Extent to which your company cooperate with your customers to acquire new knowhow/technology.	Rangus & Drnovšek, (2013)
8.	Extent to which your company engage with your customers in the process of testing new products/services.	Rangus & Drnovšek, (2013)

Therefore, eight items were adopted to reflect the construct of customer involvement based on literatures from Isobe, Makino, and Montgomery (2004); Kappelman (1995); and Rangus and Drnovšek (2013). The details of items or questions are tabulated in Table 4.3 below.

ii. External Participation

External participation, according to Vrande et al., (2009), will enable the recovery of innovations that were initially abandoned or neglected due to disappointing results. Through participation, alliances and joint ventures with external partners and competitors (Inauen & Schenker-Wicki, 2012), organizations will be able to invest in small start-ups and other businesses. This context is especially important to SMEs wanting to shift to a more open platform and compete with larger industry players. External participation has long been a central of interest to both, academic research and industry players. The studies of collaboration with various partners outside the firm has span in multi disciplines.

In the light of open innovation, external participation is listed as one integral activity that contributes to the inflows of ideas and knowledge that increase external technological collaboration Chesbrough (2003).

Other studies (Inauen & Schenker-Wicki, 2012; Soeldner, Roth, Danzinger, & Moeslein, 2013; Van De Vrande, Lemmens, & Vanhaverbeke, 2006; West & Bogers, 2013), to name a few, are evidence of research that tries to relate external participation as one of the important aspects connected to innovation capability and firm performance.

In order to measure the ability of the organization in implementing the items under external participation, the following six items were adopted from Isobe et al., (2004), and Rangus and Drnovšek, (2013). Table 4.4 below shows the detail questions related to this sub-dimension.

Table 4. 4
Questions Used in External Participation

No.	Questions	Related Source
1.	Extent to which your company aggressively participate with external parties through technological alliances.	Rangus & Drnovšek, (2013)
2.	Extent to which your organization is willing to invest in external collaboration should the desired technology are proven valuable.	Rangus & Drnovšek, (2013)
3.	Extent to which your company believe that investing in a new joint venture could result in acquiring new know-how/technology to your company.	Rangus & Drnovšek, (2013)
4.	Extent to which your company believe that the use of know-how/technology from the outside can significantly contribute to the innovation of your company.	Rangus & Drnovšek, (2013)
5.	Extent to which your company believe that it is beneficial to determine systemic and formal ways of searching for external know-how/technology.	Rangus & Drnovšek, (2013)
6.	Extent to which your company believe that the know-how/technology your company have bought can create new opportunities for the company.	Rangus & Drnovšek, (2013)

iii. External Research and Development (R&D)

Networks activities may come in the various forms. One of those that was mention by Chesbrough et al., (2006) which is for organizations to explore activities in external R&D and failing to do so, will cause organization to face severe competitive advantage. This has also been proven true in a lot of other study (Cassiman & Veugelers, 2004; De Marchi, Di Maria, & Micelli, 2013; Lokshin, Belderbos, & Carree, 2008; Mata & Woerter, 2013; van de Vrande et al., 2009).

Gassmann (2006), as quoted in Vrande et. al, (2009), claims that organizations are not able to conduct all R&D activities in isolation as they need to capitalize and expand on their external knowledge, which can comes from the decision to either licensed or bought. Arvanitis, Wörter, Mohnen, and Lokshin (2013), for instance, study the relationship between external knowledge acquisition strategies and the innovation performance and found that there is a positive economies of scale that relates activities in external acquisition of R&D to firms' innovation performance.

This study will tables questions relating to external networking which were adopted from Rangus & Drnovšek (2013), and National Survey of Innovation (MOSTI, 2012). Table 4.5 below shows the details of questionnaires that are comprised of 4 items.

Table 4. 5
Questions Used in External R&D

No.	Questions	Related Source
1.	Extent to which your company acquire new know-how/technology through R&D services provided by knowledge institutions such as universities, faculties, institutes, laboratories, etc.	Rangus & Drnovšek, (2013)
2.	Extent to which your company is willing to purchased creative work of others parties to increase the stock of knowledge and its use to devise new and improved goods, services and processes.	(MOSTI, 2012).
3.	Extent to which your company acquire new know-how/technology through informal ties with researchers from various laboratories.	Rangus & Drnovšek, (2013)
4.	Extent to which your company acquire new know-how/technology through mentoring university interns.	Rangus & Drnovšek, (2013)

iv. Inward Intellectual Property (IP) Licensing

Organizations can also acquire inward intellectual property (IP) licensing, which can come in various forms such as, the license of patents, copyrights or trademarks, in order to leverage from external innovation activities (H.W.

Chesbrough, 2003). This may help accumulate the internal technological knowledge and speed up innovation activities. In order to measure the ability of the organization in implementing the items under this sub-dimension the following questions were adopted from Rangus and Drnovšek, (2013). The Table 4.6 below shows the details of four items related to inward intellectual property (IP) licensing.

Table 4. 6
Questions Used in Used in Inward IP Licensing

No.	Questions	Related Source
1.	Extent to which your company usually buy the intellectual property of other companies to ensure successful development of your company's new products/services.	Rangus & Drnovšek, (2013)
2.	Extent to which your company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	Rangus & Drnovšek, (2013)
3.	Extent to which your company usually buy the intellectual property of other companies to ensure successful development of your company's new products/services.	Rangus & Drnovšek, (2013)
4.	Extent to which your company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	Rangus & Drnovšek, (2013)

v. External Networking

External networking is another dimension closely associated to explain open innovation (Chesbrough et al., 2006; Dittrich & Duysters, 2007; Gay, 2014; S. Lee et al., 2010a). There were many activities, which can be associated with external networking. In the context of open innovation, the activities reflecting external networkings are those involving the activities to acquire, maintain, nurture the connections with external sources or counterparts of social capital, are it individuals, groups or organizations. Gay (2014), confirms that external networks is a major determinants of both SMEs and large organizations' competitiveness.

Due to material and resource scarcity, SMEs can participate actively in external network activities with big industries. Likewise, the study by Rahman and Ramos (2014), mentioned how SMEs have been found the importance of collaboration between SMEs and other organizations in an open innovation model, in order to promote innovation processes to be more adaptable to open innovation with a significant contribution on targeting issues and perspectives in relation to their development, such as product, process and service innovation.

The Table 4.7 below shows the detail of 13 items related to inward IP licensing which was adopted by literatures from (Allied Consultant Europe, (2012), Hung and Lin (2013), Rangus and Drnovšek (2013), and Arnkil (2010).

Table 4. 7
Questions Used in External Networking

No.	Questions	Related Source
1.	To what extent does your company actively engaged as a member of a cluster?	(Allied Consultant Europe, 2012)
2.	To what extent does your company successfully launched and/or implemented collaborative R&D projects within a consortium of partners?	(Allied Consultant Europe, 2012)
3.	To what extent does your company use Internet platforms and virtual networks for posting challenges to get ideas for product/ service development?	(Allied Consultant Europe, 2012)
4.	To what extent does your company has internal structures and processes for managing partnerships and networks?	(Allied Consultant Europe, 2012)
5.	To what extent does your company regularly exchanges business information with salesperson or marketers?	Hung & Lin, (2013)

No.	Questions		Related Source
6.	To what extent does your company collaborate with:		
	a.	Your customers	Rangus and Drnovšek (2013),
	b.	Your suppliers	Rangus and Drnovšek (2013)
	c.	Research community (universities, research centers, technology transfer agencies, etc.)	Rangus and Drnovšek (2013)
	d.	Your competitors	Rangus and Drnovšek (2013)
	e.	Other companies engaged in activities which are different than yours	Rangus and Drnovšek (2013)
	f.	Other companies engaged in high technology industries	Rangus and Drnovšek (2013)
	g.	Creative individuals	Arnkil (2010)
	h.	Government/public authorities	Arnkil (2010)

4.5.1.3 Independent Variable 2 - Technology Exploitation Construct and Dimensions

Technology exploitation is referred as purposive outflows activities of an organization to leverage existing technological capabilities outside the boundaries of organization (van de Vrande et al., 2009). Another view to consider in understanding exploitation is from the definitions given by March (1991) in which he referred to as the process of "refinement, choice, production, efficiency, selection, implementation and execution".

In the context of the study, technology exploitation will be referred to as the outbound activities between SMEs involved in a particular triple helix projects and the collaborating partners from the 1) universities as a research bodies that assist in R&D activities and technology transfer; 2) government through the triple helix governing bodies or agencies that provides supports in term of financial aid and commercialization channels; and 3) industries that assist in the marketing activities and prospects. The activities involved adopt three major categories as suggested by Vrande et. al. (2009) with the intention of enhancing and expanding the existing technological capabilities from within the organization to external boundaries outside the organizations. In details, the activity involves venturing, outward licensing of intellectual property (IP), and the employee involvement (non-R&D workers) throughout the organization innovation process. The definitions of each practice in technology exploitation are tabled in Table 4.8 below.

Table 4. 8
Dimensions of Technology Exploitation Practices

Dimensions	Definition
Venturing	Company's involvement and willingness to acquire/collaborate with new business organizations based on the profitable knowledge and resources the organizations possessed.
Outward Intellectual Property (IP) Licensing	Company's involvement and willingness to take advantage over their own internal developed IPs, by selling it to other firms that might find it as profitable to their organizations.
Employee Involvement	Company's involvement and willingness to leverage its' internal resources by capitalizing on the initiatives and knowledge of current employees, including those who are not employed at the internal R&D department.

(Source: Vrande et al, 2009)

25 items were adopted from various literatures with the intention to measure technology exploitation. The respective dimensions are explained under the sub-dimensions below. A rating scale of 1 to 5, which represents the attitude and perception from very low to very high, is developed to reflect the ability of

organizations in implementing technology exploitation through the items developed.

i. Venturing

Venturing as highlighted in the study of Vrande et al. (2009), is defined as 'starting up new organizations drawing on internal knowledge such as spin-off and spin-out process'. Chesbrough et al., (2006b), has earlier argued that external corporate venturing is a management practice that can help stimulate corporate growth. In detail, corporate venturing allows companies to benefit from early involvement in new technologies or business opportunities. Investments in universities or research bodies, for instance, enable companies to access new emerging technologies or trends available in local and global market.

Further, companies may also benefit from delayed financial commitment as they can take a step-by-step measure to avoid large up-front costs. From the point of SMEs, corporate venturing is often argued as an innovative edge that benefits smaller organizations like SMEs as they can compete with larger organizations taking advantage over their size and nimbleness and responds faster to business environmental changes (Rosenbusch, Brinckmann, & Bausch, 2013). The potentials of venturing to smaller firms was also highlighted by Chesbrough (2003), drawing from a case of 22 successful projects, which turned, into new ventures exceeding their parent company.

Hence, nine items developed under venturing is adopted from previous literatures by Vrande et al., (2009), Zahra (1996), and Rangus and Drnovšek, (2013). The items are as tabulated in Table 4.9 below.

Table 4. 9
Questions Used in Venturing

No.	Questions	Related Source
1.	Extent to which your company has entered many new industries	Zahra (1996)
2.	Extent to which your company has expanded your international operations significantly	Zahra (1996)
3.	Extent to which your company has acquired many companies in very different industries	Zahra (1996)
4.	Extent to which your company has created various new lines of products and services	Zahra (1996)
5.	Extent to which your company has established or sponsored various new ventures	Zahra (1996)
6.	Extent to which your company has focused on improving the performance of your current business rather than entering new industries	Zahra (1996)
7.	Extent to which your company cooperate with external partners when launching your own new products/services on the market.	Rangus & Drnovšek, (2013)
8.	Extent to which your company use external sources of know-how/technology when developing new activities related to the present operation of the company	Rangus & Drnovšek, (2013)
9.	Extent to which your company are willing to cooperate with the partners from the outside when developing new activities related to the present operation of the company	Rangus & Drnovšek, (2013)

ii. Outward Intellectual Property (IP) Licensing

Outward IP licensing was referred by Vrande et al., (2009), as the activity of gaining profit from the selling of their internal IP license to business outside. West and Gallagher, (2006), identify the value that comes together with open innovation is the opportunity of gaining higher returns for innovative innovations and leveraging their IPs externally. The study further posited that through open innovation, knowledge sources are no longer limited to just internal use but rather using creative methods of exploiting organization's IP outside. The outgoing trade however, is not an easy game, and it depends on the appropriateness of the conditions (van de Vrande et al., 2009). Quoting from West (2003), failure to control the conditions may lead to knowledge spillovers that allow competitors to imitate innovations. Therefore, the study suggests a proper IP rights strategies to be in place to govern the issue.

The study therefore adopted five items developed under the external IP licensing from Rangus and Drnovšek, (2013). The item and the related source is displayed in Table 4.10 as shown.

Table 4. 10
Questions Used in Outward IP Licensing

No.	Questions	Related Source
1.	Extent to which your company is willing to sell part of your IP (e.g. patent, trademark).	Rangus & Drnovšek, (2013)
2.	Extent to which your company are prepared to introduce your products/services that have been developed through investing into a new joint venture	Rangus & Drnovšek, (2013)
3.	Extent to which your company believe that selling your IP could harm your company as it would give competitors access to our know-how/technologies.	Rangus & Drnovšek, (2013)
4.	Extent to which your company believe that selling your IP rights through licensing is important for the growth of the company.	Rangus & Drnovšek, (2013)
5.	Extent to which your company believe that the government's efforts for protection of selling IP rights benefited your company.	Rangus & Drnovšek, (2013)

iii. Employee Involvement

Another construct that make up to explain technology exploitation is employee involvement. In order to leverage from the internal knowledge, informal ties with employees, regardless of whatever departments they are from, has been proven important to understand how new products can be better developed and commercialized (H.W. Chesbrough, 2003; van de Vrande et al., 2009). Several other studies have also demonstrated the same view to prove that employee involvement is now on of the important aspects that boost innovation and firm performance (Lichtenthaler, 2012; Reed et al., 2012; Y. Yang & Konrad, 2011).

Due to that, the following items were formulated to measure the construct of employee involvement. Table 4.11 below tabulated the eleven items derived from Gupta and Govindarajan (2000), Rangus and Drnovšek (2013), and the National Survey of Innovation Malaysia (MOSTI, 2012) adopted to measure the employee involvement dimension.

Table 4. 11
Questions Used in Employee Involvement

No.	Questions	Related Source
1.	Extent to which your employees are regularly rotated between different functions in your company.	Gupta & Govindarajan, (2000)
2.	Extent to which there is regular discussion about possibilities for collaboration between units in your company.	Gupta & Govindarajan, (2000)
3.	Extent to which your company coordinates information sharing between units through a knowledge network.	Gupta & Govindarajan, (2000)
4.	Extent to which your company has cross-functional teams to exchange knowledge between departments	Gupta & Govindarajan, (2000)
5.	Extent to which your company has standardized work processes for cooperation between units	Gupta & Govindarajan, (2000)

No.	Questions	Related Source
6.	Extent to which your company has often involve multiple organizational units in strategic decision-making	Gupta & Govindarajan, (2000)
7.	Extent to which your company uses temporary workgroups for collaboration between units on a regular basis	Gupta & Govindarajan, (2000)
8.	To what extent does your company actively encourage communication among unrelated groups of employees in the company.	Rangus & Drnovšek, (2013)
9.	Extent to which your employees are sent for internal or external training which is directly aimed at the development and/or introduction of innovation	(MOSTI, 2012)
10.	To what extent does your company award your employees if they bring external knowhow/technology that improves our products/services.	Rangus & Drnovšek, (2013)
11.	When developing new ideas, to what extent does your company often consider the suggestions of employees who are not part of the research and development team.	Rangus & Drnovšek, (2013)

4.5.1.4 Mediating Variable - Trust Construct and Dimensions

Open innovation depends highly on trust to succeed. In this study, trust is a mediating variable that is theoretically extracted to measure its influence on the relationship between technology exploration and technology exploitation towards open innovation adoption. Trust is defined as the willingness of one party to be vulnerable to the actions of another in return for certain actions (Mayer et al., 1995). These include taking actions that result in positive outcomes as well as appropriate actions that prevent negative outcomes (Anderson & Narus, 1990), to the other party in which the firm has confidence in. Mishra, (1996) further describes that trust refers to the vulnerability of the firm's level of belief that the other party is competent, open, concerned and reliable.

Reflecting from the studies of previous literatures (Adams, Waldherr, Sartori, & Adams, 2008; Bews & Martins, 2002; Dovey, 2009; K. P. Hung & Lin, 2013; Khairul Shazi, 2014; Lewicki & Bunker, 1995, 1996; Ratnasingam, 2013; TÓTH, 2013; Watson, 2005), this study operationalized trust, as the positive experienced of the SMEs derived from their willingness to be vulnerable to the actions of others when dealing with the three triple helix players namely the university, government, and the industry throughout the project with the expectation that their collaborating partners will perform positive actions that will boost their level of open innovation activities.

In other words, it can be understood that, trust in the context of this study is part of the innovation activity which is the willingness of SME (the firm) to be vulnerable to the actions of triple helix helices (the agents the firm interacts with) based on the expectation that the helices (the firm's agents) will perform a particular action important to the SMEs (the firm), irrespective of the ability to monitor or control that other party (Mayer et al., 1995).

Castaldo, Premazzi, & Zerbini (2010), has also defined trust as the expectation that a subject, distinguished by some specific characteristics (e.g. honesty, benevolence, competence), will perform future actions aimed at producing positive results for the trust or in situations of consistent perceived risks and vulnerability. Trust has thus been viewed as (1) a belief, sentiment, or expectation; and as (2) a behavioral intention that reflects reliance on the other party and involves vulnerability and uncertainty on the part of the firm.

There are three dimensions to support trust in the context of this study. Based on the trust positions by the studies of (M. K. O. Lee et al., 2001; Mayer et al., 1995; Schoorman et al., 2007; Zadjabbarp, 2009)(M. K. O. Lee et al., 2001; Mayer et al., 1995; Schoorman et al., 2007; Zadjabbarp, 2009) together with some other studies from previous literatures, which have been discussed in Chapter 2, three dimensions of trust, was constructed, namely the competence trust, credibility trust, and benevolence trust. The choice of the three dimensions are for the reason that it has been widely utilized in various fields since Mayer et al., (1995) (D. Harrison McKnight, 2005; Gefen, 2002; D. Z. Levin, Cross, & Abrams, 2002; Ratnasingam, 2013; Zadjabbarp, 2009).

Each of these dimensions is then supported by three sub-dimensions to further understand the abilities of the respondents to achieve the level of respective trust towards the three helices (university-government-industry) separately. This is crucial to the study because open innovation is a rich process (Henry Chesbrough, 2012a; Henry W Chesbrough & Appleyard, 2007), where knowledge and ideas exchange between various partners happens internally and externally. The study put forward the claim that along with the open innovation process, the levels of trust dimensions varies where collaborating partners who may trust one another in one situation, may not display the same level of trust in other situations. These trust variations, according to Beckett and Jones (2012), stem from various reasons such as the organizational competencies, the nature of the contract put forward, and the level of goodwill a partner expects.

In details, 22 items were constructed to represent the construct of trust as a whole, and are further expanded to measure three scopes (university-government-industry) with the intention to separately measure the trust under the lights of three dimensions towards three respective triple helices. Just as the other constructs involved in the study, the construct of trust too uses a rating scale of 1 to 5, which represents the attitude and perception ranging from *very low* to *very high* to reflect the ability of organizations in implementing trust. Based on the available evidence given, the details of each dimension are discussed as follows.

i. Competence Trust

Competence trust according to Ratnasingam (2013), is the trust to the other partner's capability judged from their knowledge, expertise and everything related to the expectation. This concept is also supported by Ettlinger (2003), who refers to the same type of trust as emotive or capacity trust. In another supporting view, quoting from Mayer et al., (1995), Lui (2009), referrers competence trust as the confidence of one party over the ability of another party to perform its share of workload in an exchange and Lui argues that in the climate where competence trust is high, one party is willing to be vulnerable to other party in risky situations.

This study will refer to trust as the belief that an organization has the ability to do what it says it will do. Five items were adopted from Watson (2005) and Levin, Cross, and Abrams, (2002) to measure competence trust and are further expanded to measure competence trust towards the university/research centers, the government, and the industries respectively, and resulted to 15 items altogether. The list of items according to the respective scopes are tabled in Table 4.12 below.

Table 4. 12
Questions Used in Competence Trust

No.	Items	Related Source
	Research Community (Universities, Research Centers, Technology Transfer Agencies, Etc.)	
1.	Extent to which your company feels confident about the research body's skills.	Levin et al., (2002); Watson, (2005)
2.	Extent to which your company feels that the university has the ability to accomplish what it says it will do	Levin et al., (2002); Watson, (2005)
3.	Extent to which your company believes that the university is known to be successful at the things it tries to do.	Levin et al., (2002); Watson, (2005)
4.	Extent to which your company believes that the university has adequate knowledge in one or several area related to the working project.	Levin et al., (2002); Watson, (2005)
5.	Extent to which your company feels that the university has enough resources to help your company for market expansion	Levin et al., (2002); Watson, (2005)
	Government	
6.	Extent to which your company feels confident about the government and its agencies capabilities.	Levin et al., (2002); Watson, (2005)
7.	Extent to which your company feels that the government and it's agencies have the ability to accomplish what it says it will do	Levin et al., (2002); Watson, (2005)
8.	Extent to which your company believes that the government and its agencies are known to be successful at the things it tries to do.	Levin et al., (2002); Watson, (2005)
9.	Extent to which your company believes that the government and its agencies have adequate knowledge in one or several area related to the working project.	Levin et al., (2002); Watson, (2005)
10.	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	Levin et al., (2002); Watson, (2005)
	Industries	
11.	Extent to which your company feels confident about the organization business capabilities.	Levin et al., (2002); Watson, (2005)
12.	Extent to which your company feels that the organization has the ability to accomplish what it	Levin et al., (2002); Watson, (2005)

No.	Items	Related Source
	says it will do	
13.	Extent to which your company believes that the organization is known to be successful at the things it tries to do.	Levin et al., (2002); Watson, (2005)
14.	Extent to which your company believes that the government and its agencies have adequate knowledge in one or several area related to the working project.	Levin et al., (2002); Watson, (2005)
15.	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	Levin et al., (2002); Watson, (2005)

ii. Credibility Trust

The study of credibility trust has been emphasized in a few literatures. Examples from studies by Scarbrough, Swan, Amaeshi, & Briggs (2013), and Aurifeille & Medlin, (2009), refer credibility trust as a trust based on a positive assessment of the competencies and credibility of the other partner, which counts for their prior experience, skills, professional background, and verification of their credentials by previous ties. Hung and Lin (2013), emphasize credibility as an important facet of trust, which reflects the desired partners as having the required skills and knowledge to fulfill the job reliably and effectively.

This study adopts credibility trust as an engagement reflected towards collaborating partners as having the required skills and knowledge to fulfill the job reliably and effectively. In particular, 8 items were developed by adopting from Hung and Lin (2013), and Adams et al., (2008). The questions are then further spread out under the sub-headings of Credibility Trust to Research

Community; Credibility Trust to Government; and Credibility Trust to Industry and resulted to a total of 24 items in a whole. The details of items are tabulated in Table 4.13.

Table 4. 13
Questions Used in Credibility Trust to Research Community

No.	Questions	Related Source
	Research Community (Universities, Research Centers, Technology Transfer Agencies, Etc.)	
1.	Extent to which your company believes that the research body has been frank in dealing with you.	Hung & Lin, (2013)
2.	Extent to which your company is confident that the research body is knowledgeable about the research they conduct.	Hung & Lin, (2013)
3.	Extent to which your company is confident that the research body is honest about any problems occurs during the project duration.	Hung & Lin, (2013)
4.	Extent to which your company can depend on the research body to be fair throughout the research project.	Adams et al., (2008),
5.	Extent to which your company is confident that the research body is an honorable partner.	Adams et al., (2008),
6.	Extent to which your company is confident that the research body honor their words.	Adams et al., (2008),
7.	Extent to which your company is confident that the research body keep their promises.	Adams et al., (2008),
8.	Extent to which your company is confident that the research body is telling the truth.	Adams et al., (2008),
	Government	
9.	Extent to which your company believes that the government and its agencies have been frank in dealing with you.	Hung & Lin, (2013)
10.	Extent to which your company is confident that the government and its agencies are knowledgeable about their functions.	Hung & Lin, (2013)
11.	Extent to which your company is confident that the government and its agencies are honest about any problems that occurs during the project duration.	Hung & Lin, (2013)
12.	Extent to which your company can depend on the government and it’s agencies to be fair throughout the	Adams et al., (2008),

No.	Questions	Related Source
	research project.	
13.	Extent to which your company is confident that the government and its agencies are honorable partners.	Adams et al., (2008),
14.	Extent to which your company is confident that the government and its agencies honor their words.	Adams et al., (2008),
15.	Extent to which your company is confident that the government and its agencies keep their promises.	Adams et al., (2008),
16.	Extent to which your company is confident that the government and its agencies are telling the truth.	Adams et al., (2008),
	Industries	
17.	Extent to which your company believes that the industrial big players have been frank in dealing with you.	Hung & Lin, (2013)
18.	Extent to which your company is confident that the industrial big players are knowledgeable about their products and market.	Hung & Lin, (2013)
19.	Extent to which your company is confident that the industrial big players are honest about any problems that occurs during the partnering project duration.	Hung & Lin, (2013)
20.	Extents to which your company can depend on the industrial big players are to be fair throughout the research project.	Adams et al., (2008),
21.	Extent to which your company is confident that the industrial big players are honorable partners.	Adams et al., (2008),
22.	Extent to which your company is confident that the industrial big players honor their words.	Adams et al., (2008),
23.	Extent to which your company is confident that the industrial big players keep their promises.	Adams et al., (2008),
24.	Extent to which your company is confident that the industrial big players are telling the truth.	Adams et al., (2008),

iii. Benevolence Trust

This study makes use of the definition provided by Mayer et al., (1995), where benevolence is reflected as the Extent in which one party, is perceived to want to do good, having a vested emotional interest (Khairul Shazi, 2014), and showing care and concerns in helping the other counter parts. Aurifeille & Medlin (2009), point's benevolence trust to a belief that the other party will treat the other party well, even under the risky business conditions.

Benevolence trust is sometimes discussed as goodwill trust (Pavlou & Dimoka, 2006; Ratnasingam, 2013), which is generalized as the firm's effort to seek support from the other partner who are percept as being honest, caring and displays benevolence criteria. A study by Meng (2012), for instance, emphasizes on the lack of goodwill trust among 'project partners' could deteriorate the performance and desired outcome.

This study developed 9 items which were initially adopted from (Adams et al., 2008; K. P. Hung & Lin, 2013; D. Z. Levin et al., 2002) and are then broaden to measure benevolence trust towards the three collaborative partners of triple helix. For that purpose, three sub-headings were created, namely the benevolence trust to research community; benevolence trust to government; and benevolence trust to industry and 27 items are accumulated as a whole.

Table 4. 14
Questions Used in Benevolence Trust

No.	Questions	Related Source
Research Community (Universities, Research Centers, Technology Transfer Agencies, Etc.)		
1.	Extent to which your company feels that the research body cares for you.	Hung & Lin, (2013); Levin et al., 2002)
2.	Extent to which your company feels that the research body has gone out on a limb (risking their reputation) in times of shortages.	Hung & Lin, (2013)
3.	Extent to which your company feels that the research body has been on your side.	Hung & Lin, (2013)

No.	Questions	Related Source
4.	Extent to which your company feels that the research body is like a friend.	Hung & Lin, (2013)
5.	Extent to which your company feels that the research body has your company's best interests in mind.	Adams et al., (2008); Levin et al., (2002)
6.	Extent to which your company feels that the research body is motivated to protect your company.	Adams et al., (2008); Levin et al., (2002)
7.	Extent to which your company feels that the research body work to protect your company.	Adams et al., (2008); Levin et al., (2002)
8.	Extent to which your company feels that the research body watches your company back.	Adams et al., (2008); Levin et al., (2002)
9.	Extent to which your company feels that the research body looks out for your company.	Adams et al., (2008); Levin et al., (2002)
	Government	
10.	Extent to which your company feels that the government and its agencies care for you.	Hung & Lin, (2013); Levin et al., 2002)
11.	Extent to which your company feels that the government and its agencies have gone out on a limb (risking their reputation) in times of shortages.	Hung & Lin, (2013)
12.	Extent to which your company feels that the government and its agencies have been on your side.	Hung & Lin, (2013)
13.	Extent to which your company feels that the government and its agencies are like friends.	Hung & Lin, (2013)
14.	Extent to which your company feels that the government and its agencies have your company's best interests in mind.	Adams et al., (2008); Levin et al., (2002)
15.	Extent to which your company feels that the government and its agencies are motivated to protect your company.	Adams et al., (2008); Levin et al., (2002)
16.	Extent to which your company feels that the government and its agencies work to protect your company.	Adams et al., (2008); Levin et al., (2002)
17.	Extent to which your company feels that the research body watches your company back.	Adams et al., (2008); Levin et al., (2002)
18.	Extent to which your company feels that the government and its agencies look out for your company.	Adams et al., (2008); Levin et al., (2002)
	Industries	

No.	Questions	Related Source
19.	Extent to which your company feels the industrial big players care for you.	Hung & Lin, (2013); Levin et al., (2002)
20.	Extent to which your company feels that the industrial big players have gone out on a limb (risking their reputation) in times of shortages.	Hung & Lin, (2013)
21.	Extent to which your company feels that the industrial big players have been on your side.	Hung & Lin, (2013)
22.	Extent to which your company feels that the industrial big players are like friends.	Hung & Lin, (2013)
23.	Extent to which your company feels that the industrial big players have your company's best interests in mind.	Adams et al., (2008); Levin et al., (2002)
24.	Extent to which your company feels that the industrial big players are motivated to protect your company.	Adams et al., (2008); Levin et al., (2002)
25.	Extent to which your company feels that the industrial big players work to protect your company.	Adams et al., (2008); Levin et al., (2002)
26.	Extent to which your company feels that the industrial big players watch your company back.	Adams et al., (2008); Levin et al., (2002)
27.	Extent to which your company feels that the industrial big players look out for your company.	Adams et al., (2008); Levin et al., (2002)

4.5.2 Analysis of Instruments Validity

The data gathered for this study will be collected and based from the answers given via the survey form. Instruments, collected in this manner are likely to face measurement errors (Kumar, 2011), which will then clout the accuracy of the quality of the findings. Hence, prior to the data collection, the study needs to first ensure that the issue of validity and reliability are underlined (Sekaran, 2011).

There are three major criteria to be used for evaluating a measurement tool. The three are validity, reliability and practicality. Validity is the degree to which an instrument is measuring what it is suppose to measure and reliability is referring to the consistency of the of the results of an assessment test over time (Cooper & Schindler, 2010).

The instruments used in this study, were adopted from related literatures of previous studies, which directly supports the face validity. In the situation where the instruments are lack of measurement scales, some measures will be developed and refined to fit to the concepts it purports to measure. Another instrument validity measure used is the content validity, where in the research methodology concepts refer to the suitability of the questions on the concept it's representing. It is an important measure as it ensures that the measurements used are adequate and represents the concept to be tested (Sekaran, 2011). In doing so, a few academic members and SMEs representative have been approached to get their experts opinion.

This study proposes to adopt the Item Response Theory (IRT), in which, it will make use of the modern test theory (MTT) to analyze the test items. As the study intends to use Rasch measurement model, the instruments reliability and validity will be determined using the methods applicable to Rasch. This is in line with Bond and Fox (2013), where the study mentioned the concept of fit as a 'quality-control mechanism' needs to be ascertained to see whether the assumption of unidimensionality is represented empirically.

Accordingly, the above-mentioned steps is performed to ensure the quality of the instruments used in this study, before the full blown of study is conducted. In classical test theory reliability and validity of measures are derived from

Cronbach-α and factor analysis. Likewise, in Rasch measurement model, the Cronbach alpha measurement is still utilized to test the reliability of items and it produced the reliability measures for person and items.

The separation between person and items is also used to measure the reliability of the instrument. Logits scale is a representative of the individual ability, who responds to the items in different magnitude of difficulty (Bond & Fox, 2013). Unidimensionality is a detection of construct validity in the tests that has been developed. Items should test the constructs, which measure a single dimension only. Local independence will occur when an item has no correlation with another item in the same test. Unidemensionality and local independence are important to measure the internal consistency of the instrument using the principal component of analysis (PCA). Fit statistics is the criteria of mean square (MNSQ) to identify the information-weighted (Infit) and outlier-sensitive (Outfit). The MNSQ values are ranging from zero to infinity with expected value of 1. Items outside the range value of MNSQ are considered misfit, which means the items are erratic while some items are considered overfit, meaning the items are too predictive.

4.5.3 Pilot Study

A pilot study is an important aspect that needs to be conducted to ensure that the research instrument as a whole functions well and is workable in the actual scenario (Bryman & Bell, 2011). The role of pilot study is to allow researcher to refine the questions to suit the respondents' understandings and to ensure no problems will be encountered during the actual data gathering process (Eric, 2006). The study, in particular, used an interview method guided by the questionnaire during the piloting process. This is done with the purpose to validate the content and to improve the questionnaires. This process is deemed important to give the researcher the actual experience and feel of using the developed questionnaire in the actual context.

Sixteen companies were involved in the pilot study. The potential companies was extracted from the list of SMEs involved in one particular university-industry collaboration project. The choice was due to the fact that the companies involved in the pilot study, must be able to have almost the same collaboration experience with the targeted respondents. The companies were contacted upfront to seek for their approval to participate in the pilot study and at the end sixteen companies agreed to be interviewed. The returned rate was 100 % as it was conducted face-to-face. During the interview, the respondents were asked to answer the questionnaire and to point out on any ambiguity or comments on any of the items. This includes the translation of English and Bahasa Malaysia used. At the end, the questionnaire were adjusted and improvised based on the comments gathered during the pilot study.

A summary statistic table were constructed using Rasch measurement technique and the Cronbach Alpha value are tabled as below. From Table 4.15, the range of internal reliability falls between 0.777 to 0.935. Following the suggestion by (Sekaran, 2011), where the threshold value for the Cronbach Alpha value should above 0.7, it can be concluded that the instrument use to measure the constructs is fit to be used in the study.

Table 4. 15
Reliability of Constructs for Pilot Study

Variables	Cronbach's Alpha
Technology Exploration	0.88
Technology Exploitation	0.78
Trust	0.94
Open Innovation Adoption	0.75
All Constructs	0.94

4.5.4 Method of Data Analysis

In order to answer the research questions of this study, several statistical methods will be used to analyze the data collected. Data screening and cleaning will be conducted to check any abnormalities prior to the data analysis. It will then be followed with data analysis using descriptive statistic such as the percentage of firms according to size and number of employees.

However, as this study adopts the Item Respond Theory (IRT) and Rasch Model analysis method, instrument construct will be measured using Rassch to ensure that it is suppose to measure perfectly what it is intend to measure. The concept of unidimensionality, item fit or "quality control mechanism, ability and difficulty of person and items respectively and reliability issues (Bond & Fox, 2013), will also be conducted prior to the data analysis.

Following the reliability and validity analysis through Rasch analsysis techniques, three major analyses will then be performed under the lights of the three perspectives set to answer the research questions and objectives of the study conducted.

Firstly, to meet Perspective I of the study, which intend to look into the relationship between the proposed variables Rasch data were imputed and analyzed using Structural Equation Modeling (SEM) through SmartPLS 3.0 to test the hypotheses developed (H_1 to H_7). An assessment for structural model was also conducted to confirm the causal and correlational links between the variables.

Secondly, to fulfill Perspective II, which is to investigate the success factors and challenges for organizations to achieve the difficulty levels of technology exploration, exploitation, and trust in the light of open innovation, Rasch analysis will be used where, the item measures will be extracted from the variable map and sorted through their placements in logit continuum measurement. The placements will serve as the basis for the grouping of success factors and the challenges.

Finally, in order to achieve Perspective III, which is to profile the organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust, the study will employ Rasch analysis once again. Using the person (organization) and item measures on their logit places in the Rasch continuum (variable map), the organization will be profiled according to the strata value and will then be mapped according to the challenging and success factors each respective groups are able to meet.

4.6 Chapter Conclusion

In conclusion, this chapter explains the research methodology for this research. Firstly, This research is a descriptive study that employs a survey method. Respondents from SMEs were randomly selected to respond to the questionnaires. Rigorous literature review on open innovation and other variables were conducted to provide the basis for the conceptual framework. Four variables with their operational definitions were developed. Seven research objectives and fourteen testable statements have been developed to test the relationship among the listed variables. A random sampling method from the population was used to reflect the potential respondents. Due to the nature of study, which involves a lot of technological jargons, the questionnaires will be distributed directly to selected respondents using face-to-face structured interviews (questionnaires) where it will be handed to the respondents during visits or through any form of one-to-one appointment or during gathering organized by the triple helix committee. A panel of experts review consisting of the academic members and SMEs representative was consulted to validate the content of the instruments. Lastly, a Rasch measurement model will be used to validate the instruments construct and to analysis the data.

CHAPTER 5

DATA ANALYSIS OF RESULTS AND FINDINGS

5.1 Introduction

This chapter outlines the details of the analysis and findings of the study. The chapter comprises several sections. The earlier sections of the chapter will describe on the sample of study (Section 5.2), which includes the descriptions of respondents' background (Section 5.3), and the response rate from the returned questionnaire (Section 5.4). This will then be followed by the non-response bias report in Section 5.5 to confirm no significant difference exist between the early and the late responses. Section 5.6 reports the respondents' profile focusing of the demographic aspects of respondents and the participating organizations. Subsequently, Section 5.7 explains the data cleaning and screening process, the rating scales and instrument validation using Rasch analysis to evaluate the constructions and the quality control of the instrument being used. In precise, using the Rasch analysis techniques, three analysis will be conducted, namely i) the summary statistics of reliability and validity; ii) item misfit analysis; and iii) unidimensionality analysis.

The summary of the data analysis to be presented in this chapter is illustrated in Figure 5.1. Following the validation of the instruments, the study will further explain the findings for the three perspectives constructed, namely perspective I, II and III. Figure 5.2 summarizes the flow of the persepctives findings as mentioned.

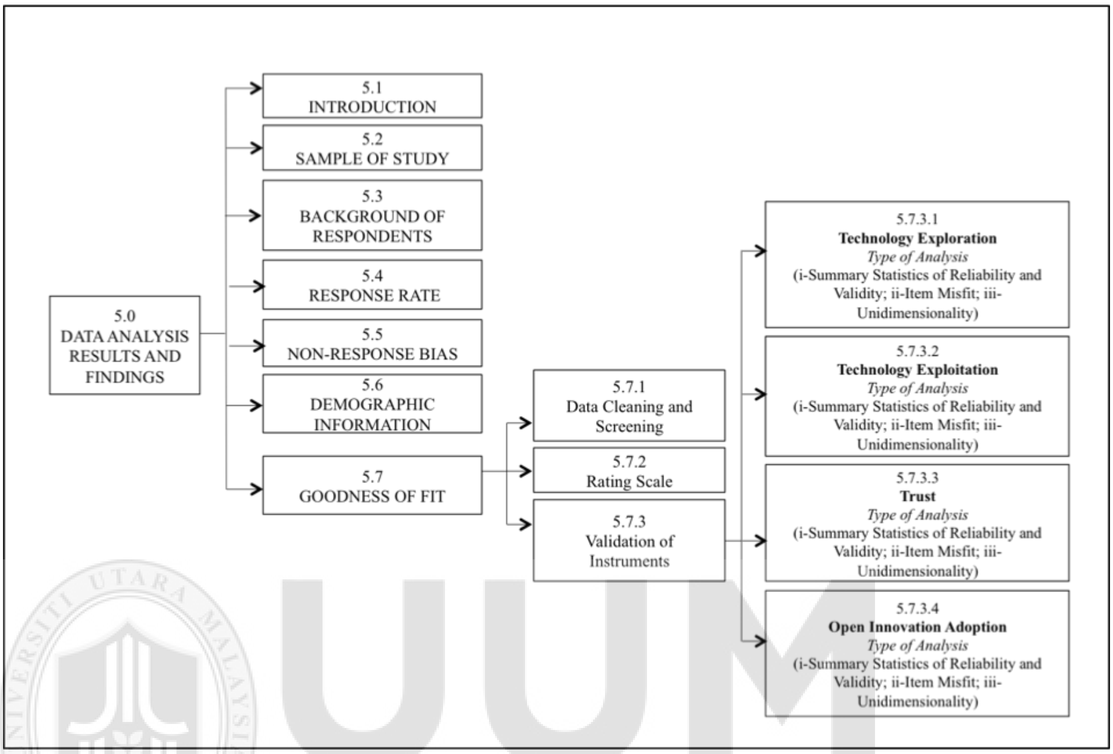

Figure 5. 1
Summary of Data Analysis Results

Section 5.8 will present the data analysis results and findings for Perspective I, where the emphasize will be on the the hypotheses testings through direct and mediating relationships among variables. In section 5.9, the study will focus on perspective II which is to categorize the success factors and challenges for organizations to achieve the difficulty levels of technology exploration, exploitation, and trust in the light of open innovation and triple helix while Section 5.10 will discuss the data anlysis results and findings for perspective III which is to profile the organizations and the potential values of open innovation adoption based on the three constructs of the study. The reporting will includes the categorization analyses of success factors and challenges an followed by the profiling of the organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust.

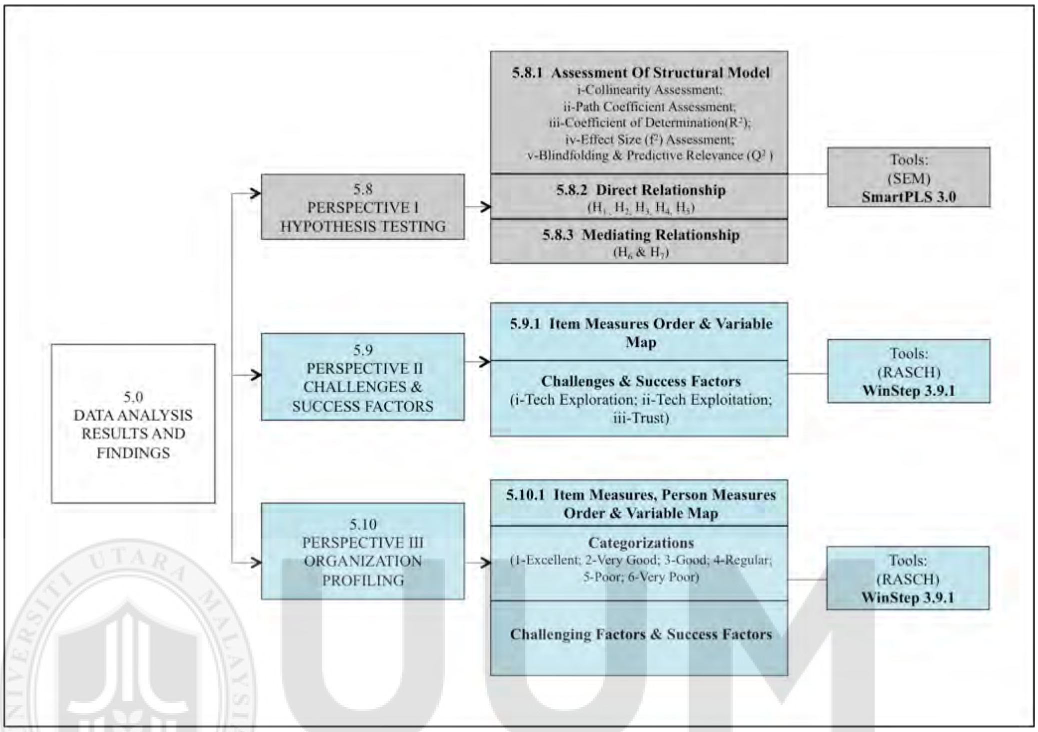

Figure 5. 2
Summary of Findings: Perspective I, II and III

5.2 Sample of Study

The focused populations of the study are the companies involved in the triple helix projects. The sampling frame was randomly derived from the database owned by a malaysian government linked agency. The list consists of companies involved in projects under various grants since the 7th Malaysia Plan. A total of 105 emails were sent out to all the companies and in the end, the number of returned questionnaires is 72 pieces. Out of the 72 returned questionnaires, 1 was omitted due to incomplete. Hence the response rate were

68.58 per cent from the list. This is bound acceptable according to Linacre (2009).

5.3 Background of Respondents

As mentioned, the respondents for this study involves 72 high technology companies which are involves in a commercialization activities of high technology products and are funded by Malaysian government through it's agency via a project which involves the collaborations between the university, government and industries.

To begin with, respondents' data were first tabulated according to demographic information, which describes each and every respondents involved. The pattern for describing the demographic follows the form of '**yyxabcdef'.** The explanation of the form is as shown in 5.1 below:

Table 5. 1
Respondents' Demographic Pattern

Label	Explanation
yy -	Represents the number of respondents involved; the number begins from **'01'**.
x -	Represents the job designation of the respondents which is categorized as follows:

Code	Indicator
1	GM and above
2	Managers OR AM
3	Management Rep OR AM Rep
4	Others

Label	Explanation

a - Refers to the length of business operation, where:

Code	Indicator
1	Less than 5 years
2	5-20 years
3	22-25 years
4	more than 25 years

b - Refers to the number of employees in the organization. The respective codes represents the following:

Code	Indicator
1	Less than 5
2	5 - 30
3	32 - 75
4	76 - 200
5	More than 200

c - Represents the ownership status of the company where the coding indicates the following:

Code	Indicator
M	Malaysian
F	Foreign
C	Combine

d - Refers to the average sales per year for the last 3 years. Indicators are as bellow:

Code	Indicator
1	Between RM200,000 - RM500,000
2	Between RM502,000 - RM2 million
3	Between RM2.2 million - RM 5 million
4	Between RM5.2 million - RM20 million
5	More than RM20 million

e - Represents the average profit per year for the last 3 years.

Code	Indicator
1	Between RM200,000 - RM500,000
2	Between RM502,000 - RM2 million
3	Between RM2.2 million - RM 5 million
4	Between RM5.2 million - RM20 million
5	More than RM20 million

5.4 Response Rate

The data of this study was assembled from 205 high technology companies who were engaged with the technology development programme govern by a government-linked company since the 7th Malaysian Plan. Through their various grants, the projects were aimed to create a group of icons of internationally successful companies which have received funding and other assistance from the Government and to provide support and means to local companies by assisting them to increase capacity, capability and competitiveness via technology enhancements. The programmed which supports the triple helix model, highlights the synergy between the university-industry-government linkage and envisioned a strategic ecosystem for businesses to grow and create unique and commercial value for further market expansion.

From the total 205, a thorough checking was made on the contact numbers and person in charge to confirm the existence of the companies. Prior agreement was also sought to ensure that participation to the research is on volunteer basis. Results then show that out of the total 133, only 105 companies are still active and emails were sent out to the respective email addresses where at the end 72 emails were replied and 1 was dropped out as incomplete reply. Table 5.2 below summarizes the distribution of the questionnaires.

Table 5. 2
Summary of Response Rates

Response	Frequency / Rate
Distributed questionnaires	105
Returned questionnaires	72
Usable questionnaires	71
Uncompleted questionnaires	1
Response rate	68.58%
Usable response rate	67.62%

5.5 Non Response Bias

A non-response bias is considered one of the fundamental aspects as it assures accuracy in the statistics results of the research conducted. It refers to the situation where significant difference exists between respondents who attended to the questionnaires distributed and those who did not. Citing from Amstrong and Everton (1977) who emphasized on the importance to obtain a similarity pattern between the persons who responded and from those who do not to allow the researcher to generalize the respondents as being true to represent the population.

Comparing differences between the early and the late respondents conducted the non-response bias test; where the late respondents serve as the ‘proxy’ for non-respondents (Noor Liza, 2014). In line with it, two distinct groups of respondents were identified; the first being those who responded before December 2015; and the second group are those who responded after December 2015. In other words, the later group of respondents (after December 2015) will be reflecting a sample of non-respondents and will be treated as the representative of the non-respondents group. An independent sample t-test using SPSS was conducted to compare the mean scores between the two groups identified.

Table 5.3 displays the group statistics comparison of means, standard deviation, and standard error mean between all the variables involved and as shown in Table 5.4, there are no significant differences between the group whose answers collected before December 2015 and after December 2015. This can be seen from the p-values of all variables involved are above 0.05 and ranged between 0.151 to 0.968. Hence, it can be concluded that non-response bias would not be an issue as the samples gathered are able to represent the total population identified and be used to generalize this study.

Table 5. 3
Group Statistics of Independent Samples t-test

	GROUPS	N	Mean	Std. Deviation	Std. Error Mean
TEXPLORE	Early Response	21	114.81	26.214	5.720
	Late Response	50	115.56	27.699	3.917
TEXPLOIT	Early Response	21	80.48	15.022	3.278
	Late Response	50	81.94	15.164	2.144
TRUST	Early Response	21	212.33	43.662	9.528
	Late Response	50	218.06	44.938	6.355
OIA	Early Response	21	51.19	9.315	2.033
	Late Response	50	52.16	11.608	1.642

Table 5. 4
Independent Samples T-Test Results for Non Response Bias

		Levine's Test for Equality of Variances		t-test for Equality of Means		
		F	**Sig.**	**t**	**do**	**Sig. (2-tailed)**
TEXPLORE	Equal variances assumed	0.028	0.867	-.106	69	.916
	Equal variances not assumed			-.108	39.601	.914
TEXPLOIT	Equal variances assumed	0.002	0.968	-.372	69	.711
	Equal variances not assumed			-.374	37.945	.711
TRUST	Equal variances assumed	0.306	0.582	-.494	69	.623
	Equal variances not assumed			-.500	38.634	.620
OIA	Equal variances assumed	2.113	0.151	-.339	69	.736
	Equal variances not assumed			-.371	46.522	.712

5.6 Demographic Information

5.6.1 Respondents' Demographic Information

This section highlights the information of respondents involved in the study. It presents information related to respondents' job profile, which among others includes the job designation, the number of years in the designated position and the number of years with the company.

5.6.1.1 Respondents' Job Designation

The results of Table 5.5 shows that from the total number of respondents involve, 37 (51.4%) are represented by the General Managers and above. 29.2% of the respondents are either Managers or Assistant Managers while management representatives or assistant managers representatives represent the other 19.4%.

Table 5. 5
Respondents' Job Designation

Job Designation	Frequency	Percentage (%)
General Managers or above	37	51.4
Managers or Assistant Managers	21	29.2
Management Representatives or Assistant Managers Representatives	14	19.4
Total	**72**	**100**

5.6.1.2 Years in Designated Position

As for years in the designated position held by respondents involved, 47.2% of respondents (34) were those with less than 5 years holding the current position, and 37.5% (27) were those who are in their designated position between 5 to 20 years. 12.5% are in longer tenure between 11 to 25 years in current position and those with more than 15 years in the current position is represented by 2.8%. The details are as displayed in Table 5.6.

Table 5. 6
Respondents' Years in Designated Position

Years in Designated Position	Frequency	Percentage (%)
Less than 5 years	34	47.2
5-20 years	27	37.5
22-25 years	9	22.5
More than 25 years	2	2.8
Total	**72**	**100**

5.6.1.3 Years Working with the Company

The study also takes into account the years of working experience each respondents had in the current company represented. As displayed in Table 5.7

below, most respondents (31) involved are those with 5 to 10 years with the company (43.1%). A group of 26 respondents have less than 5 years of experience with the company (36.1%). 15.3% have been with the industry for around 11 to 15 years and the rest have more than 15 years of experience with the company represented.

Table 5. 7
Respondents' Years Working With The Current Company

Years in Designated Position	Frequency	Percentage (%)
Less than 5 years	26	36.1
5-20 years	31	43.1
11-15 years	11	15.3
More than 15 years	4	5.6
Total	**72**	**100**

5.6.2 Organization Demographic Profiles

This section identifies the organizational demographic of the respondents. Among the highlights are respondents' job designation, years of organizations' business operation, number of employees, company's ownership, sectors, average sales and profits.

5.6.2.1 Years of Business Operation

The organizations involved are also being classified by their years of business operation. From the Table 5.8, it can be understood that 26.4% of the organizations involved have been in existence for more than 15 years, while 25% are companies of 11 to 15 years of age. Most of the organizations participated in this research are of 5 to 10 years of existence and that counts for around 32% from the total respondents. The small percentage of 16.7% is companies that have been in presence for less than 5 years.

Table 5. 8
Years of Business Operation

Years of Business Operation	Frequency	Percentage (%)
Less than 5 years	18	25.0
5-10 years	24	33.3
11-15 years	12	16.7
More than 15 years	18	25.0
Total	**72**	**100**

5.6.2.2 Number of Employees

In terms of number of employees, as reflected in Table 5.9, majority of companies involved in this study, with around 38% are companies with 5 to 30 employees, and 30.6% of companies are with the minimum of 31 and the maximum of 75 employees. Almost 15% of the companies have less than 5 workers, and a small number of around 8.3% has more than 76 workers and the other 8.3% remaining of the companies have more than 200 employees.

Table 5. 9
Number of Employees

Number of Employees	Frequency	Percentage (%)
Less than 5	11	15.3
5 - 30	27	37.5
32 - 75	22	30.6
76 - 200	6	8.3
More than 200	6	8.3
Total	**72**	**100**

5.6.2.3 Company's Average Sales

In term of company's average sales per-year for the last 3 years, it is an interesting fact to note that almost 43% of respondents report average sales figure between RM1.1 million to RM5 million. The second largest group (26.4%) are companies with average sales between RM100,000 to RM500,000, followed by 13.9% of companies involved are those with average sales between RM501,000 to RM1 million. It is also notable that 9.7% companies declared their sales of between RM5.1 million to RM10 million; while companies with the average sales of more than 10 million are represented by around 7% from the total companies involved.

Table 5. 10
Company's Average Sales

Average Sales	Frequency	Percentage (%)
Between RM100,000 - RM500,000	23	31.9
Between RM501,000 – RM1 million	7	9.7
Between RM1.1 million - RM5 million	26	36.1
Between RM5.1 million – RM10 million	7	9.7
More than RM10 million	9	12.5
Total	**72**	**100**

5.6.2.4 Company's Average Profits

Aside from the average sales, the company's average profit was also part of the demographic concern raised to the companies involved. As shown in Table 5.11, close to 54.2% declared their yearly average profit for the past 3 years as being around RM100,000 to RM500,000. 15.3% represented companies with average per-year profit between RM501,000 to RM1 million, and 23.6% are those with the average profit of between RM1.1 million to RM 5 million. Five companies in particular are the ones with a higher profit; four companies (5.6%) being more than RM5.1 million and one company declared an average profit per-year of more than RM10 million.

Table 5. 11
Company's Average Profit

Average Profit	Frequency	Percentage (%)
Between RM100,000 - RM500,000	39	54.2
Between RM501,000 – RM1 million	11	15.3
Between RM1.1 million - RM5 million	17	23.6
Between RM5.1 million – RM10 million	4	5.6
More than RM10 million	1	2.4
Total	**72**	**100**

5.7 Goodness of Fit

As mentioned, the validity of the measurements scales used in this study will be measured using Rasch analysis. This is in accordance to the Rasch measurement framework following the IRT which stands from the point that the data must fit to a particular model with a specific qualities (Andrich, 1978). To do so, each scale is measured to confirm the internal consistency using the Polychromous Rasch Model (PRM). Prior to the analysis, the data cleaning and screening will first be conducted to ensure that the data are free from any errors in coding, missing data or/and input errors.

5.7.1 Data Cleaning and Screening

Table 5.12 below is derived from the Winstep application; one of the tool used in Rasch analysis. The table below tabulated the frequency of respondents answers based on the category labels from the likert scales used in the instrument. The total responses derived from the total observed counts are 10,224 with a total of 142 items and 72 respondents. No missing data was reported. The category scores also reported the exact scales used in the instruments indicating that there were no data entry errors in the data collection. The table is further illustrated in the Figure 5.3.

Table 5. 12
Frequency of Responses

Category Label	Category Scores	Observed Counts	Percentage (%)
1	1	731	7
2	2	1103	11
3	3	2411	24
4	4	4014	39
5	5	1965	19
Missing		0	0

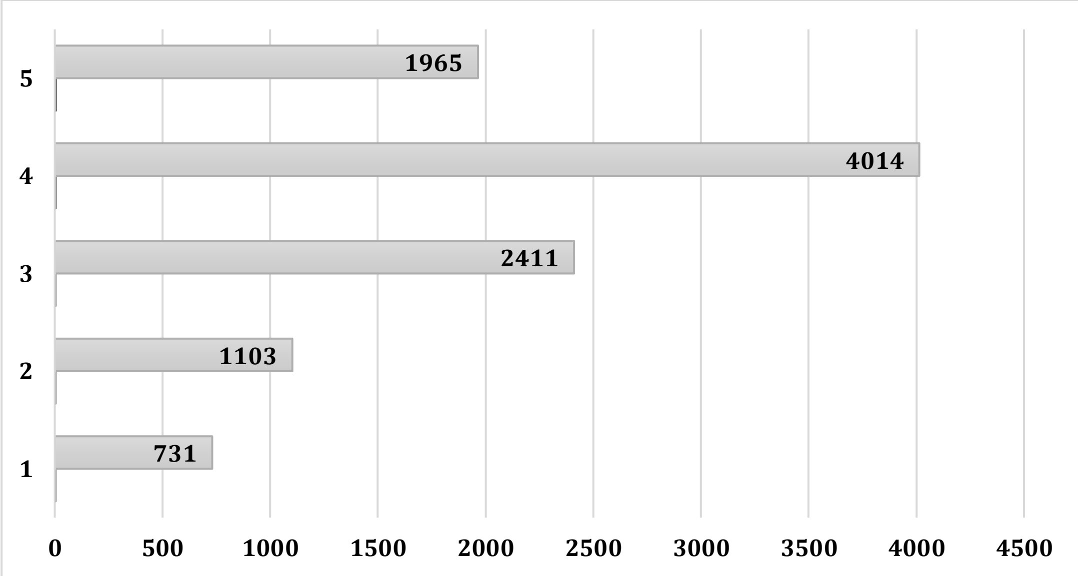

Figure 5. 3
Frequency of Responses

5.7.2 Rating Scale

As mentioned, the study makes use of Likert scales rating where respondents rate their perceptions on the items listed in the questionnaire. This Rensis Likert's method, as understood, interprets each scale as having an equal range over the full range of the scales used. This assumption justifies for the scale to be treated as an interval rather than ordinal item scoring (Linacre, 1994). Another assumption of Likert scaling is the assumption that "the trace lines (ICCs) of all items of the questionnaire coincide approximately and implies that there is no attention paid to item `strengths' [difficulties]". However, Rasch model does not substantiate with this argument due to the fact that not all items measured in polychromous data contributes to an equal latent trait; and human (respondents) responses are liable to variances. A Rasch scale is claimed to be a psychometrical interval scale, which means that the items and respondents are statistically measured and scaled on the same continuum. Every items measured holds its own particular Rasch estimates of item difficulty, and all items share a common threshold to all items (Bond & Fox, 2015).

Table 5. 13
Rating Scales

Category number	**1**	**2**	**3**	**4**	**5**
Category label	Very low	Low	Moderate	High	Very high

The rating scales for this study in particular, are based on rankings from 1 to 5 reflecting approval and disapproval to statements in the instrument used. The ranks are listed in the Table 5.13 and the appropriateness of the scales must be first measured prior to further analysis. The study makes use of suggestions from Linacre (2002); in line with Andrich (1978b); which suggest the simplest representation to assess category functioning is to statistically examine using category frequencies and average measures for each response option. Other than these, the rating scales characteristics also include the thresholds, or structure calibration; and category fit statistics (Wright & Master, 1982). The structure calibration should increase by at least 1.40 *logit*; but not more that 5.00 *logit* to avoid large gaps in the construct (Linacre, 1999). To further understand, a probability curve of the scales involved was develop in the form of graphical representation to inspect the distinction between the threshold. Linacre (1999) highlighted that each category must be able to show a distinct peak in the probability curve graph or else, further investigation needs to be done if the probability curve appear to be 'flat' (Bond et al, 2007). This study adopts both approach and therefore, the graphical and the statistical methods will be presented. Table 5.14 and Figure 5.4 depict the results of the category rating scale.

Table 5. 14
Diagnostics Rating Scales

Category label	Observed Count	Average Measure	Infit Mean Square	Outfit Mean Square	Structure Calibration
1	731	-1.19	1.12	1.11	None
2	1103	-0.39	0.93	0.87	-1.21
3	2411	+0.31	0.97	0.94	-0.78
4	4014	+0.89	1.06	1.05	0.12
5	1965	+1.44	1.03	1.01	1.87

```
P      -+-------+-------+-------+-------+-------+-------+-------+-
R  1.0 +                                                         +
O      |                                                         |
B      |                                                        5|
A      |1                                                    555 |
B   .8 + 11                                               555    +
I      |   11                                            55      |
L      |     1                                         55        |
I      |      11                                      5          |
T   .6 +        1                                  55            +
Y      |         1                      4444      5              |
    .5 +          11                 444    444 55               +
O      |            1              44          *4                |
F   .4 +             1      3333334           5  444             +
       |          2222*222*3    4433        55      4            |
R      |       222     133 22  4    333    5         444         |
E      |     22       331    **        3355             44       |
S   .2 +  222        3   11 4  22      5533               44     +
P      |22        333     4*1    22  55    33               4444 |
O      |        33      44   11    **        333                4|
N      |  333333   44444      5****  22222      333333           |
S   .0 +***********55555555555     1111111***********************+
E      -+-------+-------+-------+-------+-------+-------+-------+-
       -3      -2      -1       0       1       2       3       4
        Person [MINUS] Item MEASURE
```

Figure 5. 4
Category Probabilities: Modes-Structure Measures at Intersections

With reference to Figure 5.4, it can be seen that almost all categories have distinct peaks and there is no category that exist under the other category. This graph is supported by the results shown in Table 5.14. The Outfit Mean square results for all categories is less than 2.0; which fits to the suggestion as proposed by Linacre (1999). Additionally, Table 5.14 also shows that the calibration structure reported is between 1.21 *logit* to 1.87 *logit*; which again adhere to Linacre's (1999) suggestion that the calibration structure should increase by at least 1.40 *logit* and not more than 5.0 *logit*, and should increase monotonically. Therefore, the rating scale chased for this study will be retained as 1 to 5 representing the range of agreeableness from 'very low' to 'very high'.

5.7.3 Validation of Instruments

Prior to further data interpreting analysis, it is important to confirm on how the data fits to the Rasch model. Hence, the validity and reliability testing must be performed to isolate the misfit items used in the instrument and allow only the viable and reasonable items. In Rasch analysis, the fit statistics analysis is used to ensure the fitness of the construct and item validity (Azrilah et al, 2008). The importance of how data must fit to the model in Rasch measurement was also emphasized by Bond et al (2007); and the concept of fit must work mutually with the concept of unidimensionality. The concept of unidimensionality in Rasch, refers to the idea of a single latent trait being able to represents the performance of items forming the instruments (Brentari & Golia, 2007). It is therefore important for the data to fit to the model so as to ensure invariant measurement within the model's unidimensional framework (Bond et al. 2007).

Fit statistics, as mentioned, are reported in two dimensions of chi-square ratios, namely the infit and the outfit mean square statistics. Bond et al (2007) explained that the two results are used to report discrepancies between the Rasch model prescriptions and the empirical data.

In order for data to fit to the Rasch model, a few criteria's must be met (Azrilah, 2010; Bond & Fox, 2015; W.P. Jr Fisher, 2007; J. Linacre, 2012). The three criteria to be met are listed in Table 5.15 below. It is important to note that various literatures suggest various standards when identifying the outliers. When evaluating the point measure correlation (Pitmen Corr), each value must carry positive index to ensure that all items used, works towards a parallel set of constructs (Bond & Fox, 2015). The acceptance level is set between 0.4 *logit* to 0.8 *logit*. As for outfit mean square (MNSQ), it is important to first understand that Rasch reports both the infit and the outfit statistics for fit indices. 'Infit' refers to "inlier-sensitive or information-weighted fit" (J. Linacre, 2012) which is said to be sensitive to the pattern of responses for items targeted on the person. On the contrary, 'outfit' refers to "outlier-sensitive fit", which is more sensitive to responses to items with difficulty far from a person (J. Linacre, 2012). Linacre (2012), suggested that, when measuring fit statistics for person or items, the 'outfit' fit statistics (in particular the outfit MNSQ), should be used instead of 'infit', for the reason that the outfit statistic is more prudent to outliers. This according to Linacre is important as it helps to assist and rectify fit issues. MNSQ is a representation of a chi-square calculation for fit statistics, which measures the level of association (J. Linacre, 2012) and the acceptable range should be between 0.5 *logit* to 1.5 *logit.* The calculation on MNSQ should construct an average that is near to 2.0 and therefore, any readings within the range of 0.5 to 1.5 *logit* will approve the fact that the data is fit to the model and is therefore productive for measurement. The interpretation of MNSQ fit statistics is as shown in Table 5.15 below.

Table 5. 15
Interpretation of MNSQ Fit Statistic Values

Mean-square Value	Implication for Measurement
> 2.0	Distorts or degrades the measurement system. May be caused by only one or two observations.
1.5 - 1.0	Unproductive for construction of measurement, but not degrading.
0.5 - 1.5	Productive for measurement.
< 0.5	Less productive for measurement, but not degrading. May produce misleadingly high reliability and separation coefficients.

Source: (J. Linacre, 2012)

The outfit Z-Standardized (Zests), on the other hand, reports the probability of the mean-square statistics which occur by chance when the data fits to the model (J. Linacre, 2012). The accepted range for outfit ZStd is set to be between ±2.0 *logit* ; which reflects a 95 per cent confidence interval, or, 5 per cent significant level (Azrilah, 2010). Thus, items located outside the range as listed in Table 5.16, are considered outliers and need to be separated for further investigation and modification (J. Linacre, 2012).

Table 5. 16
Quality Control for Rasch Fit Data

Criteria's	Acceptance Level
1. 'Point measure correlation' (PtMea Corr)	0.4 to 0.8
2. Outfit 'Mean Square' (MNSQ)	0.5 to 1.5
3. Outfit 'Z- Standard' (ZStd)	-2.0 to +2.0

Source: (Azrilah, 2010)

The study employed 142 items in total to measure 4 constructs. The discussion of misfit items will be done separately according to each construct. Using Winsteps application (version 3.91.0) as the tool, a table known as Item Measured Table will be obtained to show the measurement details for each item being evaluated. Another important point to understand, is the way mean and standard deviation (SD) value is represented in Rasch model.

Cronbach alpha (KR-20) kid raw scores "test" reliability is the conventional "test" reliability index. It reports an approximate test reliability based on the raw scores of this sample. It is only reported for complete data. Cronbach Alpha is an estimate of the person-sample reliability (person-score-order reproducibility). Classical Test Theory does not usually compute an estimate of the item reliability (item-value-order reproducibility), but it could. Winsteps reports both person-sample reliability (person-measure-order reproducibility) and item reliability (item-measure-order-reproducibility).

5.7.3.1 Technology Exploration

i. Summary Statistics of Reliability and Validity

Technology exploration is build using a 35 items construct. The five dimensions involved were customer involvement, external participation, external research and development (R&D), inward IP licensing, and external networking. A total of 2,450 data points were generated from 71 organizations. As mentioned earlier, the number of data points shows that the data is in sufficient range to prove its relevance to provide the a stable person and item measures. From the summary statistics table, 1 respondent was reported to score a minimum extreme value, which accounted to 1.4 percent from the total number of respondents. Therefore, this particular respondent (organization) will be omitted from the analysis of this particular construct.

The Cronbach alpha (KR-20) for the instrument used to measure technology exploration was at 0.96. This signifies a very good internal consistency reliability of items used to measure a single latent trait (Fisher, 2007) and a good indicator to measure technology exploration activities needed to ensure open innovation adoption.

Table 5.17 below displays the details of fit statistics analysis for technology exploration measurement for 70 (non-extreme) organization. This is to ensure that the data collected fits to the Rasch model.

Table 5. 17
Summary Fit Statistics for Technology Exploration –Before Item Deletion

	Item (I = 35)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	1.00	-0.10	0.67	1.00	-0.20
SD	0.66	0.30	1.60	0.94	0.51	2.00
Maximum	1.56	2.33	5.90	2.14	2.59	5.00
Minimum	-1.01	0.39	-4.70	-2.66	0.25	-4.40
Reliability Indices						
Separation		4.03			3.82	
Reliability		0.94			0.94	
Stud Error		0.11			0.11	
Cronbach Alpha (KR-20)				0.96		

The organization (person) reliability reported a value of 0.94 *logit* with 0.11-logit value of standard error (SE). The value suggest that the instrument used had an excellent ability range with sufficient rating length scale with adequate numbers of categories per items and acceptable target respondents (W. P. J. Fisher, 2007).

The organization fit statistics analysis on the mean value for both the outfit Mean Square (MNSQ) and Z-Score (ZSTD) displays the value of 1.00 *logit* and -0.20 *logit* respectively; which are very close to the expected value of 1 and 0. The score unveils that the 35 items chosen to measure technology exploration are indeed focusing the exact type of respondents. It is also imperative to note that the scores points out to the fact that the produced data is at the reasonable prediction level of responses to the items. In addition, the overall organization mean measure is at 0.67 *logit* supporting the indicator that the majority of the organizations find difficulty in endorsing the items in technology exploration instrument. The maximum value for organization ability is at 2.14 *logit* and the minimum measure is at -2.66 *logit*, which adds up to a total of 4.80 *logit* length scale.

Additionally, as displayed in Table 5.17 above, the mean values for the items was at 1.00 for outfit $MNSQ_{item}$ and -0.10 for outfit $ZStd_{item}$. The values, which are very close to the expectation of 0 and 1, implies that the instrument used in the research context has aim the right type of respondents to measure the latent trait.

However, from the summary fit statistics above, the readings for outfit $MNSQ_{item}$ ranges from the minimum value of 0.39 to 2.33 *logit* and the $ZStd_{item}$ lies between -4.70 to 5.90 *logit* indicating there are outliers among the items being measured under the construct of technology exploration. This is in accordance to the quality control criteria for rash fit data. Therefore, a further investigation on outfit MNSQ and ZStd value is needed to identify the item misfits.

ii. Item Misfit Analysis

In order to identify the outlier items for the construct of technology exploration, an item measures table is produced. Table 5.18 below provides the details of the item measure readings. Following the quality control criteria for Rasch fit data (Azrilah 2011), it can be clearly identified that a total of two items fall in the category of major misfit and one item is in the range of minor misfit. The outliers are graphically presented in the GCC Graph in Figure 5.5.

Table 5. 18
Technology Exploration – Item Measures

Item	Measure	Outfit		Pt. Mea Corr	Remarks
		MNSQ	ZSTD		
B11	-0.22	1.01	0.10	0.57	Normal
B12	-0.09	0.95	-0.20	0.63	Normal
B13	0.46	1.49	**2.60**	0.58	Minor Misfit
B14	1.20	1.06	0.40	0.55	Normal
B15	-0.44	1.02	0.20	0.66	Normal
B16	-0.06	0.97	-0.10	0.59	Normal
B17	0.22	0.93	-0.40	0.63	Normal
B18	-0.64	0.75	-1.50	0.73	Normal
B21	-0.41	0.99	0.00	0.70	Normal

Item	Measure	Outfit		Pt. Mea Corr	Remarks
		MNSQ	ZSTD		
B22	-0.78	0.87	-0.70	0.76	Normal
B23	-0.73	0.79	-1.30	0.74	Normal
B24	-1.01	0.84	-0.90	0.74	Normal
B25	-0.57	0.71	-1.80	0.76	Normal
B26	-0.98	0.82	-1.10	0.75	Normal
B31	-0.27	1.14	0.90	0.67	Normal
B32	-0.06	1.14	0.90	0.61	Normal
B33	-0.20	0.98	0.00	0.68	Normal
B34	0.80	1.14	0.90	0.56	Normal
B41	1.15	0.93	-0.40	0.54	Normal
B42	0.34	1.10	0.60	0.64	Normal
B43	0.05	1.11	0.70	0.63	Normal
B44	-0.20	0.87	-0.70	0.69	Normal
B51	-0.20	0.76	-1.50	0.74	Normal
B52	0.52	**0.39**	**-4.70**	0.77	Major Misfit
B53	0.46	1.29	1.70	0.53	Normal
B54	0.65	0.81	-1.10	0.60	Normal
B55	-0.09	0.95	-0.20	0.64	Normal
B56	-0.67	0.80	-1.10	0.71	Normal
B57	-0.20	1.05	0.30	0.53	Normal
B58	-0.37	1.07	0.50	0.69	Normal
B59	1.56	0.76	-1.40	0.51	Normal
B510	0.84	0.97	-0.10	0.49	Normal
B511	-0.22	1.13	0.80	0.75	Normal
B512	1.09	**2.33**	**5.90**	**0.20**	Major Misfit
B513	-0.92	1.13	0.80	0.75	Normal

Total Item Removed = 3

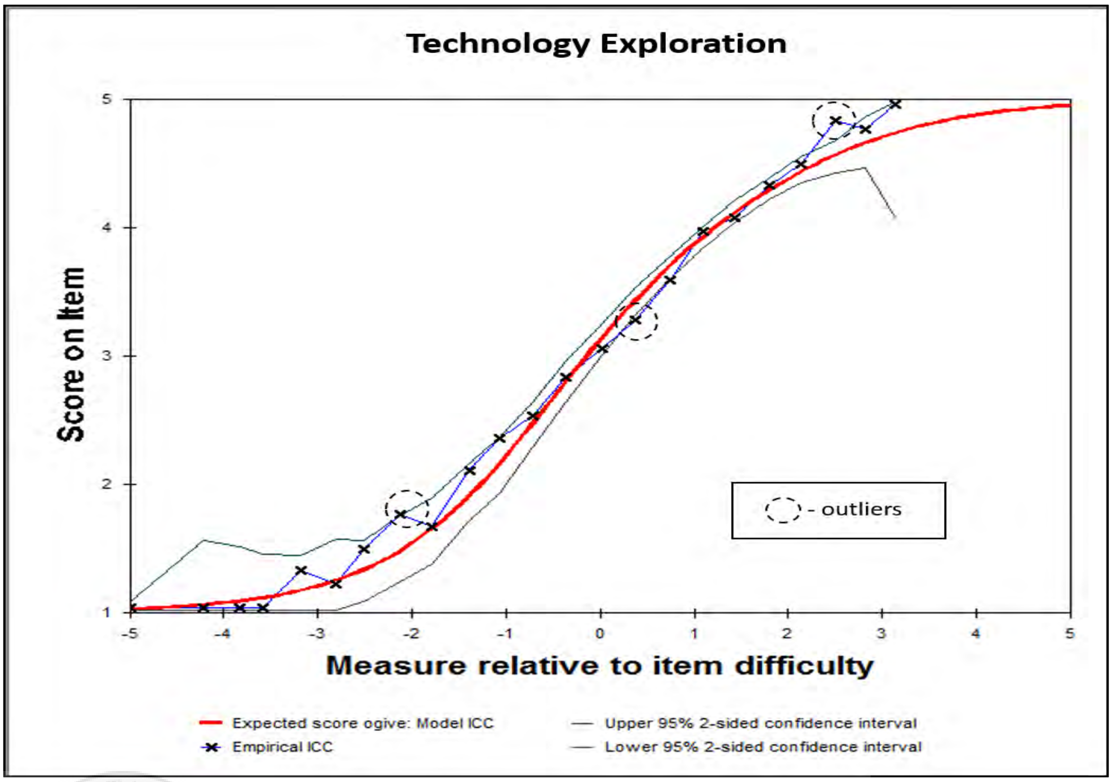

Figure 5. 5
GCC Graph for Technology Exploration- Before Item Deletion

All three items were removed for further investigation and a total of 32 items are then considered valid to represent technology exploration. The renewed version of summary statistics are produced and the new improvised readings are displayed in Table 5.19 below. Likewise, Figure 5.6 further portrays the improvised GCC graph for technology exploration after the misfit items deletion.

Table 5. 19
Summary Fit Statistics for Technology Exploration –After Item Deletion

	Item (I = 32)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	0.99	0.00	0.77	0.99	-0.20
SD	0.66	0.16	0.90	0.99	0.51	1.90
Maximum	1.69	1.32	1.80	2.29	2.69	4.90

	Item (*I = 32*)			*Person* (*N=70*)		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Minimum	-0.97	0.69	-2.00	-2.83	0.26	-4.20
Reliability Indices						
Separation		4.02			3.86	
Reliability		0.94			0.94	
Stud Error		0.12			0.12	
Cronbach Alpha (KR-20)				0.95		

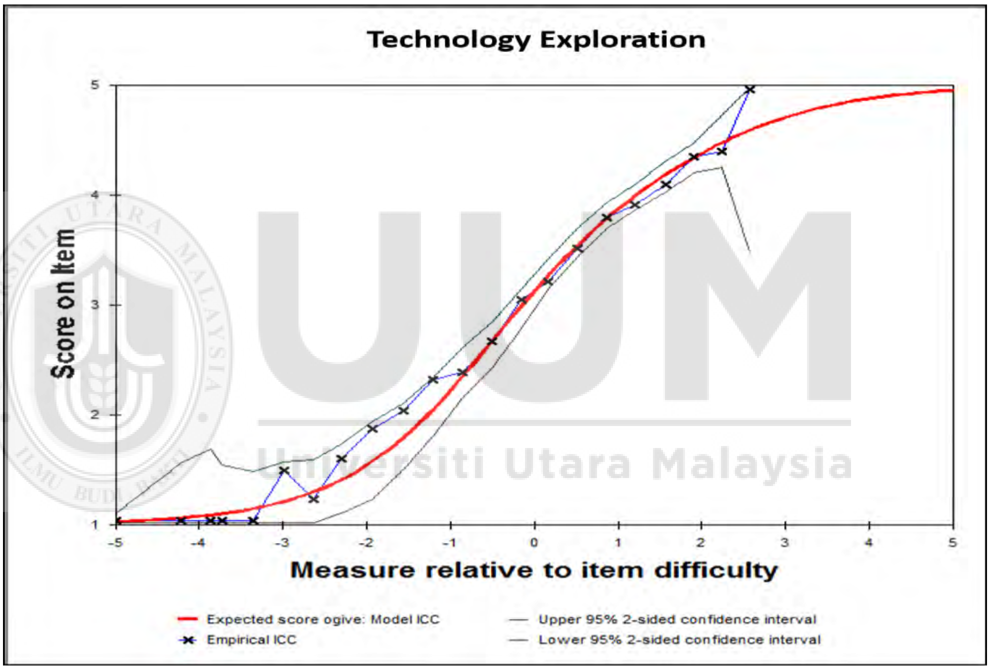

Figure 5. 6
GCC Graph for Technology Exploration After Item Deletion

As shown by the summary statistic table shown in Table 5.19 above, the Cronbach alpha (KR-20) for the instrument is now at 0.95 *logit* and is still in the range to be considered as having a very good internal consistency reliability of items used to measure a single latent trait (Fisher, 2007) .

It can be noted that the value for outfit $MNSQ_{item}$ are now range between 0.69 to 1.32 *logit*, which is within the acceptable range of 0.50 to 2.80 *logit*

(W.P. Jr Fisher, 2007); and the outfit $ZStd_{item}$ readings are now between -2.00 to 1.80 *logit* which depicts the acceptable range of -2.0 to 2.0 *logit* value (Azrilah, 2010; W.P. Jr Fisher, 2007).

To calculate how the persons are spread adequately across the item and trait continuum, it is important to measure the strata value. The number of strata (H) is formulated using the equation as shown below. The value of person separation index (G), which equals to 3.86 was computed into the strata formula (shown below), and has yielded five distinct strata. The five distinct strata suggest that the organizations were spread adequately into five groups across the persons on the trait continuum, and this value according to Fisher (2007), is a very good person strata separation readings. The formula to obtain the number of strata is as follows:

$$\boxed{H = (4G + 2)/3}$$

iii. Unidimensionality Analysis

Table 5.20 below is derived from the standardized residual variance table which depicts the strength of unidimensionality of the instruments, in which the items used must be related to the same construct (Bond & Fox, 2015).

Table 5. 20
Standardized Residual Variance In Eigenvalue Units – Technology Exploration

			Empirical(%)		Modeled (%)
Total raw variance in observations	=	63.82	100.00		100.00
Raw variance explained by measures	=	31.82	49.90		50.80
Raw variance explained by persons	=	15.40	24.10		24.60
Raw Variance explained by items	=	16.41	25.70		26.20
Raw unexplained variance (total)	=	32.00	50.10	100.00	49.20
Unexplained variance in 1st contrast	=	6.13	9.60	19.20	

The observed percentage of raw variance explained by measures is 49.90 per cent and is adjacent to the percentage of raw variance expected by model, which is at 50.80 per cent; and this value unveils a strong measurement dimension following the suggestion by Conrad et al., (2009). Only 9.60 percent of the unexplained variance in 1st contrast is displayed, is considered as good following suggestion from Fisher (2007). Thus, it is imperative to consider that the 32 item used in the instrument to measure technology exploration are related to the latent variable and measures in the same direction (Bond & Fox, 2015).

5.7.3.2 Technology Exploitation

i. Summary Statistics of Reliability and Validity

The construct of technology exploitation that makes use of 25 items yielded a total of 1,750 data points from a number of 71 respondents. The items were distributed under three dimensions, namely venturing, outward IP licensing and employees involvement. The data points suggested that the data provided a sufficient range to remain useful and stable as person measures estimates and so as to obtain useful and stable item calibrations. As Rasch analysis measured both person and item reliability, it can be well understood that the person reliability is referring to the organizations (respondents) being measured. The summary statistics table reported 1 respondent with minimum extreme score. This is a representation of 1.4 per cent of the total respondents measured. A minimum extreme scores refer to respondents answering all minimum ‘1’ answers to all items. Rasch make use of non extreme person estimates to measure the calibration. Thus, the extreme respondent reported (1 person) is omitted in the count of Rasch measurements.

The Cronbach’s alpha (KR-20) value is 0.90, indicating a good internal consistency reliability of items in the scale of measuring a single latent trait or construct (W.P. Jr Fisher, 2007). In other words, respondents are responding consistently to the items being used. The overall data-fit test was also performed to ensure that the data fits to the Rasch model prior to the item fit analysis; which will then confirm the data location on the logit continuum scale. The placement on the measurement scale is crucial as it will indicate whether the data showed suitable overall fit to the Rasch model. Table 5.21 below presents the descriptive summary on the overall findings for persons and items of technology exploitation.

Table 5. 21
Summary Fit Statistics for Technology Exploitation – Before Deletion

	Item (i = 25)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	1.00	-0.10	0.42	1.01	-0.10
SD	0.58	0.33	1.80	0.60	0.47	1.60
Maximum Measure	1.12	2.34	6.60	1.52	2.57	4.00
Minimum Measure	-1.23	0.60	-3.00	-2.01	0.31	-3.40
Reliability Indices						
Separation	3.14			2.24		
Reliability	0.94			0.83		
Stud Error	0.12			0.07		
Cronbach Alpha (KR-20)				0.90		

Table 5.21 shows the summary fit statistics of 70 organizations (non-extreme) being measured. The organization (person) reliability (β) is 0.83 *logit* and the standard error (SE) is at 0.07 *logit*. This indicates that the 25 items used to measure technology exploitation provided a good range of difficulties in measuring the organizations' ability (W.P. Jr Fisher, 2007). The person fit statistics investigation on outfit Mean Square (MNSQ) and Z-Score (ZStd) shows that the value for outfit $MNSQ_{person}$ was 1.00 *logit* and the $ZStd_{person}$ was -0.10 *logit*; which are very near to the expected value of 1 and 0. The person mean β_{person} is equal to 0.42 *logit* indicating that the majority of the organizations find difficulty in endorsing the items in technology exploitation instrument. The maximum value for organization ability is at 1.52 *logit* and the minimum measure is at -2.01 *logit* with a total of 3.53 *logit* length scale.

As for the items analysis, Table 5.21 reports the reading of item reliability (μ) as 0.94 *logit* with 0.12 *logit* standard error (SE) suggesting that the instrument used has a very good fit rating scale criteria quality that fits to the model (Fisher, 2007). The item reliability explains the replicability of the items that should occurs should these set of items are to be given to another sample of respondents of the same size (Bond & Fox, 2015). The item mean, on the other hand, is set at the value of $\mu_{item} = 0.00$ *logit* to ensure that each organization has an equal chance of success in responding to the item that matches their ability. The mean value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ are 1.00 *logit* and -0.10 *logit* respectively, which exhibits that the value are very close to the expectation value of 0 and 1. This serve as an indicator that most of the items used in the construct of technology exploitation has indeed targeted the organization distribution. Further fit statistics investigation of an outfit Mean-Square (MNSQ) and outfit Z-Score (ZStd) for items being measured is needed to identify the outliers by unexpected behavior from the organization when answering the items. An important point to be noted from Table 5.21 above are that the maximum value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ for items lies between -3.00 *logit* to 6.60 *logit*, which points out items sitting outside the range.

ii. Item Misfit Analysis

Figure 5.7 from the Item Characteristics Curves (ICC) graph highlights on the items that do not fit to the criteria's as highlighted. It also indicates that further investigation needs to be performed to identify misfit items used in the technology exploitation construct.

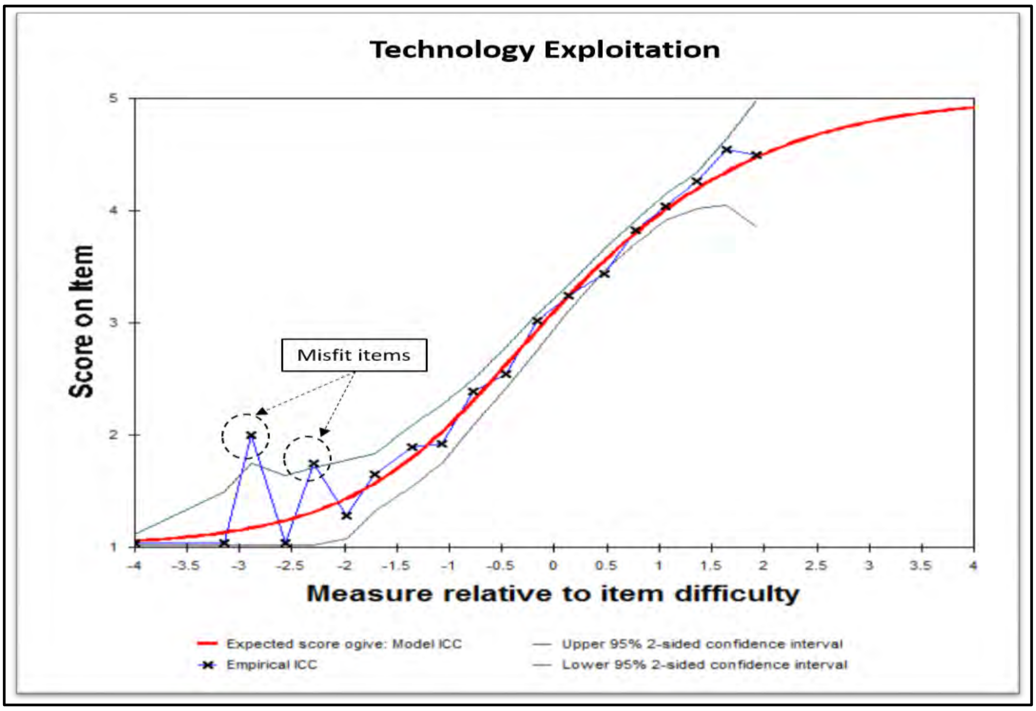

Figure 5. 7
GCC Graph for Technology Exploitation

Table 5.22 below lists all 25 items used in measuring the construct of Technology Exploitation. The item measures, and the three 'quality control' readings which are the Point Measure Correlation (PTMEA CORR) and the outfit $MNSQ_{item}$ and $Zstd_{item}$ were tabled for further analysis. After the analysis, a total of five items were removed for further investigation. This is in accordance to the suggestions made by (Green & Frantom, 2002). Details of the items removed are as listed in Table 5.22 below.

Table 5. 22
Technology Exploitation – Item Measures

Item	Measure	Outfit		PTMEA	Remarks
		MNSQ	ZStd	CORR	
A11	0.49	1.33	**2.00**	**0.33**	Minor Misfit
A12	1.12	1.22	1.40	**0.30**	Minor Misfit
A13	0.98	0.98	-0.10	0.44	Normal
A14	0.33	0.83	-1.10	0.45	Normal
A15	1.12	0.60	**-3.00**	0.56	Minor Misfit
A16	-0.56	1.13	0.70	0.57	Normal
A17	-0.60	1.15	0.90	0.60	Normal
A18	-0.69	0.93	-0.30	0.63	Normal
A19	-1.23	0.98	0.00	0.67	Normal
A21	0.36	1.00	0.10	0.52	Normal
A22	-0.42	0.75	-1.50	0.66	Normal
A23	0.84	2.34	**6.60**	0.00	Minor Misfit
A24	-0.26	1.13	0.80	0.53	Normal
A25	-0.34	0.86	-0.80	0.54	Normal
A31	0.19	0.79	-1.30	0.50	Normal
A32	-0.34	0.69	-1.90	0.57	Normal
A33	-0.19	0.67	**-2.10**	0.59	Minor Misfit
A34	0.04	1.23	1.40	0.44	Normal
A35	0.17	1.01	0.10	0.40	Normal
A36	0.02	0.98	-0.10	0.51	Normal
A37	0.19	0.81	-1.20	0.47	Normal
A38	-0.48	1.08	0.50	0.63	Normal
A39	-0.30	0.91	-0.50	0.65	Normal
A310	-0.12	0.77	-1.40	0.59	Normal
A311	-0.34	0.77	-1.40	0.61	Normal
Total Item Removed = 5					

Table 5.23 below is the summary statistic description for technology exploitation after the items removal process. It can be noted that the outfit $MNSQ_{item}$ now lies between 0.70 *logit* to 1.38 *logit*, which has improved from

the previous readings. The same improvements can also be seen in the outfit $ZSTD_{item}$ readings where the indicators for minimum and maximum readings now reads -1.90 to 1.90 *logit,* which fit into the specified 'quality control' readings (Azrilah, 2011) . The GCC Graph in Figure 5.8 below illustrates the improved version of the items' outliers, where the group of items measuring the construct of technology exploitation is now within the 95 confidence interval. The Cronbach's alpha (KR-20) value is still at 0.90 *logit* and is still a good internal consistency reliability of items in the scale of a single latent trait or construct (Fisher, 2007).

The person fit statistics investigation on outfit Mean Square (MNSQ) and Z-Score (ZStd) shows that the value for outfit $MNSQ_{person}$ was 1.00 *logit* and the $ZStd_{person}$ was -0.10 *logit*; which are very near to the expected value of 1 and 0. This depicts that the current 20 items used are indeed targeting the right type of respondents in measuring the latent traits in technology exploitation. The results also point out that the produced data is at the reasonable prediction level of responses to the items. The person mean β_{person} = 0.42 *logit* reveals that the majority of the organizations find difficulty in endorsing the items in technology exploitation instrument. The maximum value for organization ability is at 2.05 *logit* and the minimum measure is at -2.22 *logit* with a total of 4.27 *logit* length scale.

Table 5. 23
Summary Fit Statistics for Technology Exploitation –After Item Deletion

	Item (i = 20)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	1.00	-0.00	0.64	1.00	-0.20
SD	0.50	0.27	2.00	0.73	0.53	2.50
Maximum Measure	2.25	1.38	1.90	2.05	2.82	4.00
Minimum Measure	-2.24	0.70	-1.90	-2.22	0.34	-2.70
Reliability Indices						
Separation		3.14			2.26	
Reliability		0.91			0.84	
Std Error		0.11			0.09	
Cronbach Alpha (KR-20)				0.90		

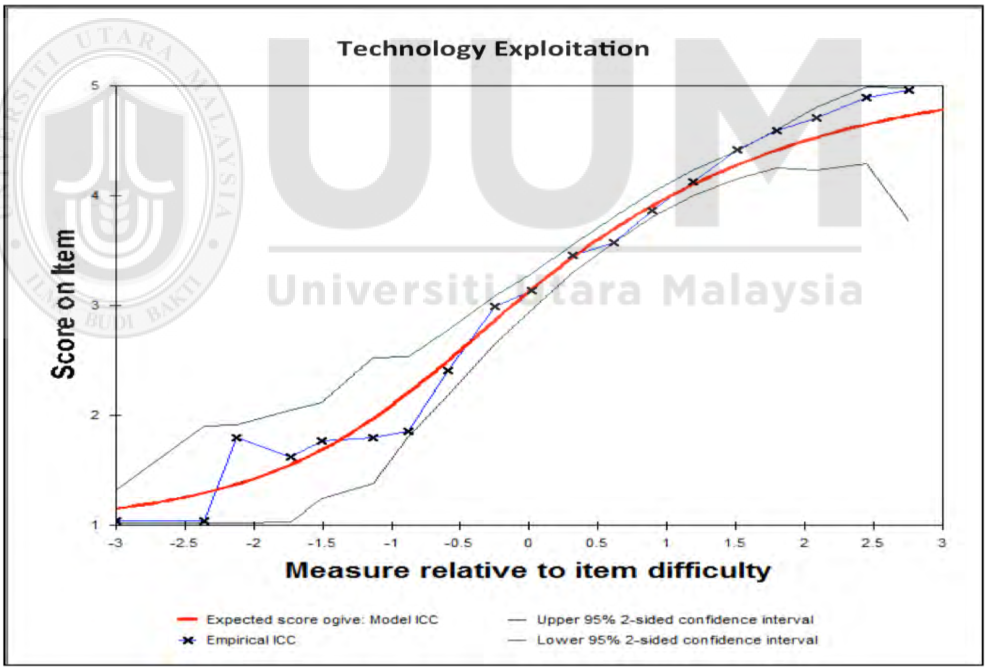

Figure 5. 8
GCC Graph for Technology Exploitation After Items Deletion

The next step is to calculate the strata value to further understand how organizations are spread adequately across the person and trait continuum. The number of strata (H) is formulated using the equation of H=(4G+2)/3, where the value of person separation index (G) is at 2.26 was computed into the strata formula (shown below), and resulted to a value of 3.25. The number reflected a good quality for person strata value. Additionally, the figure suggests that the organizations were spread adequately into five groups across the items on the trait continuum, and this value according to Fisher (2007), is a very good person strata separation readings.

iii. Unidimensionality Analysis

The principal concern of factor analysis is the resolution of a set of items linearly in terms of a small number of categories or 'factors'. This resolution can be accomplished by the analysis of the correlations among the items (Harman, 1961).

Table 5. 24
Standardized Residual Variance In Eigenvalue Units - Technology Exploitation

			Empirical(%)		Modeled (%)
Total raw variance in observations	=	31.94	100.00		100.00
Raw variance explained by measures	=	11.94	37.40		38.50
Raw variance explained by persons	=	4.62	14.50		14.90
Raw Variance explained by items	=	7.32	22.90		23.60
Raw unexplained variance (total)	=	20.00	62.60	100.0	61.50
Unexplained variance in 1st contrast	=	4.40	13.80	22.00	

Table 5.24 depicts the strength of unidimensionality of the instruments where the items used must be related to the same construct (Bond & Fox, 2015). The reported raw variance explained by measures is 37.40 which is close to the value of variance expected by model, which is at 38.50 per cent; and this value is considered as a moderate measurement dimension following the suggestion by

Conrad et al., (2009). The unexplained variance in 1st contrast is at 13.80 per cent, which explains that 13.80 per cent of the variance supports unidimensionality and is considered as a ‘fair’ instrument to measure the construct of technology exploitation (Fisher, 2007). Therefore, it can be explained that the items measuring the construct of technology exploitation within the organization are indeed measuring the same composite of abilities (Bond & Fox, 2015).

5.7.3.3 Trust

i. Summary Statistics of Reliability and Validity

The instrument to measure trust in the study was constructed using 66 items adopted from various past studies. In particular, the study focuses exclusively on three dimensions, adopted from Hung & Lin, (2013); Adams et al., (2008); Watson, (2005); Brattström, Löfsten & Richtnér (2012). The dimensions are competence, credibility and benevolence trust. Evidence from the global statistics table derived from the Winsteps application of Rasch revealed that the construct of trust generated a total of 4,686 active data points from a total of 71 respondents. The number of data points is congruent to the fact that the data were large enough to remain useful and stable for the organization measure estimates and to obtain a practical item calibrations.

Table 5. 25
Summary Fit Statistics for Trust

	Item (i = 66)			Person (N=70)		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	0.98	-0.20	0.92	0.98	-0.70
SD	0.45	0.19	1.20	1.30	0.62	3.50
Maximum Measure	0.76	1.53	2.80	3.50	3.38	8.70
Minimum Measure	-1.26	0.59	-2.80	-2.07	0.09	-9.00
Reliability Indices						
Separation		2.43			6.73	
Reliability		0.85			0.98	
Std Error		0.06			0.16	
Cronbach Alpha (KR-20)				0.98		

The Cronbach's alpha (KR-20) value is 0.98, indicating an excellent internal consistency reliability of items in the scale of measuring a single latent trait or construct (Fisher, 2007). This implies that the items measuring the construct will deliver consistent scores as respondents are responding consistently to the items being used. Additionally, prior to the item fit analysis, the overall data-fit test was performed to ensure the placement of the data on the measurement scale. This is crucial as it will confirm whether the data collected by the target respondents are suitable and overall fit to the Rasch model.

Table 5.25 above shows the summary fit statistics of 71 organizations involved. The organization (person) reliability (β) is at 0.98 *logit* and the standard error (SE) is 0.16 *logit*, where both values denote an excellent criterion (Fisher, 2007). Thus, the 66 items used in the construct of trust provided a good range of difficulties in measuring the organizations' ability towards the various levels of difficulties (Fisher, 2007). The person outfit Mean Square (MNSQ) and Z-Score (ZStd) shows that the value for outfit $MNSQ_{person}$ is at 0.98 *logit* and the $ZStd_{person}$ is at -0.70 *logit*; which are near to the expected value of 1 and 0. These results allude that the 66 items used are directed towards the right type of respondents to measure the latent trait for the construct of trust. Additionally, the numbers reveal that the data gathered is at a reasonable prediction level of responses to the items. Another important fact to consider is the value of person mean measure, which shows +0.92 *logit* with the standard deviation (SD) of 1.30 *logit.* This is an important indicator that points to the fact that there is a greater spread of person measures in comparison to the item measures (Bond & Fox, 2015). Based on the person measure's result, it can also be understood that the organizations involved in this particular study, find the items in the construct, easy to endorsed (Bond & Fox, 2015).

As for the items analysis, the summary statistic table above, reports the reading of item reliability (μ) as 0.85 *logit* with 0.06 *logit* standard error (SE), which depicts that the instrument used has a very good fit rating scale criteria quality that fits to the model (Fisher, 2007). As mentioned, the item reliability explains the replicability of the items that should occurs should these set of items are to be given to another sample of respondents of the same size (Bond & Fox, 2015). Meanwhile, the item mean (μ_{item}) has always been predefine set at 0.00 *logit* to ensure that each person (organization) has an equal chance of success in responding to the item that matches their ability. The mean value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ are respectively at 0.98 *logit* and -0.20 *logit* respectively, which exhibits that the value are very close to the expectation value of 0 and 1. The fact that the values are near to the 1 and 0 expectation is important as it becomes an important indicator that the items developed to represent the construct of trust has indeed targeted the organization distribution.

ii. Item Misfit Analysis

Further fit statistics investigation of an outfit Mean-Square (MNSQ) and outfit Z-Score (ZStd) for items being measured is needed to identify the outliers by unexpected behavior from the organization when answering the items. The reported maximum value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ for items lies between -2.80 *logit* to 2.80 *logit*, indicating that there are misfit items. In order to identify the item outliers, the quality control criteria suggested by Azrilah (2011) is being used as a guideline. The result signifies that there are six items classified as minor misfit or outliers. The list of the misfit items is listed in Table 5.26 and is illustrated graphically in Figure 5.9 below.

The item measures, and the three 'quality control' readings which are the Point Measure Correlation (PTMEA CORR) and the outfit $MNSQ_{item}$ and $Zstd_{item}$ were tabled for further analysis. After the analysis, a total of six items were removed for further analysis. This is in accordance to the suggestions made by (Green & Frantom, 2002). Details of the items removed are as listed in Table 5.26.

Table 5. 26

Trust – Item Measures

Item	Measure	Outfit		PTMEA	Remarks
		MNSQ	ZStd	CORR	
D1U1	-0.17	1.08	0.50	0.72	Normal
D1U2	-0.11	1.25	1.50	0.67	Normal
D1U3	0.10	1.17	1.00	0.63	Normal
D1U4	-0.72	0.93	-0.40	0.71	Normal
D1U5	0.20	1.21	1.20	0.62	Normal
D1G1	0.25	1.12	0.70	0.64	Normal
D1G2	-0.39	1.04	0.30	0.74	Normal
D1G3	0.57	1.11	0.70	0.69	Normal
D1G4	-0.20	1.15	0.90	0.59	Normal
D1G5	-0.31	0.85	-0.90	0.72	Normal
D1N1	-0.14	0.72	-1.80	0.72	Normal
D1N2	-0.06	0.91	-0.50	0.68	Normal
D1N3	0.25	1.01	0.10	0.67	Normal
D1N4	0.17	1.09	0.60	0.66	Normal
D1N5	0.74	1.13	0.80	0.62	Normal
D2U1	0.35	0.70	-2.00	0.75	Normal
D2U2	-0.09	0.88	-0.70	**0.82**	Minor Misfit
D2U3	0.37	0.59	**-2.80**	0.78	Minor Misfit
D2U4	0.37	1.02	0.20	0.66	Normal
D2U5	0.52	0.63	**-2.50**	0.75	Minor Misfit
D2U6	0.57	0.80	-1.20	0.72	Normal
D2U7	0.42	0.76	-1.50	0.74	Normal
D2U8	-0.36	1.11	0.70	0.77	Normal
D2G1	-0.57	1.01	0.10	0.82	Normal
D2G2	-0.31	0.99	0.00	0.78	Normal
D2G3	-0.48	0.97	-0.10	0.76	Normal
D2G4	-1.19	1.22	1.20	0.69	Normal
D2G5	0.07	1.13	0.80	0.60	Normal
D2G6	-0.17	0.75	-1.60	**0.83**	Minor Misfit
D2G7	0.15	1.04	0.30	0.61	Normal
D2G8	-0.01	0.88	-0.70	0.66	Normal
D2N1	-0.20	0.90	-0.60	0.76	Normal

Item	Measure	Outfit		PTMEA	Remarks
		MNSQ	ZStd	CORR	
D2N2	-0.14	0.70	-2.00	0.72	Normal
D2N3	0.12	0.79	-1.30	0.73	Normal
D2N4	0.22	0.88	-0.70	0.67	Normal
D2N5	-0.17	1.08	0.50	0.62	Normal
D2N6	0.59	1.24	1.40	0.59	Normal
D2N7	0.07	0.70	-2.00	0.73	Normal
D2N8	-0.45	0.80	-1.20	0.78	Normal
D3U1	0.30	0.80	-1.30	0.75	Normal
D3U2	0.15	0.80	-1.20	0.76	Normal
D3U3	0.07	0.70	-2.00	0.80	Normal
D3U4	0.22	0.86	-0.80	0.77	Normal
D3U5	0.02	0.97	-0.10	0.77	Normal
D3U6	-0.75	**1.53**	**2.80**	0.70	Minor Misfit
D3U7	-0.91	1.12	0.80	0.72	Normal
D3U8	-0.45	1.19	1.10	0.75	Normal
D3U9	-0.98	1.03	0.20	0.68	Normal
D3G1	-1.26	1.02	0.20	0.68	Normal
D3G2	0.35	1.09	0.60	0.68	Normal
D3G3	-0.88	0.79	-1.30	0.76	Normal
D3G4	0.07	1.28	1.60	0.51	Normal
D3G5	0.10	0.80	-1.20	0.69	Normal
D3G6	-0.11	1.10	0.70	0.62	Normal
D3G7	0.02	0.87	-0.80	0.68	Normal
D3G8	0.17	1.00	0.00	0.70	Normal
D3G9	0.42	1.11	0.70	0.64	Normal
D3N1	0.37	1.00	0.10	0.63	Normal
D3N2	0.76	1.32	1.80	0.61	Normal
D3N3	0.67	0.71	-1.90	0.78	Normal
D3N4	0.22	1.01	0.10	**0.81**	Minor Misfit
D3N5	0.20	1.08	0.50	0.64	Normal
D3N6	0.47	0.89	-0.60	0.73	Normal
D3N7	0.52	0.86	-0.80	0.74	Normal
D3N8	0.33	0.92	-0.50	0.73	Normal
D3N9	-0.01	1.19	1.10	0.66	Normal
Total Item Removed = 6					

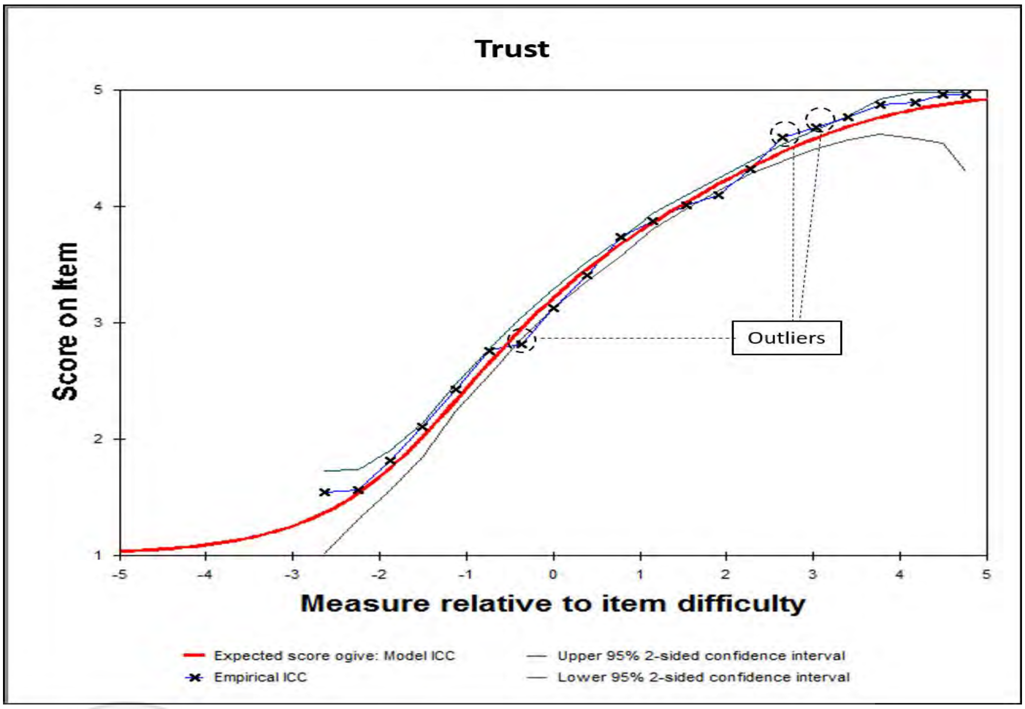

Figure 5. 9
GCC Graph for Trust Before Item Deletion

Table 5.27 below is the summary description for trust after the items removal process. The outfit $MNSQ_{item}$ now lies between 0.69 *logit* to 1.32 *logit*, which has improved from the previous readings. The same improvements can also be seen in the outfit $ZSTD_{item}$ readings where the indicators for minimum and maximum value now reads -1.00 to 1.80 *logit,* which fits into the specified 'quality control' readings. The Cronbach's alpha (KR-20) value is still at 0.98 *logit* and is still an excellent consistency reliability of items in the scale of a single latent trait or construct (Fisher, 2007). Nevertheless, the 60 items used in measuring trust is still a good instrument as it offers a good range of difficulties in measuring the organizations' ability (Fisher, 2007).

The GCC Graph in Figure 5.10 below further illustrates the improvised version after the item deletion.

Table 5. 27
Summary Fit Statistics for Trust –After Item Deletion

	Item (i = 60)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	0.98	-0.20	0.96	0.98	-0.70
SD	0.45	0.27	2.20	1.23	0.62	3.30
Maximum Measure	0.75	1.32	1.80	3.44	3.33	8.00
Minimum Measure	-1.32	0.69	-1.00	-2.67	0.09	-8.5
Reliability Indices						
Separation	2.43			6.05		
Reliability	0.85			0.97		
Std Error	0.06			0.25		
Cronbach Alpha (KR-20)				0.98		

Following the process of other constructs involved, the next step is to calculate the strata value (H). The value of person separation index (G), which equals to 6.05 was computed into the strata formula (H=(4G+1)/3), and has yielded a value of 8.40, and is considered as an excellent readings for person strata separated value. The value suggests that the organizations were spread adequately into eight groups across the items on the trait continuum.

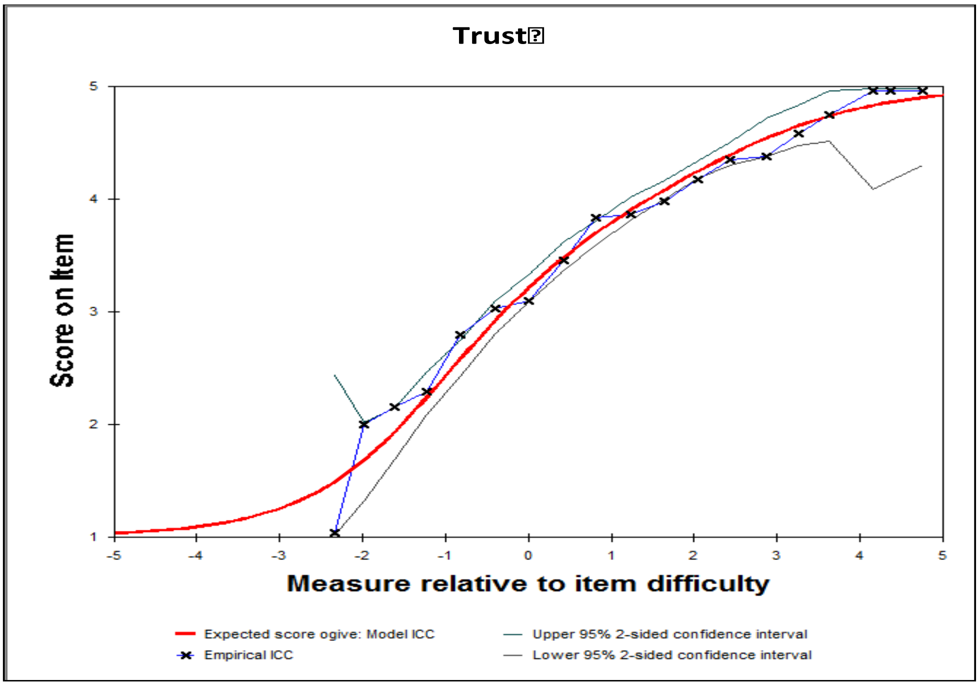

Figure 5. 10
GCC Graph for Trust After Item Deletion

iii. Unidimensionality Analysis

To support the assumptions of unidimensionality as purports by Rasch model, an analysis to test whether the items involved are related to the same construct (Bond & Fox, 2015). The results are shown in Table 5.28 below.

Table 5. 28
Standardized Residual Variance In Eigenvalue Units - Trust

			Empirical(%)		Modeled (%)
Total raw variance in observations	=	118.50	100.00		100.00
Raw variance explained by measures	=	58.50	49.40		50.20
Raw variance explained by persons	=	34.27	28.90		29.40
Raw Variance explained by items	=	24.23	20.40		20.80
Raw unexplained variance (total)	=	60.00	50.60	100.00	46.90
Unexplained variance in 1st contrast	=	11.77	9.90	19.60	

The reported raw variance explained by measures is at 49.40 per cent and is near to the modeled value of raw variance explained by measures, which is at

50.20 per cent. The value is considered a strong measurement dimension following the guidelines by Conrad et al., (2009). It is also unveiled that the unexplained variance in the first factor contrast is at 9.90 per cent, and is indicated as a good category for an instrument measurement (Fisher, 2007). Thus, one can conclude that the items measuring the construct of trust among the organization towards the triple helix players are indeed measuring the same composite of abilities (Bond & Fox, 2015).

5.7.3.4 Open Innovation Adoption

i. Summary Statistics of Reliability and Validity

The construct of open innovation adoption was developed based on 16 items adopted from past literatures. In particular, the study focuses exclusively on three dimensions, adopted from Zhang, (2013); and Doroodian et al., (2014). The dimensions are satisfaction; innovation process; and intellectual property (IP) protection. The construct bring about 2,272 data points from a total of 71 respondents and represents an adequate number of data to remain useful and stable for the organization measure estimates and to obtain a practical item calibrations.

Table 5. 29
Summary Fit Statistics for Open Innovation Adoption –Before Item Deletion

	Item (i = 16)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	1.00	-0.10	1.04	1.00	-0.40
SD	0.48	0.33	1.80	1.49	0.72	2.10
Maximum Measure	0.75	1.98	4.60	5.47	3.22	4.10
Minimum Measure	-0.70	0.53	-3.10	-2.13	0.10	-4.30
Reliability Indices						
Separation		2.51			3.27	
Reliability		0.86			0.91	
Std Error		0.12			0.18	
Cronbach Alpha (KR-20)				0.94		

The Cronbach's alpha (KR-20) value is 0.94 which explains that the internal consistency reliability of items in the scale of measuring a single latent trait or construct is at excellent level (Fisher, 2007). The result also implies that the items used in the instrument measuring the construct will deliver a consistent scores as respondents are responding consistently to the items being used.

Table 5.29 above shows the summary fit statistics of 71 person (organizations) and the 16 items constructed to represent the open innovation adoption. The person reliability (β) is at 0.91 *logit* with the standard error (SE) of 0.18 *logit*, and both values represent an excellent criterion as highlighted in the rating scale quality criteria by Fisher (2007). Thus, it can be asserted that the 16 items' instrument being used in the construct provides a good range of difficulties and can be used to measure the organizations' ability towards the various levels of difficulties (Fisher, 2007) in the open innovation adoption. In addition, the table also reveals that the person outfit Mean Square ($MNSQ_{person}$) and Z-Score ($ZStd_{person}$) are both at 1.00 *logit* and -0.40 *logit* respectively; and these values, which are almost the same to the expected value of 1 and 0, supports the fact that all of the items used in open innovation adoption are directed towards the right type of respondents. The instrument reflected the ability to measure the latent trait of the desired construct. Another important point is, the values reveal that the data gathered is at a reasonable prediction level of responses to the items. Additionally, the value of person mean measure, which shows +1.04 *logit* with the standard deviation (SD) of 1.49 *logit* further acknowledged that the organizations involved in this particular study, find the items in the construct, as easy to endorsed (Bond & Fox, 2015).

ii. Item Misfit Analysis

As for items analysis, the item reliability (μ) reading from the summary statistic table in Table 5.29 is 0.86 *logit* with 0.12 *logit* standard error (SE), indicating that the instrument used has a good fit rating scale criteria quality that fits to the model (Fisher, 2007). As mentioned by Bond & Fox, (2015), the strength of item reliability explains the replicability of the items that should occurs should these set of items are to be given to another sample of respondents of the same size. As for the item mean (μ_{item}), it can be noted that it has always been pre set to 0.00 *logit* to ensure that each person (organization) has an equal chance of success in responding to the item that matches their ability. Moreover, the mean value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ are respectively at 1.00 *logit* and -0.10 *logit* respectively and exhibits that both values are very close to the expectation value of 0 and 1. As highlighted previously, the fact that the values are near to the 1 and 0 expectation is important as it becomes an important indicator that the items developed to represent the construct of trust has indeed targeted the organization distribution.

As for the fit statistics analysis, the reported maximum value for outfit $MNSQ_{item}$ and outfit $ZStd_{item}$ for items is reported to be between -3.10 *logit* to 4.60 *logit*, designating that there are outliers among the items. The result, following the quality control criteria suggested by Azrilah (2011), signifies that there are two outliers classified as minor misfit and one item is classified as major misfit. The list of the misfit items can be referred from Table 5.30 and is illustrated graphically in Figure 5.11 below. In total, four items were taken out for further analysis following the suggestions made by Green & Frantom, (2002).

Table 5. 30
Open Innovation Adoption – Item Measures

Item	Measure	Outfit		PTMEA	Remarks
		MNSQ	ZStd	CORR	
C11	-0.08	1.13	0.80	0.73	Normal
C12	-0.13	0.93	-0.40	0.77	Normal
C13	-0.19	0.53	**-3.10**	**0.82**	Minor Misfit
C14	-0.02	1.41	**2.10**	0.65	Minor Misfit
C15	-0.55	1.08	0.50	0.67	Normal
C21	-0.46	0.66	-2.00	0.80	Normal
C22	-0.31	0.79	-1.20	0.79	Normal
C23	-0.49	0.67	-2.00	0.77	Normal
C24	-0.70	0.97	-0.10	0.73	Normal
C31	0.60	0.98	0.00	0.69	Normal
C32	0.75	0.78	-1.30	0.75	Normal
C33	0.73	0.83	-1.00	0.71	Normal
C34	0.65	1.23	1.30	0.65	Normal

Item	Measure	Outfit		PTMEA	Remarks
		MNSQ	ZStd	CORR	
C35	-0.43	1.13	0.70	0.61	Normal
C36	0.20	0.89	-0.60	0.79	Normal
C37	0.41	**1.98**	**4.60**	**0.38**	Major Misfit
Total Item Removed = 4					

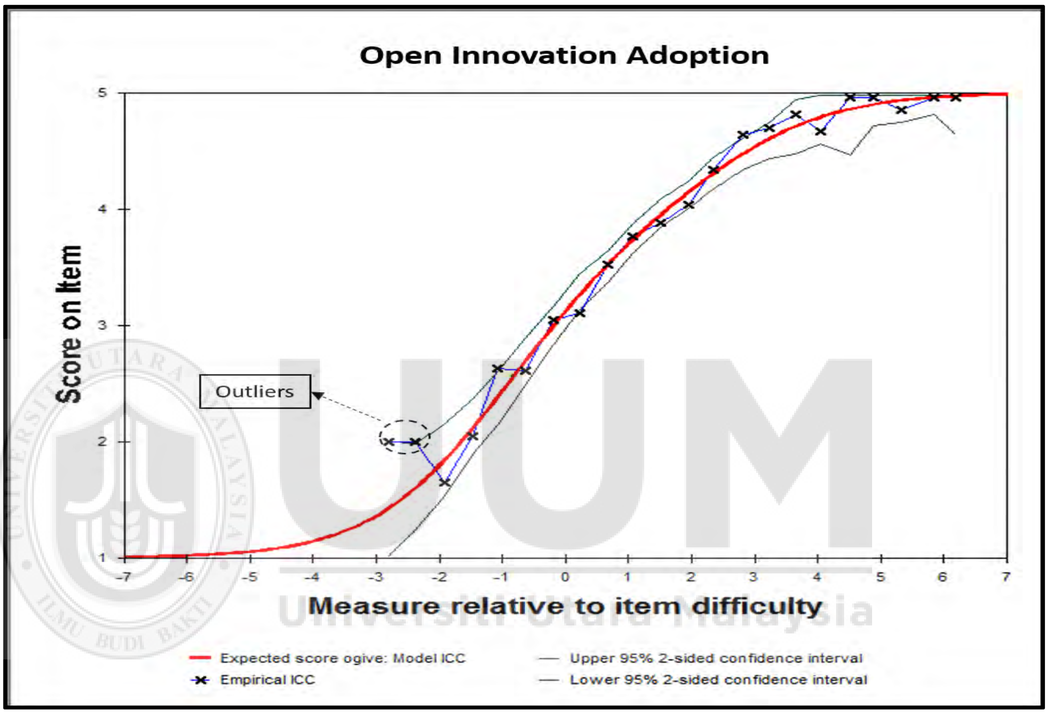

Figure 5. 11
GCC Graph for Open Innovation Adoption- Before Items Deletion

Table 5.31 below is the summary description for the construct of open innovation adoption after the items deletion process. The value for outfit $MNSQ_{item}$ are now showing the distance between 0.68 to 1.67 *logit* which is much better result compared to previous readings. This is also true to the outfit $ZSTD_{item}$ reading where the indicators for minimum and maximum values now read -1.00 to 1.90 *logit.* The GCC Graph in Figure 5.12 below also illustrates the improvised version of the items' outliers, where the group of items measuring the construct of open innovation adoption is now within the 95 confidence interval.

Table 5. 31
Summary Fit Statistics for Open Innovation Adoption – After Item Deletion

	Item (i = 12)			*Person (N=70)*		
	Measure	Outfit		Measure	Outfit	
		MNSQ	ZSTD		MNSQ	ZSTD
Mean	0.00	1.00	-0.20	0.97	1.00	-0.30
SD	0.52	0.27	2.50	2.30	0.70	2.90
Maximum Measure	0.70	1.67	1.90	4.43	2.86	3.60
Minimum Measure	-0.74	0.68	-1.00	-2.80	0.11	-3.70
Reliability Indices						
Separation		2.74			2.69	
Reliability		0.88			0.88	
Std Error		0.25			0.27	
Cronbach Alpha (KR-20)				0.92		

Next, is to calculate the strata value to confirm the pattern of how the organizations are spread across the trait continuum. The number of strata (H) is calculated using the strata formula, which counts for the value of person separation index (G). The person separation index is equals to 2.69, and yields a strata value of 3.92. The value when compared to the quality criteria of rating scale instrument, by Fisher, (2007), is considered to be a good figure to represent the construct of trust in the study. The figure also conform to the understanding that organizations, in the context of implementing trust, can be group under 3 to 4 distinct groups across the items on the trait continuum.

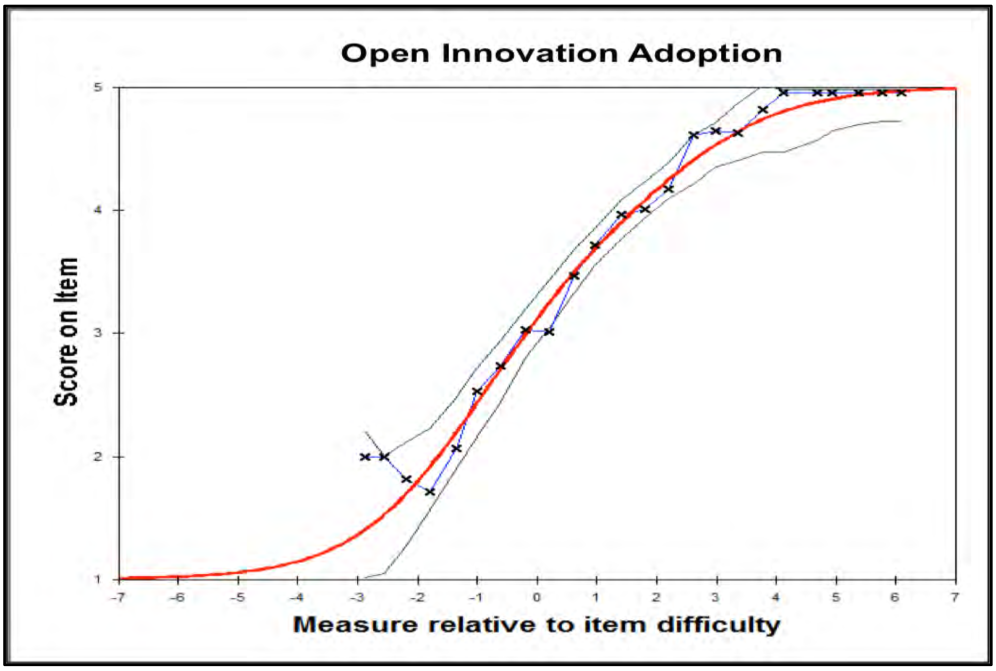

Figure 5. 12
GCC Graph for Open Innovation Adoption - After Items Deletion

iii. Unidimensionality Analysis

The assumption of Rasch model is that all the information in the data gathered by the persons must be able to be explained by the latent measures (Linacre, 1998). Through the residuals principal component analysis (PCA) as shown in Table 5.32 below, it can be seen that the raw variance explain by the measures is approximately at 54.70 per cent which is very closed to the expected target of 55.20 percent.

Table 5. 32
Standardized Residual Variance In Eigenvalue Units – Open Innovation Adoption

			Empirical(%)	Modeled (%)
Total raw variance in observations	=	35.30	100.00	100.00
Raw variance explained by measures	=	19.30	54.70	55.20
Raw variance explained by persons	=	11.66	33.00	33.40
Raw Variance explained by items	=	7.64	21.60	21.80
Raw unexplained variance (total)	=	16.00	45.30	44.80
Unexplained variance in 1st contrast	=	4.58	13.00	

The result is considered as a strong measurement dimension following the guidelines by Conrad et al., (2009). The result is also in line with the required minimum total raw variance explained by measures of 50.00 per cent and more. However, the findings reveal that the unexplained variance in the first contrast is at 23.00 per cent, which is considered as a 'fair' category for an instrument (Fisher, 2007). For that reason, it can be surmised that the items measuring the construct of open innovation adoption are fairly measuring the same composite of abilities (Bond & Fox, 2015).

5.8 Perspective I : Relationship Findings

Seven hypotheses were developed to answer the above research questions; which in particular are five hypotheses related to direct relationships between constructs and two hypotheses were developed to test the mediation effect. The testing of hypotheses was constructed by imputing Rasch data into the application of Smarts version 3.2.4 to test the causal relationship between the variables.

The steps of importing the Rasch data into SEM was referred to the suggestions made by Bond & Fox (2015) in which, they suggested two steps to be followed:

Step 1: The construction and the quality control of the measurement scales for every variable (construct) involved.

Step 2: The data to be imputed to SEM are the person measures and each of their standard errors (SE).

The proposed steps were in conjunction to the study made by Boon, Millar, Lake, Cottrell, and King (2010), where Rasch data wherein the common environment, latent variable are normally treated as a variable which are generated by various dimensions (or indicators). Generally, the variables are formulated using a simple, unit weighted addition of the dimensions involved, without taking into consideration the measurement properties of each dimensions. In other words, the dimensions used to form the variables are taken with the assumption that it is free from measurement errors. Adding to that, these variables are then used as a continuous variables in the general linear modeling techniques (egg: multiple regression) to predict relationships between them. These assumptions may lead to problems such as:

a. The unit weight addition neglected the possibilities that some dimensions (item?) may contribute more than others in the formation of the variable.
b. Unit weight addition may lead to a low construct validity variable.

In order to overcome these issues, Rasch data was used to obtained one measurement scale for each variable that can be used for structural equation modeling (SEM). Therefore, the Rasch residual PCA was used to ensure any underlying latent traits that were subsumed in the hypothesized variables was taken into account. These traits were then imported to SEM. In particular, each person measures and their respective standard errors for each hypothesized variables were used as a single item and are imputed in the structural equation models. The conceptual framework is presented again in Figure 5.13 in the form of structural model for further understanding.

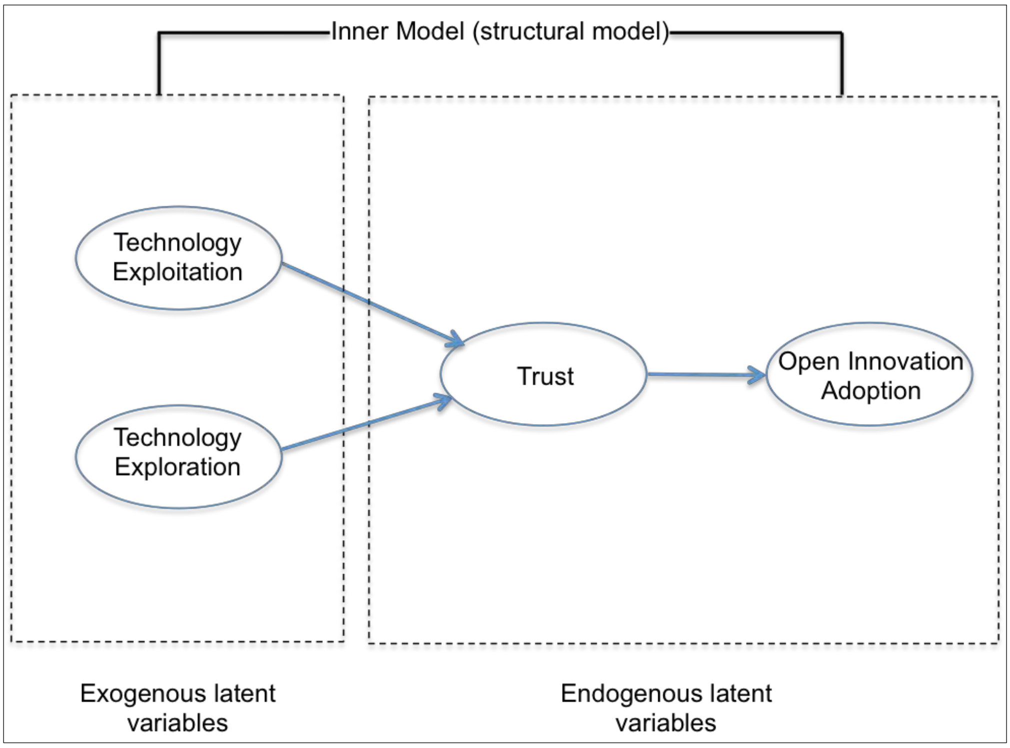

Figure 5. 13
Structural Model

5.8.1 Assessment Of Structural Model

As mentioned, the study uses PLS-SEM in order to test the relationship between the variables. Prior to testing the hypotheses developed, the PLS-SEM algorithm and the bootstrapping methods was performed to the structural model. The study follows the five steps structural model assessment procedure as proposed by Hair (2014).

i. Step 1 : Collinearity Assessment

Collinearity occurs when two predictors are highly correlated or in other word means redundant. When this happen, it may cause a wrong sign when reading the regression coefficient as the predictors may not be able to explain unique or independent information on the regression between the variables. To ensure that, the collinearity assessment is conducted and the variance inflation factor (VIF) reading is taken and tabled in Table 5.33 below. The VIF readings indicates that there are no collinearity issues as all VIF scores are less than the threshold of 5.00 as suggested by Hair (2014).

Table 5. 33
Results of Collinearity Test

	EXPLORE	EXPLOIT	TRUST	OIA
EXPLORE			2.768	3.698
EXPLOIT			2.768	2.774
TRUST				1.814

Note: EXPLORE – Technology Exploration; EXPLOIT – Technology Exploitation; OIA – Open Innovation Adoption

ii. Step 2 : Path Coefficient Assessment

The next step is to assess the path coefficient of the structural model. As Hair mentioned, "the path coefficients have a standardized value between -1 and +1". A path coefficient reading close to +1 indicates a strong positive relationship, where else a scoring close to -1 will indicate a strong opposite relationship. The reading too will help to indicate (almost) a significant results of the relationships. This means that any readings approaching 0.00 will signify a poor relationship. To do so, a bootstrapping calculation is performed and the results of path coefficient are shown in Table 5.34.

Table 5. 34
Results of Path Coefficient

	EXPLORE	EXPLOIT	TRUST	OIA
EXPLORE			0.716	0.872
EXPLOIT			-0.059	-0.074
TRUST				0.009

Note: EXPLORE – Technology Exploration; EXPLOIT – Technology Exploitation; OIA – Open Innovation Adoption

It can be seen from the Table 5.34 above, the path coefficients between technology exploration and trust, as well as between technology exploration and open innovation adoption are close to +1, which suggest that there exist a strong positive relationships in the two situations. However, a poor path coefficient scorings for the relationship between technology exploitation and trust; and technology exploitation and open innovation adoption signal a no significant relationship between the variables Hair (2014).

iii. Step 3 : Coefficient of Determination (R^2) Assessment

The next step is to get the R^2 readings, which are the squared correlation of actual and the predicted values of the combined effects of the exogenous variables on the endogenous variables. The results displayed in Table 5.35 explained that technology exploitation and technology exploration together developed 46% of the variance in trust; and 67% of the variance in open innovation adoption. Following Cohen (1988, 2013), where R^2 values of 0.26, 0.13, or 0.02 for endogenous latent contracts can be classified as substantial, moderate and weak; it can be proven that the R^2 scoring for the endogenous variables of this study resulted as substantial. In other words, the exogenous latent variables are able to substantially explain the predictive accuracy (Hair, 2014) of the endogenous variables.

Table 5. 35
Results of Coefficient of Determination (R^2)

	R Square (R^2)	Results
Trust	0.459	Substantial
Open Innovation Adoption	0.672	Substantial

iv. Step 4 : Effect Size (f^2) Assessment

Additional to the R^2 values, it is also important to calculate the effect size (f^2) of the variables and that is to explain the change in R2 value should one exogenous variable is not in presence to explain the endogenous variables. The difference between the two scenarios is reflected in the f^2 readings and is displayed in Table 5.36 below.

Table 5. 36
Results of Effect Size (f^2)

	TRUST	OIA
EXPLORE	0.336	0.628
EXPLOIT	0.002	0.006
TRUST		0.000

Note: EXPLORE – Technology Exploration; EXPLOIT – Technology Exploitation; OIA – Open Innovation Adoption

The results indicate that the effect size for technology exploration, is somewhat large to explain the relationship for the endogenous variable of trait and is large enough to explain the open innovation adoption. This is following the suggestions by Cohen (1988, 2013) where an f2 value of 0.35 is considered large; 0.15 is medium; and 0.02 is small. On the other hand, the effect size of technology exploitation is considered as small following Cohen (1988, 2013). Even though the sample size for this study was 71, the formal power analysis was conducted as recommended by Peng and Lai (2012).The analysis using a statistical power analysis program, called G*power 3, yielded a 0.90 statistical power reading which pointed to the fact that the sample size of 71 is adequate to achieve a high level of power and reduce type II error. Therefore, the statistical power analysis proves that this research is adequate (Peng & Lai, 2012).

v. Step 5 : Blindfolding and Predictive Relevance (Q^2) Assessment

The final step in the assessment of structural model is to examine the Q^2 value, referred as Stone-Gesser's Q^2 value. The reason to perform this assessment is to accurately predicts the relevant data points by the indicators in the reflective measurement model of endogenous constructs (Hair et al., 2010). A blindfolding is an iterative technique and will be used to complete the assessment. Through the blindfolding technique, a Q^2 value will be calculated and value greater than zero will indicate the path model predictive relevance (Azwadi Ali, 2010; Hair et al., 2010). Aside from Q^2 , it is also important to indicate the H^2 (cross-validated redundancy), to confirm the fit of the measurement model. The result is tabled in Table 5.37 below. The Q^2 results for all variables are all greater than zero, which directly point predictive relevance.

Table 5. 37

Predictive Quality Indicator of the Model

Endogenous Latent Variable	R Square (R^2)	Cross-Validated Communality (Q^2)
Trust	0.449	0.552
Open Innovation Adoption	0.672	0.376

5.8.2 Direct Relationship

Before the testing of mediating effect, bootstrapping with resample of 500 was run to obtain the t-value with the attempt to test whether the direct relationship is significant. The path coefficients and the bootstrapping results were displayed in Figure 5.14 and Table 5.38.

i. Hypothesis 1: There is relationship between technology exploration and open innovation adoption.

The results from the bootstrapping signify that the t value is equivalent to 2.296, which is above the cut off value of 1.96. This is shown in Table 5.38 and Figure 5.14. Therefore it can be posited that there is a positive relationship between technology exploration and open innovation adoption ($\beta = 0.393$, $t = 2.296$, $p < 0.05$). Consequently, it can be concluded that Hypothesis 1 is supported.

ii. Hypothesis 2: There is relationship between technology exploitation and open innovation adoption.

Result from the output of the bootstrapping PLS-SEM as shown in Table 5.38 and Figure 5.14 points to the t-value as 0.456, which is lower than the cutoff value of 1.96. This result serves as an indicator that the relationship between the technology exploitation and open innovation adoption is insignificant (β = 0.067, t = 0.456, $p < 0.05$). Thus, based on the result, no conclusion can be formed and Hypothesis 1 failed to receive empirical support and is rejected. It can be concluded that the null hypothesis is challenged and fail to be rejected. Aside from all necessary steps to ensure no sampling and measurement error, the power analysis (G*power) was also performed and the result was at 0.80, which is in line with Cohen's (1977, 1988) effect size measures. In that manner, it can be said that the insignificant relationship is not related to the methodological issues.

iii. Hypothesis 3: There is relationship between technology exploration and trust.

As shown in Table 5.38 and Figure 5.14 below, there is a significant relationship between technology exploration and trust. Results from the bootstrapping analysis, showed that the t-value is equal to 5.671 and is higher than the cutoff value of 1.96. Thus a significant association between the two variables was found (β = 0.892, t = 5.671, $p < 0.05$) , supporting Hypothesis 3.

iv. Hypothesis 4: There is relationship between technology exploitation and trust.

As for Hypothesis 4, it is found that the path coefficient from technology exploitation to trust was insignificant (β = -0.149, t = 0.855, $p < 0.05$). Thus, based on the result, no conclusion can be formed and Hypothesis 4 failed to receive empirical support and is rejected.

v. **Hypothesis 5: There is relationship between trust and open innovation adoption**

The result as reflected in Table 5.38 and Figure 5.14 below, confirms a significant relationship between trust and open innovation adoption ($\beta = 0.398$ t = 3.230, $p < 0.05$). Therefore, Hypothesis 5 is empirically supported.

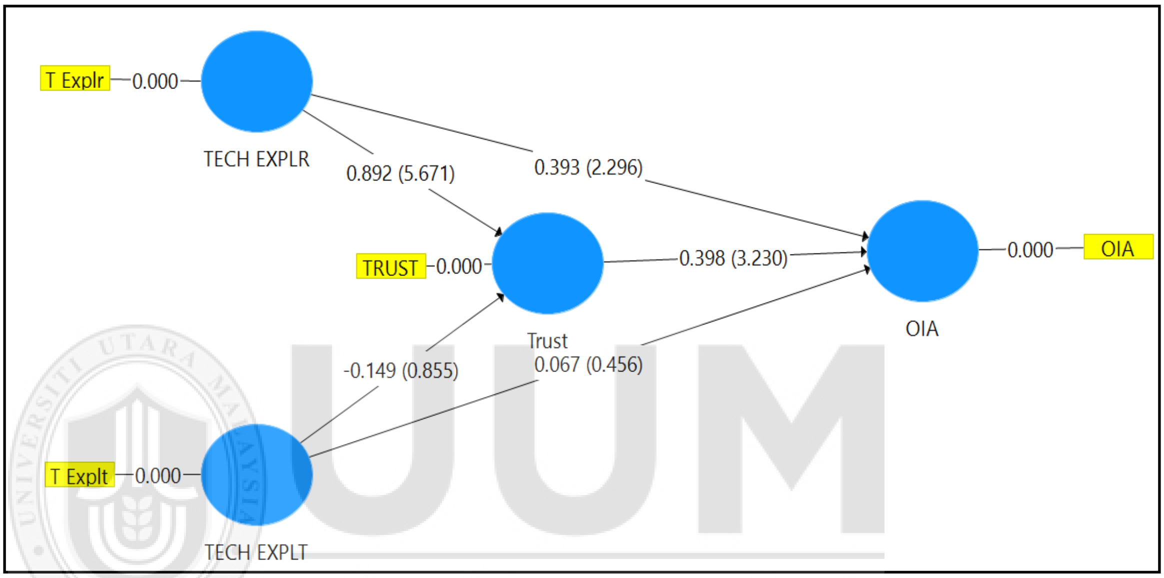

Figure 5. 14
PLS-Path Modeling

Table 5. 38
Results of Direct Relationship

Hypothesis	Relationship	Beta (β)	t-value	Decision
H1	T EXPLR → OIA	0.393	2.296	Supported
H2	T EXPLT → OIA	0.067	0.456	Not Supported
H3	T EXPLR → TRUST	0.892	5.671	Supported
H4	T EXPLT → TRUST	-0.149	0.855	Not Supported
H5	TRUST → OIA	0.398	3.230	Supported

Note: $p < 0.05$ ($t > 1.96$)
T EXPLR – Technology Exploration; T EXPLT – Technology Exploitation; TRUST – Trust; OIA – Open Innovation Adoption

5.8.3 The Mediating Effect

Results from the bootstrapping analysis for the mediating effect of trust are tabled in Table 5.39. The analysis outcome of β and t-values for Hypothesis 6 and Hypothesis 7 are also illustrated in the same table.

Table 5. 39
Results of Mediation Relationship

Hypotheses	Relationship	Indirect Effect (β)	t-value	Bootstrapped Confidence Interval (CI) 95% LL	95% UL	Decision
H6	EXPLR → TRUST → OIA	0.355	2.535	0.139	0.719	Supported
H7	T EXPLT → TRUST → OIA	-0.059	0.774	-0.278	0.045	Not Supported

Note: $p < 0.05$ ($t > 2.96$)
T EXPLR – Technology Exploration; T EXPLT – Technology Exploitation; TRUST – Trust; OIA – Open Innovation Adoption

i. **Hypothesis 6: Trust mediates the relationship between technology exploration and adoption of open innovation.**

As shown in Table 5.39, the bootstrapping analysis showed that the indirect effect (β= 0.355) was significant with the t-value of 2.535. Result from bootstrapped confidence interval (CI) with indirect effect of 95% reports the lower limit (LL) value of 0.139 and the upper limit (UL) of 0.719; and the range between the two limits did not overlapped a 0 value in between, which further confirms a mediation relationship between the variables (Preacher & Hayes, 2004).

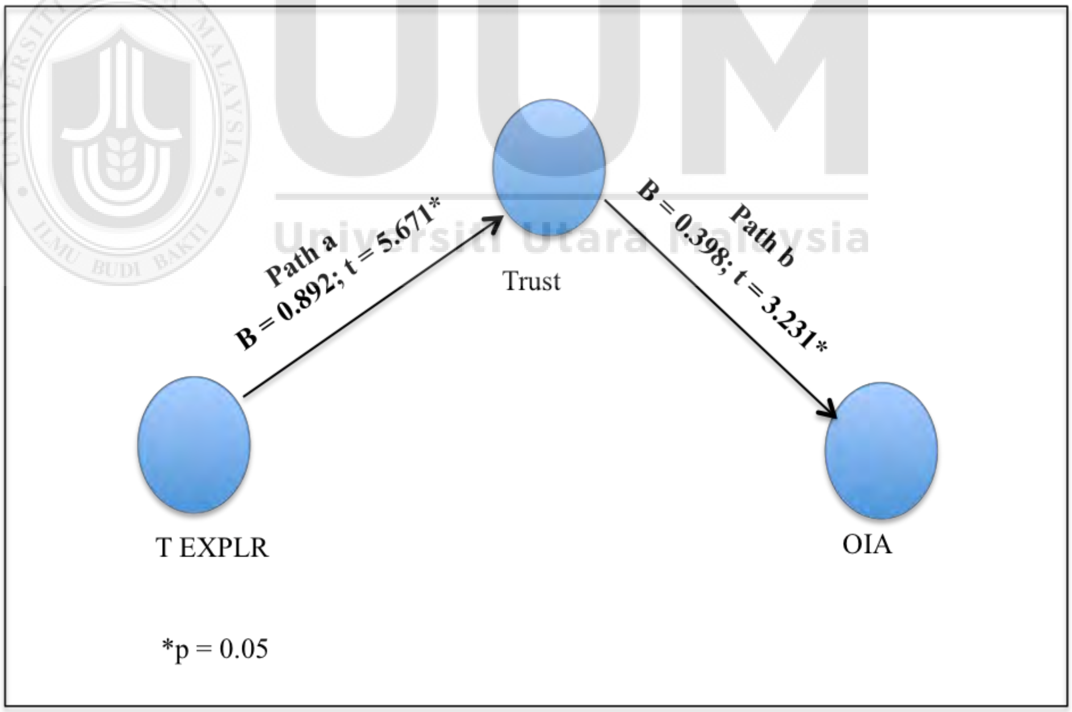

Figure 5. 15
Analysis Outcome of H6 (T EXPLR → TRUST → OIA)

In short, Hypothesis 6 is supported and it can be empirically concluded that trust mediates the relationship between technology exploration and open innovation adoption ($\beta = 0.355$ $t = 2.535$, $p < 0.05$).

ii. Hypothesis 7: Trust mediates the relationship between technology exploitation and adoption of open innovation.

Table 5.39 exhibits the results from the bootstrapping analysis where the indirect effect ($\beta = -0.059$) with t-value of 0.774 was insignificant. Further, the scores from bootstrapped confidence interval (CI) with indirect effect of 95% reports the lower limit (LL) value of -0.278 and the upper limit (UL) of 0.045; and the range between the two limits overlaps with 0 value in between, which empirically refutes a mediation relationship between the variables (Preacher & Hayes, 2004). Thus, it can be concluded that trust does not mediate the relationship between technology exploitation and open innovation adoption ($\beta = -0.059$, $t = 0.774$, $p < 0.05$); and Hypothesis 7 is rejected.

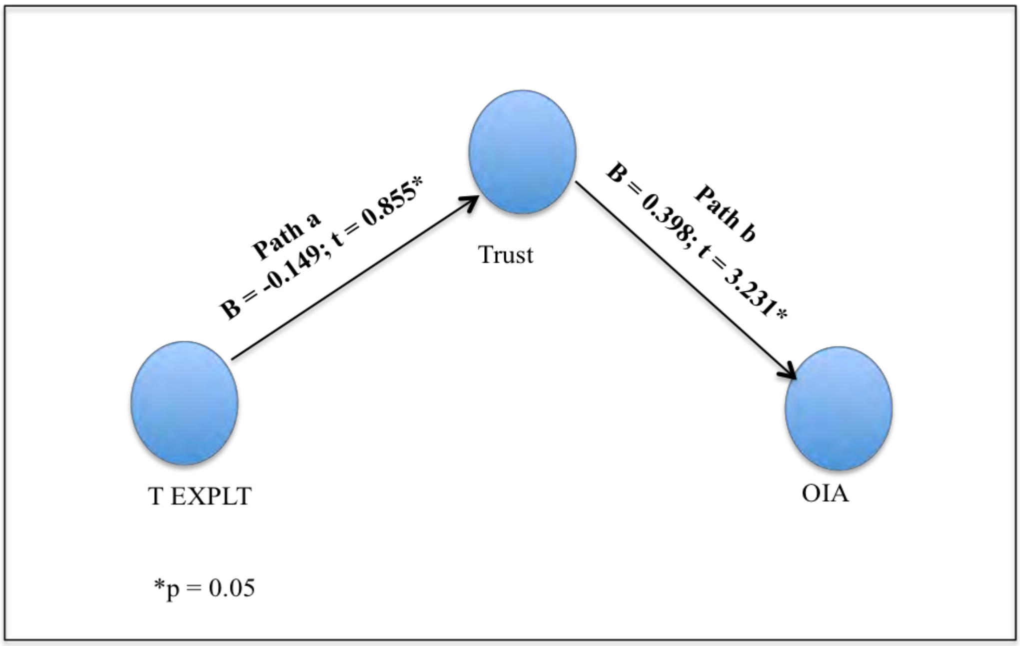

Figure 5. 16
Analysis Outcome of H7 (T EXPLT → TRUST → OIA)

5.8.4 Summary of the Hypotheses Findings

Table 5.40 below summarizes the hypotheses testing. As shown, from the total of seven hypotheses, three hypotheses were not supported.

Table 5. 40
Summary of Findings

H	Descriptions	Results
Results of Direct Relationship		
H1	**5.8.4.1 There is relationship between technology exploration and open innovation adoption.**	Supported
H2	**5.8.4.2 There is relationship between technology exploitation and open innovation adoption.**	Not Supported
H3	**5.8.4.3 There is relationship between technology exploration and trust.**	Supported
H4	**5.8.4.4 There is relationship between technology exploitation and trust.**	Not Supported
H5	**5.8.4.5 There is relationship between trust and open innovation adoption**	Supported
Results of Mediation Effect		
H6	**5.8.4.6 Trust mediates the relationship between technology exploration and adoption of open innovation.**	Supported
H7	**5.8.4.7 Trust mediates the relationship between technology exploitation and adoption of open innovation.**	Not Supported

5.9 Perspective II: Categorizing Success Factor And Challenges For Organizations To Adopt Open Innovation

This study was also set out with the aim to seek answers to the questions of what are the abilities of organizations in the light of implementing technology exploration, technology exploitation and trust towards open innovation adoption. To do so, a further Rasch analysis was performed. A thorough look into each item measures were conducted to identify what are the areas that can be classified as success factors and challenges that needs to be met by organizations to adopt open innovation. The findings will be discussed in accordance to the constructs involved as it is important to specifically understand which of the items are perceived as achievable or challenging by the organizations involved.

5.9.1 Organizations Ability to Implement Technology Exploration

The ability of organizations to meet the difficulties of the various items can be scrutinized by listing the item measures. Prior to the investigation of items measures, the organizations will have to be grouped according to the strata value calculated on the earlier part of the study. This is to explain how the organizations are spread along the measurement continuum. Hence, it is best to first re-visit some important value, which has been derived from the summary statistic table, discussed previously in this chapter. It can be learnt from the summary statistic table displayed in Table 5.19, the person separation reading for the construct of technology exploration is at 3.86 *logit.* Likewise, from the strata value calculation, it was also learnt that the organizations were spread adequately into five groups. The five groups separation is a very good indicator for a person strata separation (Fisher, 2007). For the purpose of this study, the researcher choose to address the different categories as 'Excellent', 'Good', 'Regular', 'Poor', and 'Very Poor'. A matrix categorization table is then developed by making use of the person mean ($\bar{x}$) and standard deviation (σ) value. Table 5.41 further explains the matrix categorization that can be used as a basis to profile the organizations to further understands how organizations perceive technology exploration.

Table 5. 41
Categorization Matrix for Technology Exploration - Persons

Categories	**Position in normal distribution**	**Logit**	**n**	**%**
Excellent	$(\bar{x}+\sigma)$ to ∞	1.76 to ∞	7	10.0
Good	$\bar{x}$ to $(\bar{x}+\sigma)$	0.77 to 1.76	32	45.7
Regular	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.22 to 0.77	21	30.0
Poor	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-1.21 to -0.22	5	7.1
Very Poor	∞ to $(\bar{x}-2\sigma)$	∞ to -1.21	5	7.1
			70	**100**

As depicted in the categorization matrix table above, approximately more than half of the organizations (39 out of 70) are located above the mean value for organizations , which equals to 0.77 *logit*. The totals, which account for 55.7% denote that the majority of the organizations involved can easily endorsed most of the items under the construct of technology exploration. Only 31 organizations (44.3%) are located below the mean organization value ($\bar{x}$ = 0.77), which indicate the group of organizations that find difficulties in sanctioning to most of the items in the constructs.

Moving forward, is to closely look at each items and their respective item measures that makes up the construct of technology exploration. The item measures as shown in the item measurement tables in Table 5.42 provide a pattern and view of the items position on the continuum measurement scale. Generally, the items can be grouped into two main categories, where the cut off point will be where the mean value (μ_{item}) is at 0.00 *logit*. Items which are located below the μ_{item} = 0.00 *logit* are categorized as easy items, and items located above the μ_{item} = 0.00 *logit* are categorized under difficult items. The division between the difficult items and the easy items can also be referred from the variable-map in Figure 5.17, which represents the technology exploration's items as well as the organizations involved. The map provides a graphical representation of the persons (organization) and the items position in the logit continuum. One finding that can be ascertained from the variable map in Figure 5.17 below, is the close distance between the hierarchy of items along its logit continuum, which reveals a good spread of items along the trait and a high reliability of the scale for the construct.

It can be seen from Table 5.42, the most difficult items, which are located at the top of the list hold the item measures ranged from 0.05 *logit* to 1.56 *logit;* whilst the much easier items, which are located at the bottom of the table are with item measures value between -1.01 *logit* to -0.06 *logit*. For the purpose of this study, the researcher chose to classify the difficult items as challenges that need to be focused at, in order for organization to achieve a better implementation of technology exploration. The easy items, on the hand will be referred to as the success factors that need to be strengthen by organizations to ensure success in the implementation of technology exploration. To understand further, the two categories will be explained separately.

Table 5. 42

Measure Order Of Items For Technology Exploration

Item Code	Item	Measure	Model SE	Remarks
B59	Extent of collaboration with competitors.	1.56	0.14	Difficult Item
B14	Extent of engagement with customers in training or instructing others (as trainer).	1.20	0.13	Difficult Item
B41	Extent of buying the intellectual property (IP) of other companies to ensure successful development of own new products/services.	1.15	0.13	Difficult Item
B510	Extent of collaboration with other companies that are engaged in activities, which are different than own company.	0.84	0.14	Difficult Item
B34	Extent of acquiring new know-how/technology through mentoring university interns.	0.80	0.14	Difficult Item
B54	Extent to which the company has internal structures and processes for managing partnerships and networks.	0.65	0.14	Difficult Item
B53	Extent to which the company use Internet platforms and virtual networks for posting challenges to get ideas for product/ service development.	0.46	0.14	Difficult Item
B42	Extent to which the company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	0.34	0.14	Difficult Item
B17	Extent to which the company cooperate with customers to acquire new knowhow/technology.	0.22	0.14	Difficult Item
B43	Extent to which the company believe that buying IP rights through licensing from other companies is important for the growth of the company.	0.05	0.15	Difficult Item
B16	Extent to which the company usually developed new product/service in light of customer wishes and suggestions.	-0.06	0.15	Easy Item
B32	Extent to which the company is willing to purchased creative work of others parties to increase the stock of knowledge and its use to devise new and improved goods, services and processes.	-0.06	0.15	Easy Item
B12	Extent to which customers are usually involved in the process of new product/service development.	-0.09	0.15	Easy Item
B55	Extent to which the company regularly exchanges business information with salesperson or marketers.	-0.09	0.15	Easy Item
B33	Extent to which the company acquire new know-how/technology through informal ties with researchers from various laboratories.	-0.20	0.15	Easy Item

Item Code	Item	Measure	Model SE	Remarks
B44	Extent to which the company believe that the government's efforts for protection of buying IP rights benefited the company.	-0.20	0.15	Easy Item
B51	Extent to which the company actively engaged as a member of a cluster.	-0.20	0.15	Easy Item
B57	Extent to which the company collaborate with suppliers	-0.20	0.15	Easy Item
B11	Extent to which the company obtain important product/market information from customers rather than internal sources (internal search).	-0.22	0.15	Easy Item
B511	Extent to which the company collaborate with other companies engaged in high technology industries	-0.22	0.15	Easy Item
B31	Extent to which the company acquire new know-how/technology through R&D services provided by knowledge institutions such as universities, faculties, institutes, laboratories, etc.	-0.27	0.15	Easy Item
B58	Extent to which the company collaborate with research community (universities, research centers, technology transfer agencies, etc.) .	-0.37	0.16	Easy Item
B21	Extent to which the company aggressively participate with external parties through technological alliances.	-0.41	0.16	Easy Item
B15	Extent to which the company engage with your customers in evaluating own product/services.	-0.44	0.16	Easy Item
B25	Extent to which the company believe that it is beneficial to determine systemic and formal ways of searching for external know-how/technology.	-0.57	0.16	Easy Item
B18	Extent to which the company engage with customers in the process of testing new products/services.	-0.64	0.16	Easy Item
B56	Extent to which the company collaborate with own customers	-0.67	0.16	Easy Item
B23	Extent to which the company believe that investing in a new joint venture could result in acquiring new know-how/technology to the company.	-0.73	0.17	Easy Item
B22	Extent to which the company is willing to invest in external collaboration should the desired technology are proven valuable.	-0.78	0.17	Easy Item
B513	Extent to which the company collaborate with Government/public authorities	-0.92	0.17	Easy Item
B26	Extent to which the company believe that the know-how/technology the company have bought can create new opportunities.	-0.98	0.17	Easy Item

Item Code	Item	Measure	Model SE	Remarks
B24	Extent to which the company believe that the use of know-how/technology from the outside can significantly contribute to the innovation.	-1.01	0.17	Easy Item

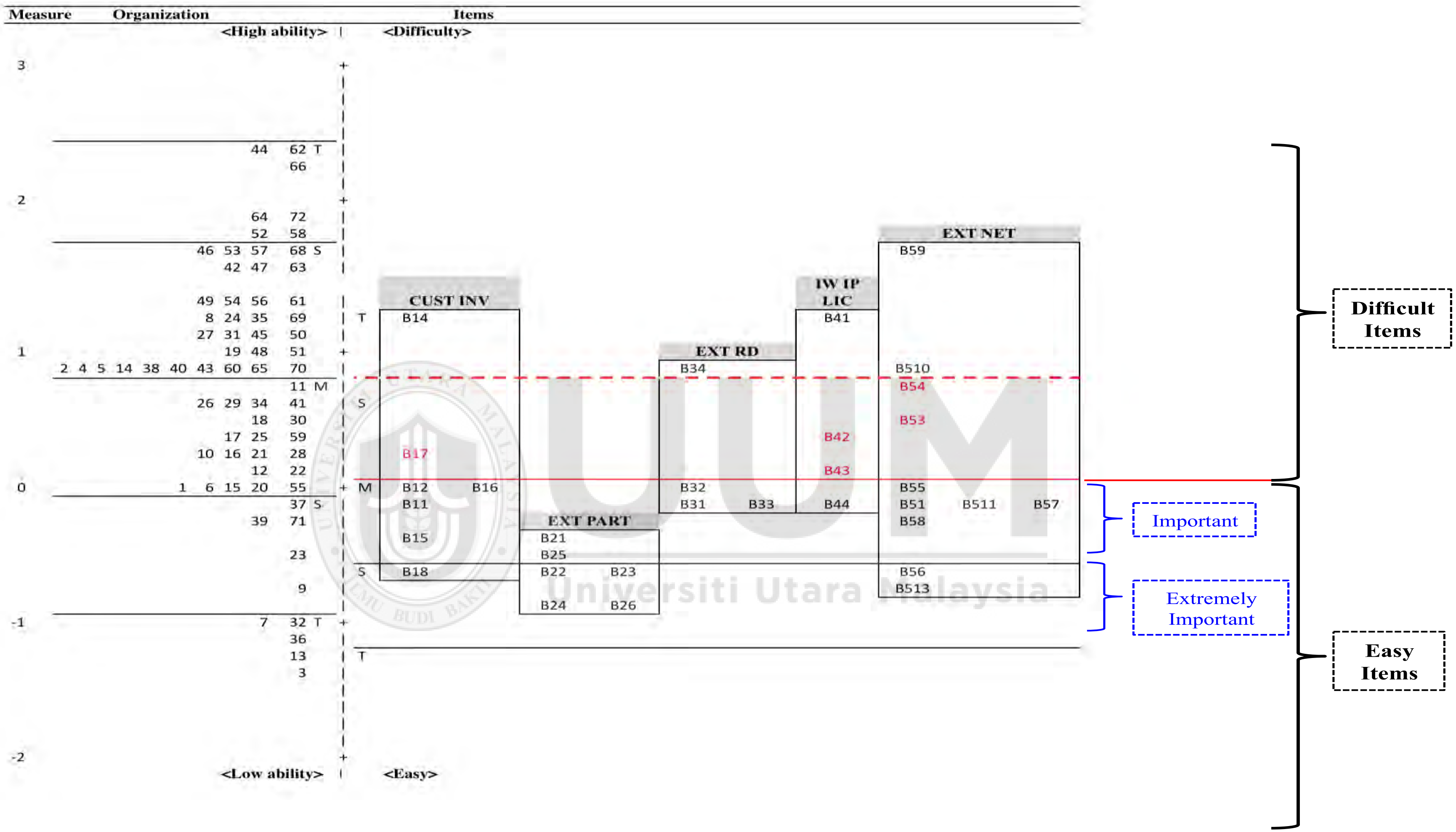

Figure 5. 17
Variable Map for Technology Exploration

5.9.1.1 Challenges

From the total of 32 items, only ten items were considered as difficult items, which showed low endorseability, by organizations and high *legit* measures. Item B59 with the item measure value of 1.56 *logit* and SE of 0.14 makes the most difficult item to be agreed upon in the technology exploration construct. Table 5.43 is also developed to look into this item in details. Specifically, item B59 represents the extent to which organizations' collaborate with competitors is the most challenges task to be done when considering technology exploration. Item B43, is the lowest in the continuum of difficult item making it among the items that is closest to the success factor group. In other word this means that item B43, which refers to the extent to which the company believe that buying IP rights through licensing from other companies is important for the growth of the company, if being taken into considerations, may push the organizations to believe or implement the item better.

Another noteworthy finding to look at is out of the ten difficult items, five items are scattered between μ_{item} (0.00 *logit*) and $\mu_{organization}$ (0.77 *logit*) . These items, although seen as difficult, can be explained as items that are achievable by organizations should they need to exercise a better implementation of technology exploration. It is shown in the categorization of challenges item in Table 5.43 below.

Table 5. 43
Categorization Of Challenges Items For Technology Exploration

Rank	Code	Item	Measure
Highly Challenging			
1	B59	Extent of collaboration with competitors.	1.56
2	B14	Extent of engagement with customers in training or instructing others (as trainer).	1.20
3	B41	Extent of buying the intellectual property (IP) of other companies to ensure successful development of own new products/services.	1.15
4	B510	Extent of collaboration with other companies that are engaged in activities, which are different than own company.	0.84
5	B34	Extent of acquiring new know-how/technology through mentoring university interns.	0.80
Challenging			
6	B54	Extent to which the company has internal structures and processes for managing partnerships and networks.	0.65
7	B53	Extent to which the company use Internet platforms and virtual networks for posting challenges to get ideas for product/ service development.	0.46
8	B42	Extent to which the company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	0.34
9	B17	Extent to which the company cooperate with customers to acquire new knowhow/technology.	0.22
10	B43	Extent to which the company believe that buying IP rights through licensing from other companies is important for the growth of the company.	0.05

5.9.1.2 Success Factors

The remaining 22 items are grouped under easy items as the scoring of the item measures fall below the value of $\mu_{item,\ which}$ is equals to 0.00 *logit*. Additionally, the easy items can be further separated into smaller groups, for thorough analysis. With the μ_{item} at 0.00 *logit* position and the standard deviation (SD_{item}) at 0.66 *logit* as the cut-off point, the categorization matrix table is then produced based on the three SD placements on the logit continuum, namely ‘S’ to represent the 1st SD; and ‘T’ for 2nd SD. Table 5.44 below represents the matrix categorization for organization implementing easy items under technology exploration and it is reflected in the variable-map (Figure 5.18) above. To further understand and explain these success factors, the researcher choose to segregate the items into two groups, namely the important and the highly important group. Table 5.44 below represents the list of success factor items for technology exploration.

Table 5. 44
Categorization Matrix for Technology Exploration –Items

Categories	**Position In Normal Distribution**	**Range of Position in Item Measure**	**n**	**%**
Highly Important	1st SD – 2nd SD	-0.66 to -1.32 *logit*	6	27.30
Important	μ - 1st SD	0.00 to - -0.66 *logit*	16	72.72

Generally, it can be learnt from Table 5.44 above that mainly the easy items fall into two main categories; namely the ‘Important’ and ‘Highly Important’. 16 items are group under the ‘Important’ category, and 6 items falls under the ‘Highly Important’ categories. Each group represents a 27% and 73% apportionment from the total of 22 easy items from the technology exploration construct. The segregation of ‘Important’ and ‘Highly Important’ grouped is also illustrated in the variable map in Figure 5.18. The items represented by each group are tabled in Table 5.45.

Table 5. 45

Success Factors For Technology Exploration

Rank	Code	Item	Measure
Highly Important			
1	B24	The use of know-how/technology from the outside can significantly contribute to the innovation of organization.	-1.01
2	B26	The know-how/technology bought , can create new opportunities for the company.	-0.98
3	B513	Collaboration with Government/public authorities	-0.92
4	B22	Willingness to invest in external collaboration should the desired technology are proven valuable.	-0.78
5	B23	Investing in a new joint venture could result in acquiring new know-how/technology.	-0.73
6	B56	Collaboration with customers	-0.67
Important			
7	B28	Customers' engagement in the process of testing new products/services.	-0.64
8	B25	Systemic and formal ways of searching for external know-how/technology must be determined	-0.57
9	B25	Customer's engagement in evaluating current product/services.	-0.44
10	B22	Participation with external parties through technological alliances.	-0.42
11	B58	Collaboration with research community (universities, research centers, technology transfer agencies, etc.)	-0.37
12	B32	Acquiring new know-how/technology through R&D services provided by knowledge institutions such as universities, faculties, institutes, laboratories, etc.	-0.27
13	B22	Obtaining important product/market information from customers rather than internal sources (internal search).	-0.22
14	B522	Collaboration with other companies engaged in high technology industries	-0.22
15	B33	Acquiring new know-how/technology through informal ties with researchers from various laboratories.	-0.20
16	B44	The government's efforts for protection of buying IP rights benefited the organization.	-0.20
17	B52	Active engagement as a member of a cluster.	-0.20
18	B57	Collaboration with suppliers	-0.20
19	B22	Customers' involvement in the process of new product/service development.	-0.09

20	B55	Exchanges business information with salesperson or marketers on regular basis	-0.09
21	B26	Developing new product/service in light of customer wishes and suggestions.	-0.06
22	B32	Willingness to purchased creative work of other parties to increase the stock of knowledge and its use to devise new and improved goods, services and processes.	-0.06

A closer look to item B24 from the 'Highly Important' group, will point to the item of "The use of know-how/technology from the outside that can significantly contribute to the innovation of organization.". This means that when referred to the variable map, item B24 is located on the bottom of the hierarchy of the item continuum denoting agreeableness from most of the organizations to this particular item (Bond & Fox, 2015). The position for this particular item denotes that almost all of the organizations find that the external technology acquisition is important for innovation performance as been reflected in past studies (K. P. Hung & Lin, 2013; Jemala, 2010). It is also necessary to note at item B32 that is the last in the group of 'Important' (item measures = -0.06 *logit*), which is very close to mean item of 0.00 *logit.* The item represents the willingness of organization to purchase creative work of other parties to increase the amount of knowledge and its use to devise new and improved goods, services and processes. The position of the item in the logit continuum indicates that most organizations agree to the fact that external works of other parties is useful and may benefit their innovation process. This has been claimed true as among the best companies around the world who survived and succeed in a long period of time are those that is claimed to be creative and innovative in the sense where they make use of creative ideas by others as a spring board to create unique products or services of their own (Burrus, 2013).

However, this climate has got to be strengthen by respective collaborative helices to ensure that the organizations ' level of confidence remain intact.

In conclusion, the verification of the items from the construct has indeed produced acceptable values and is reliable to be used in measuring technology exploration. The readings from Cronbach Alpha is at 0.95 *logit*, with item and person reliability at 0.94 *logit*. Both values for item reliability and person reliability reflected as a very good rating scale for a measurement (Fisher, 2007). Through the item measures and mean value (0.00 *logit*), the items were further grouped to success factors and challenges to represent easy and difficult items to be endorsed by respondents, and the most difficult and easiest items were abled to be picked from the list. Additionally, the two groups were then further analyzed to identify sub-categories. The study identified items that are considered to be achievable for organizations to take action upon, in the light of implementing technology exploration. The study also managed to sub-grouped the easy items into two distinct categories, namely the 'Important' and the 'Highly Important' items for further discussions.

5.9.2 Organizations Ability To Implement Technology Exploitation

The following set of Rasch analysis, attempts to conduct a deeper examination on the items that makes the construct of technology exploitation. Table 5.46 shows the list of items for the construct of technology exploitation sorted according to the item measures. The most difficult items are located at the top of the list, while the much easier items are located at the bottom of the table. The item measures as shown provide an initial impression of the location of the items in the continuum scale. A person-item variable map in Figure 5.19 below also helps to understand the position of the items along the continuum scale. Generally, the items can be grouped into two main categories, where the cut off point will be where the mean value (μ_{item}) is 0.00 *logit*. Items which are located below the μ_{item} = 0.00 *logit* are categorized as easy items, and items located above the μ_{item} = 0.00 *logit* are categorized under difficult items.

In order to compare the item measures for technology exploitation, the organizations will first be classified into a number of groups. As mentioned, a strata value will need to be calculated to understand how the organizations are spread along the measurement continuum. The summary statistic table for the construct of technology exploitation (Table 5.21), highlighted the person separation value as 2.26. Based from the strata calculation (H=(4G+2)/3), the strata value was finalized at 3.30, which depicted that the organizations can be spread adequately into four groups. The indication that the person strata separation is at the value between 3 to 4 denotes a very good quality criteria (Fisher, 2007). Using the figures from the summary statistic table of technology exploitation, the person mean ($\mu_{organization}$)$_{\text{, which}}$ is equal to 0.64 *logit*, and the SD $_{organization}$, which is at 0.73 *logit* , the following categorization matrix table was developed. Likewise, the researcher addresses the different categories as 'Excellent', 'Good', 'Regular', 'Poor', and 'Very Poor'.

Table 5. 46

Categorization Matrix for Technology Exploitation

Categories	**Position in normal distribution**	**Logit**	**n**	**%**
Excellent	$(\bar{x}+\sigma)$ to ∞	1.37 to ∞	10	14.3
Good	$\bar{x}$ to $(\bar{x}+\sigma)$	0.64 to 1.37	25	35.7
Regular	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.09 to 0.64	28	40.0
Poor	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-0.82 to -0.09	4	5.7
Very Poor	∞ to $(\bar{x}-2\sigma)$	∞ to -0.82	3	4.3
			70	**100**

Results from the categorization matrix table above highlights a few useful findings. Firstly, it can be seen that half of the organizations involved in this study, are those who can be grouped under 'Good' and 'Excellent' categories. The reason being is because the *logit* scorings for the two groups in the normal distribution are above the mean value of organizations ($\mu_{organization}$ = 0.64 *logit*). The two groups represents 50 percent of the total respondents. Meanwhile, another half (50%) of the respondents falls below the organization mean value. It can be further analyzed that out of this figure, the biggest portion (28 organizations) falls under the regular group. Only seven organizations are categorized as 'Poor' and 'Very Poor', which can be understood as those with lower logit scorings and can be viewed as having among the lowest ability to achieve the difficulties for items under technology exploitation construct.

Table 5. 47

Measure Order Of Items For Technology Exploitation

Item Code	Item	Measure	Model SE	Remarks
A13	Extent to which your company has acquired many companies in very different industries	0.98	0.22	Difficult Item
A21	Extent to which your company is willing to sell part of your IP (e.g. patent, trademark).	0.36	0.22	Difficult Item
A24	Extent to which your company has created various new lines of products and services	0.33	0.22	Difficult Item
A32	Extent to which your employees are regularly rotated between different functions in your company.	0.29	0.23	Difficult Item
A37	Extent to which your company uses temporary workgroups for collaboration between units on a regular basis	0.29	0.23	Difficult Item
A35	Extent to which your company has standardized work processes for cooperation between units	0.27	0.23	Difficult Item
A34	Extent to which your company has cross-functional teams to exchange knowledge between departments	0.04	0.23	Difficult Item
A36	Extent to which your company has often involve multiple organizational units in strategic decision-making	0.02	0.23	Difficult Item
A310	To what extent does your company award your employees if they bring external knowhow/technology that improves our products/services.	-0.22	0.23	Easy Item
A24	Extent to which your company believe that selling your IP rights through licensing is important for the growth of the company.	-0.26	0.24	Easy Item
A39	Extent to which your employees are sent for internal or external training which is directly aimed at the development and/or introduction of innovation	-0.30	0.24	Easy Item
A25	Extent to which your company believe that the government's efforts for protection of selling IP rights benefited your company.	-0.34	0.24	Easy Item
A312	When developing new ideas, to what extent does your company often consider the suggestions of	-0.34	0.24	Easy Item

Item Code	Item	Measure	Model SE	Remarks
	employees who are not part of the research and development team.			
A32	Extent to which there is regular discussion about possibilities for collaboration between units in your company.	-0.34	0.24	Easy Item
A22	Extent to which your company are prepared to introduce your products/services that have been developed through investing into a new joint venture	-0.42	0.24	Easy Item
A38	To what extent does your company actively encourage communication among unrelated groups of employees in the company.	-0.48	0.24	Easy Item
A26	Extent to which your company has focused on improving the performance of your current business rather than entering new industries	-0.56	0.25	Easy Item
A27	Extent to which your company cooperate with external partners when launching your own new products/services on the market.	-0.60	0.25	Easy Item
A28	Extent to which your company use external sources of know-how/technology when developing new activities related to the present operation of the company	-0.69	0.25	Easy Item
A29	Extent to which your company are willing to cooperate with the partners from the outside when developing new activities related to the present operation of the company	-2.23	0.27	Easy Item
	TOTAL = 20			

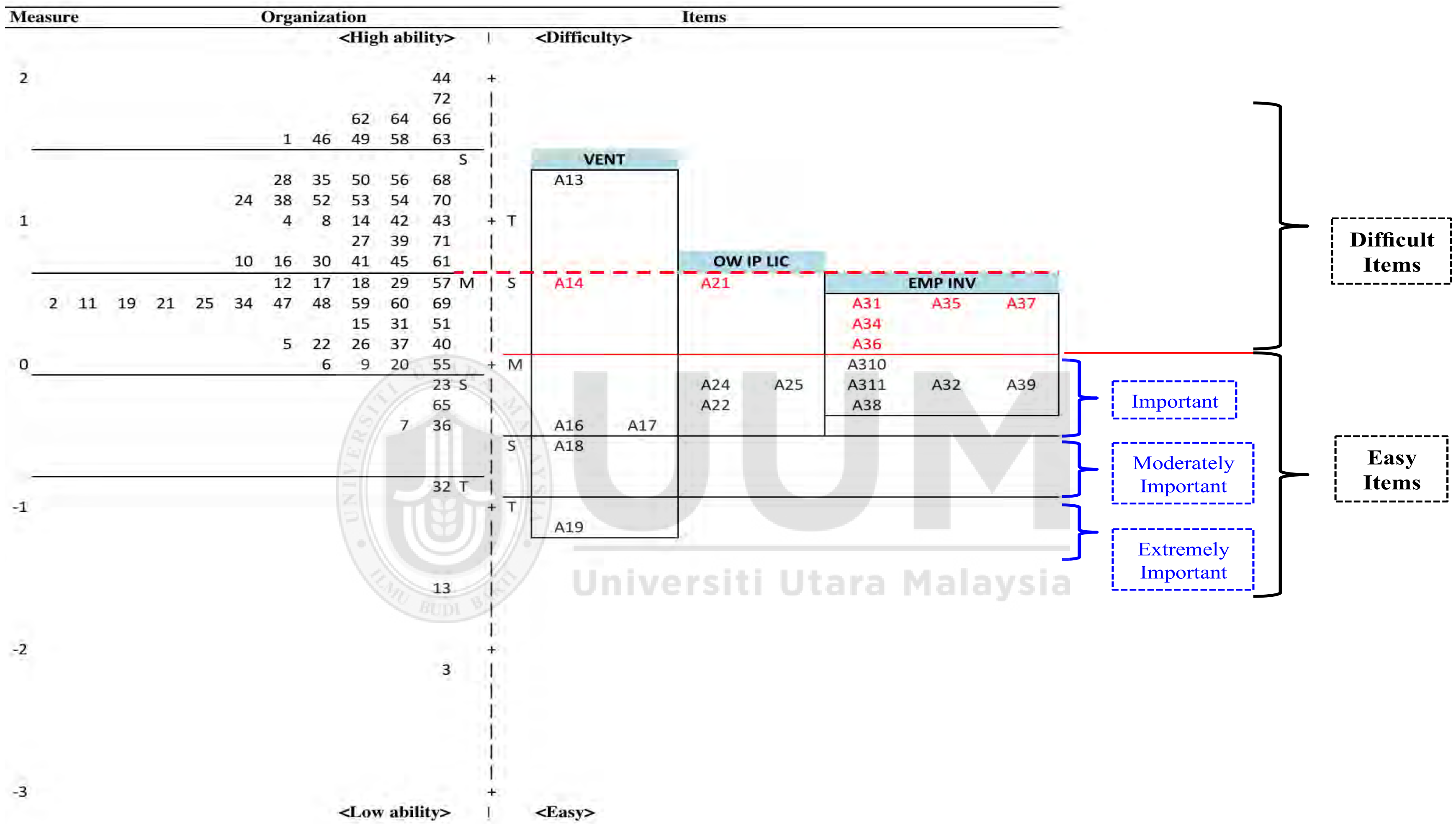

Figure 5. 18
Variable Map for Technology Exploitation

With regards to the item measurements for all items that add up to the construct, a thorough investigation needs to be conducted to understand the ability of respondents in employing technology exploitation. The item measures listing is tabled in Table 5.47, sorted in accordance to the item measures scoring by each item. Like previous exercise, the items are divided into two main categories; namely, the difficult and easy items. The μ_{item} =0.00 *logit* was chosen as the cut off value to differentiate between the two main groups. The item measures ranges from the lowest value of -2.23 *logit* to the highest of 0.98 *logit.* In particular, the difficult items sit between 0.02 *logit* to 0.98 *logit*, while the easy items is within the range of -2.23 *logit* to -0.22 *logit*. The division between these two categories can also be seen from the Rasch Wright person-item map in Figure 5.19 above.

For the purpose of discussion, the researcher chose to refer to the difficult items as challenges and the easy items as success factors. The two distinct group is needed in order to focus on the areas that require attention should the organizations intend of implementing a better technology exploitation in the future. The success factors items will also be sub divided to smaller groups to differentiate the level of difficulties in implementing the construct.

5.9.2.1 Challenges

The study initially began by choosing 25 items to represent three dimensions that shapes technology exploitation based on adopted questionnaires from previous studies in the same area. Out of the total number of items, 5 items were identified as outliers based on the Rasch fit data quality control. These items were not included for further analysis. From the remaining 20 items, 8 items were associated as difficult items. A closer look to the variable-map shown in Figure 5.19, will allow us to see that from the total number of difficult items, seven items were dispersed in between the μ_{item} and $\mu_{organization.}$ Although some organizations find difficulty in endorsing to these items, it can be considered that these items are highly achievable items to the organization in comparison to the items that sits at a higher position.

Table 5.48 below categorizes the challenges items for technology exploitation. The most difficult item to be agreed by most organizations (0.98 *logit*) is item A13, which represents the extent to which the companies acquired many other companies in a very different industries. This item is considered as a highly challenging item that requires attention if technology exploitation are to be encouraged among business organizations and SMEs in particular.

It can also be noticed that 7 other difficult items, are scattered between the mean items of 0.00 *logit* and the mean organization of 0.64 *logit*. As mentioned, these items, although seen as difficult, can be understood as challenges items that are achievable by organizations for a better implementation of technology exploitation. Therefore, for the necessary bodies to encourage more SMEs involvement in technology exploitation activities, these items should be focus in advance. It is also noteworthy to find that five out of seven items listed in the important category are from the dimensions of employee involvement (A32, A37, A35, A34 and A36).

Table 5. 48
Categorization Of Challenges Items For Technology Exploitation

Rank	Code	Item	Measure
Highly Challenging			
1	A13	Extent to which company acquired many other companies in very different industries	0.98
Challenging			
2	A21	Extent to which company is willing to sell part of their own IP (e.g. patent, trademark).	0.36
3	A24	Extent to which company created various new lines of products and services	0.33
4	A32	Extent to which employees are regularly rotated between different functions in the company.	0.29
5	A37	Extent to which company uses temporary workgroups for collaboration between units on a regular basis	0.29
6	A35	Extent to which company has a standardized work processes for cooperation between units	0.27
7	A34	Extent to which company has cross-functional teams to exchange knowledge between departments	0.04
8	A36	Extent to which company has often involve multiple organizational units in strategic decision-making	0.02

5.9.2.2 Success Factors

As for the easy items, where the item measures scoring are less than the item mean value of 0.00 *logit,* a more detailed analysis was conducted to broaden the understanding of how organizations perceive the implementation of technology exploitation. 12 items represent high endorseability with high *logit* scorings and three categories were further plotted; specifically the ‘Important’, ‘Moderately Important’, and ‘Highly Important’ group. The division between the groups was constructed based on the formula that takes into account the mean and standard deviation (SD) value of the items. The three groups were based on the 1st SD (S) and 2^{nd} SD (T). Table 5.49 below displays the matrix categorization for the easy items from the technology exploitation construct.

Table 5. 49
Categorization Matrix Have Items For Technology Exploitation

Categories	**Position In Normal Distribution**	**Range of Position in Item Measure**	**n**	**%**
Highly Important	2nd SD – ∞	-2.00 to - ∞	1	5
Moderately Important	1st SD - 2nd SD	-0.50 to -2.00 *logit*	3	25
Important	μ - 1^{st} SD	0.00 to -0.50 *logit*	8	40

It can be ascertained, from Table 5.49 above, one item is considered as being a highly important item. From the measure order of the items list, A29 has been captured as a highly important item. The item, which represents the 'willingness of the organization to cooperate with partners from the outside when developing new activities related to the present operation of the company' is seen to be the easiest item of all. It can also be understood that this item must be critically met for organizations wanting to implement technology exploitation in the future. The failure of doing so might pull down the organizations' ability to implement technology exploitation. 3 items are categorized as moderately important, as the items measures are within the range of the 1^{st} SD and 2^{nd} SD. Meanwhile, 8 items that sit in the important group represents the items that are perceived as worthy and need to be performed together with the other two groups of moderately important and highly important items. The measures which are the nearest to the value of 0.00 *logit* bring the meaning that if not attended or improvised might push the items to fall to difficult items category. These items if improvised or upgraded might give a better impact to organizations implementing it. Thus, as most organizations are able to performed all these items, it is fair to conclude that the important, moderately, and highly important items serve as a success factors for organizations implementing technology exploitation.

Table 5. 50
Measure Order Of Items For Technology Exploitation

Rank	Code	Item	Measure
Highly Important			
1	A29	Willingness to cooperate with the partners from the outside when developing new activities related to the present operation of the company.	-2.23
Moderately Important			
2	A28	The use of external sources of know-how/technology when developing new activities related to the present operation of the company	-0.69
3	A27	Cooperate with external partners when launching your own new products/services on the market.	-0.60
4	A26	Focused on improving the performance of your current business rather than entering new industries	-0.56
Important			
5	A38	Actively encourage communication among unrelated groups of employees in the company.	-0.48
6	A22	Preparedness to introduce your products/services that have been developed through investing into a new joint venture	-0.42
7	A25	Believe that the government's efforts for protection of selling IP rights benefited your company.	-0.34
8	A322	Often consider the suggestions of employees who are not part of the research and development team.	-0.34
9	A32	There are regular discussions about possibilities for collaboration between units in your company.	-0.34
10	A39	Employees are sent for internal or external training which is directly aimed at the development and/or introduction of innovation	-0.30
11	A24	Believe that selling the company’s IP rights through licensing is important for the growth of the company.	-0.26
12	A320	Award employees if they bring external knowhow/technology that improves company’s products/services.	-0.22

In general, the verification of the items used in technology exploitation has undeniably produced values that qualify the construct to be used as an instrument to measure technology exploitation. The Cronbach Alpha's (KR20) value of 0.90 further supports the notion. Both the person reliability index which is at 0.84 and the item reliability index value of 0.91 qualify as a 'Good' and 'Very Good' indicators in accordance to Fisher, (2007) quality scale.

5.9.3 Organizations Ability to Exercise Trust

The following analysis was conducted to answer the research question of "What are the success factors and challenges for organizations to achieve trust?". To do so, the same exercise applied to technology exploration and technology exploitation will be applied. This is done by studying the items that make up the trust constructs via their item measures with the attempt to scrutinize and understand the placement of each items in the logit continuum. The list of items used to measure the construct of trust are listed in Table 5.51, assembled and sorted according to each of their item measure. The most difficult items are located at the top of the list, while the much easier items are located at the bottom of the table. The item measure readings can also be understood as the reflection of how each of the items are plotted throughout the Rasch Wright person-item measurement scale. The position of these items is visualized in Figure 5.20 below. The items can be grouped into two main categories, where the cut off point will be where the mean value (μ_{item}) is at 0.00 *logit*. This position is to give a 50:50 chance for organizations to succeed in responding to the items that matches their ability. Therefore, the items which are located below the μ_{item} = 0.00 *logit* are categorized as easy items, and items located above the μ_{item} = 0.00 *logit* are categorized under difficult items.

Table 5. 51
Measure Order Of Items For Trust

Item Code	Item	Measure	Model SE	Remarks
D3N2	Extent to which your company feels that the industrial big players have gone out on a limb (risking their reputation) in times of shortages.	0.76	0.25	Difficult Item
D2N5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	0.74	0.25	Difficult Item
D3N3	Extent to which your company feels that the industrial big players have been on your side.	0.67	0.25	Difficult Item
D2N6	Extent to which your company is confident that the industrial big players honor their words.	0.59	0.26	Difficult Item
D2G3	Extent to which your company believes that the government and it's agencies are known to be successful at the things it tries to do.	0.57	0.26	Difficult Item
D2U6	Extent to which your company is confident that the research body honor their words.	0.57	0.26	Difficult Item
D3N7	Extent to which your company feels that the industrial big players work to protect your company.	0.52	0.26	Difficult Item
D3N6	Extent to which your company feels that the industrial big players are motivated to protect your company.	0.47	0.26	Difficult Item
D2U7	Extent to which your company is confident that the research body keep their promises.	0.42	0.26	Difficult Item
D3G9	Extent to which your company feels that the government and it's agencies look out for your company.	0.42	0.26	Difficult Item
D2U4	Extent to which your company can depend on the research body to be fair throughout the research project.	0.37	0.26	Difficult Item
D3N2	Extent to which your company feels the industrial big players care for you.	0.37	0.26	Difficult Item
D2U2	Extent to which your company believes that the research body has been frank in dealing with you.	0.35	0.26	Difficult Item
D3G2	Extent to which your company feels that the government and it's agencies have gone out on a limb (risking their reputation) in times of shortages.	0.35	0.26	Difficult Item
D3N8	Extent to which your company feels that the industrial big players watch your company back.	0.33	0.26	Difficult Item
D3U2	Extent to which your company feels that the research body cares for you.	0.30	0.26	Difficult Item
D2G2	Extent to which your company feels confident about the government and it's agencies capabilities.	0.25	0.26	Difficult Item

Item Code	Item	Measure	Model SE	Remarks
D2N3	Extent to which your company believes that the organization are known to be successful at the things it tries to do.	0.25	0.26	Difficult Item
D2N4	Extent to which your company can depend on the industrial big players are to be fair throughout the research project.	0.22	0.26	Difficult Item
D3U4	Extent to which your company feels that the research body is like a friend.	0.22	0.26	Difficult Item
D2U5	Extent to which your company feels that the university has enough resources to help your company for market expansion	0.20	0.26	Difficult Item
D3N5	Extent to which your company feels that the industrial big players have your company's best interests in mind.	0.20	0.26	Difficult Item
D2N4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	0.27	0.26	Difficult Item
D3G8	Extent to which your company feels that the research body watches your company back.	0.27	0.26	Difficult Item
D2G7	Extent to which your company is confident that the government and it's agencies keep their promises.	0.25	0.26	Difficult Item
D3U2	Extent to which your company feels that the research body has gone out on a limb (risking their reputation) in times of shortages.	0.25	0.26	Difficult Item
D2N3	Extent to which your company is confident that the industrial big players are honest about any problems that occurs during the partnering project duration.	0.22	0.26	Difficult Item
D2U3	Extent to which your company believes that the university is known to be successful at the things it tries to do.	0.20	0.26	Difficult Item
D3G5	Extent to which your company feels that the government and it's agencies have your company's best interests in mind.	0.20	0.26	Difficult Item
D2G5	Extent to which your company is confident that the government and it's agencies are honorable partners.	0.07	0.26	Difficult Item
D2N7	Extent to which your company is confident that the industrial big players keep their promises.	0.07	0.26	Difficult Item
D3U3	Extent to which your company feels that the government and it's agencies are like friends.	0.07	0.26	Difficult Item
D3G4	Extent to which your company feels that the research body has been on your side.	0.07	0.26	Difficult Item

Item Code	Item	Measure	Model SE	Remarks
D3U5	Extent to which your company feels that the government and it's agencies work to protect your company.	0.02	0.26	Difficult Item
D3G7	Extent to which your company feels that the research body has your company's best interests in mind.	0.02	0.26	Difficult Item
D2G8	Extent to which your company is confident that the government and it's agencies are telling the truth.	-0.02	0.26	Easy Item
D3N9	Extent to which your company feels that the industrial big players look out for your company.	-0.05	0.26	Easy Item
D2N2	Extent to which your company feels that the organization has the ability to accomplish what it says it will do	-0.08	0.26	Easy Item
D2U2	Extent to which your company feels that the university has the ability to accomplish what it says it will do	-0.10	0.26	Easy Item
D3G6	Extent to which your company feels that the government and it's agencies are motivated to protect your company.	-0.13	0.26	Easy Item
D2N2	Extent to which your company feels confident about the organization business capabilities.	-0.16	0.26	Easy Item
D2N2	Extent to which your company is confident that the industrial big players are knowledgeable about their products and market.	-0.19	0.26	Easy Item
D2U2	Extent to which your company feels confident about the research body's skills.	-0.19	0.27	Easy Item
D2N5	Extent to which your company is confident that the industrial big players are honorable partners.	-0.21	0.27	Easy Item
D2G4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	-0.21	0.27	Easy Item
D2N2	Extent to which your company believes that the industrial big players have been frank in dealing with you.	-0.21	0.27	Easy Item
D2G5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	-0.33	0.27	Easy Item
D2G2	Extent to which your company is confident that the government and it's agencies are knowledgeable about their functions.	-0.33	0.27	Easy Item
D2U8	Extent to which your company is confident that the research body is telling the truth.	-0.36	0.27	Easy Item

Item Code	Item	Measure	Model SE	Remarks
D2G2	Extent to which your company feels that the government and it's agencies have the ability to accomplish what it says it will do	-0.39	0.27	Easy Item
D2N8	Extent to which your company is confident that the industrial big players are telling the truth.	-0.44	0.27	Easy Item
D3U8	Extent to which your company feels that the research body watches your company back.	-0.47	0.27	Easy Item
D2G3	Extent to which your company is confident that the government and it's agencies are honest about any problems that occurs during the project duration.	-0.47	0.27	Easy Item
D2G2	Extent to which your company believes that the government and it's agencies have been frank in dealing with you.	-0.60	0.27	Easy Item
D2U4	Extent to which your company believes that the university has adequate knowledge in one or several area related to the working project.	-0.72	0.28	Easy Item
D3G3	Extent to which your company feels that the government and it's agencies have been on your side.	-0.82	0.28	Easy Item
D3U7	Extent to which your company feels that the research body work to protect your company.	-0.85	0.28	Easy Item
D3U9	Extent to which your company feels that the research body looks out for your company.	-0.92	0.28	Easy Item
D2G4	Extent to which your company can depend on the government and it's agencies to be fair throughout the research project.	-1.17	0.29	Easy Item
D3G1	Extent to which your company feels that the government and it's agencies care for you.	-1.32	0.29	Easy Item

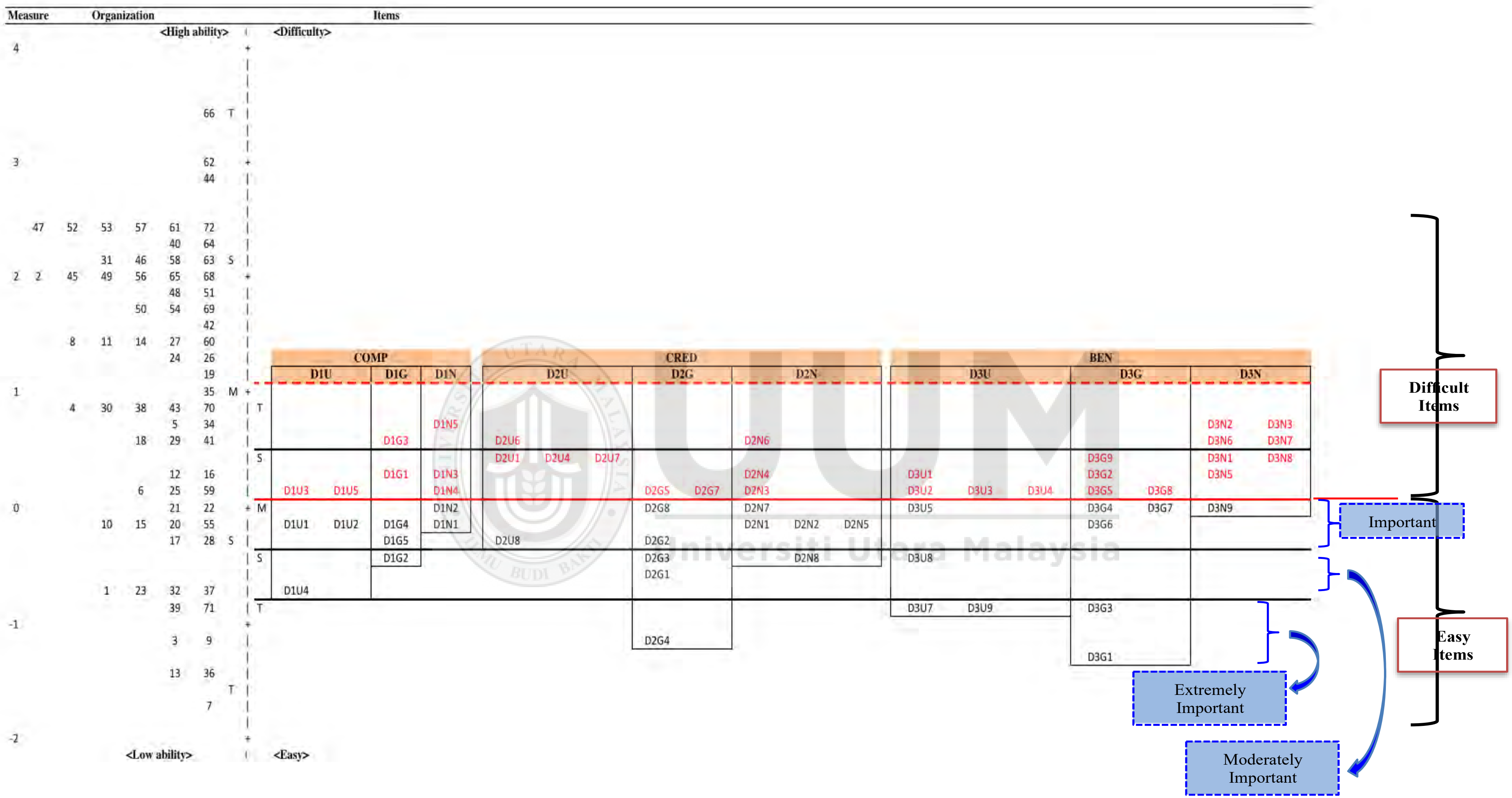

Figure 5. 19

Variable Map for Trust

For the purpose of discussion, again, the researcher choose to refer to the easy items as success factors and the difficult items as challenges, which needs to be focused on, should the organizations intend to exercise a better trust in the future. The success factor items will also be sub divided into smaller groups to differentiate the level of difficulties in implementing the construct. The items will be father grouped under highly challenges, moderately challenges and challenges items. Prior to that, a further strata value analysis was conducted to learn how many groups can the organizations represent in the light of their ability to exercise the trust construct. To do so, some important readings was extracted from the summary statistic table (Table 5.25). With the value of person separation equals to 6.05 *logit*, the strata value was confirmed at 8.40, which shows that the organizations can be spread adequately into eight groups. This indicator is regarded as an excellent value to reflect the trust construct as tabled by Fisher, (2007). Moreover, using the person mean value of 0.96 *logit*, and the SD of 1.23 *logit*, the following categorization matrix Table 5.52 was constructed. With reference to the other construct of the studies, the researcher addresses the different categories as 'Excellent', 'Good', 'Regular', 'Poor', and 'Very Poor'.

Table 5. 52
Categorization Matrix for Trust

Categories	Position in normal distribution	Logit	n	%
Excellent	$(\bar{x}+2\sigma)$ to ∞	3.42 to ∞	1	1.4
Very Good	$(\bar{x}+\sigma)$ to $(\bar{x}+2\sigma)$	2.19 to 3.42	12	17.1
Good	$\bar{x}$ to $(\bar{x}+\sigma)$	0.96 to 2.19	22	31.4
Regular	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.27 to 0.96	22	31.4
Poor	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-1.50 to -0.27	12	17.1
Very Poor	∞ to $(\bar{x}-3\sigma)$	∞ to -1.50	1	1.4
			70	**100**

The categorization matrix table above brings together a few useful results. Firstly, it can be seen that half of the organizations involved in this study, are those who can be grouped under 'Good', 'Very Good' and 'Excellent' categories. The reason being is because the *logit* scorings for these three groups in the normal distribution are above the organization mean value of 0.96 *logit*. The three groups represents 50 percent of the total respondents. Meanwhile, another half (50%) of the respondents falls below the organization mean value, where the biggest portion (22 organizations) are under the regular group. The remaining of 12 other organizations are categorized as 'Poor' and one organization falls under a 'Very Poor' category.

5.9.3.1 Challenges

The trust construct was made up of 66 items in the beginning of the study but was further reduced to 60 items as 6 items were considered outliers. The decision was made due to the fact that the item readings for outfit MNSQ, outfit ZSTD and the Point Measure Correlation value that does not achieved the desired quality control criteria. The construct of trust contain three dimensions as referred to previous literatures, namely Competency, Credibility, and Benevolence. Each of these dimensions was further divided into three subgroups to represent trust towards the three institutions of triple helix. The first being the research body (universities, R&D Labs etc.); the second is the government (Ministries, agencies, etc.); and the third is the Industry (large industries or business key players). 35 items out of the 60 total trust items belong to the difficult item group, while the other 25 items are considered as easy items. Unlike the previous constructs discussed in the earlier section of this study, where the proportion of the easy items are much bigger than the difficult items; trust, on the other hand shows a different result. The total number of difficult items seems to outweigh the easier items. It can therefore be learnt that organizations are faced with difficulties in endorsing to the items in trust construct.

A closer look to the difficult items, leads to the point that all difficult items are within the range of mean item and the mean organization. This can be seen from Figure 5.20. The meaning to this is that, even though organizations find difficulty in endorsing to these items, but it can be considered that these items are highly achievable items to the organizations. Table 5.53 below list the categorization matrix for the difficult items of trust. Out of the three groups, the highest contributor to the difficult group came from the benevolence trust cluster with 18 items out of the total 35 difficult items. This represents 51.4% from the total items. Out of this, the biggest portion are the benevolence towards industries, which contributed 20% of the total difficult items.

The second group is the credibility trust, which takes up 28.5% from the total difficult items of the construct. It can be seen that the most difficult trust items for credibility trust is the credibility trust towards research bodies and industries where both indicate 11.4%.

The least of all the three components of difficult items is the competence trust (20.0%) and the most challenging items to be conformed is the competence trust towards industries (8.6%).

Table 5. 53
Categorization Matrix for Challenging Items– Categories of Trust

Dimensions	**Codes**	**n**	**%**
Competence	D1	(7)	20.00
Research Bodies	D1U	2	5.7
Government	D1G	2	5.7
Industries	D1N	3	8.6
Credibility	D2	(9)	28.50
Research Bodies	D2U	4	11.4
Government	D2G	2	5.7
Industries	D2N	4	11.4
Benevolence	D3	(18)	51.40
Research Bodies	D3U	5	14.3
Government	D3G	6	17.1
Industries	D3N	7	20.0
TOTAL		**35 items**	

Apart from identifying which out of the three trust group contributed to the most challenging items, there is also a need to pinpoint the most difficult item to be endorsed by most of the organizations. This is done by selecting the item with the highest item measure from the list of all items involve in the construct of trust. In the case of trust constructs, all the items are scattered within the range of mean item and mean organization. Therefore, following the practice of previous construct analysis, all the difficult items of trust are grouped and referred as 'challenging' and no item falls under the highly challenging group.

Table 5. 54
Categorization Of Challenging Items For Trust

Rank	Code	Item	Measure
Challenging			
1	D3N2	Extent to which your company feels that the industrial big players have gone out on a limb (risking their reputation) in times of shortages.	0.76
2	D2N5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	0.74
3	D3N3	Extent to which your company feels that the industrial big players have been on your side.	0.67
4	D2N6	Extent to which your company is confident that the industrial big players honor their words.	0.59
5	D2G3	Extent to which your company believes that the government and it's agencies are known to be successful at the things it tries to do.	0.57
6	D2U6	Extent to which your company is confident that the research body honor their words.	0.57
7	D3N7	Extent to which your company feels that the industrial big players work to protect your company.	0.52
8	D3N6	Extent to which your company feels that the industrial big players are motivated to protect your company.	0.47
9	D2U7	Extent to which your company is confident that the research body keep their promises.	0.42
10	D3G9	Extent to which your company feels that the government and it's agencies look out for your company.	0.42
11	D2U4	Extent to which your company can depend on the research body to be fair throughout the research project.	0.37
12	D3N2	Extent to which your company feels the industrial big players care for you.	0.37
13	D2U2	Extent to which your company believes that the research body has been frank in dealing with you.	0.35
14	D3G2	Extent to which your company feels that the government and it's agencies have gone out on a limb (risking their reputation) in times of shortages.	0.35
15	D3N8	Extent to which your company feels that the industrial big players watch your company back.	0.33

16	D3U2	Extent to which your company feels that the research body cares for you.	0.3
17	D2G2	Extent to which your company feels confident about the government and it's agencies capabilities.	0.25
18	D2N3	Extent to which your company believes that the organization are known to be successful at the things it tries to do.	0.25
19	D2N4	Extent to which your company can depend on the industrial big players are to be fair throughout the research project.	0.22
20	D3U4	Extent to which your company feels that the research body is like a friend.	0.22
21	D2U5	Extent to which your company feels that the university has enough resources to help your company for market expansion	0.2
22	D3N5	Extent to which your company feels that the industrial big players have your company's best interests in mind.	0.2
23	D2N4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	0.27
24	D3G8	Extent to which your company feels that the research body watches your company back.	0.27
25	D2G7	Extent to which your company is confident that the government and it's agencies keep their promises.	0.25
26	D3U2	Extent to which your company feels that the research body has gone out on a limb (risking their reputation) in times of shortages.	0.25
27	D2N3	Extent to which your company is confident that the industrial big players are honest about any problems that occurs during the partnering project duration.	0.22
28	D2U3	Extent to which your company believes that the university is known to be successful at the things it tries to do.	0.2
29	D3G5	Extent to which your company feels that the government and it's agencies have your company's best interests in mind.	0.2
30	D2G5	Extent to which your company is confident that the government and it's agencies are honorable partners.	0.07
31	D2N7	Extent to which your company is confident that the industrial big players keep their promises.	0.07

32	D3U3	Extent to which your company feels that the government and it's agencies are like friends.	0.07
33	D3G4	Extent to which your company feels that the research body has been on your side.	0.07
34	D3U5	Extent to which your company feels that the government and it's agencies work to protect your company.	0.02
35	D3G7	Extent to which your company feels that the research body has your company's best interests in mind.	0.02

With reference to Table 5.54 above, the highest item measure is 0.76 *logit* which belongs to item D3N2 and reflects the Extent to which the company feels that the industrial big players have gone out on a limb, risking their reputation in times of shortages. Although , on one hand, there were evidence from previous studies that shows how smaller organization can benefit from strategic alliances or collaborations activities with bigger players, but empirical studies on the other hand, has also shown how smaller organizations may risk themselves to larger organizations (H. Yang, Zheng, & Zhao, 2014) when participating in the collaboration environment with high uncertainties.

5.9.3.2 Success Factors

Next is to assess the easy items, where the item measures scoring are less than the item mean value of 0.00 *logit.* Further analysis to this cluster drew some findings that can be further discussed. To begin with, the divisions between the group were constructed based on the formula that takes into account the mean and standard deviation (SD) value of the items. When mapped to the list of item measures, three categories managed to be plotted. The three categories were based on the 1st SD (S), 2nd SD (T). For easy reference, the study choose to specifically differentiate the groups as 'Important', 'Moderately Important', and 'Highly Important'. Table 5.55 below display the categorization for easy items under trust construct.

Table 5. 55
Categorization of Items – Trust

Categories	Position In Normal Distribution	Range of Position in Item Measure	n	%
Highly Important	2nd SD – ∞	-0.90 to -1.35 *logit*	3	12
Moderately Important	1st SD - 2nd SD	-0.45 to -0.90 *logit*	6	24
Important	μ - 1st SD	0.00 to - 0.45 *logit*	16	64

The categorizations of the easy items are another important points to discuss about. Overall, it can be understood that the three groupings for easy items as shown in Table 5.55 above, signify that organizations are able to look into areas in trust that has exactingly perceived as easy to be endorsed to. These areas, if taken seriously, may enhance and create a better, if not stronger ties between the organizations and helices involved in the triple helix projects. From the list the easiest item of all, the lowest *logit* scoring of -1.32 logit is D3G1, which represents the extent to which organization feels that the government and it's agencies care for the company. In order words, the organizations believe that there is no issue with this statement and therefore it is highly agreeable. Thus, importantly, for organizations to build a better trust in the future, especially in the light of triple helix, it is very important that this area must be taken care and nurtured. Aside from item D3G1, two more items that fall under 'Extremely Important' category are D2G4 (Extent to which organization can depend on the government and it's agencies to be fair throughout the research project) and D3U9 (Extent to which organization feels that the research body looks out for the company). Aside from that, six items are grouped under the category of moderately important, while 16 remaining items are classified as important. Details of the items for these categories is presented in Table 5.56 below.

Table 5. 56
Measure Order Of Items For Trust

Rank	Code	Item	Measure
Highly Important			
1	D3G1	Extent to which your company feels that the government and it's agencies care for you.	-1.32
2	D2G4	Extent to which your company can depend on the government and it's agencies to be fair throughout the research project.	-1.17
3	D3U9	Extent to which your company feels that the research body looks out for your company.	-0.92
Moderately Important			
4	D3U7	Extent to which your company feels that the research body work to protect your company.	-0.85
7	D3G3	Extent to which your company feels that the government and it's agencies have been on your side.	-0.82
8	D1U4	Extent to which your company believes that the university has adequate knowledge in one or several area related to the working project.	-0.72
9	D2G1	Extent to which your company believes that the government and it's agencies have been frank in dealing with you.	-0.60
10	D3U8	Extent to which your company feels that the research body watches your company back.	-0.47
11	D2N8	Extent to which your company is confident that the industrial big players are telling the truth.	-0.44
Important			
12	D2G3	Extent to which your company is confident that the government and it's agencies are honest about any problems that occurs during the project duration.	-0.47
13	D1G2	Extent to which your company feels that the government and it's agencies have the ability to accomplish what it says it will do	-0.39
14	D2U8	Extent to which your company is confident that the research body is telling the truth.	-0.36

15	D2G2	Extent to which your company is confident that the government and it's agencies are knowledgeable about their functions.	-0.33
16	D1G5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	-0.33
17	D2N1	Extent to which your company believes that the industrial big players have been frank in dealing with you.	-0.21
18	D1G4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	-0.21
19	D2N5	Extent to which your company is confident that the industrial big players are honorable partners.	-0.21
20	D1U1	Extent to which your company feels confident about the research body's skills.	-0.19
21	D1N1	Extent to which your company is confident that the industrial big players are knowledgeable about their products and market.	-0.19
22	D2N2	Extent to which your company feels confident about the organization business capabilities.	-0.16
23	D1U2	Extent to which your company feels that the government and it's agencies are motivated to protect your company.	-0.13
24	D3G6	Extent to which your company feels that the university has the ability to accomplish what it says it will do	-0.10
25	D1N2	Extent to which your company feels that the organization has the ability to accomplish what it says it will do	-0.08
26	D3N9	Extent to which your company feels that the industrial big players look out for your company.	-0.05
27	D2G8	Extent to which your company is confident that the government and it's agencies are telling the truth.	-0.02

In summary, the trust construct has been verified through its person and item measures and has produced an acceptable results and can therefore be considered reliable to be used in measuring trust among organizations. Results from the analysis has shown that the Cronbach alpha's value posit a high value of 0.98, while the item reliability is equals to 0.85 *logit* , and persons (organization) reliability is equal to 0.97. The readings for item and person reliability, when justified to the quality scale by Fisher (2007), indicated that the items for the instrument is at 'good' state and reliable, where else, the person reliability achieved an 'excellent' state and can be understood that the instruments have perfectly fit to the organization chosen.

5.10 Perspective III: Organization Profiling and The Potential Values of Open Innovation Adoption Based on Technology Exploration, Technology Exploitation and Trust

The final objective of the study is to profile the organizations and to analyze the potential values of open innovation adoption, based on the implementation of technology exploration, technology exploitation and trust. To do so, a few analyses will have to be conducted via Rasch analysis. This section will focus mainly on the item and person measures, accompanied by some important values, which will be derived from the summary statistic table developed from the earlier stage of analysis. The comparison of $mean_{item}$ values for each construct will be conducted to prove the importance of technology exploration, technology exploitation, as well as trust towards open innovation. The use of variable-map will be highly emphasized to assist in visualizing the placement of persons and the items along the *logit* continuum.

5.10.1 Summary Statistics

To begin with, a summary statistics table with all the constructs will be built via Winsteps application. A total of 124 items were assembled from four constructs; which are technology exploration, technology exploitation, trust and open innovation adoption. A total of 8,750 active data points from 70 respondents were reported from the global fit statistics report. No missing datapoints were detected, and therefore the number of active datapoints denoted the fact data are large enough to remain useful for the organization measure estimated and fit for a practical item calibration. The result from all constructs put together, is displayed in the summary statistics table as below:

Table 5. 57
Summary Fit Statistics for All

	Item (i = 124)	***Person (N=70)***
	Measure	
Mean	0.00	0.73
SD	0.48	0.85
Maximum Measure	1.59	2.40
Minimum Measure	-1.20	-1.34
Reliability Indices		
Separation	2.90	6.98
Reliability	0.89	0.98
Std Error	0.04	0.10
Cronbach Alpha (KR-20)	0.99	

Table 5.57 shows the summary fit statistics of 70 organizations involved. From the summary fit statistics above, the Cranach's alpha (KR-20) reported an excellent internal consistency reliability of 0.99. This value serves as an indicator that the respondents are responding consistently to all the items involved. The item reliability is equals to 0.89 *logit* with the SE value of 0.04 *logit*. On the other hand, the organization (person) reliability reported a value of 0.98 *logit* with the standard error (SE) value of 0.10 *logit*. This value is considered an excellent value that can be presented for an instrument (Fisher,

2007). Therefore, a conclusion that can be drawn from these fact is the 124 items put together, provided a good range of difficulties in measuring the organizations' ability towards the various levels of difficulties (Fisher, 2007).

The person separation was used to calculate the number of statistically distinct levels (strata) of organizations that can be explained through all the items involved (Wright & Masters, 2002). The formula of (H = (4 x person separation index + 1) /3) was used; and the statistical scoring resulted to 9.60, indicating an excellent criterion (Fisher, 2007).

Table 5.58 was developed to explain on the categorization of organizations that can be further explained and analyze. The organizations were separated into 6 categories (following the person separation value of 6.98 *logit*) as tabled below.

Table 5. 58
Categorization Matrix for Organizations with Technology Exploration, Technology Exploitation, Trust and Open Innovation Adoption

Categories	**Position in normal distribution**	**Logit**	**n**	**%**
Excellent	$(\bar{x}+2\sigma)$ to∞	2.43 to 3.28	3	4.3
Very Good	$(\bar{x}+\sigma)$ to $(\bar{x}+2\sigma)$	1.58 to 2.43	11	15.7
Good	$\bar{x}$ to $(\bar{x}+\sigma)$	0.73 to 1.58	27	38.6
Regular	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.12 to 0.73	16	22.9
Poor	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-0.97 to -0.12	11	15.7
Very Poor	∞ to $(\bar{x}-2\sigma)$	-1.82 to -0.97	2	2.9
			70	**100**

The following table lists down the person measures for all the organizations involved in the study. The reason to do so, is to further understand the nature and characteristics of organizations that falls under the same groupings listed above.

Table 5. 59
Person Measure Order Of Organizations Profiling

No	Organization Code	Measure	Model SE
Excellent			
1	62	2.40	0.15
2	44	2.33	0.15
3	66	2.28	0.15
Very Good			
4	72	1.88	0.14
5	64	1.84	0.13
6	58	1.77	0.13
7	52	1.70	0.13
8	68	1.65	0.13
9	46	1.60	0.13
10	57	1.59	0.13
11	53	1.57	0.13
12	42	1.55	0.13
13	63	1.54	0.13
14	47	1.49	0.13
Good			
15	49	1.41	0.12
16	61	1.41	0.12
17	56	1.37	0.12
18	54	1.32	0.12
19	35	1.29	0.12
20	08	1.28	0.12
21	69	1.26	0.12
22	24	1.24	0.12
23	27	1.18	0.12
24	45	1.17	0.12
25	50	1.17	0.12
26	31	1.15	0.12
27	19	1.03	0.11

No	Organization Code	Measure	Model SE
28	48	1.03	0.11
29	51	1.03	0.11
30	14	0.93	0.11
31	60	0.93	0.11
32	04	0.90	0.11
33	43	0.90	0.11
34	40	0.89	0.11
35	65	0.89	0.11
36	05	0.86	0.11
37	02	0.85	0.11
38	38	0.83	0.11
39	70	0.83	0.11
40	11	0.80	0.11
41	29	0.62	0.11
Regular			
42	34	0.60	0.11
43	41	0.60	0.11
44	26	0.59	0.11
45	30	0.55	0.11
46	18	0.45	0.10
47	25	0.34	0.10
48	59	0.34	0.10
49	17	0.33	0.10
50	10	0.24	0.10
51	16	0.21	0.10
52	28	0.21	0.10
53	21	0.20	0.10
54	12	0.18	0.10
55	22	0.18	0.10
56	01	0.06	0.10
57	20	0.02	0.10
Poor			
58	55	0.02	0.10
59	06	0.01	0.10
60	15	0.01	0.10

No	Organization Code	Measure	Model SE
61	37	-0.16	0.10
62	39	-0.27	0.09
63	71	-0.27	0.09
64	23	-0.52	0.09
65	09	-0.71	0.09
66	32	-1.02	0.10
67	07	-1.05	0.10
68	36	-1.06	0.10
Very Poor			
69	13	-1.29	0.10
70	03	-1.34	0.10

Moving forward, what can be seen from Table 5.59 above is that most of the organizations falls under the category of ‘Good’ (38.6%) and ‘Regular’ (22.9%). This results unveiled that majority of the organizations are able to endorsed most of the items in all constructs involved. A closer look to the two highest groups which are the ‘Excellent’ and the ‘Very Good’ category will explain that majority of the organizations under these two groups are those that share common characteristics in terms of the size of organization, the average sales and the average profits. Table 5.60 represents the percentage of the abilities for the organizations in these two highest categories. More than 90% of the organizations in the ‘Excellent’ group are those who had above average for the three characteristics. In the case of ‘Very Good’ category, more than 60% of the organizations declared above average for two of the characteristics. It is however noticeable, that out of the total number of organization under this group, only 27.3% reported above average profits.

Table 5. 60
Analysis Of The Common Characteristics For The Two Highest Groups

Characteristics	Groups	
	Very Good	Excellent
Organization Size	91.0%	100%
Average Sales	63.6%	100%
Average Profit	27.3%	91%

It is also important to have a closer look at the two most bottom group in the organizations profiling, which in this study are referred to as 'Poor' and 'Very Poor'. The understanding of the common characteristics shared by these group is important in order to understand as well as to find the reasoning's that explain the position of the group in continuum. In addition, the understanding of the commonality shared by this group enable the respective parties to tackle the basic reasoning to push them to a higher level of group for better adoption of open innovation in the future.

The Table 5.61 below, further explains the common characteristics shared by most organizations under the two groups of 'Poor' and 'Very Poor'. The findings showed that more than 55% of organizations achieve below average for the three reported characteristics. This is true to the 'Poor' group, and as for the 'Very Poor' group, all organizations that belongs here are those with below average ability.

Table 5. 61
Analysis Of The Common Characteristics For The Two Bottom Groups

	Groups	
Characteristics	**Poor**	**Very Poor**
Organization Size	54.5%	100%
Average Sales	63.6%	100%
Average Profit	91%	100%

Therefore, from the organization profiling, it can be understood that organizations under the same abilities shared several commonalities in terms of characteristics and that is namely; the size of organizations; the average sales; and the average profits.

5.10.2 Items and Persons Measure Order

In order to look at the ability of organizations to achieve the difficulties of items from all constructs (technology exploration, technology exploitation, trust, and open innovation adoption), the following steps will table all the 124 items involved according to their item measures and the standard errors (SE). The items will be sorted according to their measures, which points to their placement along the Rasch continuum scale. The same practice of identifying the difficult and the easy items will be conducted. Each item measure will then be compared to the mean item (μ_{item}) value of 0.00 *logit*. The items with the scoring above the μ_{item}, will be classified as difficult items, whilst the item measures with value lesser than the μ_{item}, will be observed as easy items. Additionally, a variable-map will be constructed to see how each item from all constructs are scattered in the logit continuum.

Table 5. 62
Measure Order Of Items For Technology Exploration, Technology Exploitation, Trust and Open Innovation Adoption

Item Code	Item	Measure	Model SE
Difficult Item			
	Highly Challenging		
B59	To what extent does your company collaborate with: 4) Your competitors	1.56	0.14
B14	Extent to which your company engage with your customers in training or instructing others (as trainer).	1.20	0.13
B41	Extent to which your company usually buy the intellectual property of other companies to ensure successful development of your company's new products/services.	1.15	0.13
A13	Extent to which your company has acquired many companies in very different industries	0.98	0.12
B510	To what extent does your company collaborate with:5) Other companies engaged in activities which are different than yours	0.84	0.14
B34	Extent to which your company acquire new know-how/technology through mentoring university interns.	0.80	0.14
D3N2	Extent to which your company feels that the industrial big players have gone out on a limb (risking their reputation) in times of shortages.	0.76	0.15
C32	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 2) Designs	0.75	0.16
D1N5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	0.74	0.15
C33	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 3) Trademarks	0.73	0.16
	Highly Challenging		
D3N3	Extent to which your company feels that the industrial big players have been on your side.	0.67	0.15
B54	To what extent does your company has internal structures and processes for managing partnerships and networks?	0.65	0.14

Item Code	Item	Measure	Model SE
C34	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 4) Copyrights	0.65	0.16
C31	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 1) Patents	0.60	0.16
D2N6	Extent to which your company is confident that the industrial big players honor their words.	0.59	0.16
D1G3	Extent to which your company believes that the government and it's agencies are known to be successful at the things it tries to do.	0.57	0.16
D2U6	Extent to which your company is confident that the research body honor their words.	0.57	0.16
D3N7	Extent to which your company feels that the industrial big players work to protect your company.	0.52	0.16
D3N6	Extent to which your company feels that the industrial big players are motivated to protect your company.	0.47	0.16
B53	To what extent does your company use Internet platforms and virtual networks for posting challenges to get ideas for product/ service development?	0.46	0.14
D2U7	Extent to which your company is confident that the research body keep their promises.	0.42	0.16
D3G9	Extent to which your company feels that the government and it's agencies look out for your company.	0.42	0.16
D2U4	Extent to which your company can depend on the research body to be fair throughout the research project.	0.37	0.16
D3N1	Extent to which your company feels the industrial big players care for you.	0.37	0.16
A21	Extent to which your company is willing to sell part of your IP (e.g. patent, trademark).	0.36	0.12
D2U1	Extent to which your company believes that the research body has been frank in dealing with you.	0.35	0.16
D3G2	Extent to which your company feels that the government and it's agencies have gone out on a limb (risking their reputation) in times of shortages.	0.35	0.16
B42	Extent to which your company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	0.34	0.14
A14	Extent to which your company has created various new lines of products and services	0.33	0.12
D3N8	Extent to which your company feels that the industrial big players watch your company back.	0.33	0.16

Item Code	Item	Measure	Model SE
D3U1	Extent to which your company feels that the research body cares for you.	0.30	0.16
D1G1	Extent to which your company feels confident about the government and it's agencies capabilities.	0.25	0.16
D1N3	Extent to which your company believes that the organization are known to be successful at the things it tries to do.	0.25	0.16
B17	Extent to which your company cooperate with your customers to acquire new knowhow/technology.	0.22	0.14
D2N4	Extent to which your company can depend on the industrial big players are to be fair throughout the research project.	0.22	0.16
D3U4	Extent to which your company feels that the research body is like a friend.	0.22	0.16
C36	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 6) Join development agreements	0.20	0.16
D1U5	Extent to which your company feels that the university has enough resources to help your company for market expansion	0.20	0.16
D3N5	Extent to which your company feels that the industrial big players have your company's best interests in mind.	0.20	0.16
A31	Extent to which your employees are regularly rotated between different functions in your company.	0.19	0.13
A37	Extent to which your company uses temporary workgroups for collaboration between units on a regular basis	0.19	0.13
A35	Extent to which your company has standardized work processes for cooperation between units	0.17	0.13
D1N4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	0.17	0.16
D3G8	Extent to which your company feels that the research body watches your company back.	0.17	0.16
D2G7	Extent to which your company is confident that the government and it's agencies keep their promises.	0.15	0.16
D3U2	Extent to which your company feels that the research body has gone out on a limb (risking their reputation) in times of shortages.	0.15	0.16
D2N3	Extent to which your company is confident that the industrial big players are honest about any problems that occurs during the partnering project duration.	0.12	0.16
D1U3	Extent to which your company believes that the university is known to be successful at the things it tries	0.10	0.16

Item Code	Item	Measure	Model SE
	to do.		
D3G5	Extent to which your company feels that the government and it's agencies have your company's best interests in mind.	0.10	0.16
D2G5	Extent to which your company is confident that the government and it's agencies are honorable partners.	0.07	0.16
D2N7	Extent to which your company is confident that the industrial big players keep their promises.	0.07	0.16
D3G4	Extent to which your company feels that the government and it's agencies are like friends.	0.07	0.16
D3U3	Extent to which your company feels that the research body has been on your side.	0.07	0.16
B43	Extent to which your company believe that buying IP rights through licensing from other companies is important for the growth of the company.	0.05	0.15
A34	Extent to which your company has cross-functional teams to exchange knowledge between departments	0.04	0.13
A36	Extent to which your company has often involve multiple organizational units in strategic decision-making	0.02	0.13
D3G7	Extent to which your company feels that the government and it's agencies work to protect your company.	0.02	0.16
D3U5	Extent to which your company feels that the research body has your company's best interests in mind.	0.02	0.16
D2G8	Extent to which your company is confident that the government and it's agencies are telling the truth.	-0.01	0.16
D3N9	Extent to which your company feels that the industrial big players look out for your company.	-0.01	0.16
B16	Extent to which your company usually developed new product/service in light of customer wishes and suggestions.	-0.06	0.15
B32	Extent to which your company is willing to purchased creative work of others parties to increase the stock of knowledge and its use to devise new and improved goods, services and processes.	-0.06	0.15
D1N2	Extent to which your company feels that the organization has the ability to accomplish what it says it will do	-0.06	0.16
C11	The extent to which your collaboration with external partners helps your company to reduce innovation risk.	-0.08	0.17
B12	Extent to which your customers are usually involved in the process of new product/service	-0.09	0.15

Item Code	Item	Measure	Model SE
	development.		
B55	To what extent does your company regularly exchanges business information with salesperson or marketers?	-0.09	0.15
D1U2	Extent to which your company feels that the university has the ability to accomplish what it says it will do	-0.11	0.16
D3G6	Extent to which your company feels that the government and it's agencies are motivated to protect your company.	-0.11	0.16
A310	To what extent does your company award your employees if they bring external knowhow/technology that improves our products/services.	-0.12	0.13
C12	The extent to which your collaboration with external partners helps your company to reduce new product/process development cost	-0.13	0.17
D1N1	Extent to which your company feels confident about the organization business capabilities.	-0.14	0.16
D2N2	Extent to which your company is confident that the industrial big players are knowledgeable about their products and market.	-0.14	0.16
D1U1	Extent to which your company feels confident about the research body's skills.	-0.17	0.17
D2N5	Extent to which your company is confident that the industrial big players are honorable partners.	-0.17	0.17
B33	Extent to which your company acquire new know-how/technology through informal ties with researchers from various laboratories.	-0.20	0.15
B44	Extent to which your company believe that the government's efforts for protection of buying IP rights benefited your company.	-0.20	0.15
B51	To what extent does your company actively engaged as a member of a cluster?	-0.20	0.15
B57	To what extent does your company collaborate with:2) Your suppliers	-0.20	0.15
D1G4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	-0.20	0.17
D2N1	Extent to which your company believes that the industrial big players have been frank in dealing with you.	-0.20	0.17
B11	Extent to which your company obtain important product/market information from our customers rather	-0.22	0.15

Item Code	Item	Measure	Model SE
	than internal sources (internal search).		
B511	To what extent does your company collaborate with: 6) Other companies engaged in high technology industries	-0.22	0.15
A24	Extent to which your company believe that selling your IP rights through licensing is important for the growth of the company.	-0.26	0.14
B31	Extent to which your company acquire new know-how/technology through R&D services provided by knowledge institutions such as universities, faculties, institutes, laboratories, etc.	-0.27	0.15
A39	Extent to which your employees are sent for internal or external training which is directly aimed at the development and/or introduction of innovation	-0.30	0.14
C22	To what extent does your company collaborated with external partners in the following innovation phase: 2) The experimentation process?	-0.31	0.17
D1G5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	-0.31	0.17
D2G2	Extent to which your company is confident that the government and it's agencies are knowledgeable about their functions.	-0.31	0.17
A25	Extent to which your company believe that the government's efforts for protection of selling IP rights benefited your company.	-0.34	0.14
A311	When developing new ideas, to what extent does your company often consider the suggestions of employees who are not part of the research and development team.	-0.34	0.14
A32	Extent to which there is regular discussion about possibilities for collaboration between units in your company.	-0.34	0.14
D2U8	Extent to which your company is confident that the research body is telling the truth.	-0.36	0.17
B58	To what extent does your company collaborate with:3) Research community (universities, research centers, technology transfer agencies, etc.)	-0.37	0.16
D1G2	Extent to which your company feels that the government and it's agencies have the ability to accomplish what it says it will do	-0.39	0.17
B21	Extent to which your company aggressively participate with external parties through technological alliances.	-0.41	0.16

Item Code	Item	Measure	Model SE
A22	Extent to which your company are prepared to introduce your products/services that have been developed through investing into a new joint venture	-0.42	0.14
C35	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects? 5) Non disclosure agreements and other contractual agreements	-0.43	0.17
B15	Extent to which your company engage with your customers in evaluating your product/services.	-0.44	0.16
D2N8	Extent to which your company is confident that the industrial big players are telling the truth.	-0.45	0.17
D3U8	Extent to which your company feels that the research body watches your company back.	-0.45	0.17
A38	To what extent does your company actively encourage communication among unrelated groups of employees in the company.	-0.48	0.14
D2G3	Extent to which your company is confident that the government and it's agencies are honest about any problems that occurs during the project duration.	-0.48	0.17
C23	To what extent does your company collaborated with external partners in the following innovation phase: 3) The idea development process?	-0.49	0.17
C15	The extent to which your collaboration with external partners helps your company to open new markets	-0.55	0.18
A16	Extent to which your company has focused on improving the performance of your current business rather than entering new industries	-0.56	0.15
B25	Extent to which your company believe that it is beneficial to determine systemic and formal ways of searching for external know-how/technology.	-0.57	0.16
D2G1	Extent to which your company believes that the government and it's agencies have been frank in dealing with you.	-0.57	0.17
A17	Extent to which your company cooperate with external partners when launching your own new products/services on the market.	-0.60	0.15
B18	Extent to which your company engage with your customers in the process of testing new products/services.	-0.64	0.16
B56	To what extent does your company collaborate with:1) Your customers	-0.67	0.16
A18	Extent to which your company use external sources of know-how/technology when developing new activities related to the present operation of the company	-0.69	0.15

Item Code	Item	Measure	Model SE
C24	To what extent does your company collaborated with external partners in the following innovation phase: 4) The commercialization process?	-0.70	0.18
D1U4	Extent to which your company believes that the university has adequate knowledge in one or several area related to the working project.	-0.72	0.18
B23	Extent to which your company believe that investing in a new joint venture could result in acquiring new know-how/technology to your company.	-0.73	0.17
B22	Extent to which your organization is willing to invest in external collaboration should the desired technology are proven valuable.	-0.78	0.17
D3G3	Extent to which your company feels that the government and it's agencies have been on your side.	-0.88	0.18
D3U7	Extent to which your company feels that the research body work to protect your company.	-0.91	0.18
B513	To what extent does your company collaborate with: 8) Government/public authorities	-0.92	0.17
B26	Extent to which your company believe that the know-how/technology your company have bought can create new opportunities for the company.	-0.98	0.17
D3U9	Extent to which your company feels that the research body looks out for your company.	-0.98	0.18
B24	Extent to which your company believe that the use of know-how/technology from the outside can significantly contribute to the innovation of your company.	-1.01	0.17
D2G4	Extent to which your company can depend on the government and it's agencies to be fair throughout the research project.	-1.19	0.19
A19	Extent to which your company are willing to cooperate with the partners from the outside when developing new activities related to the present operation of the company	-1.23	0.17
D3G1	Extent to which your company feels that the government and it's agencies care for you.	-1.26	0.19

There are two major areas that can be looked at closely from Table 5.62 above. Once again, this study will make use of the term ‘Challenging Factors’ ’to refer to the difficult items and ‘Success Factors’ to denote easy items according to the item measures listed.

Table 5. 63
Categorization Matrix Of Items

Categories	**Position In Normal Distribution**	**Range of Position in Item Measure**	**n**	**%**
Highly Challenging	$(\bar{x}+2\sigma)$ to $(\bar{x}+3\sigma)$	0.96 to ∞	4	3.2
Moderately Challenging	$(\bar{x}+\sigma)$ to $(\bar{x}+2\sigma)$	0.48 to 0.96	14	11.3
Challenging	$\bar{x}$ to $(\bar{x}+\sigma)$	0.00 to 0.48	40	32.3
Highly Critical	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.48 to 0.00	44	35.5
Moderately Critical	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-0.96 to -0.48	16	12.9
Critical	$(\bar{x}-3\sigma)$ to $(\bar{x}-2\sigma)$	∞ to -0.96	6	4.8
			124	**100**

The list of items is further divided into several other smaller groups to rank the items according to their type of challenges and success factors. As a result, six groupings were derived as noted in Table 5.63. By using the item standard deviation (SD) value of 0.48 *logit* and the mean value of 0.00 *logit,* the results suggest that for challenging items where item measures are above the mean item of 0.00 *logit* , three groups can be used to further explain the items and likewise, for items that can be classifies as success factors, three division were further extracted.

5.10.2.1 Challenging Factors

It can be learnt that from the total of 124 items, 46.8% of items are perceived as difficult and the other 53.2% are somewhat considered easy items to be endorsed by respondents. 58 items were grouped under the challenging factors and four factors that are highly challenging to the organizations are B59, B14, and B41and A13. It is also noteworthy to learn that three out of the four items under this category are technology exploration items. Details of each item are shown in Table 5.64 below and illustrated in the variable map shown in Figure 5.18.

Table 5. 64
Highly Challenging Items

Item Code	Item
B59	Extent to which company collaborate with their competitors
B14	Extent to which company engage with their customers in training or instructing others (as trainer).
B41	Extent to which company usually buy the intellectual property (IP) of other companies to ensure successful development of their company's new products/services.
A13	Extent to which company has acquired many companies in very different industries

Specifically, these items are seen to be the most difficult items to be agreed upon by most of the organizations. From the wright variable-map shown in Figure 5.20 below, it can be seen that only eight organizations are located above item B59 (highest item measure). The organizations are coded under the entry code of 62, 44, 66, 64, 72, 52, 58, and 68. On the other hand, two organizations (coded as 03, and 13) are the two organizations with the lowest person measure values that do not possess any abilities to achieve any level of item difficulties. Specifically, the results denote that the two organizations are not able to be matched to any items from all the constructs involved. A thorough analysis on these organizations will lead to the fact that they attain similar characteristics in term of the size of the organizations; sales; and profit obtained. When analyze, the highest eight organizations are those who owns above the average figures for the three characteristics mentioned. On the contrary, the two most bottom organizations, are those with below than average in terms of size, sales and profit. This findings is congruent to the fact that open innovation capacities, which is reflected in technology exploration and technology exploitation activities are significantly associated with financial performance (Ahn et al., 2013). In another related study, firm size is positively related to firm's openness and although smaller organizations is said to possess open innovation intensity, but, larger firms are said to be more open (S. Brunswicker & Van de Vrande, 2014).

5.10.2.2 Success Factors

As for success factors, among the important highlights from the results as is the 44 items that are scattered under the highly critical category. Although seen as easy, it is important to ensure that organizations continuously percept and believe on the items as they are doing now. In other words, it is important that their abilities to meet the item difficulties be sustained, if not improved to encourage the growth of technological activities, increase trust, and adopt open innovation better.

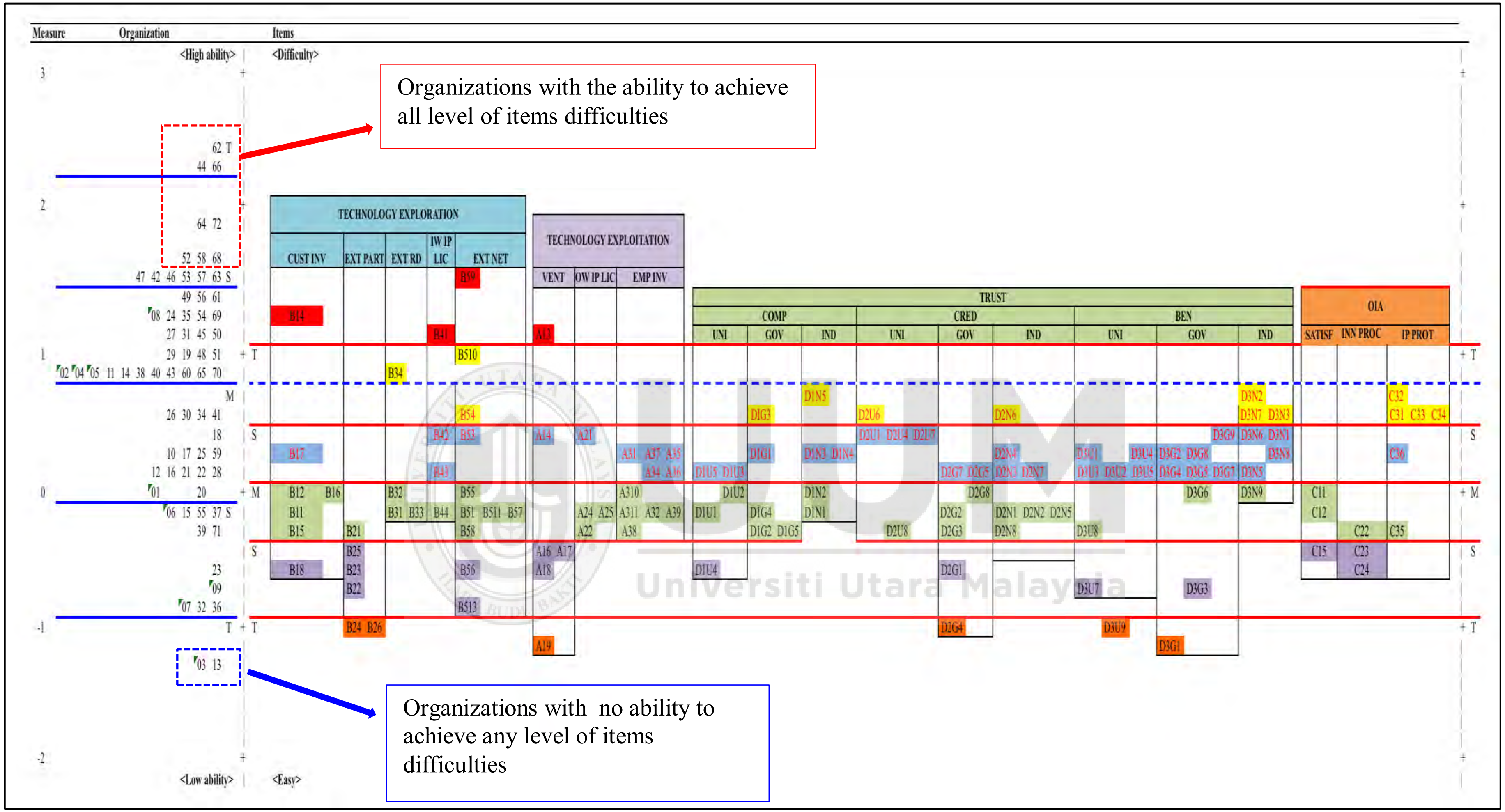

Figure 5. 20
Variable Map for All Constructs : Technology Exploration, Technology Exploitation, Trust and Open Innovation Adoption

5.10.3 Profiles

This section presents discussion of the findings for the research objective that targets to profile the organizations and to understand the potential values of open innovation adoption based on technology exploration, technology exploitation and trust. The discussion will be based on the five categories identified; namely the 'Excellent', 'Very Good', 'Good', 'Regular', 'Poor', and 'Very Poor'. The division of categories together with the number of organizations each categories represents are listed in Table 5.65 below.

Table 5. 65
Categorization Matrix for Organizations with Technology Exploration, Technology Exploitation, Trust and Open Innovation Adoption

Categories	**Position in normal distribution**	**Logit**	**n**	**%**
Excellent	$(\bar{x}+2\sigma)$ to ∞	2.43 to 3.28	3	4.3
Very Good	$(\bar{x}+\sigma)$ to $(\bar{x}+2\sigma)$	1.58 to 2.43	11	15.7
Good	$\bar{x}$ to $(\bar{x}+\sigma)$	0.73 to 1.58	27	38.6
Regular	$(\bar{x}-\sigma)$ to $\bar{x}$	-0.12 to 0.73	16	22.9
Poor	$(\bar{x}-2\sigma)$ to $(\bar{x}-\sigma)$	-0.97 to -0.12	11	15.7
Very Poor	∞ to $(\bar{x}-2\sigma)$	-1.82 to -0.97	2	2.9
			70	**100**

i. Category 1: Excellent

Out of the total respondents involved in the study, 4.3% can be categorized as an excellent group. In particular, the group is represented by organization 62 with person measure equals to 2.40 *logit*; organization 44 with 2.33 *logit*; and organization 66 with 2.28 *logit* (Table 5.59 and Figure 5.20). Based on the demographic characters shown in Table 5.66, the excellent group consists of organizations that have been in operation for more than 11 years and with the strength of around 31 to 75 numbers of staff. These organizations also reported an average sales volume of between RM1.1 million to 10 million and average profit of more than RM500,000.00 to RM5 million.

Table 5. 66
Demographic Profiling

	Excellent	Very Good	Good	Regular	Poor	Very Poor
The length of years of business operation						
Less than 5 years			7	3	1	
5-10 years		3	7	8	4	2
11-15 years	2	5	5	2	4	
More than 15 years	1	3	8	3	2	
The number of employees in the organization.						
Less than 5			4	3	2	1
5-30			13	6	4	1
31 - 75	3	9	6	7	2	
76 - 200		1	3		1	
More than 200		1	1		2	
Average sales per year for the last 3 years.						
Between RM100,000 - RM500,000		1	9	5	2	1
Between RM501,000 - RM1 million		3	4	1	2	1
Between RM1.1 million - RM 5 million	1	6	13	7	3	
Between RM5.1 million - RM10 million	2	1		1	3	
More than RM20 million			1	2	1	
Average profit per year for the last 3 years.						
Between RM100,000 - RM500,000		4	15	10	6	1
Between RM501,000 - RM1 million	1	4	6	3	1	1
Between RM1.1 million - RM 5 million	2	3	6	2	3	
Between RM5.1 million - RM10 million				1		
More than RM20 million					1	

ii. Category 2: Very Good

The second group, which is referred to as the 'Very Good' cluster, involves organizations with logit values of between 1.58 to 2.43 *logit*. The group consists a mixture of organizations that are able to achieve almost all difficulty levels in all items of constructs involved. The demographic characteristics shared by this group are presented in Table 5.66 above. An important factor to note is that, this group is organizations that have been established for more than 5 years with the strength of manpower of more than 30 people. These characteristics are almost similar to those of the excellent category.

On the other hand, although this group reported a variance of all categories from the average sales group, majority of the organizations under this group (7 out of 11) are those with more than RM5 million worth of average sales per year. This is also true for the amount of average profit gained, where majority of the organizations in the group reported an average profit of more than RM500,000.00.

In terms of the difficulty of items to achieve, only one item is considered a difficult item to majority of the group. The item is represented by item B59 with the item measure of 1.56 *logit* and a standard error of 0.14 *logit*. The item signifies the extent to which the company collaborate with their competitors. In particular, eight out of 11 organizations (person measures less than 1.70 *logit*) posit difficulties in achieving this item.

iii. Category 3: Good

The third category is accredited as ‘Good’ where the logit values are in between 0.73 to 1.58 *logit*. A total of 27 organizations, which accounts to 38.6% of total respondents involve reside in this category. The demographic characteristics’ breakdown by this group is presented in Table 5.66. The category which represents the majority number of organizations involved is still considered to be a good group because of it’s person measure position on the logit continuum which is above the level of person mean which equals to 0.73 *logit* or higher.

It can also be seen from the variable map in Figure 5.20, that there are six items that are seen to be difficult and are scattered above the ability level of this category. The number which represents 4.8% of the total items (6 out of 124 items) is considered to be relatively small. The difficult items for this groups are tabled below.

Table 5. 67
Difficult Items For ‘Good’ Category

Item Code	Item	Measure	Model SE
B59	Extent to which company collaborate with their competitors	1.56	0.14
B14	Extent to which company engage with their customers in training or instructing others (as trainer).	1.20	0.13
B41	Extent to which company usually buy intellectual property (IP) of other companies to ensure successful development of their company’s new products/services.	1.15	0.13
A13	Extent to which company has acquired many companies in very different industries	0.98	0.12
B510	Extent to which company collaborate with other companies engaged in activities which are different than yours	0.84	0.14

B34	Extent to which company acquire new know-how/technology through mentoring university interns.	0.80	0.14

It is interesting to see that out of all items involved as shown in Table 5.67 above, only one item is from the construct of technology exploitation (item code A13) while the rest are from the technology exploration construct (B59, B14, B41,B510, and B34).

iv. Category 4: Regular

The next category is referred to as a regular group where the person measures are between -0.12 to 0.73 *logit*. A total of 16 organizations are listed under this group and the demographic characteristics are provided in Table 5.66. The characteristics are noticeably moderate to almost all companies under this category. In other word, what can be seen from the common characteristics, the group is likely to have some set back issues in comparison to the other categories mentioned above. One, is in term of companies' maturity as most companies are established in less than 10 years. It is also obvious that all organizations reported a moderate strength of staff which is less than 75 people. On the other hand, the majority reported average sales are less than RM5 million (13 out of 16 companies), whilst the average profits are also less than RM500,000.00.

v. Category 5: Poor

Category 5 is signified as a poor group where the person measures are ranged low between -0.97 to -0.12 *logit*. A total of 11 companies are listed under this group and the demographic characteristics are provided in Table 5.66. One distinct characteristics shared by companies under this category is on the number of employees and the reported average profit of the year. Majority of the companies reported staff strength of less than 30 people and average profit of below RM500,000.00.

The group in particular is located at the bottom of the logit continuum and the position when referred to the variable map in Figure 5.20 will indicate that almost all item were not able to be achieved by majority of this group. In other words, most of the companies under this group are not able to meet with the difficulty levels of all constructs involved. Out of all items involve in the study, only three items are scattered below the minimum person measure value which is at -1.06 *logit* and SE value at 0.10 *logit.* Specifically, only three items managed to be achieved by this group. The items are D2G4, A19 and D3G1. Therefore to understand further on the nature of 'poor' category, the discussion will focus on the three achieved items to explore the potentials of the companies under this category and how they can best adopt open innovation.

vi. Category 6: Very Poor

The final category is the lowest category in the organization profiling. Only two companies, representing 2.9% from all the respondents involved in this study are reportedly to be in this group. The logit scoring for these companies are very low with the reading of -1.82 to -0.97 *logit.* From the demographic profiling in Table 5.66 above, both companies has been established between 5 to 10 years and reported a low man power strength which explains that the companies are still among the new company in the market with very minimal capabilities in comparison to the rest of the categories. The average sales and profit are also reportedly to be at the lowest range.

5.11 Chapter Conclusion

Overall, this chapter presented the results from the data analyses and the findings of the study. Two major analyses were involved in the context of the study. The first being Rasch measurement model, which make use of Winstep application software to validate the data through three processes and the results were explained via the summary statistics table, unidimensionality, and item fit table.

The second analysis used in the study is PLS-SEM, targeted to meet the objective of Perspective I which is to measure the relationship between variables (constructs). Prior to the relationship testing, the assessment of the structural model was conducted to confirm on the necessary validation of the results. The findings are structured according to the research questions and the objectives of study. There were seven hypotheses involved with regards to direct and mediating effect. The summary of the hypotheses testing is tabled and explained accordingly. As for Perspective II and III, through Rasch analysis, the persons and items involved are being put in the same measurement logits, and the results are discussed from the perspectives of the ability of respondents against the difficulties of items in respective constructs as well as from the angle of all constructs put together. The findings are then used to assist in categorizing the challenge and success factors from the construct of technology exploration, technology exploitation and trust. The result was further sliced and diced to profile the organizations to understand the potential values of open innovation adoption that can be explain from the perspective of technology exploration, technology exploitation and trust.

CHAPTER 6

DISCUSSIONS OF FINDINGS, CONCLUSIONS & RECCOMENDATIONS

6.1 Introduction

This final chapter discusses the findings and results presented in Chapter 5. Specifically, this chapter revisits the overview of the study, recapitulates the findings, followed by discussions, contributions to the subject of research, and implications from the theoretical, managerial and methodological perspectives. To recap, the study was designed to meet the three perspectives developed basSed on the research objectives. Section 7.2 will first look at the overview of the study and will be followed by Section 7.3 that will discuss on the findings of the Perspective I, which is to understand the relationship that exist between technology exploration, technology exploitation, trust and open innovation adoption (RQ_1 to RQ_7). Section 7.4 will continue to discuss Perspective II, which points to the categorization of success factors and challenges of each construct in the light of the ability of respondents will be discussed (RQ_8 to RQ_{10}). Subsequently, Section 7.5 will put forward the interpretation of six organization profiles (Perspective III) which are based on the person's (organization's) logit measures. (RQ_{11}) Section 7.6 discusses the implications of study from the perspective of theoretical, managerial and methodological and the chapter ends with the recommendations for future research and the limitations of current study.

6.2 Overview of the Study

The ground of the study was build with the purpose to investigate the relationship between technology exploration and technology exploitation towards open innovation adoption; and to look into the mediation effect of trust (competency, credibility, benevolence) between technology exploration (customer involvement, external participation, outsourcing red, inward IP licensing, external networking); technology exploitation (venturing, outward IP licensing, employee involvement); and open innovation adoption. Additionally, the aim of the study was also to look into the ability of the respondents to achieve various levels of difficulties in technology exploration, technology exploitation, trust and open innovation adoption. Finally, the study aimed to categorize success factors and challenges faced by organizations to adopt open innovation for future business strategy.

The conceptual framework used in this study, was structured based on the diffusion of innovation theory (DIF); making use of two independent variables (technology exploration and technology exploitation), one mediating variable (trust) and one dependent variable (open innovation adoption).

The target population for this study are high technology-based companies involved in triple–helix project; which engage collaboration activities with three helices; namely the university (as research body); industry; and government (via their agencies). Specifically, the study chose one particular project, which was initiated and organized by the Malaysian government and spearheaded by one of its agency. The project which was developed to assist local companies to share innovation, knowledge sharing and technological advancements with the aim to solve specific issues faced by companies in relation to the application of technology. This special project was referred to as an ecosystem and is triple helix in nature, consist of 205 current listings of high-technology companies in total. Hence, at the end, the response rate were 80.89 per cent from the list.

In order to achieve the research objectives, the study made use of two analyses. Firstly, Rasch measurement model was used to obtain logit measurement for each respondents and items used in the questionnaire distributed. The underlying theory used to govern the choice of Rasch analysis was Item Response Theory (IRT), and the study put forward the notion that the ordinal likert-scaling is relatively a weak representation of measurement as the scale does not account for the amount of the differences between the categories. The ordinal scales data are said to imply only the spectrum of categories represented as “greater,” ”better,” or “more preferred” rather than the degree of how much. Furthermore, Rasch analysis, which represents a psychometrical assessment, allows the researcher to draw a psychometric characteristics pattern of the respondents, based on the assessment items. The validity and reliability of each variables (constructs) involved in the study are discussed based on the analysis of the summary statistics, unidimensionality and the item fits category.

Furthermore, Rasch analysis was also used to determine the categorization of item difficulties and organization abilities. When categorizing success factors and challenges, the items are sorted based on the item measures to differentiate between the difficult and the easy items. The easy items are classified as success factors and the difficult items are termed as challenges. Likewise, organizations are also tabled based on the person measures to categorize and to further understand the latent characteristics shared among the organizations in respective groups. The results from Rasch analysis reported a few important findings. The findings are presented from the perspectives of each construct. Summary of findings are tabled in Table 7.1 below:

Table 6. 1
Summary of Categorization Findings

Construct		**Success Factors (Easy Items)**			**Challenges (Difficult Items)**	
Technology Exploration	**22**	Highly Important	6	**10**	Highly Challenging	5
		Important	16		Challenging	5
Technology Exploitation	**12**	Highly Important	1	**8**	Highly Challenging	1
		Moderately Important	3			
		Highly Important	8		Challenging	7
Trust	**35**	Highly Important	3	**25**	Highly Challenging	0
		Moderately Important	6			
		Highly Important	16		Challenging	35

The second analysis used in this study is the Partial Least Square-Structural Equation Modeling (PLS-SEM). The analysis was chosen to examine the relationship of the variables as well as to test the mediating effect of trust towards the relationship between technology exploration, technology exploitation and open innovation adoption. In order to meet the Rasch measurement requirement, the data imputed to PLS-SEM make use of the quality control as highlighted in Bond & Fox, (2015); which account for each person measures and their standard errors (SE). Seven hypotheses were developed to test the research objectives related to the relationship between the independent variables, mediating and dependent variables. The results revealed that four hypotheses were supported, while three others were not.

6.3 Discussions of the Findings

The following sections will discuss the findings in accordance to the perspectives that has been developed in the context of the current study. Figure 6.1 below will graphically explain the flow of discussion.

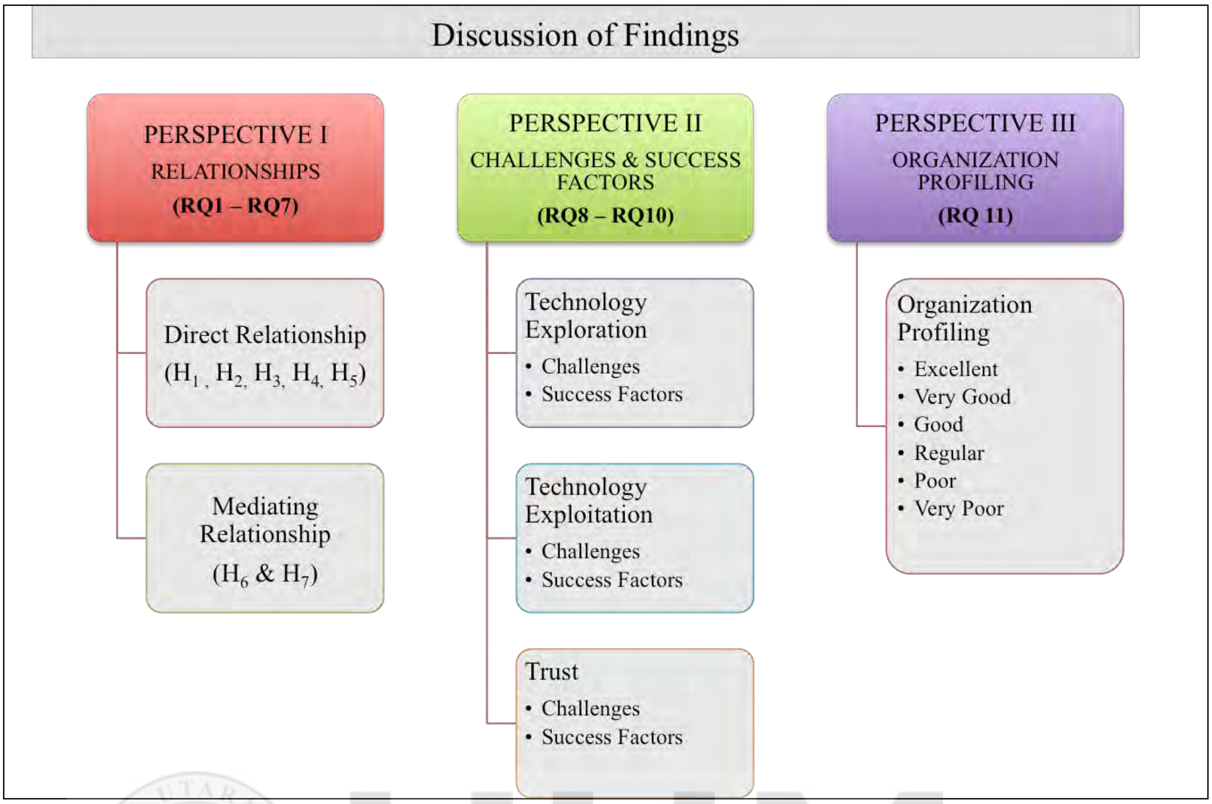

Figure 6. 1
Summary of Discussion of Findings

6.3.1 Pespective I

Perspective I of the study is developed to investigate the relationship between technology exploration, exploitation and its influence towards open innovation adoption among SMEs and to investigate the mediating relationship of trust on technology exploration and exploitation towards open innovation adoption. In doing so, seven hypotheses were developed to test the direct and the mediating relationship among the variables.

6.3.1.1 RO 1: To investigate the degree of relationship between technology exploration and open innovation adoption.

The first research objective was to investigate the degree of relationship between technology exploration and open innovation adoption among SMEs participating in the triple helix project in Malaysia. The research findings from the study unveiled that technology exploration is found to have a significant relationship with open innovation adoption; and therefore supports H_1. The result is consistent with the findings from previous studies (Jemala, 2010; H. Lee, Cha, & Park, 2016; J. H. Lee et al., 2003; S. Lee et al., 2010a; Parida et al., 2012; Torkomian, 2016) in which these scholars have reported similar findings that points to technology exploration being one of the major ingredient related to open innovation.

This finding is also congruent to several prior studies that look deeper into the dimensions that make up the construct of technology exploration. For instance the studies by Chesbrough (2003), Ciesielska and Iskoujina (2012), Gassmann and Bader (2006), and Von Hippel (2005) pointed to the importance of customer involvement in open innovation settings, as organizations will be able to leverage from the customers' ideas and the spectrum of knowledge that the customers may have on their experience and the market demands. In terms of external participation, the result is also supported by the study of (Love & Roper, 2015; Pangarkar & Wu, 2013). Love and Ropper (2015), for instance, mentioned that open innovation through its external participation helps the SMEs to overcome the shortcomings of the innovation process through risk and resource sharing. The study further preconditioned the success of open innovation through external participation is only at its best when the firms are operating is a solid system where the partners are "plentiful and are easily accessible" such as triple helix.

Another study by Borgers, Radziwon, and Billberg (2014), have found similar findings where open innovation in SMEs is said to be strongly contributed by the efficient utilization of external knowledge gathered from the outsourcing activities. The choice to outsource is found to be related to the firm's size and the limited financial resources faced by SMEs. The finding is also in line with the study by (Teirlinck & Spithoven, 2013), in which they imperatively note that R&D outsourcing is an important factor to open innovation as it may provide an option to SMEs who have to deal with the limited internal resources. As for the inward IP licensing, the factor of technology licensing is also found to have positive impact on the organization innovation in organizations which prioritized their internal R&D (Tsai & Wang, 2007).

6.3.1.2 RO 2: To investigate the degree of relationship between technology exploitation and open innovation adoption.

This next research objective was constructed to investigate the relationship between technology exploitation and open innovation adoption. The results, however does not supports H2. In specific, technology exploitation does not have a significant relationship with open innovation adoption. Although the result is conflicting to the study of (S. Lee et al., 2010), who found that exploitation is an important element to open innovation in comparison to exploration. This result however is consistent with the study by (Bryant & Bryant, 2014; Coras & Tantau, 2014; Cosh & Zhang, 2012) in which the implementation of technology exploitation is not significantly link to open innovation adoption. Although Chesbrough (2003) highlighted the essentials of both technological activities (exploration and exploitation) in open innovation, but due to the business limitation and resource scarcity, SMEs tend to choose just one type of activity over the other to align their exploitation strategy with their business model and their strategic intention (Bryant & Bryant, 2014). This is an important factor to be noted as SME might risk its ‘focus’ and its potential growth in the long run if they deviate towards exploiting strategy (Coras & Tantau, 2014; Huizingh, 2011). Another study by Cosh and Zhang (2012), is also in line with the findings where their study found that SME’s engagement in outbound activities (exploitation) is not significantly related to firm innovation performance.

Another study by Lichtenthaler, (2010) supports this findings by pointing to the fact that outward (exploitation) technology licensing is not an important activity which requires a dedicated licensing function on its own, but rather it should be blended together within the technology commercialization process instead of the open innovation process. Additionally, there has also been prove that the open innovation approach gives conflicting results which according to Sağ, Sezen and Güzel (2016), are due to different conditions which is related to the difference between the developing and developed countries.

6.3.1.3 RO 3: To investigate the degree of relationship exists between technology exploration and trust.

The third research objective of this study was positioned to look at the relationship between technology exploration and trust. The study found evidence that supports to the hypothesis tested. H3 is supported denoting that technology exploration does indeed has a relationship with trust. Very little was found in the literature on how technology exploration is empirically connected to trust. However, the result of this study is consistent with the findings of

(Rovira Nordman & Tolstoy, 2011; Salampasis, Mention, & Torkkeli, 2014). The study by Salampasis et al (2014) emphasized that building trust is a challenging task and very time consuming in management, and that it is highly dependable to both intra and extra organizations (exploitation and exploration). On the other hand, the study by Rovira et al (2011), supports the findings by highlighting the importance of knowledge transfer through the customer involvement (technology exploration) and this is deemed an important aspects in building trust between organizations. To add further, a similar study by (Hasche, Linton, & Öberg, 2017) support this finding in the manner where they emphasized that so far, the study of trust has been explored from the context of the communities or parties involved or as a preconditioned that will contribute to parties involved, neglecting the fact that trust can also be developed out of the collaboration process. This fact corroborates with the finding of this study, as both technology exploration and exploitation are activities involved in the inward and outward collaboration process.

6.3.1.4 RO 4: To investigate the degree of relationship exists between technology exploitation and trust.

The fourth research objective of the study sought to determine the existence of relationship between technology exploitation and trust. The objective has led to the development of H4 and was further tested. However the result does not support the hypothesis, and therefore H4 was rejected. In other words, this result pointed to the fact that technology exploitation is not significant to be related to trust. Although open innovation is defined as the use of purposive inflows and outflows of knowledge (exploration and exploitation) to accelerate the internal innovation and expand the markets for external use of innovation (H.W. Chesbrough, 2003). In another view, trust is found to have a reciprocal linkage with open innovation activities (exploration and exploitation) (Salampasis et al., 2014). However a study by (Abu El-Ella, Pinkwart, & Bessant, 2014) is inline with the present findings, in which the study supports the situation in the lights of employee involvement, which is one of the dimension in technology exploitation.

The challenge with open innovation, according to (Abu El-Ella et al., 2014), comes from the technologies threat itself where digitized knowledge is vulnerable for illegal encoding, storing and transmitting activities which may led to 'misappropriation' and impede the trust framework. In another similar study, outbound activities (exploitation) is associated with greater risk compared to inbound activities (exploration) where organizations may jeopardize the opportunity to experience the created value (Schroll & Mild, 2011), and as risk and trust are two essential components in decision making involving transactions of collaboration agreements (Jøsang & Presti, 2004), it can therefore be associated that exploitation activities may not assist in building trust towards the helices involved.

6.3.1.5 RO 5: To investigate the degree of relationship exists between trust and open innovation adoption.

In response to the fifth research objective of this study, trust was found to have a significant relationship with open innovation adoption. This serve as an evidence to support hypothesis H5. The result of this study is also found to be consistent with the findings of (Hasche et al., 2017; Shamah & Elsawaby, 2014) where trust is found to be a core component in open innovation that will ensure successful flow of information and knowledge between collaborative parties. Another similar study that supports the results is the study by (Ye & Kankanhalli, 2013), where the findings pointed to the fact that trust is an important contextual element between 'solvers' and 'seekers' in open innovation process.

6.3.1.6 RO 6: To investigate any mediating relationship of trust on technology exploration and open innovation adoption.

Hypothesis H6 was developed to find evidence of trust as a mediating factor to the relationship between technology exploration and open innovation adoption. From the perspective of open innovation studies, there has been a substantial body of evidence from previous research that try to relate trust as an important component to open innovation (Ciesielska & Iskoujina, 2012; Dovey, 2009; Fawcett et al., 2012; Graser & Jansson, 2005; Grudzewski et al., 2008; Lin, 2012; Olkkonen et al., 2000; Ratnasingam, 2013; Westergren & Holmström, 2012), or in the collaboration related activities (Hattori & Lapidus, 2004; Msanjila & Afsarmanesh, 2011). Msanlinja and Afsarmanesh (2011) found that trust must be properly managed to ensure a continuous mediating effect for successful collaboration. In the study by Ciesielska and Iskoujina (2012), for instance, trust has been proven as an important success factor in open innovation and similarly, a study by Thatcher et al., (2012), proves trust as having an important role in shaping the behavior towards intention to explore technologically. Hence, result from mediating analysis proves to be in line with the argument from previous studies.

6.3.1.7 RO 7: To investigate any mediating relationship of trust on technology exploitation and open innovation adoption.

The last hypothesis for this study (H7) was constructed to find evidence of trust as mediating factor to the relationship between technology exploitation and open innovation adoption. However, as the direct relationship between technology exploitation and open innovation adoption is proven to be insignificant (H7); and the result from the mediating analysis support to the fact that there is no mediation effect of trust in the relationship between technology exploitation and open innovation adoption. As mentioned above, although open innovation put forward the notion of purposive use of inflows and outflows of knowledge (exploration and exploitation) to encourage open innovation (H.W. Chesbrough, 2003), the finding however does not signifies the stand. The finding too is not aligned with some of the previous studies that tried to relate trust as an important component to open innovation (Ciesielska & Iskoujina, 2012; Dovey, 2009; Fawcett et al., 2012; Graser & Jansson, 2005; Grudzewski et al., 2008; Lin, 2012; Olkkonen et al., 2000; Ratnasingam, 2013; Westergren & Holmström, 2012). One possible explanation to this is probably the study by (Lichtenthaler & Ernst, 2008; Schroll & Mild, 2011) where they pointed that firms adopt more inbound strategies (technology exploration) in comparison to outbound strategies (technology exploitation). Given the limitation to practice and experience technology exploitation as much as technology exploration, could be the reason that contributes to the insignificance results.

6.3.2 Pespective II

Perspective II of the study is to investigate the success factors and challenges for organizations to achieve the difficulty levels of technology exploration, exploitation, and trust in the light of open innovation and triple helix. Based from the item measures, the study managed to identify challenges and the success factors that contributes to the understanding of what are the drivers that will help to elevate or hinders the open innovation adoption process. The findings from the analysis will be discussed from the three constructs involved in explaining open innovation adoption.

6.3.2.1 RO 8: To investigate success factors and challenges for organizations to achieve technology exploration.

In response to research objective 8, the study aims at investigating the success factors and challenges perceived by organizations when dealing with technology exploration. The study has found that most of the items under the construct of technology exploration are considered as easy items. As explained, this denotes that organizations involved have high agreeableness to most of the items. A valuable information that can be derived from this findings is these set of easy items which are referred to as the success factors serve as the benchmarks for other organizations expecting to participate in the similar context of triple helix settings or planning to practice inbound activities in the open innovation platforms. Reversely, the study also found that 10 out of 32 items from the construct could be interpreted as challenging items.

A closer look to the items as a whole will lead to the fact that the most challenging item in technology exploration is the extent to which organizations' collaborate with competitors. This finding is consistent to the study by Ritala et al. (2015) in which the study put forward the notion that organizations took a longer time to trust competitors in their joint venture activities, as they fear that they might risk their internal knowledge to their competitors. Consequently, the least challenging item which is reflected from the lowest item in the difficult item continuum is the extent to which the company believe that buying IP rights through licensing from other companies is important for the growth of the company. This finding denotes that although to a certain extent organizations agree that the external IP licensing is crucial for the growth of the company but due to SME's limitations (Hakikur Rahman & Ramos, 2013), the dependency to the external partners might put the organizations at a susceptible situation. Another possible support for this findings is the fact that IP management is an expensive process which almost often is associated with high technological needs and nature (Bigliardi & Galati, 2016a; S. Brunswicker & Van de Vrande, 2014). Correspondingly, to further enhance the understanding from the list of difficult items, the study chose to further divide the items to represent the 'Highly Challenging' and 'Challenging' group. Although seen as difficult, the listing of items for the 'Challenging' group can be explained as items that are achievable by organizations should they need to exercise a better implementation of technology exploration. In other words, if extra measures were to be taken to tackle these challenging items, it may lead to a better adoption of open innovation in the future.

To understand the success factors, the researcher also chose to further group the items into two, namely the 'Important' and the 'Highly Important' group. It can be learned that the extent to which organization believes that the use of know-how/technology from the outside can significantly contribute to the innovation of organization, becomes the easiest item to be endorsed. This means that almost all organizations involved in the context of the study are fully aware and has well accepted the fact that technological knowledge is one of the crucial ingredients in technology exploration. This is in line with the previous study by (K. P. Hung & Lin, 2013; Inauen & Schenker-Wicki, 2012; Jemala, 2010).

Furthermore, the study also shown that organizations are willing to purchase creative work of other parties to increase the amount of knowledge and its use to devise new and improved goods, services and processes. This particular item is one of the items that were mark as an important item to the organization. The item measurement position leads to the fact that most organizations agree that external works of other parties is useful and may benefit their innovation process. This findings is supported by (Burrus, 2013), who has set forth that a longer surviving organizations are those that leverage from the creative ideas of others to create unique products and services of their own.

6.3.2.2 RO 9: To investigate success factors and challenges for organizations to achieve technology exploitation.

Open innovation adoption relates to the purposive inflows and outflows of internal and external ideas and knowledge (H.W. Chesbrough, 2003). Hence, it is also crucial to understand the challenges and success factors related to the outbound technological activities which can also be addressed as technology exploitation (van de Vrande et al., 2009).

The first findings with regards to this matter is out of the total number of items that make up the construct, eight were associated as challenging items. The extent to which the companies acquired many other companies in very different industries became the most challenging item to be endorsed in this construct. This item is considered as a highly challenging item that requires attention if technology exploitation are to be encouraged among business organizations and SMEs in particular. This could be true as in the case of Malaysia for instance, although SMEs are aware with role of innovation towards their growth, and the importance of acquiring skills from the other companies (Jamieson, Fettiplace, & York, 2012), the insufficient access of resources limits these companies from acquiring new or advance technologies from others (Ismail et al., 2010).

In addition, the study also demonstrates that employee involvement issues are among the challenging items to be focused at. Five out of seven items, which relates to employee involvement, are listed in the challenging group. This evidence is important because previous studies has relate that the importance of employee engagement to innovation activities within the companies (Abu El-Ella et al., 2014).

In terms of success factors, three groups could be derived further (‘Highly Important’, ‘Moderately Important’, ‘Important’). The findings signify that majority of the organizations are willing to cooperate with partners from the outside when developing new activities related to the present operation of the company. The position of the item in the logit continuum reflects to the fact that this stand must be critically met for organizations wanting to implement outbound activities in the future. This finding is parallel with previous study by (Vahter, Love, & Roper, 2014).

6.3.2.3 RO 10: To investigate success factors and challenges for organizations to achieve trust

With regards to research objective 10, the objective is to understand the motivating and the hindering factors that affect organization trust towards their partners. In the context of the current study, it expects to shed lights in understanding the SMEs trust towards the triple helices involved in the triple helix project they participated in.

Unlike the previous constructs discussed in the earlier section of this study, where the proportion of the easy items are much bigger than the difficult items; trust, on the other hand shows a different result. The total number of challenges (difficult items) seems to outweigh the success factors (easier items). It can therefore be learnt that organizations are faced with difficulties in endorsing to the items in trust construct. However, an interesting fact derived by the measures of these item which are scattered within the range of mean item and the mean organization, lead to the understanding that even though organizations find difficulties in endorsing to these items, but it can be considered that these items are highly achievable items to the organizations.

This study focus on the dimensions of competency, credibility, and benevolence to represent trust and were further segmented into three subgroups to explain

SMEs trust towards the three respective helices. The helices, as mentioned, are the universities (research bodies), governments (agencies) and industrial players. It can also be learnt, from the findings, that organizations at large tend to show evidence that there are issues of trust towards industrial players in comparison to universities and government. In precise, the study found that the most challenging item by the organizations is the extent to which they feel that the industrial players have gone out off their limb and risk their reputation in times of resource shortages. It is important to bear in mind that from the triple helix context, the synergy between SMEs and triple helix players are beneficial to all parties as both sides can take the advantage from the reciprocal process of contributing and receiving benefits from each other's presence (Brink & Madsen, 2016). However, a possible explanation to the finding was that smaller organizations may risk themselves in formidable situation as larger organizations hold a bigger share from the value created by collaboration (H. Yang et al., 2014).

From another view, the study has also discovered that among the least challenging issues for the SMEs are their benevolence trust towards the government and it's agencies, where the findings indicate that there is a lack of trust to the government in terms of which they believe the government will work to protect their company. Conjointly, the same was expressed when explaining the extent of their benevolence trust towards the university in the context of believing that their university counterparts have the SMEs best interests in their agenda. Judging from the logit measures of these two issues, the study suggests that precautious arrangements need to be put in place by respective helices in order to improve the trust on the said matters. This is bound critical as the placement of these two issues suggested that, if it were to be addressed quickly, it is likely that the two issues may become the success factors that will determine a better adoption to open innovation.

The study also demonstrates important findings that explain the success factors that are seen to be easy or highly endorsable by organizations for the construct of trust. These areas, if taken seriously, may enhance and create a better, if not stronger ties between the organizations and helices involved in the triple helix projects. The extent to which organization feels that the government and its agencies care for the company was reflected as the easiest item. Importantly, this particular element reflected on the benevolence trust – the type of trust that allows SMEs as the knowledge seekers to engage in the knowledge management process and learn abundantly from the process.

6.3.3 Pespective III

Perspective III of this study is developed with the intention to profile the organizations based of the constructs involved. In doing so, the items and the organizations involved have been analyzed using Rasch techniques and the measures are then plotted in a variable map to reflect the ability of the organizations when meeting the difficulties of each item. The analysis provides valuable information and output that helps to explain the latent characteristics shared by companies reflected in respective groups explained as below.

6.3.3.1 RO 11: To profile organizations and the potential values of open innovation adoption based on technology exploration, exploitation and trust.

In respond to Perspective III, this research attempted to profile the orgnizations involved by discussing the potential values of open innovation adoption based on technology exploration, technology exploitation and trust. The study has managed to profile the organizations into six categories namely; the 'Excellent'; 'Very Good'; 'Good'; 'Regular'; 'Poor'; and 'Very Poor'. The percentage of organizations representing each category is displayed in Table 7.2 below.

Table 6. 2
Categorization Matrix for Organizations with Technology Exploration, Technology Exploitation, Trust and Open Innovation Adoption

Categories	n	%
Excellent	3	4.3
Very Good	11	15.7
Good	27	38.6
Regular	16	22.9
Poor	11	15.7
Very Poor	2	2.9
	70	**100**

It can be learnt from the table above that the four highest group which are represented by 'Excellent', 'Very Good', 'Good' and 'Regular' reflect the majority of the organizations involved. With reference to Chesbrough's (2003) definition of open innovation, the study suggests that majority of the organizations has indeed practiced open innovation through their innovation activities.

i. **Category 1: Excellent**

The study also revealed that the highly capable organizations are those that are larger in terms of organization size which suggest that firm size is related to the firm's openness. This is in line with the study by Brunswicker and Vrande (2014), where larger organizations are said to be more open. Another important point to denote is that larger organizations may be associated with the advantage of gaining product reputation and are normally in better position to be compared to the younger competitors in market as they are reflected of having better skilled personnel and better R&D (Julienti Abu Bakar & Ahmad, 2010), hence these organizations stand a chance to be seen as a more interactive collaboration partners.

ii. **Category 2: Very Good**

The group consists of a mixture of organizations that are able to achieve almost all difficulty levels in all items of constructs involved. The organizations shared almost similar characteristics to those of the 'Excellent' category. However, in terms of the difficulty of items to achieve, only one item is considered as a difficult item to majority of this category. The item which signifies the extent to which the company collaborate with their competitors stand out to be the most difficult item in comparison to the other items involved. In particular, six out of 11 organizations posit difficulties in achieving this item. This is true as it takes longer time for competitors to be trusted in joint venture activities as organizations fear that knowledge will be leaked out and be used by competitors to gain competitive advantage (Ritala, Olander, Michailova, & Husted, 2015).

Hence, it can be understood that these organizations have the potentials of becoming an excellent group in adopting open innovation. These organizations are those who are willing to collaborate with external partners and participate in triple helix projects as they have confidence and trust in the helices they are involved with. Even tough, there has been evidence that the key to future talent management is by sharing the same pool of talents together with the competitors from the same industry (Doyle, 2015), however, majority of the organizations are still holding back from their competitors due to business competition and as SME suffers from the firm size setbacks, organization are taking precautious steps to protect their knowledge resources before committing to collaborate with their competitors.

iii. Category 3: Good

The third category is accredited as 'Good' and a total of 27 organizations, which accounts to 38.6% of total respondents involve, reside in this group. A closer look to the items that are perceived as difficult to this category, will enable us to understand that aside from difficulties collaborating with competitors, SMEs involved are also signaling issues in engaging with customers as a trainer to provide product, service or related knowledge to others. Although organizations tend to show proves of agreeableness that customers' involvement activities are important and benefit them (van de Vrande et al., 2009), organizations however, are still skeptical to allow customers' to be too involved in the process. This could be due to the fact that too much customers' involvement could lead to dependency on customers' only view and personality and could create tension between the customers and the employers (Bigliardi & Galati, 2016a).

iv. Category 4: Regular

The study reflected a total of 16 organizations that are listed under this category. When viewed from the perspective of constructs being measured, the study look into which dimensions from the constructs are seen to be among the challenging items for the group. Firstly, from the technology exploration contract, external networking and customer involvement are the most challenging dimensions for the group with 9 out of 14 difficult items. As mentioned earlier, SMEs suffers from limited capabilities (Hakikur Rahman & Ramos, 2014; van de Vrande et al., 2009), leading them with tough decision to decide on the best way possible to collaborate with external partners for the betterment of their innovation capacities and market opportunities (Ullrich & Vladova, 2016). Too much customers' involvement could lead to dependency on customers' only view and personality and could create tension between the customers and the employers (Bigliardi & Galati, 2016a).

Secondly, from the perspective of technology exploitation, employee involvement is one dimension that is seen to be difficult to the group where six out of nine items are reported to be difficult. The current study was based by the work of Lindegaard, (2011) and Vrande et al. (2009) in which they claimed that employee-driven innovation in the context of open innovation is needed as employees can be empowered to manage the relationship with various collaborators. The basis for this stand is that employees have the necessary potential to drive creative thinking which is an integral component to innovation and change (Amundsen, Aasen, Gressgård, & Hansen, 2014). However, the success involvement of employees into the innovation process is warrant by the cooperative culture and management practices within the company (Amundsen et al., 2014), which according to the study can only be achieved in long term projection. From one angle, the success of open innovation has always been associated with employees' attitudes (Burcharth et al., 2014; Naqshbandi, Kaur, & Ma, 2014). On the other hand, innovation and R&D activities are highly in need of a larger manpower as the higher the number of employees is associated with the greater possibilities for success (Wynarczyk, 2013).

As for the construct of trust, out of the three dimensions of trust involved, benevolence trust is reportedly to be the most challenging with 19 items out of 38 items are reported to be difficult for this group. Benevolence trust in this study reflected the extent in which one party, is perceived to want to do good, having a vested emotional interest (Khairul Shazi, 2014), and showing care and concerns in helping the other counter parts. A further look at the level of trust to respective helices involve in the triple helix project, will point to the benevolence trust towards the industry player as being the most challenging group of items. The reason to explain this situation can be related to various reasons such as the limitations in terms of size and maturity (Hakikur Rahman & Ramos, 2010, 2014; van de Vrande et al., 2009) to financial constraints (Bigliardi & Galati, 2016b; N. A. Rahman et al., 2016). Despite the fact that lack of relationship trust (benevolence) among 'project partners' could deteriorate the performance and desired outcome (Meng, 2012), and that smaller organization can benefit from strategic alliances or collaborations activities with bigger players in the market, but there has also been support that claims smaller organizations may risk themselves in formidable situation as larger organizations hold a bigger share from the value created by collaboration (H. Yang et al., 2014).

Lastly, is to look at the items that measure the open innovation adoption among the SMEs being studied. Out of all dimensions involved, intellectual property (IP) protection reflected the most challenging group to the ‘Regular’ group (6 out of 7). The item in particular is develop to measure the extent the company have in their possession various IP protection mechanisms when collaborating with external partners in innovation projects. The results indicate that to the most the majority of the companies under this group confirmed the possession of non-disclosure and other contractual agreements, while at the same time find difficulties to confirm on other means of mechanisms. Again, the possible explanation to this could be due to the SMEs limitations as discussed above which puts them in a vulnerable position as they do not have IP experts from within their organization and has to rely solely on the collaborative partners and the project terms they are engaged in. IP management is highly reliance to financial, technological and economic constraints and as the process involve highly formalized contracts, with structured technical innovation documentations (Bigliardi & Galati, 2016a; S. Brunswicker & Van de Vrande, 2014), it is therefore challenging for this group to be able to meet with the difficulties of the item.

v. Category 5: Poor

One distinct characteristics shared by companies under this category is on the number of employees and the reported average profit of the year. From the common demographic characteristics, it can be best understood that the group too suffers from a few limitations such as smallness, managerial capacity, financial access, knowledge scarcity, as well as internal skills and awareness (Bigliardi & Galati, 2016a; Wynarczyk, 2013). However, despite these hindering factors, majority of companies tend to be agreeable with three things being researched.

The items represent the extent the company can depend on the government and it's agencies to be fair throughout the research project; the extent the company is willing to cooperate with external partners when developing new activities related to the present operation of the company; and the extent the company feels that the government and it's agencies care on the well-being of the company.

The fact that companies are willing to cooperate with external partners is a sign that they embrace opportunities working with external partners in the areas that is related to their current business operations. This is the basis of what open innovation is and it serve as an important indicator that with better skills, knowledge and proper tools, this group can be pushed further to join the higher profiled groups. A study by Vahter, Love, and Roper (2014), highlights that for small firms to successfully benefit from open innovation strategy, the selection of appropriate collaboration partner must be determined carefully. The study also found that smaller SMEs are less open and additional linkages with external parties will benefit them more. The companies also indicate that they believe the government and its agencies are fair throughout the triple helix project and feel that the government and its agencies care for the well being of their company. This is true in the context of the role and effort that the government is continuously doing. To prosper and survive in the current economic situation, it is vital for SMEs to sought out any possible means through government funding and policies that will assist the companies financially or non-financially in their innovation process (Nel & Cook, 2016).

vi. Category 6: Very Poor

The final category is the lowest category in the organization profiling and is represented by only two organizations, representing 2.9% from all the respondents involved in this study. It can be learnt from this category that the similar characteristics among the organizations are in terms of maturity, size, sales and profit. These inadequacies may probably be the best reasons as to why this category is not able to achieve any of the items difficulty levels as been supported by previous studies (Bigliardi et al., 2012; Hakikur Rahman & Ramos, 2014; Sağ et al., 2016; van de Vrande et al., 2009; Wynarczyk, 2013).

6.4 Implications of the Study

This study provides explanation of the open innovation adoption at large and how it fits the SMEs in general and Malaysia in particular. Several implications can be drawn from this study and may best be discussed from three views, namely theoretical, managerial (practical) and methodological implications

6.4.1 Theoretical Implications

In terms of theoretical, the study contributes to the understanding of open innovation adoption from the lights of innovation diffusion theory. Diffusion is referred to as “the process by which innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2010). This study supplements the existing body of literature on how open innovation is ‘communicated’ and learnt through technological activities and various collaboration channels among members/parties within collaborative support system known as triple helix. Innovation diffusion theory (IDT), on the other hand, has been explained as the processes by which the patterns of adoption are described, explained and assists to understand whether or how new invention and implementation of technology is successfully used (Rogers, 2010). This study manages to explain and describe how open innovation is practice through the inbound and outbound activities, which involves the technology exploration and exploitation between the companies and the collaborating parties. The study, in particular looks into the pattern of how open innovation is adopted through the collaboration between the SMEs and the three helices of university, industry, and government. This study can also be seen from a deeper context in which it managed to explain the implementation of open innovation though various items difficulties and help to draw conclusion as to how best it can be confirmed and implemented as an innovation strategy that will contribute to the desired innovation performance.

The study also extends and integrates a few other theories from several areas of research, which is related to the open innovation studies. From the organizational learning theory, the concept of exploration and exploitation is said to have the impact towards the way organization learns (March, 1991). The theory argues that effects of learning can be realized in the changes of the performance distribution; and that it will at the end improve organizations' competitive advantage. Drawing the conclusion from the current study, and from the context of Malaysian SME, it can be learnt that technology exploration has a significant impact towards the adoption of open innovation in comparison to technology exploitation. This result adds further to our knowledge where technological learning through an open platform is proven to have a different impact towards the open innovation adoption where performance is part of the measure. Hence, more studies needs to be conducted to extend and enrich the dimensions of technology exploitation so that it can fit what is described from the organizational learning theory.

In the light of trust, the Social Exchange Theory (SET) has been among the most influential theory in social psychological and sociological perspective that explains social change and stability as a process of negotiated exchanges between parties. One important philosophy of SET is that relationships evolve over time into trusting, loyal and, mutual commitments (Cropanzano & Mitchell, 2005), where parties involved, find reasons to agree on a certain *rules* of exchange. As open innovation relies heavily in the collaborative environment, trust is a silver bullet to the success of open innovation adoption. It serves as glue that sticks the SMEs and the helices (partners) throughout the triple helix projects. The study has successfully able to explain the mediating role of trust in the relationship between technological strategies used and open innovation adoption.

Another theoretical implication can be seen through Perspective II and III in which the study contributed to the understanding which of the helices is deemed as the most trustable partner among the others. Of the three, the government institution through its departments and agencies is the highly trustable partner of all. This is followed by the universities and the industrial players. From the other view, the study also managed to identify that benevolence trust is the most challenging type of trust in comparison to competence and credibility trust. These findings are empirically beneficial in the direction to assist researchers in the future to further explore dimensions of open innovation adoption especially from the context of SMEs and the triple helix studies.

6.4.2 Managerial Implications

This study has a significant managerial implications to the SMEs at large, national policy makers, innovation practitioners, SMEs governing bodies, triple helices (university, government, industry) and all collaborative parties undertaking any triple helix or collaboration projects. The study in this nature provides significant outputs in helping to understand what are the drives of Malaysian SMEs to adopt open innovation and understand the challenges face by the organization as well as success factors in implementing open innovation in Malaysia. Through this study, the government through it's departments and agencies, also known as intermediaries are able to narrow the gap and shift their practices and strategy by tackling the SMEs' business needs through their collaboration with external bodies in order to boost the adoption of open innovation practices in Malaysia.

The findings of the study proves that although both technology exploration and technology exploitation are said to be the important ingredients to open innovation strategy, the impact between the two are very much different. SMEs in the triple helix projects in Malaysia are more familiar and find that the inbound activities (technology exploration) are more significant to the adoption of their open innovation in comparison to their outbound activities (technology exploitation). The possibilities that contribute to the findings are probably due to the fact that there are other dimensions that need to be considered when measuring the construct of technology exploitation. The limitations of SMEs characteristics such as the organization sizes, which explain and contribute to the lack of skills needed in major areas such as the technology, internal R&D and innovation capabilities, are also the hindering factors for the SMEs to fully adopt the open innovation strategy at large.

As far as trust is concern, the current study is also in line with previous studies that have evidenced trust as an important element to open innovation. In the light of triple helix, the lack of trust is said to be the reason that posits the low 'network dynamicity' between the SMEs and the triple helix players (Nakwa &

Zawdie, 2016), which in turn will affect the sustainability of the relationship throughout the project duration. From another view, the study found that SMEs find that benevolence trust is the most challenging trust in comparison to competence and credibility trust. The results also pointed to the fact that of all the three helices involved in the triple helix benevolence trust to industrial player is the most challenging group compared to the others. As benevolence trust relates to how a partner is seen as being honest, concern and cares to the other party, more interactive sessions and events between the SMEs and the helices must be planned. Although, currently such engagements are in place, but the effectiveness or impact of such programs are less successful and require serious attention. From the list of item difficulty measures, the highest (the most difficult) item in the construct of trust is the extent to which SME feels that the industrial big players have gone out on a limb in times of shortages. Therefore, in order to ensure that SMEs benefits from the open innovation strategy and the triple helix projects, the authorities must ensure that elements of benevolence trust are seriously highlighted when developing interactions events between the SMEs and the collaborating parties.

In other respects, one of the more significant findings to emerge from this study is that from the organization profiling analysis. The profiles serve as a benchmark for the governing and intermediary bodies to identify the characteristics of SMEs in order to understand their ability to achieve the various items under the construct being studied. Hence these profiles may serve as useful insights to various government agencies or other related bodies aiming to fully leverage from the full potential of open innovation.

6.4.3 Methodological Implications

The other important implication of the study was derived from the methodological view. As mentioned the data analyzed for this study was used on the platform of item response theory (IRT) which make use of Rasch Measurement Model and Winstep as a research tool to analyze the data, considering that IRT is seen to be the most appropriate approach as it is a psychometrical approach that is able to explain the ability of the respondents to achieve the various items suggested in the constructs involved. In other words, a Rasch analysis which is probabilistic and inferential in nature will be able to provide a pattern of item responses that will assist in the understanding on how persons and items interact based on mutual latent trait (Irvoni & Ishar, 2012). Boone, Staver, and Yale, (2014) acknowledged that Rasch is a powerful tool to be used to understand the dynamics of human traits as the analysis begins with constructing a valid and reliable measurement for the instruments being used. Therefore, this study is able to contribute to the field of open innovation and enrich the nature of quantitative methods being used in the context of open innovation studies where previous evidence have shown that the study of open innovation have been dominated by qualitative studies, represented by in-depth interviews, and case studies that are descriptive in nature (Hossain, 2013; Huizingh, 2012).

6.5 Limitation the Study

Despite the useful findings of this study, certain limitations in the present empirical study have to be acknowledged Firstly; this study has been focused to SMEs involved in a triple helix project. However, only one particular project was chosen limiting the results to be generalized across other triple helix projects, which could be different in terms of the nature of projects.

Secondly, the study made use of a cross-sectional survey for the purpose of data collection based on a specific point of time. Although a cross sectional survey is good in proving assumptions and comparing multiple variables at the same time, it may not be able to explain cause and affect relationship. In particular, the relationship may not be able to be explained from a continuous evolutions point of observation. For instance, how does the level of trust differ before and after product commercialization; or does the level of relationship between technology exploitation and open innovation adoption change over time throughout the triple helix project duration?

Finally, the data used to measure the open innovation adoption is based on the perception of the respondents. For instance, respondents were asked on the extent to which they have had experience with several IP protections when collaborating with external partners in innovation projects. Deliberations made were not based on the actual possession of IPs or the financial amount spent on IP licensing activities. Hence, comparison between respondents' perceptions towards technological activities and open innovation adoption could not be reflected by the quantity aspects of open innovation.

6.6 Direction of Future Research

This study underlines a few recommendations for future research directions in the following areas. Firstly, it would be interesting for future research to compare the experiences and perceptions of SMEs involved in various triple helix projects managed and funded by different owners. This is to provide a wider spectrums and comparison to further understand the success factors and challenges faced by the companies.

Secondly, it is recommended that future research be undertaken using a longitudinal study to examine how trust changes throughout the triple helix project duration or a long-term effect from idea generation up till product commercialization. A further study could assess and provide an advantage for researcher to analyze and understand the pattern of association between variables being studied.

Lastly, the current study would like to suggest that future research in this field, should consider measuring the open innovation adoption based on financial evidences and the actual number of IPs in possession to have a better explanation of the relationships between the constructs. This too will lead to a better understanding of their ability to achieve the level of difficulties in respective constructs involve.

6.7 Chapter Conclusion

In conclusion, the primary purpose of this study is to examine the ability of organizations to apply the various difficulty levels in technology exploration, technology exploitation, trust and open innovation adoption among SMEs involved in triple helix projects in Malaysia. In doing so, the research was guided by two perspectives. One, is to test the relationship existed between the variables (constructs) involved, and second, is to perform a Rasch analysis to further look into the ability of the SMEs involved versus the difficulties of items that made up the constructs. Thus, this particular study adopted two techniques in particular; firstly being the SEM-PLS, which is used to test the hypotheses statement constructed; and secondly the Rasch analysis to look into the ability and the difficulties of each measures via the constructs. As the study deployed Rasch measurement analysis as the ground basis of methodological gap, the raw data was validated and converted into Rasch logits prior to the hypotheses testing. Items by each constructs were then categorized based on the logits value to understand the success factors and the challenges faced by SMEs when dealing with areas of the constructs. At the end, organizations are profiled into five distinct groups to draw patterns that explain the ability of the organizations in achieving the level of difficulties among all the constructs under study. The final part of the chapter wraps up the study by discussing the theoretical and managerial implications as well as the limitations and the areas for future research.

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APPENDIX A: QUESTIONNAIRE

Siti Noratisah Mohd Nafi
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QUESTIONNAIRE

Dear respondent,

I am a PhD student and currently pursuing a doctoral degree at Universiti Utara Malaysia (UUM) under the School of Business Management (SBM), College of Business (COB). I am conducting a doctoral research study on "**Adoption of Open Innovation Among SMEs: The mediating Role of Trust in Triple Helix Projects**". The purpose of this study to explore the motives of SMEs to engage in open innovation and perceived management challenges in adopting open innovation in Malaysia

We have identified your organization as having the characteristics necessary to participate in this research study. We would very much appreciate your contribution and cooperation to complete the enclosed questionnaires within your valuable time. Your answers are very important and significant to ensure accuracy to the research study and we ensure all information obtained would be treated strictly confidential and use for academic purposes alone.

If you have any questions about the survey, I shall be contacted at 019-5710708. A summary report will be provided to the participants upon request.

Thank you for your assistance and cooperation. I hope this study will provide a significant contribution for the betterment of SMEs in Malaysia.

Yours sincerely,

Siti Noratisah Mohd Nafi
PhD Candidate

SECTION A : DEMOGRAPHY

Instruction: The questionnaire should be completed by the top manager(s) responsible for business operation or research and development. Please fill the required information below or (√) in the appropriate box.

1. *RESPONDENT'S DETAIL*

1. Job Title: ____

2. Number of years in your present position:

Less than 5 years		5 – 10 years	
11 – 15 years		> 15 years	

3. Number of years working with the company:

Less than 5 years		5 – 10 years	
11 – 15 years		> 15 years	

2. *COMPANY'S PROFILE*

1. Years of business operation:

Less than 5 years		5 – 10 years	
11 – 15 years		> 15 years	

2. Number of employees:

Less than 50		50 - 100	
100 - 150		> 150	

3. Average **sales** per year for the last 3 years

Between RM100,000 - RM500,000	
Between RM501,000 - RM1 million	
Between RM1.1 million - RM 5 million	
Between RM5.1 million - RM10 million	
More than RM10 million	

4. Average **profit** per year for the last 3 years

Between RM100,000 - RM500,000	
Between RM501,000 - RM1 million	
Between RM1.1 million - RM 5 million	
Between RM5.1 million - RM10 million	
More than RM10 million	

3. *INNOVATION DETAILS*

1. Since 2012 to date, based on the definitions provided in the guideline, how do you classify your company's innovation?
   (Please refer attachment should you require additional information)

	YES	NO
i. PRODUCT INNOVATIONS Since 2012 to date, did your company introduce any ***new or significantly improved*** goods or services?		
ii. PROCESS INNOVATIONS Since 2012 to date, did your company introduce any ***new or significantly improved production process, distribution method, or support activity*** for your goods or services?		
iii. ORGANIZATIONAL INNOVATIONS Since 2012 to date, did your company introduce any ***new or significantly improved an organizational method*** in the firm's business practices, workplace organization or external relation?		
iv. MARKETING INNOVATIONS Since 2012 to date, did your company introduce any ***new or significantly improved marketing method*** involving significant change in product design or packaging, product placement, product promotion or pricing?		
v. RESEARCH AND DEVELOPMENT Since 2012 to date, did your company carry out any ***research and development (R&D)*** activities or projects?		

2. Overall, since 2012 to date, how do you rate the following innovation activities in your company based on the scale of 1 to 5 as follows:

1 = very poor; **2** = poor; **3** = average; **4** = good; **5** = excellent

i. Getting new products to the market quickly	1	2	3	4	5
ii. Making efficient use of R&D expenditure	1	2	3	4	5
iii. Coming up with breakthrough/radical technologies	1	2	3	4	5
iv. Bringing breakthrough technologies to the market	1	2	3	4	5

SECTION B : TECHNOLOGY EXPLOITATION

Using a scale of 1 – 5, please circle the appropriate number that best describe the level of **technological exploitation** activities of your organization.

1	2	3	4	5
Very Low		Moderate		Very High

VENTURING							
Item No	**Label**	**Items**	**Rating**				
1	tl_v1	Extent to which your company has entered many new industries	1	2	3	4	5
2	tl_v2	Extent to which your company has expanded your international operations significantly	1	2	3	4	5
3	tl_v3	Extent to which your company has acquired many companies in very different industries	1	2	3	4	5
4	tl_v4	Extent to which your company has created various new lines of products and services	1	2	3	4	5
5	tl_v5	Extent to which your company has established or sponsored various new ventures	1	2	3	4	5
6	tl_v6	Extent to which your company has focused on improving the performance of your current business rather than entering new industries	1	2	3	4	5
7	tl_v7	Extent to which your company cooperate with external partners when launching your own new products/services on the market.	1	2	3	4	5
8	tl_v8	Extent to which your company use external sources of know-how/technology when developing new activities related to the present operation of the company	1	2	3	4	5
9	tl_v9	Extent to which your company are willing to cooperate with the partners from the outside when developing new activities related to the present operation of the company	1	2	3	4	5

OUTWARD INTELLECTUAL PROPERTY (IP) LICENSING							
Item No	**Label**	**Items**	**Rating**				
10	tl_oipl1	Extent to which your company is willing to sell part of your IP (e.g. patent, trademark).	1	2	3	4	5
11	tl_oipl2	Extent to which your company are prepared to introduce your products/services that have been developed through investing into a new joint venture	1	2	3	4	5
12	tl_oipl3	Extent to which your company believe that selling your IP could harm your company as it would give competitors access to our know-how/technologies.	1	2	3	4	5
13	tl_oipl4	Extent to which your company believe that selling your IP rights through licensing is important for the growth of the company.	1	2	3	4	5
14	tl_oipl5	Extent to which your company believe that the government's efforts for protection of selling IP rights benefited your company.	1	2	3	4	5

EMPLOYEE INVOLVEMENT							
Item No	**Label**	**Items**	**Rating**				
15	tl_ei1	Extent to which your employees are regularly rotated between different functions in your company.	1	2	3	4	5
16	tl_ei2	Extent to which there is regular discussion about possibilities for collaboration between units in your company.	1	2	3	4	5
17	tl_ei3	Extent to which your company coordinates information sharing between units through a knowledge network.	1	2	3	4	5
18	tl_ei4	Extent to which your company has cross-functional teams to exchange knowledge between departments	1	2	3	4	5
19	tl_ei5	Extent to which your company has standardized work processes for cooperation between units	1	2	3	4	5
20	tl_ei6	Extent to which your company has often involve multiple organizational units in strategic decision-making	1	2	3	4	5
21	tl_ei7	Extent to which your company uses temporary workgroups for collaboration between units on a regular basis	1	2	3	4	5
22	tl_ei8	To what extent does your company actively encourage communication among unrelated groups of employees in the company.	1	2	3	4	5
23	tl_ei9	Extent to which your employees are sent for internal or external training which is directly aimed at the development and/or introduction of innovation	1	2	3	4	5
24	tl_ei10	To what extent does your company award your employees if they bring external knowhow/technology that improves our products/services.	1	2	3	4	5
25	tl_ei11	When developing new ideas, to what extent does your company often consider the suggestions of employees who are not part of the research and development team.	1	2	3	4	5

SECTION B : TECHNOLOGY EXPLORATION

Using a scale of 1 – 5, please circle the appropriate number that best describe the level of **technological exploration** activities of your organization.

1 2 3 4 5
|----------------|---------------|---------------|---------------|
Very Low Moderate Very High

CUSTOMER INVOLVEMENT

Item No	Label	Items	Rating				
26	tr_ci1	Extent to which your company obtain important product/market information from our customers rather than internal sources (internal search).	1	2	3	4	5
27	tr_ci2	Extent to which your customers are usually involved in the process of new product/service development.	1	2	3	4	5
28	tr_ci3	Extent to which your company engage with your customers in training sessions (as a trainee).	1	2	3	4	5
29	tr_ci4	Extent to which your company engage with your customers in training or instructing others (as trainer).	1	2	3	4	5
30	tr_ci5	Extent to which your company engage with your customers in evaluating your product/services.	1	2	3	4	5
31	tr_ci6	Extent to which your company usually developed new product/service in light of customer wishes and suggestions.	1	2	3	4	5
32	tr_ci7	Extent to which your company cooperate with your customers to acquire new knowhow/technology.	1	2	3	4	5
33	tr_ci8	Extent to which your company engage with your customers in the process of testing new products/services.	1	2	3	4	5

EXTERNAL PARTICIPATION

Item No	Label	Items	Rating				
34	tr_ep1	Extent to which your company aggressively participate with external parties through technological alliances.	1	2	3	4	5
35	tr_ep2	Extent to which your organization is willing to invest in external collaboration should the desired technology are proven valuable.	1	2	3	4	5
36	tr_ep3	Extent to which your company believe that investing in a new joint venture could result in acquiring new know-how/technology to your company.	1	2	3	4	5
37	tr_ep4	Extent to which your company believe that the use of know-how/technology from the outside can significantly contribute to the innovation of your company.	1	2	3	4	5
38	tr_ep5	Extent to which your company believe that it is beneficial to determine systemic and formal ways of searching for external know-how/technology.	1	2	3	4	5
39	tr_ep6	Extent to which your company believe that the know-how/technology your company have bought can create new opportunities for the company.	1	2	3	4	5

EXTERNAL RESEARCH AND DEVELOPMENT (R&D)							
Item No	Label	Items	Rating				
40	tr_erd1	Extent to which your company acquire new know-how/technology through R&D services provided by knowledge institutions such as universities, faculties, institutes, laboratories, etc.	1	2	3	4	5
41	tr_erd2	Extent to which your company is willing to purchased creative work of others parties to increase the stock of knowledge and its use to devise new and improved goods, services and processes.	1	2	3	4	5
42	tr_erd3	Extent to which your company acquire new know-how/technology through informal ties with researchers from various laboratories.	1	2	3	4	5
43	tr_erd4	Extent to which your company acquire new know-how/technology through mentoring university interns.	1	2	3	4	5

INWARD INTELLECTUAL PROPERTY (IP) LICENSING							
Item No	Label	Items	Rating				
44	tr_iipl1	Extent to which your company usually buy the intellectual property of other companies to ensure successful development of your company's new products/services.	1	2	3	4	5
45	tr_iipl2	Extent to which your company is willing to buy the IP of other companies (e.g. patent, trademark) to support your company's internal development.	1	2	3	4	5
46	tr_iipl3	Extent to which your company believe that buying IP rights through licensing from other companies is important for the growth of the company.	1	2	3	4	5
47	tr_iipl4	Extent to which your company believe that the government's efforts for protection of buying IP rights benefited your company.	1	2	3	4	5

EXTERNAL NETWORKING							
Item No	Label	Items	Rating				
48	tr_en1	To what extent does your company actively engaged as a member of a cluster?	1	2	3	4	5
49	tr_en2	To what extent does your company successfully launched and/or implemented collaborative R&D projects within a consortium of partners?	1	2	3	4	5
50	tr_en3	To what extent does your company use Internet platforms and virtual networks for posting challenges to get ideas for product/ service development?	1	2	3	4	5
51	tr_en4	To what extent does your company has internal structures and processes for managing partnerships and networks?	1	2	3	4	5
52	tr_en5	To what extent does your company regularly exchanges business information with salesperson or marketers?	1	2	3	4	5
	tr_en6	To what extent does your company collaborate with:					
53	tr_en6.1	1. Your customers	1	2	3	4	5

54	tr_en6.2	2. Your suppliers	1	2	3	4	5
55	tr_en6.3	3. Research community (universities, research centers, technology transfer agencies, etc.)	1	2	3	4	5
56	tr_en6.4	4. Your competitors	1	2	3	4	5
57	tr_en6.5	5. Other companies engaged in activities which are different than yours	1	2	3	4	5
58	tr_en6.6	6. Other companies engaged in high technology industries	1	2	3	4	5
59	tr_en6.7	7. Creative individuals	1	2	3	4	5
60	tr_en6.8	8. Government/public authorities	1	2	3	4	5

SECTION C: OPEN INNOVATION ADOPTION

Using a scale of 1 – 5, please circle the appropriate number that best describe the level of **adoption of open innovation** activities of your organization.

1 2 3 4 5
|---------------|---------------|---------------|---------------|
Very Low Moderate Very High

SATISFACTION							
Item No	**Label**	**Items**	**Rating**				
61	oia_s1	The extent to which your collaboration with external partners helps your company to reduce innovation risk.	1	2	3	4	5
62	oia_s2	The extent to which your collaboration with external partners helps your company to reduce new product/process development cost	1	2	3	4	5
63	oia_s3	The extent to which your collaboration with external partners helps your company to reduce time to market	1	2	3	4	5
64	oia_s4	The extent to which your collaboration with external partners helps your company to introduce new or significantly improved process of producing your products and services	1	2	3	4	5
65	oia_s5	The extent to which your collaboration with external partners helps your company to open new markets	1	2	3	4	5

INNOVATION PROCESS							
Item No	**Label**	**Items**	**Rating**				
66	oia_ip1	To what extent does your company collaborated with external partners in the following innovation phase:	1	2	3	4	5
67	oia_ip1.1	1. The knowledge and technology development process?	1	2	3	4	5
68	oia_ip1.2	2. The experimentation process?	1	2	3	4	5
69	oia_ip1.3	3. The idea development process?	1	2	3	4	5
70	oia_ip1.4	4. The commercialization process?	1	2	3	4	5

IP PROTECTION							
Item No	**Label**	**Items**	**Rating**				
70	oia_ipp1	To what extent does your company use the following IP protection mechanisms when collaborating with external partners in innovation projects?	1	2	3	4	5
71	oia_ipp1.1	1. Patents	1	2	3	4	5
72	oia_ipp1.2	2. Designs	1	2	3	4	5
73	oia_ipp1.3	3. Trademarks	1	2	3	4	5
74	oia_ipp1.4	4. Copyrights	1	2	3	4	5
75	oia_ipp1.5	5. Non disclosure agreements and other contractual agreements	1	2	3	4	5
76	oia_ipp1.6	6. Join development agreements	1	2	3	4	5

SECTION D: TRUST

Using a scale of 1 – 5, please circle the appropriate number that best describe the level of **trust** of your organization towards your collaborative partners.

1	2	3	4	5
Very Low		Moderate		Very High

COMPETENCE TRUST							
Item No	**Label**	**Items**	**Rating**				
	t_cr1	**RESEARCH COMMUNITY (UNIVERSITIES, RESEARCH CENTRES, TECHNOLOGY TRANSFER AGENCIES, ETC)**					
77	t_cr1.1	Extent to which your company feels confident about the research body's skills.	1	2	3	4	5
78	t_cr1.2	Extent to which your company feels that the university has the ability to accomplish what it says it will do	1	2	3	4	5
79	t_cr1.3	Extent to which your company believes that the university is known to be successful at the things it tries to do.	1	2	3	4	5
80	t_cr1.4	Extent to which your company believes that the university has adequate knowledge in one or several area related to the working project.	1	2	3	4	5
81	t_cr1.5	Extent to which your company feels that the university has enough resources to help your company for market expansion	1	2	3	4	5
	t_cg1	**GOVERNMENT**					
82	t_cg1.1	Extent to which your company feels confident about the government and it's agencies capabilities.	1	2	3	4	5
83	t_cg1.2	Extent to which your company feels that the government and it's agencies have the ability to accomplish what it says it will do	1	2	3	4	5
84	t_cg1.3	Extent to which your company believes that the government and it's agencies are known to be successful at the things it tries to do.	1	2	3	4	5
85	t_cg1.4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	1	2	3	4	5
86	t_cg1.5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	1	2	3	4	5
	t_ci1	**INDUSTRIES**					
87	t_ci1.1	Extent to which your company feels confident about the organization business capabilities.	1	2	3	4	5
88	t_ci1.2	Extent to which your company feels that the organization has the ability to accomplish what it says it will do	1	2	3	4	5
89	t_ci1.3	Extent to which your company believes that the organization are known to be successful at the things it tries to do.	1	2	3	4	5

90	t_ci1.4	Extent to which your company believes that the government and it's agencies have adequate knowledge in one or several area related to the working project.	1	2	3	4	5
91	t_ci1.5	Extent to which your company feels that the government and it's agencies have enough resources to help your company for market expansion	1	2	3	4	5

CREDIBILITY TRUST							
Item No	**Label**	**Items**	**Rating**				
	t_cru1	**RESEARCH COMMUNITY (UNIVERSITIES, RESEARCH CENTRES, TECHNOLOGY TRANSFER AGENCIES, ETC)**					
92	t_cru1.1	Extent to which your company believes that the research body has been frank in dealing with you.	1	2	3	4	5
93	t_cru1.2	Extent to which your company is confident that the research body is knowledgeable about the research they conduct.	1	2	3	4	5
94	t_cru1.3	Extent to which your company is confident that the research body is honest about any problems occurs during the project duration.	1	2	3	4	5
95	t_cru1.4	Extent to which your company can depend on the research body to be fair throughout the research project.	1	2	3	4	5
96	t_cru1.5	Extent to which your company is confident that the research body is an honorable partner.	1	2	3	4	5
97	t_cru1.6	Extent to which your company is confident that the research body honor their words.	1	2	3	4	5
98	t_cru1.7	Extent to which your company is confident that the research body keep their promises.	1	2	3	4	5
99	t_cru1.8	Extent to which your company is confident that the research body is telling the truth.	1	2	3	4	5
	t_crg1	**GOVERNMENT**					
100	t_crg1.1	Extent to which your company believes that the government and it's agencies have been frank in dealing with you.	1	2	3	4	5
101	t_crg1.2	Extent to which your company is confident that the government and it's agencies are knowledgeable about their functions.	1	2	3	4	5
102	t_crg1.3	Extent to which your company is confident that the government and it's agencies are honest about any problems that occurs during the project duration.	1	2	3	4	5
103	t_crg1.4	Extent to which your company can depend on the government and it's agencies to be fair throughout the research project.	1	2	3	4	5
104	t_crg1.5	Extent to which your company is confident that the government and it's agencies are honorable partners.	1	2	3	4	5
105	t_crg1.6	Extent to which your company is confident that the government and it's agencies honor their words.	1	2	3	4	5
106	t_crg1.7	Extent to which your company is confident that the government and it's agencies keep their promises.	1	2	3	4	5
107	t_crg1.8	Extent to which your company is confident that the government and it's agencies are telling the truth.	1	2	3	4	5
	t_cri1	**INDUSTRIES**					
108	t_cri1.1	Extent to which your company believes that the industrial big players have been frank in dealing with you.	1	2	3	4	5
109	t_cri1.2	Extent to which your company is confident that the industrial big players are knowledgeable about their products and market.	1	2	3	4	5
110	t_cri1.3	Extent to which your company is confident that the industrial big players are honest about any problems that occurs during the partnering project duration.	1	2	3	4	5
111	t_cri1.4	Extent to which your company can depend on the	1	2	3	4	5

		industrial big players are to be fair throughout the research project.					
112	t_cri1.5	Extent to which your company is confident that the industrial big players are honorable partners.	1	2	3	4	5
113	t_cri1.6	Extent to which your company is confident that the industrial big players honor their words.	1	2	3	4	5
114	t_cri1.7	Extent to which your company is confident that the industrial big players keep their promises.	1	2	3	4	5
115	t_cri1.8	Extent to which your company is confident that the industrial big players are telling the truth.	1	2	3	4	5

BENEVOLENCE TRUST							
Item No	**Label**	**Items**	**Rating**				
	t_bu1	**RESEARCH COMMUNITY (UNIVERSITIES, RESEARCH CENTRES, TECHNOLOGY TRANSFER AGENCIES, ETC)**					
116	t_bu1.1	Extent to which your company feels that the research body cares for you.	1	2	3	4	5
117	t_bu1.2	Extent to which your company feels that the research body has gone out on a limb (risking their reputation) in times of shortages.	1	2	3	4	5
118	t_bu1.3	Extent to which your company feels that the research body has been on your side.	1	2	3	4	5
119	t_bu1.4	Extent to which your company feels that the research body is like a friend.	1	2	3	4	5
120	t_bu1.5	Extent to which your company feels that the research body has your company's best interests in mind.	1	2	3	4	5
121	t_bu1.6	Extent to which your company feels that the research body is motivated to protect your company.	1	2	3	4	5
121	t_bu1.7	Extent to which your company feels that the research body work to protect your company.	1	2	3	4	5
122	t_bu1.8	Extent to which your company feels that the research body watches your company back.					
123	t_bu1.9	Extent to which your company feels that the research body looks out for your company.	1	2	3	4	5
	t_bg1	**GOVERNMENT**					
124	t_bg1.1	Extent to which your company feels that the government and it's agencies care for you.	1	2	3	4	5
125	t_bg1.2	Extent to which your company feels that the government and it's agencies have gone out on a limb (risking their reputation) in times of shortages.	1	2	3	4	5
126	t_bg1.3	Extent to which your company feels that the government and it's agencies have been on your side.	1	2	3	4	5
127	t_bg1.4	Extent to which your company feels that the government and it's agencies are like friends.	1	2	3	4	5
128	t_bg1.5	Extent to which your company feels that the government and it's agencies have your company's best interests in mind.	1	2	3	4	5
129	t_bg1.6	Extent to which your company feels that the government and it's agencies are motivated to protect your company.	1	2	3	4	5
130	t_bg1.7	Extent to which your company feels that the government and it's agencies work to protect your company.	1	2	3	4	5
131	t_bg1.8	Extent to which your company feels that the research body watches your company back.					

BENEVOLENCE TRUST							
Item No	**Label**	**Items**	**Rating**				
132	t_bg1.9	Extent to which your company feels that the government and it's agencies look out for your company.	1	2	3	4	5
	t_bi1	**INDUSTRIES**					
133	t_bi1.1	Extent to which your company feels the industrial big players care for you.	1	2	3	4	5
134	t_bi1.2	Extent to which your company feels that the industrial big players have gone out on a limb (risking their reputation) in times of shortages.	1	2	3	4	5
135	t_bi1.3	Extent to which your company feels that the industrial big players have been on your side.	1	2	3	4	5
136	t_bi1.4	Extent to which your company feels that the industrial big players are like friends.	1	2	3	4	5
137	t_bi1.5	Extent to which your company feels that the industrial big players have your company's best interests in mind.	1	2	3	4	5
138	t_bi1.6	Extent to which your company feels that the industrial big players are motivated to protect your company.	1	2	3	4	5
139	t_bi1.7	Extent to which your company feels that the industrial big players work to protect your company.	1	2	3	4	5
140	t_bi1.8	Extent to which your company feels that the industrial big players watch your company back.	1	2	3	4	5
141	t_bi1.8	Extent to which your company feels that the industrial big players look out for your company.	1	2	3	4	5

~Thank you very much for your assistance and cooperation in completing this survey ~