THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE

HAFIZ MUDASSIR REHMAN

DOCTOR OF PHILOSOPHY (PHD)

FACULTY OF BUSINESS AND FINANCE

UNIVERSITI TUNKU ABDUL RAHMAN

June 2022

THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE

By

HAFIZ MUDASSIR REHMAN

Thesis submitted to the

Faculty of Business and Finance,

Universiti Tunku Abdul Rahman,

in partial fulfilment of the requirement for the degree of Doctor of Philosophy

June 2022

DEDICATION

To my beloved grandparents, Haji Muhammad Salman & Hajra Bibi; dearest parents Muhammad Nazir Malik & Noor Begum; supportive brother & sister-in-law Mobashar Rahman & Hajra Malik; both caring sisters Naheed Kausar and Fauzia Nazir, and lovely wife Septriyan Orpina. They are the biggest supporters in my life. Their role in my life was and remains immense.

ABSTRACT

THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE

Hafiz Mudassir Rehman

The manufacturing sector is an indispensable part of a country's economic system. For Malaysia, it not only helps in transmuting raw material to finished goods but also an essential driver to the country's economic growth. Owing to this sector, Malaysia holds a remarkable position in exports across the world. It is also a principal contributor to the employment of the country. Although, the manufacturing industry is deemed as the backbone of a country's growth, however, the industry also faces many challenges due to technological advancements due to the industrial revolution known as Industry 4.0.

The aim of Industry 4.0 is to realize productivity and improve efficiency. Its potential disruptive technologies are altering the way of work. Correspondingly, it poses challenges for companies to innovate and in analyzing their readiness for Industry 4.0. Thereby, current research aimed to investigate the key role of organization innovation and its enablers including knowledge-oriented leadership and decentralized organization structure. In addition, change in demographics has shaped another snag in the form of an aging workforce for manufacturing companies. Ergo, the moderating role of the aging workforce was gauged in support to readiness for Industry 4.0 by using Structural Equation Modelling (SEM).

A quantitative and qualitative methods were adopted to establish the relationships and understanding of variables. Useful responses from manufacturing companies were collected through self-administered questionnaire and interviews. The responses were examined using Smart PLS 3 and ATLAS.ti software. The results highlighted the important dual role of organization innovation for readiness of Industry 4.0. In Addition, Multi-Group Analysis was performed to confirm the importance of different aging workforce groups between organization innovation and readiness for Industry 4.0.

Current research contributed to the body of knowledge a detailed vision of Industry 4.0 and its significance for manufacturing sector in Malaysia. The research findings confirmed a noteworthy knowledge concerning high dependency of readiness for Industry 4.0 on organization innovation and moderating effect of aging workforce between them. Additionally, knowledge-oriented leadership was also identified as an enabler of organization innovation through empirical examination. The moderating role of organization innovation is of high interest for keen researchers.

Current research provides a directive for practitioners to pave the way for successful implementation of Industry 4.0. For bye, the research outcomes are thought-provoking to national policymakers which can aid in development of impressive policies for Industry 4.0 while considering the vital role of organization innovation and aging workforce. Finally, the findings will benefit the aged workers to contribute and survive in growing economy.

ACKNOWLEDGEMENT

A special thanks to Allah the almighty for guiding me and giving me strength to complete this PhD journey.

Pursuing this PhD programme has been a challenging experience for me, and it would not have been possible without the supportive efforts and synergies I got from different individuals and institutions. I am truly grateful to their contribution to make sure that my study is fulfilled accordingly.

At first, I would like to extend solemn gratitude to my supervisor Associate Professor Dr. Au Yong Hui Nee for her inspiration, supervision, constructive criticism, guidance, and valuable comments during the course of my PhD studies. My appreciation goes to Co-supervisor Assistant Professor Dr. Choong Yuen Onn as well for his persistent advice, encouragement, constant support, suggestions, and guidance in each step of the study.

Beside my supervisors, I am thankful to UTAR team for moral and physical support that created a favorable environment to continue my studies. I send my sincere appreciations to Head of Postgraduate and Research programs, all faculty members of Faculty of Business and Finance (FBF), and librarians for their best service.

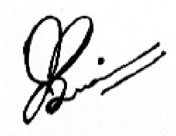
I recognize the constructive suggestions offered by examiners during the Proposal Defense (PD) and Work Completion Seminar (WCS) that helped to enhance my research from various perspectives. I am also indebted to Assistant Professor Dr. Gengeswari a/p Krishnapillai for her unwavering assistance during coursework.

Many thanks go to the staff from Institute of Postgraduate Studies and Research (IPSR) and Department of International Students Services (DISS) particularly Ms. Vani and Ms. Nurul, Ms. Shahida, Mr. Veera, and Mr. Siva for making official processes easy for me. I am deeply beholden to the generous funding received from UTAR for attaining the PhD program.

Finally, this thesis is dedicated to my grandparents Mr. and Mrs. Haji Muhammad Salman, my parents Mr. and Mrs. Muhammad Nazir Malik, my brother's family, Mr. and Mrs. Mobashar Rehman, my both sisters and my wife for their prayers, love, and encouragement during this long journey. Their physical and psychological contribution to triumph PhD programme was immense. God bless you all.

DECLARATION

I, Hafiz Mudassir Rehman, hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Tunku Abdul Rahman or other institutions.



Hafiz Mudassir Rehman

Date: June 2022

APPROVAL SHEET

This dissertation/thesis entitled "THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE" was prepared by HAFIZ MUDASSIR REHMAN and submitted as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Business & Management at Universiti Tunku Abdul Rahman.

Approved by:

Associate Professor Dr. Au Yong Hui Nee Date: 16 June 2022
Supervisor
Department of Economics
Faculty of Business and Finance
Universiti Tunku Abdul Rahman

Assistant Professor Dr. Choong Yuen Onn Date: 16 June 2022
Co-supervisor
Department of Business and Public Administration
Faculty of Business and Finance
Universiti Tunku Abdul Rahman

SUBMISSION SHEET

FACULTY OF BUSINESS AND FINANCE
UNIVERSITI TUNKU ABDUL RAHMAN

Date: June 2022

SUBMISSION OF THESIS

It is hereby certified that Hafiz Mudassir Rehman (ID No: 18ABD07059) has completed this thesis entitled "THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE" under the supervision of Associate Professor Dr. Au Yong Hui Nee from the Department of Economics, Faculty of Business and Finance and Assistant Professor Dr. Choong Yuen Onn from the Department of Business and Public Administration, Faculty of Business and Finance.

I understand that the University will upload softcopy of my thesis in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

Hafiz Mudassir Rehman

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVATIONS

4IR	Fourth Industrial Revolution
ABB	ASEA Brown Boveri
AI	Artificial Intelligence
AMO	Ability-Motivation-Opportunity
ASEAN	Association of Southeast Asian Nations
AVE	Average Variance Extracted
B2E	Business to Employee
BRIC	Brazil, Russia, India and China
CEO	Chief Executive Officer
CPS	Cyber Physical Systems
CPS	Cyber-Physical System
DFTZ	Digital Free Trade Zone
DOSM	Department of Statistics Malaysia
E&E	Electrical and Electronic
EPU	Economic Planning Unit
ESS	Employee Self Service

FMM	Federation of Malaysia Manufacturers
G7	Group of Seven Countries
GDP	Gross Domestic Product
GE	General Electric
HRDP	Human Resource Development Program
I4.0	Industry 4.0
ICT	Information and Communication Technology
IIOT	Industrial Internet of Things
Industry 4.0	Fourth Industrial revolution
INSEAD	European Institute of Business Administration
IoT	Internet of Things
IQ	Intelligent Quotient
IT	Information Technology
KUKA	Keller und Knappich Augsburg
MIDA	Malaysian Investment Development Authority
MIGHT	Malaysian Industry-Government Group for High Technology
MNC	Multi-National Companies
MOF	Ministry of Finance

MOHR	Ministry of Human Resource
MOSTI	Ministry of Science Technology and Innovation
MSS	Management Self Service
NSTIP	National Science Technology and Innovation Plan
OECD	Organization for Economic Co-operation and Development
PCR&P	Petroleum, Chemical, Rubber & Plastic
PLS	Partial Least Squares
PM	Prime Minister
R&D	Research and Development
SME	Small Manufacturing Enterprises
SMECorp	SME Corporation
UK	United Kingdom
UN	United Nation
USA	United States of America
WEF	World Economic Federation
WHO	World Health Organization
WIPO	World Intellectual Property Organization

PUBLICATIONS

Journal Articles

1. Facilitating the Malaysian Manufacturing Sector in Readiness for Industry 4.0. A Mediating Role of Organization Innovation.
   Accepted at International Journal of Asian Business and Information Management (IJABIM) under the IGI Global publishers. Web of Science (**ESCI, SCOPUS, INSPEC**).
2. Impact of Management Practices on Organisational Innovation in the Digital Age: A Study of the Manufacturing Industry in Malaysia
   Accepted at International Journal of Management Studies. Web of Science (**ESCI**).
3. Enablers for organization innovation to the readiness of Industry 4.0 and confronting the threats of aging workforce.
   Under Review at Review of Managerial Sciences (**IF=7.127**)

International Conferences

4. Barriers to Adoption of Industry 4.0 in Manufacturing Sector.
   Accepted at “ESTCON 2021” (**SCOPUS**)
5. Organization Innovation for Industry 4.0 in management perspective.
   Presented at International Conference of Business, Accounting, Finance and Economics 2019
6. The Roles of Organization Innovation and Aging Workforce in Malaysian Manufacturing Sectors' Readiness for Industry 4.0.
   Presented at BLM2-ICAM4 An International joint e-Conference 2021

CHAPTER 1

CHAPTER

1.0 INTRODUCTION

1.1. Research Background

The manufacturing industry is an essential part of a country's economic system. It is a key driver of economic growth that concentrates on production and provides value addition by converting raw materials into final useable products (Behun et al., 2018). Especially for Malaysia, the manufacturing sector is among the major contributors to economic development. In 2018, this sector alone had contributed approximately 22.8% of Malaysia's Gross Domestic Product (GDP) (Department of Statistics Malaysia [DOSM], 2018). However, the evolution of Industry 4.0 brings major disruptions in the manufacturing business environment with introduction of advance technologies. Therefore, to maintain the significant profits of this sector, the companies need constant innovation with adoption of new technologies, notably in the processes of developing smart production systems. The technologies include but are not limited to Smart Manufacturing, Artificial Intelligence (AI), the Internet of Things (IoT), and many more (Erol et al., 2016).

Industry 4.0 entails value-added processes and efficient resources utilization, mainly with the help of advanced manufacturing technologies. The primary purpose is to increase proficiency, reduce the dependency on human capital and drive the manufacturing sector towards production competitiveness (Stock & Seliger, 2016).

The integration of humans, machinery, production, and processes across different boundaries of companies enables the creation of a new intelligent value chain (Schumacher et al., 2016).

This idea of Industry 4.0 was originated in 2011 in Germany with the aim to enhance the competitiveness of the German manufacturing industry (Szozda, 2017). Since then, this concept has been adopted by a few developed countries only including the United States of America, the Russian Federation, and China (Soomro et al., 2021). Malaysia as a developing country has recently announced the "The National Policy on Industry 4.0" (Ministry of International Trade and Industry [MITI], 2018), with the idea of implementing the concept of Industry 4.0 to strengthen the manufacturing sector through innovation.

An innovative organizations should emphasize the new manufacturing system for future survivability (Palazzeschi et al., 2018), that only can be attained through the adoption of technology. Organization innovation along with embracement of new technology work together to execute operations and provide good quality products effectively. However, organization innovation does not just appear out of nowhere (Buhr, 2017) instead requires effort and challenging works. For example, companies can follow the footprints of Learning Organization to improve their innovation performances (Rehman et al., 2021). Learning Organization theory introduced by Senge (1990) described the process of innovation by stating the appropriate practices that are required for continuous learning and innovation for companies to adjust and tackle uncertainties (Theriou & Chatzoglou, 2008). The theory also discusses the creation, acquisition, and transformation of knowledge needed to face the dynamic business environment (Garvin, 1993).

Deriving from the concepts of Learning Organization, appropriate leadership and a suitable structure that supports innovation in a dynamic business environment are needed for companies to be ready for Industry 4.0. According to Donate and de Pablo (2015), leadership is an essential factor that sets the direction of a company for achieving its objective. More specifically, knowledge-oriented leadership is highly relevant to accomplish the goals of innovation performances, as every innovation implies the development and acquirement of new knowledge (Kianto et al., 2017). This leadership style focuses on knowledge creation, knowledge sharing, and knowledge application that are the crucial prerequisite of innovation. Therefore, it is considered a key enabler of innovation for any company. Additionally, it boosts innovation through actions with additional elements of motivation and communication (Donate & de Pablo, 2015).

Organization structure is another important contributing factor of organization innovation. Waruwu et al. (2020) highlighted that an organization structure facilitates and enhances innovation. Therefore, an organization structure specifically leads to a decentralized management policy, creating more autonomy for employees, thus producing a high degree of freedom is considered suitable for innovative organizations. Also, in this era of fast changes and development

(Industry 4.0), innovative organizations should establish a structure that allows free flow of communication and fewer hierarchies that can usher quick and effective decision making (Cimini et al., 2020), all of which are referring to the core concepts of decentralized organization structure.

The Malaysian manufacturing sector has been experiencing rapid evolution during the last few decades. The changes from mass production with the labor-intensive workforce to use technologies such as robotics for business efficiency, have been taken as a result of the consistent progress in automation (Ministry of International Trade and Industry [MITI], 2018). This technology-focused development, along with the emergence of Industry 4.0 is surpassing traditional business models, as well as national boundaries, since people nowadays are doing business at a much faster pace than before (Prince, 2017). To keep up the pace of these rapid changes, the companies require dynamic capabilities in form of innovation which can be achieved through right practices, allowing them to respond immediately to any possible challenges and complex situations (Teece et al., 1997). Hence, the application of dynamic capabilities in a key contributing sector (manufacturing in this case) is also important for the growth and development of Malaysia.

1.1.1. Significance of Manufacturing Sector of Malaysia

The Malaysian manufacturing sector is repositioning its future with the adoption of technologies. An established manufacturing sector paves the ways to improve productivity, innovation capacity, job creation, and ultimately, economic prosperity. This sector is also important for Malaysia, as it is the second-largest GDP contributor (22.3%) towards the economy (Economic Planning Unit [EPU], 2015). The target of the Eleventh Malaysian Plan (11MP) is to stay on track and be resilient at all times in order to achieve the yearly Gross Domestic Product (GDP) targets. Thus, Malaysia needs to strengthen its manufacturing sector to match the pace of Industry 4.0.

Internationally, Malaysia has experienced a relatively strong and competitive position in both the manufacturing and technological innovation sectors (Cornell et al., 2017). According to the 2016 Global Manufacturing Competitive Index, Malaysia was placed at the 17th position among 40 nations. It was also estimated that Malaysia could go four steps up into the 13th position by 2020 if it managed to adopt modern technologies (Giffi et al., 2016). Recently, the 2018 Future of Production Report provided a worldwide evaluation of 100 nations and positioned Malaysia in the “Leader” quadrant. The nations that are placed in the “Leader” quadrant are referring to the nations with a “strong current production base” and are also “positioned well for the future.” It is also exciting to state that Malaysia and China are the only two nations that are not from the high-income nations and were placed in the “Leader” quadrant (Kearney, 2018). On the advancement side, the 2017 Global Innovation Index ranked Malaysia at the 37th position among 127 nations, as well as 8th among the Asian countries (Cornell et al., 2017).

Besides, Malaysia aims to be in the leading innovative position for the future generation. The manufacturing industry has made Malaysia a well-known trading nation (MITI, 2018). Among 221 countries, Malaysia has also been ranked 19th as a world exporter with more than the two-third contribution from the manufacturing sector (Malaysian Investment Development Authority [MIDA], 2018; Simoes, 2017). These statistics are impressive, but Malaysia is still facing challenges in the parallel transformation of businesses to Industry 4.0.

Up until now, the manufacturing industry of Malaysia has performed a vibrant role in making the country a key player in the international value chain (Haraguchi et al., 2017). However, with the emergence of Industry 4.0 concepts, the key players of the manufacturing industry have to improve themselves in the fastest manner in order to maintain and to climb up in the current global competition race, in addition, to achieving economic development. Otherwise, other countries may perform better by adopting Industry 4.0 and will thus overtake Malaysia. Therefore, to embrace the visionary concept, it is vital to analyze the readiness of Malaysia in adopting the concepts of Industry 4.0 in the manufacturing sector, as well as to determine the awareness of stakeholders to reach the plan accordingly.

1.1.2. Readiness for Industry 4.0

The fast changes in the manufacturing landscape motivate the production sector to re-assess strategies and to remain insistent. In the context of Malaysia, industrial experts see these changes as a new era of development and opportunity. The outcome of these changes for manufacturing companies is pushing the Malaysian government authorities to re-evaluate the functions that can lead to economic growth (MITI, 2018). The government is focusing on how to invest in technologies and increase advanced manufacturing. By facilitating the transformation of the manufacturing industry, Malaysia will ultimately increase the economic well-being of its citizens.

The term "Readiness" means a state of being complete, prepared, or ready. It is also defined as "*the ability to capitalize production opportunities, mitigate risks & challenges, be resilient and agile in responding to unknown shocks*" (Kearney, 2018, p. 5). In the review of the General Electric Global Innovation Barometer, the majority of Malaysians, in comparison to other professionals from all over the world, are positive (76% vs. 68%), confident (72% vs. 60%), and excited (67% vs. 61%) about the prospects of implementing Industry 4.0 (Economic Intelligence [EI], 2018). A survey performed on more than 2000 participants from different sectors found that about 70% of the surveyed respondents planned to considerably increase their digital transformation level by 2020, while only about 33% of them ranked their current business as being digitally innovative (Geissbauer et al., 2016). The findings clearly showed the significance of readiness and its requirement for Industry 4.0.

Even though automation in manufacturing has been established for a long time, most of the Industry 4.0 concepts are not being applied yet. A few huge manufacturers and multinational companies, such as Keller und Knappich Augsburg (KUKA) and ASEA Brown Boveri (ABB), are already anticipating the benefits of this subject (Industry 4.0) (Adamu Yusuf, 2019). However, most of the local manufacturing companies do not consider this as of great significance, mainly due to low awareness of the benefits. Although these companies are likely to be the main players of this change (Bahrin et al., 2016), there is a risk of them being left behind if they remain conscious and hesitate to accept the implementation of Industry 4.0.

Malaysia has the potential to stride towards Industry 4.0, especially with the adoption of advanced technologies in the manufacturing sector (Malaysian Industry-Government Group of High Technology [MIGHT], 2018). The federal government in the Eleventh Malaysia Plan (11MP) has intended to increase industrial productivity through a greater acceptance of technologies in companies and through a raise in efficiency by improving the skills of employees (Economic Planning Unit [EPU], 2015).

The Malaysian government has also planned to spend approximately RM 210 million to support the awareness and transition to Industry 4.0 for small-medium enterprises (MITI, 2018). They have come up with technology-oriented projects to encourage the adoption of the latest technological innovations in regional markets.

MIGHT (2018) presented an initiative to tackle the country's needs in responding to the results of globalization and through the fast use of technology. In this initiative, various programs, such as the acquisition of technology, as well as nurturing the capacity development of companies and employees, are included. Malaysia targets to be at the leading position in future with technological innovation through such projects that are initiated by the government.

The set-ups of Malaysia-Korea collaboration and Robotics programs aim to exchange knowledge and techniques crucial for the development of human capital. Another official collaboration is formed between the Malaysian Institute of Microelectronic Systems (MIMOS), a national research and development (R&D) center in Information and Communication Technology (ICT) of Malaysia, and China for smart manufacturing technology research programs. Along with other continuous projects, the Malaysian government is putting efforts to create the right system for manufacturing companies in order to transform the traditional manufacturing methods and follow the newest technological innovation to ensure that they can stay competitive worldwide (Bahrin et al., 2016).

The MITI took some pre-emptive measures for the purpose of transforming the Malaysian manufacturing sector. One initiative is "The National Policy on Industry 4.0" which was introduced in 2018 to achieve the country's economic goals. The philosophy behind the policy is to *attract* patrons to Industry 4.0, mainly for the improvement of procedures and implementation of new technologies. Moreover, the program supports and *creates* the right environment for technology adoption and *transformation* of manufacturing capabilities for the readiness to embrace Industry 4.0 (MITI, 2018). However, the concept of Industry 4.0 is too broad and therefore requires a complete restructuring of the existing manufacturing system. In current research, some important factors essential for manufacturing companies to play their role in the transition phase of Industry 4.0 are analyzed and discussed.

1.1.3. Shift Factors for Industry 4.0

Developing countries need to embark on the journey of Industry 4.0, first by transforming their manufacturing sector. For this purpose, the major shift factors, including *People, Process, and Technology*, are identified as important components in manufacturing companies (MITI, 2018). World Economic Forum [WEF] (2018) has also identified technology and human capital as the key drivers of Industry 4.0. Companies are comprised of a group of people (employees), thus their success is highly dependent on their employees' performances, management, and how they are controlled (Hecklau et al., 2016).

For Industry 4.0, people (human capital) should be the main priority of every company (MITI, 2018). The most important part for human capital is leadership, as this treats people as an asset and promotes knowledge-sharing behavior for innovation (Leroy et al., 2018). Therefore, Industry 4.0 requires leadership with knowledge-oriented advantage and has as an extra motivational element. These can ensure the development of human capital and provide supports to existing talents that are needed for the achievement of the company's objectives (Agarwal, 2017). Besides, the demographic shift is making Malaysia an aging society (Institute of Labour Market Information and Analysis [ILMIA], 2017). The aging workforce is a critical factor for companies in the context of Industry 4.0 (Shamim et al., 2016). The difference between birth and death rates may affect the progress towards Industry 4.0 implementation, if not handled tactfully. In addition, Malaysia may also face the reduction of young employees' workforce due to this demographic change.

Secondly, the improvement of whole business processes in manufacturing is a key for Industry 4.0 readiness. The concept of Industry 4.0 is not about adopting new technologies only, but it also includes modifying business processes responsively (Hecklau et al., 2016). The rapid transformation of processes is crucial for future manufacturing competitiveness to ensure its contribution to the nation's economic prosperity. Therefore, reforming processes is critical in helping manufacturing companies to produce highly customized products, along with efficient services. Additionally, this smart production concept requires continuous innovation (Mohelska & Sokolova, 2018). Thereby, to support continuous improvement in processes, the climate of innovation coupled with suitable practices like knowledge-oriented leadership and decentralized organization structure, is important (Shamim et al., 2016).

Finally, to use the full potential of Industry 4.0, all the companies need to adopt new technologies. Moreover, they have to find a balance between people, processes, and technology (Dworschak & Zaiser, 2014). “People” refers to the workforce that is led and motivated by knowledge-oriented leaders, “Process” refers to the flexibility to support the transformation of manufacturing towards a new industry paradigm, while “Technology” is used to assist smart manufacturing. Most importantly, the requirement of technology with an aging workforce should be synchronized for industrial competitiveness (Schinner et al., 2017). The readiness for Industry 4.0 can only be achieved if all the three shift factors are aligned with the requirement of Industry 4.0.

1.2. Problem Statement

The importance of learning for the progression of companies has become increasingly relevant, in line with the development of Industry 4.0 concepts. It conceptualizes the ability of a company to stay advanced and competent in the market through the development and acquisition of knowledge (Serban, 2021). Nowadays, knowledge is considered a primary source for creating an advantageous competitive environment (Sadeghi & Rad, 2018). Hence, various companies are looking for a solution to achieve and maintain this competitive advantage. Academical and industrial experts suggested knowledge-oriented leadership be executed in companies to attain advantage (Obeidat & Abdallah, 2014; Hatane, 2015), as it plays a vital role in the creation, storage, and application of knowledge

(Donate & de Pablo, 2015). Such leaders are devoted to facing challenges, advocating innovation, and maintaining competitiveness with their skills of managing knowledge, specifically by considering it as the asset of a company.

In this new era of development, more and more companies are moving towards smart manufacturing. The notion of advanced manufacturing is to align with forthcoming and digital production systems (Erol et al., 2016). It is clear these idealistic ideas lead to complexities, (either technical or operational) throughout the organizational levels (Erol et al., 2016). These challenges can only be tackled through appropriate practices, for example, knowledge oriented leadership and appropriate structure of organization (Gilchrist, 2016; Shamim et al., 2016). Yet, in the context of innovation and Industry 4.0, the prior literature has mainly discussed the problems and opportunities associated with this concept. Most of the published research on this topic does not pay much attention to organizational practices, such as knowledge-oriented leadership, even though this is an influencing factor that facilitates changes (organization innovation) for Industry 4.0 (Shamim et al., 2016).

Companies that can deal with the complexities of new production systems will be able to withstand and survive these industrial changes (Erol et al., 2016). However, it is not simple for the companies to adopt smart manufacturing, as digital changes are usually associated with innovating challenges (Hecklau et al., 2016). The complexity of these intelligent manufacturing systems leads to uncertainty about the organizational practices in achieving organization innovation. According to

Ivanov et al. (2016), when the future directions of an organization are unclear and complex, then the company needs to come up with new and appropriate practices to cope with these challenges. Two of the vital practices that can develop innovation capacity are “knowledge-oriented leadership and decentralized organization structure” (Shamim et al., 2016).

However, there is lack of investigation on specific leadership style; knowledge-oriented leadership and appropriate structure of organization that support organization innovation and upcoming rapid technological shift important to achieve Industry 4.0 (Shamim et al., 2016). Thereby, a research with the Malaysian setting is required to determine the practices and contributing factors for innovative organizations in Industry 4.0 (Abdullah et al., 2017). The scarcity of empirical research in context of knowledge-oriented leadership and innovation has also been emphasized by Naqshbandi and Jasimuddin (2018). It was also recommended by Malaysian researchers, Mohelska and Sokolova (2018) to carry out more research on leadership and structure in the assistance of organizational innovation for effective implementation of Industry 4.0.

On the other hand, the fast-advancing pace of technology has changed the nature of projects. These projects are now categorized as short development period projects. The high rate of changes in technology and processes thus requires the continuous innovation of manufacturing companies (Shamim et al., 2016). Advanced countries that rely on the manufacturing sector are also trying to reinvigorate and seek innovative solutions in terms of production techniques so that they can compete globally (Lee et al., 2014).

The manufacturing companies of Malaysia should also make innovation a part of their routine and develop long-term abilities that can assist in the achievement of Industry 4.0. Industry 4.0 can only be possible with the help of knowledge-oriented leadership and additional support of decentralized organization structure, as only these two factors have the potential to influence changes positively (Shamim et al., 2016). Ultimately, innovative organizations can endure in the vibrant business conditions of Industry 4.0.

Along with the opportunities that are presented by innovation, more resources and high-risk sustainability are required, but all these lead to managerial challenges. Therefore, the adoption of innovation should be handled and implemented after tactful analysis. Past literature usually emphasizes the direct effects of organization innovation (Akbar et al., 2020; Chan et al., 2019; Sharma et al., 2016), but very few studies discussed the mediating role of innovation according to different organizational aspects and overall performances (Anning-Dorson, 2018; Uzkurt et al., 2013). Umrani and Johl (2018) also highlighted the mediating role of organization innovation to achieve organizational goals. However, the indirect roles of organization innovation, its antecedents, and consequences still required examination (Zafar & Mehmood, 2019). Therefore, the roles need to be addressed and confirmed so that the possible risks of manufacturing companies from being left behind in Industry 4.0 adoption can be reduced.

According to Akdil et al. (2018), projects that are associated with Industry 4.0 are much costly with a lot of risks involved. The main issue regarding this concept is the lack of information from the manufacturing companies regarding Industry 4.0 concepts. In an industry-wide survey conducted by Schumacher et al. (2016), a wide range of problems, such as the lack of strategic guidance and perception of highly complex Industry 4.0 concepts, companies are uncertain about the outcomes of Industry 4.0 (in terms of benefits), and most importantly, the companies failed to assess their readiness for Industry 4.0, were identified as the factors that impaired the practices of Industry 4.0.

Several developed countries have demonstrated resilience in Industry 4.0 acceptance, but this concept in emerging countries' settings have seldom been investigated (Fatorachian & Kazemi, 2018). Especially in Malaysia, the manufacturing companies are still in the initial stages of their understanding of Industry 4.0. Large multinational companies may have experienced the readiness for Industry 4.0 based on the information passed down from their overseas offices, but they may not have truly applied these concepts in Malaysia (Rajagopal et al., 2018). According to the policy prepared for Industry 4.0, there is less knowledge available among the manufacturing companies on the effects and needs for Industry 4.0. Moreover, they have lesser know-how about readiness to embark on Industry

4.0 and the shortage of skilful talents in the area of new technologies used in the manufacturing industry (Ministry of International Trade and Industry [MITI], 2018). Since many of the companies are struggling in the transition phase, hence the research on assessment and guidelines for their readiness are highly recommended and called for.

To encourage and spread awareness among the manufacturing companies, the Malaysian government has recently announced its National Policy for Industry 4.0. The policy has highlighted several issues, including a limited understanding of manufacturing companies about their readiness, the lack of awareness for Industry 4.0, and many more (Ministry of International Trade and Industry [MITI], 2018). Therefore, in the direction of becoming competitive, the manufacturing companies need to know about readiness for Industry 4.0 (Juhary, 2019). The knowledge that can be provided to manufacturers through guidelines for their readiness help them in finding ways forward to Industry 4.0 implementation (Akdil et al., 2018).

Although the subject of Industry 4.0 has become prominent among most of the research centers and companies (Dais, 2017; Drath & Horch, 2014; Hermann et al., 2015), there are not many research for Malaysian academicians and practitioners. Recent research on Industry 4.0 conducted in Malaysia that analyzed the technology adoption and readiness issues for industry 4.0 was from the automotive and information technology sectors only (Maavak & Ariffin, 2018; Soomro et al., 2021). Besides that, a few researchers on this topic highlighted the possible challenges but were related to learning in the academic sector (Juhary, 2019; Maavak & Ariffin, 2018; Mudin et al., 2018). So, by considering the importance of the manufacturing sector, as well as Industry 4.0 for Malaysia, the study on the readiness for Industry 4.0 of associated companies is in demand.

In parallel to the benefits contributed by the advancement of technologies, there are major challenges that are directly affecting the workers and the nature of works (Romero et al., 2016). The challenges are not only associated with the adoption of technology but also with the availability of qualified and trained employees in companies (Schumacher et al., 2016). The key challenge ahead that impacts the availability of human resources is due to a demographic shift in Malaysia (Institute of Labour Market Information and Analysis [ILMIA], 2017). The difference between birth and death rates creates workforce problems for the Malaysian manufacturing companies, especially with an increased in the aging workforce (Romero et al., 2016).

The aging workforce is considered the most influencing challenge faced by a country. More old workers on the jobs can affect the outcomes of a company. This will not only cause a problem for the businesses but for the individuals as well. Older working individuals experience problems in their functional capacity, proficiency, motivation, trainability, working ability, and unemployment. Similarly, businesses with aging employees also face various problems, such as efficiency, competitiveness, absentees, tolerance for change, work organization, workplace environment, and recruitment (Rahim et al., 2018). Therefore, the aging workforce is an important subject, with relevant literary works that have been considerably grown over the past several years (Pease, 2017).

The Malaysian manufacturing sector, as a top employment provider as well, has crucial responsibility to tackle these problems effectively (MITI, 2018). According to Hecklau et al. (2016), this social challenge (aging workforce) is highly important and requires further investigations and actions. Rietzschel and Zacher (2015) also believed that more research regarding innovation and the moderating role of the aging workforce in companies are required. Hence, it is recommended to understand the moderating effects of an aging workforce with innovation and technological changes that are brought by Industry 4.0 (Hitt et al., 2017).

1.3. Questions of the Research

The following research questions are formulated from the research gap:

1. Is there a positive relationship between knowledge-oriented leadership and organization innovation?
2. Is there a positive relationship between decentralized organization structure and organization innovation?
3. Is there a positive relationship between organization innovation and readiness for Industry 4.0?

4. Is there a positive relationship between knowledge-oriented leadership and readiness for Industry 4.0?
5. Is there a positive relationship between decentralized organization structure and readiness for Industry 4.0?
6. Does the aging workforce moderate the relationship between organization innovation and readiness for Industry 4.0?
7. Does the organization innovation mediate the relationship between knowledge-oriented leadership and readiness for Industry 4.0?
8. Does the organization innovation mediate the relationship between decentralized organization structure and readiness for Industry 4.0?

1.4. Objectives of the Research

The following research objectives are formulated from the research questions:

1. To examine the positive relationship between knowledge-oriented leadership and organization innovation.
2. To examine the positive relationship between decentralized organization structure and organization innovation.
3. To examine the positive relationship between organization innovation and readiness for Industry 4.0.
4. To examine the positive relationship between knowledge-oriented leadership and readiness for Industry 4.0.

5. To examine the positive relationship between decentralized organization structure and readiness for Industry 4.0.
6. To examine the moderating effect of the aging workforce between organization innovation and readiness for Industry 4.0.
7. To examine the mediating effect of organization innovation between knowledge-oriented leadership and readiness for Industry 4.0.
8. To examine the mediating effect of organization innovation between decentralized organization structure and readiness for Industry 4.0.

1.5. Significance of the Research

The concept of Industry 4.0 is picking up the pace among researchers and practitioners. The immense benefits of Industry 4.0 from routine work include, but are not limited to, the usage of data and statistics as primary abilities linked with technologies to provide customized solutions to the end-users (Prince, 2017). Various manufacturing companies are now suggesting the carrying out of Industry 4.0 idea to create smart industries.

Knowing the importance of the manufacturing market in securing their future industrial state, many nations, including Malaysia, have released Industry 4.0 related policies. These policies include related guidelines and programs that support the research and development, in addition to the implementation of technological innovation and procedures for the readiness of Fourth Industrial Revolution

(Industry 4.0). This current research is also a small effort to contribute in multiple ways to the development of the Industry 4.0 concept.

1.5.1. Theoretical Significance

Industry 4.0 is considered an important factor and has recently become prominent among the research centers (Dais, 2017; Drath & Horch, 2014; Hermann et al., 2015). However, there is still not much data and direction for the Malaysian academicians and practitioners to analyze and discuss on. Recent research on Industry 4.0 conducted in Malaysia analyzed the readiness of the automotive and information technology sector only (Maavak & Ariffin, 2018; Soomro et al., 2021). Hence, there is a lack of studies available on the readiness of Industry 4.0 in the manufacturing sector, especially in the Malaysian setting. As a result, it is crucial to explore this concept further for better understanding and achieving maximum benefits, largely by contemplating the significance of Industry 4.0 for the manufacturing sector. To the best of the researcher's knowledge, current research study is the earliest attempt to examine the conceptual foundation of readiness for Industry 4.0 in the Malaysian manufacturing industry.

Secondly, it is an effort to draw the attention of researchers towards the role of organizational approaches, namely "*knowledge-oriented leadership and decentralized organization structure*", as these factors are unheeded before in the technological perspective for Industry 4.0 (Shamim et al., 2016). The examinations of the relationships between antecedents of organization innovation; “knowledge-oriented leadership, and decentralized organization structure” may add a noteworthy contribution to the existing literature.

Thirdly, the findings from current research may contribute to the Industry 4.0 literature by examining the mediating role played by organization innovation for “knowledge-oriented leadership and readiness for Industry 4.0” and “decentralized organization structure and readiness for Industry 4.0”. The existing literature mostly discussed the direct effects of organization innovation (Akbar et al., 2020; Chan et al., 2019; Sharma et al., 2016), but very few studies have focused on the mediating role of innovation with different organizational aspects and overall performances (Anning-Dorson, 2018; Umrani & Johl, 2018; Uzkurt et al., 2013). Therefore, the indirect role of organization innovation, its antecedents, and consequences are still unexplored and are thus of high interest for future researchers (Zafar & Mehmood, 2019). In conclusion, the examination of the mediating role of organization innovation is reflected as the important point of this research and may add a valuable contribution to the body of knowledge.

Fourthly, the current research attempts to advance the existing literature by examining the moderating role of an aging workforce. Prior researchers have frequently utilized the age variable as a moderator while assessing the adoption of technology (Tarhini et al., 2014). However, in the context of “Industry 4.0”, that is yet to be widely adopted, even though the aging workforce is highly relevant and requires further research and action to understand its impacts (Hecklau et al., 2016; Hitt et al., 2017; Rietzschel & Zacher 2015). Thus, the moderating role of the aging workforce will be an essential lead for the researchers in understanding the new demographic shifts in the era of Industry 4.0.

Lastly, taking into account of Learning Organization and Dynamic Capability theory, current research presents the prospect to identify organizational approaches that are required for a manufacturing company to become responsive in order to counter any upcoming challenges caused by Industry 4.0. Past literature on Learning Organization theory discussed the model with some common actions (Hatane, 2015), including empowerment for employees, promoting dialogue, suitable leadership, and sharing culture. Filstad and Gottschalk (2010) also examined some values, such as openness, knowledge orientation, and changes in the Learning Organizations context. The theoretical application to examine the organization practices (knowledge-oriented leadership and decentralized organization structure in this case) in order to determine these actions and values required for organization innovation and Industry 4.0 have not been made before.

1.5.2. Practical Significance

The embracement of the Industry 4.0 concept is a chief concern for all businesses and national stakeholders. With the help of this, the major sector (manufacturing) that contributes to the economy can flourish and prosper, while the industries that adopt Industry 4.0 advancements may have a competitive edge over global competitors. Therefore, current research is important to provide useful understandings from a managerial perspective and to reassess their companies' strategies. It allows them to find appropriate organizational approaches that are required in the prospect of Industry 4.0. The aim of current research is to provide a practical contribution to the businesses and stakeholders, as well as policymakers.

At present, the companies are seeking ways to improve innovation to acknowledge the industrial trends that occur with a fast shift in technologies and processes. Current research will help the Malaysian manufacturers to determine the contributing factors that promote innovation for the readiness of Industry 4.0. By knowing the enablers for readiness, the knowledge will help the manufacturers in analyzing their company strategies and in developing plans for projects accordingly to meet the pace of the market. In addition, it will also assist in identifying the gaps and improvement areas required for Industry 4.0 transformation.

Besides, Malaysia is expecting an increase in the aging workforce. Thus, the imperative findings regarding the role of the aging workforce will help the decision-makers and authorities to prepare related strategies. Apart from that, the current research will spread awareness about the significance of this concept (Industry 4.0) by highlighting the beneficial impacts for the manufacturing industry and economy of the country. The stakeholders and policymakers, including the Ministry of Finance (MOF), Ministry of Science Technology Innovation (MOSTI), Ministry of

Human Resource (MOHR), and Ministry of Education (MoE), are crucial decision-makers. The results may provide an opportunity for these government groups to formulate strategies and policy enforcement for Industry 4.0 that includes but is not limited to budget allocation, infrastructure development, technology adoption, talent acquisition, and research. The goal is to raise economic well-being of Malaysians by facilitating changes in manufacturing sector. Accordingly, the current research will offer several ways to achieve the long-term economic objectives of the manufacturing industry and country through the implementation of Industry 4.0.

1.6. Scope of the Research

The motivation of current research is to analyze the function of organization innovation in helping the companies to prepare for Industry 4.0, more specifically, the manufacturing companies of Malaysia. The framework also contributes to addressing the practices of manufacturing companies that are suitable for organization innovation. Additionally, the research offers an empirical and theoretical investigation in the top-performing sector of Malaysia for its readiness for Industry 4.0. Furthermore, the current research investigates the organizational practices that are valuable in improving innovation performances as a means to support fast changes due to technological advancement.

In light of Learning Organization and Dynamic Capability theory, current research emphasizes the practices that affect organization innovation and play crucial roles in matching the pace of Industry 4.0. The practices are mainly about *"knowledge-oriented leadership"* and *"decentralized organization structure"*. Hence, they can be analyzed to support innovation and preparation for Industry 4.0. Importantly, the intervening impact caused by organizational innovation and the moderating role of the aging workforce are of high interest.

With the recent introduction of the Malaysian Industry 4.0 policy framework, it is intended that the findings of this research will contribute to dealing with the various challenges that may occur during the development of the new industrial shift. In addition, the findings will help the stakeholders to achieve the policy goals in an effective manner and work as a guide for the manufacturing companies of Malaysia in applying the best practices that support advantageous changes.

1.7. Operationalized Definition of Variables

Table 1.1 presents the definitions of variables that are included in this research. Total five variables including two independent variables, one dependent variable, a mediator, and moderator are defined below.

Table 1.1
Definition of Variables

Variable	Definition	Author
Knowledge-Oriented Leadership	"Knowledge-oriented leadership is based on a mixture of transformational and transactional leadership styles, along with communication and motivational elements. It includes knowledge creation, transfer, storage and application."	Donate and de Pablo (2015, p. 2)
Decentralized Organization Structure	"This structure seeks to reduce the hierarchy and distribute more decision-making authority to a greater number of employees. It enables companies to become more flexible and to better handle unanticipated events."	O'Grady (2019, p. 225)
Organization Innovation	"Organization Innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a pre-emptive action to influence the environment. Hence, innovation includes new product or new service and new process or new technology."	Baregheh, Rowley and Sambrook (2009, p. 1326)
Industry 4.0	"Industry 4.0 refers to recent technological advances where the internet and supporting technologies (e.g., embedded systems) serve as a backbone to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form a new kind of intelligent, networked and agile value chain."	Schumacher et al. (2016, p. 162)

Continued next page

Readiness for Industry 4.0	"It is the ability to capitalize production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown shocks"	Kearney (2018, p. 5)
Aging Workforce	The "aging workforce" are workers with age 55 years or above.	Murthy, et al. (2019)

1.8. Thesis Organization

The current thesis is organized into five chapter. Chapter one outlines the background of research including, problem statement, research questions and objectives, significance of the research and identifying the scope of the research. A comprehensive review of variables including "*knowledge-oriented leadership, decentralized organization structure, organization innovation, readiness for Industry 4.0, and aging workforce"* has been presented in Chapter two. Moreover, the five direct hypotheses and two indirect hypotheses have been deduced from literature. Chapter 3 explains the methodology adopted in current research that contains research philosophy, research approach and research design. A data collection method and sample technique have also been described as well. Furthermore, the development of measurement scale, data analysis comprises measurement and structural model have been discussed. Chapter four presents the descriptive and inferential results to confirm the hypotheses. Finally, chapter five discusses the results and accomplishment of objectives, followed by research contribution, limitations and future recommendation.

1.9. Summary

This chapter outlined the introduction to the thesis. It starts with the background and overview of Industry 4.0, manufacturing sector significance; its readiness, and shift factors of Industry 4.0. The second section of this chapter has addressed the research problem and the research gap from the extant literature. The third section includes research questions and research objectives. Research significance and research scope are discussed in the next section. Finally, the definition of variables and summary of the chapter is provided. The following chapter will discuss the literature relevant to current research objectives and questions.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1. Introduction

This chapter has discussed the existing literature of understudy variables and relationships. The first section contains the background of industrial revolutions. The second section explain the underpinning theories. Followed by review of variables and hypotheses development. Finally, the research framework is presented.

2.2. Background of Industrial Revolutions

Industrialization is the modification of products and services according to the needs of humans. The revolution of industrialization emerged from Britain in the 1800s and spread across Europe and America. According to Olsson and Yuanjing (2018), the first industrial revolution occurred during the age of steam, as when in 1784, the first machinery was created. The second revolution occurred during the age of electricity in 1870 when the first slaughterhouse was made. The third revolution occurred in 1969 and was about transformation when the programmable logic controller was introduced. The fourth industrial revolution concept was introduced in 2013 based on Cyber-Physical Systems. The history of the industrial revolution is as follows:

2.2.1. First Industrial Revolution

The First Industrial Revolution started to show its impact in Britain between 1750 and 1830 (Kelly & Ó Gráda, 2019). With mechanization, steam and coal were used instead of timber, thus creating the ability to move and transport products to the manufacturers. In this “Mechanization Age”, also known as the period of new technological innovation (Bolat & Bas, 2018), steam energy played a crucial role in delivering coal and heavy machines. The use of energy sources, such as coal, iron, and steam, has also multiplied railway development.

Due to these developments, people shifted from villages to urban areas to work in industries. The consumption classes of products also shifted, as the products produced were not just for royal family members only, but also for the capitalist class. From the unique production of products that catered for royal family members in European countries in the 16th and 17th centuries, the commercial trend was created. By 1900, the production was able to cater to growing middle classes. So, more people were able to own a household full of products and to travel by themselves to nearby cities, setting new demand for vehicles (Daemmrich, 2017).

2.2.2. Second Industrial Revolution

This second industrial revolution emerged mainly from the use of electricity in manufacturing systems and the application of electric energy in assembly lines. The power-driven set ups in the production system first began with the installation for slaughtering procedures in the abattoir. These assembly lines were introduced in 1870 with a slaughterhouse located in the USA (Harteis, 2018). Small rail-type carts were used to chop various meats. The lever system then carried the chopped meats to each of the employees waiting at the station. In the next decades, Henry Ford applied the same concept at the “Ford Motor”. Ford's huge industrial manufacturing and electronically operated system have quickly boosted industrialization. The second revolution thus led to new requirements to provide infrastructure from the government. The trend of jobs has moved toward manufacturing, and by 1916, about one-third of the population in America worked in manufacturing (Daemmrich, 2017).

2.2.3. Third Industrial Revolution

The first revolution was the mechanization of production, and the second was the serialization of production. The Third one is defined as the automation of production. In this interval, science developments, such as computer systems, microelectronics, fiber optics, and lasers, have changed the ways of manufacturing. Markets have been globalized with improvements in communication and transports.

One of the basic improvements is the idea of sustainability that was introduced due to the reduction of world resources (Özüdoğru et al., 2018). Table 2.1 below summarizes the technological advancements and the year of their emergence.

Table 2.1

Summary of Industrial Revolutions

Year	Revolutions	Technology
1784	First Industrial Revolution (Industry 1.0)	Mechanical weaving loom
1870	Second Industrial Revolution (Industry 2.0)	Assembly line introduced
1969	Third Industrial Revolution (Industry 3.0)	The programmable logic control system
2013	Fourth Industrial Revolution (Industry 4.0)	Cyber-Physical Production System

Note. With every new revolution complexity level in operations increases

2.3. Review of Industry 4.0

Undoubtedly, the non-renewable resources and environmental issues have generated a need for alternative power sources, such as solar and wind-powered electricity. However, innovations that were not even possible before and advanced aspects of technologies, such as the Internet of Things and Smart Manufacturing, have emerged during the 4th Industrial Revolution known as Industry 4.0. Smart Manufacturing creates plans for all the units that are associated with manufacturing to work together directly or indirectly in partnership, meaning that machines will be using Artificial Intelligence and self-configuration to complete the complex tasks as an approach to deliver low-cost, high-quality products (Bahrin et al., 2016). The idea is to strengthen the manufacturing sector with the implementation of Industry 4.0 concepts. It highly impacts manufacturing sector by revamping production system and developing new products and services. The prediction is that Industry 4.0 has essential impacts on the economies of many nations (Davies, 2015; Özüdoğru et al., 2018).

Currently, Industry 4.0 is a trending topic and many research studies are debating its applications (Fatorachian & Kazemi, 2018; Kolberg et al., 2017). Almost all country researchers from developed countries like Germany, the United Kingdom, the United States of America, Japan, China & Russia and developing countries namely Malaysia, Singapore, Thailand & Pakistan have tried to contribute to this meaningful concept. The extant literature discussed different aspects of Industry 4.0, however there is still lack of research with managerial perspective as well as comprehensive understanding of manufacturing (Piccarozzi et al., 2018; Schneider, 2018).

The concept of Industry 4.0 was started in 2011 from hannover fair for high-tech strategy, with a purpose to improve the manufacturing sector (Kuo et al., 2019). Since then, this concept has been adopted by many countries to improve their manufacturing sector especially. According to Sarbu (2022), the adoption of industry 4.0 is of much importance for Germany. It is leading country with deep roots in industry which enables it for Industry 4.0. Due to smart factory and other innovative concepts Germany is leader for other countries who wants to adopt industry 4.0 (Crnjac et al., 2017).

The United Kingdom is also geared up for Industry 4.0 implementation. Infect, all European Union are trying to implement strategies for the adoption industry 4.0 technologies. These policies are prepared to target digitalization and to motivate all countries for adoption at country level. During last decade, 25 major plans were introduced specifically for Industry 4.0. The examples of those policies are but not limited to "Digital Single Marker, Strategy Europe 2020 & Digital Innovation Hubs" (Teixeira et al., 2022; Liao et al., 2017).

In the United States of America, Industry 4.0 has developed its roots with the announcement of Advanced Manufacturing Partnership policy. The purpose is to build local manufacturing capabilities, enabling innovation, securing talent, invest in new advance technologies including robotics & develop energy efficient manufacturing system (Kuo et al., 2019).

China has announced its policy plan of 10 years in 2015 to improve production system. It is to be done by innovation-based manufacturing, prioritizing quality over quantity, attract talent and improve environment. This plan is first stage of grand three-stages plan. The goal is to promote Made in China by providing quality products, creating more China brands, improve manufacturing capability, develop new materials, and produce key components of major products around the world (Li, 2018).

From developing countries, Thailand has introduced Thailand 4.0 by dividing their industries into two categories “S Curve and New S Curve” in order to build them under their national plan. Moreover, the Eastern Economic Corridor (EEC) was also inculcated under industry 4.0 to transform industry and build strong connectivity between ASEAN countries. (Kohpaiboon, 2020). Whereas Pakistan is on initial stages of Industry 4.0 preparation. The stakeholders are focusing on improvement of current system by introducing new technologies. But they have to build capacity and capability first to match the requirements of industry 4.0. The policy is yet to be published; however, the awareness and research interests are getting wider.

Malaysia has introduced “Industry 4wrd” an Industry 4.0 policy in 2018. The purpose behind is to improve manufacturing system, The formula is to follow “ACT” policy, where “A” is to “attract” stakeholders for the improvement of procedures and implementation of new technologies. “C” for “creating” favorable environment for adoption of industry 4.0 concepts and “T” for “transforming” manufacturing abilities for change. (MITI, 2018).

To reap maximum benefits from industry 4.0, countries should start moving towards transformation. Currently, almost every country is trying to step into this meaningful transformation without any delay. Few developed and developing countries' revitalization plans are listed below in Table 2.2.

Table 2.2
Industry Revitalization Plan (Industry 4.0)

Country	Plan	Reference
Germany	Industrie 4.0	Kuo et al. (2019)
USA	Advanced Manufacturing Partnership (AMP)	
United Kingdom	Future of Manufacturing	
Japan	Industrial Value Chain Initiative"	
Republic of Korea	Strategy for Innovation in manufacturing industry 3.0	
China	Made in China 2025	
Taiwan	Productivity 4.0	
Malaysia	Industry 4wd	
Thailand	Thailand 4.0	
Australia	The Next Wave of Manufacturing	Teixeira and Tavares-Lehmann (2022)
Korea	Manufacturing Innovation 3.0 Strategic Action Programme	
India	Make in India	
Singapore	Research, Innovation and Enterprise 2020 Plan	
Brasil	Plano de CT&I para Manufatura Avançada no Brasil – ProFuturo	
Russia	Digital Economy	
France	La Nouvelle France Industrielle	
South Africa	Manufacturing Indaba	

2.3.1. Challenges of Industry 4.0

Although every country is trying to put all in and grab the opportunities which Industry 4.0 brings along, yet there are some challenges that slowed down its adoption. A literature review is conducted to identify the challenges that developed and developing countries are facing during the transformation.

Though many developed countries like Germany, USA and Japan have already implemented most part of Industry 4.0 practices, still they face challenges during the transformation process. The list of challenges relevant challenges in context and scope of current research have been highlighted in Table 2.3.

Table 2.3

Challenges for Industry 4.0 Transformation

Challenges	**Countries**	**References**
Lack of Strategy, Resource Scarcity, Lack of Standards, Poor Data Security, Market Volatility, Short-term Innovation, Complex Processes, Difficult Transformation, Competition, Human resources, Customer Orientation, Financial Constraint, Immature IT, Management Support, Lack of skill, Resistance to Change, Complexity, Time Taking, Costly, Risk, Complexity, Talent Acquisition, Talent Retention, Lack of Awareness, Training of Employees, Gaining confidence of employees, Inadequate Skill, Demographic Issues, Social Issues, Ethical	Germany, Japan, China, USA, Russia, India, Thailand, Malaysia,	Schröder (2016); Kiel et. al. (2020); Prause (2019); Stachová et al. (2019); Zhou et al. (2015); James, et al. (2022); Sony et al. (2021); Yadav et al. (2020); Shamim et al. (2016); Moktadir et al. (2018); Ghobakhloo,

Issues, Huge Cost, Data Security, Lack of Skills, Internet Connectivity, Poor Management, Aging Society, Shorter Product Life, Organizational and production fit, Lack of Technological Infrastructure, Job Opportunities, Human-machine symbiosis, Data Management, Knowledge Management, Technology Management, Workforce Management	(2018); Kadir et al. (2019); Sony et al. (2021)

Some of the major challenges faced in Industry 4.0 transformation by the developed and developing countries including Germany, Japan, China, USA, India, Thailand, and Malaysia are "Lack of Strategy, Lack of Awareness, Knowledge Management, Technology Management, Workforce, and Organization/Management Support" (Kiel et al., 2020; Prause, 2019; Zhou et al., 2015; James, et al., 2022; Sony et al., 2021; Yadav et al., 2020; Shamim, et al., 2016; Moktadir et al., 2018; Ghobakhloo, 2018; Kadir et al., 2019).

2.4. Learning Organization Theory

Organizational leaders and theorists believed that the concept of learning organizations is associated with the rapid changes that are occurring, mainly due to the changes in business conditions, uncertainty, and competition (Kontoghiorghes et al., 2005). These organizations develop competitive advantages through continuous innovation to avert business risks. In general, the Learning Organization theory (LO) presented by Senge (1990) is suitable to describe the innovation of organizations. A learning organization is theorized as the adoption of appropriate organizational practices that support continuous learning to adapt to the rapid changes of the business environment (Theriou & Chatzoglou, 2008). The theory also discusses the creation, acquisition, and transformation of knowledge to face the dynamic environment (Garvin, 1993).

Past literature discussed different features of learning organizations that include "*leadership that support learning*" (Hatane, 2015), "*flatter hierarchy*" (Otala, 1995), "*open communication*" (Phillips, 2003; Pool, 2000), "*risk-taking"* (Goh, 1998; Rowden, 2001), "*support and recognition for knowledge sharing*" (Griego et al., 2000; Wilkinson & Kleiner, 1993), "*rewarding those who promote innovation*" (Griego et al., 2000; Phillips, 2003), "*support and provision of learning environment*" (Gephart et al., 1996; Robinson et al., 1997) and "*knowledge management*" (Loermans, 2002; Selen, 2000).

Linking the features discussed above of learning organization with the concepts of "*knowledge-oriented leadership and decentralized organization structure",* it is derived that both practices are vital factors that initiate such actions and improve innovation in response to the rapid fluctuations of Industry 4.0. Former factor supports learning and improvement by providing the important knowledge and information that are relevant for an organization to achieve its innovation performances and goals (Mabey et al., 2012). It also identifies the acquisition and application of knowledge that build organization innovation (Naqshbandi & Jasimuddin, 2018) since every innovation implies the development of new knowledge (Kianto et al., 2017).

Since modern-day companies are regularly experiencing a dynamic and competitive environment, thus these require fast decisions to become effective and capture all the upcoming opportunities for success (Court, 2011). Again, organization innovation is vital to becoming flexible and responsive to rapid changes. Therefore, by drawing from the concepts of Learning Organization theory, all the companies require open communication, an innovation-focused environment, risk-taking, and flexibility, which are the core concepts of a decentralized organization structure. This structure supports the development of new ideas and interaction, enabling the companies to focus on innovation and fast reaction to changes (Arnold et al., 2005; Watkins, 1998).

In application to Learning Organization theory, "*knowledge-oriented leadership and decentralized organization structure*" work as the enablers for organization innovation. Knowledge-oriented leadership energizes innovation by fostering new information to bring meaningful modifications (Mabey et al., 2012). New knowledge that is created and shared is considered as a key for the companies to innovate continuously. Additionally, a decentralized organization structure acts as an enabler through promoting learning and development, subsequently empowering the companies to aim on innovation and rapid response to changes. Moreover, it reduces communication barriers and empowers the employees in decision-making. All of these ultimately assist in innovation for purposeful changes.

2.5. Dynamic Capability Theory

Industry 4.0 is bringing effective changes in the business processes, but these changes need enormous abilities from the companies to match with the speed and to create a competitive advantage. The essence of this process is captured by Dynamic Capability Theory that states the capacity of the organization to deal with dynamic and complex situations (Teece et al., 1997). Dynamic capability is an ability of a firm to achieve new advantages and perform tasks in opposing situations with the help of appropriate practices. Moreover, dynamic capability states that organizations must build themselves continuously and competently, especially when the situation is critical and complex with technological changes are rapid and the future is difficult to be predicted (Teece et al., 1997), like the situations that may occur in "Industry 4.0". Not limited to that, it also states that organizations must create the required ability to respond rapidly to any threats, as well as to grab any upcoming opportunities (Teece, 2018).

This ability of an organization is very crucial that can be developed by applying the proper practices and achieving continuous innovation that assists changes. Wheeler (2002) suggested knowledge-based practices because these approaches can create innovation and enable organizations to face a dynamic business environment. However, not every employee will step out from their definite roles to get in ad-hoc troubleshooting since this requires dynamic abilities and therefore needs specific leader-type personnel (Lee & Kelley, 2008). Thereby, knowledge-oriented leadership acts as an enabler that brings forward organization innovation by facilitating new and valuable knowledge for favorable changes (Mabey et al., 2012). This application of knowledge-oriented leadership is vital for modern-day organizations. The knowledge these leaders bring along helps in developing innovation and enabling their organizations to tally with the speed of Industry 4.0.

Another vital practice, "decentralized organization structure" is also important in aiding the organization to build competencies and to face the uncertain business environment. It assists decision-making by empowering employees, consequently increasing response time and averts risks (Dedahanov et al., 2017). Such favorable conditions can eventually build organizational abilities to enable a fast reaction to change. Therefore, both of these practices improve an organization to be capable enough to grab opportunities and block threats during Industry 4.0 transformation, ultimately acquiring a competitive advantage.

2.6. Review of Variables

In the following section, the literature review of variables, including *"knowledge-oriented leadership, decentralized organization structure, organization innovation, readiness for Industry 4.0, and an aging workforce"*, is explained.

2.6.1. Knowledge-Oriented Leadership

Knowledge is power and is considered the most essential asset of any organization. It differentiates good companies over others by developing a competitive advantage. Considering its importance, knowledge should be shared between the employees in the form of organizational knowledge (Sigala & Chalkiti, 2015). For this reason, the role of leadership motivating the employees and promoting knowledge-sharing practices is deemed valuable.

Leadership is also crucial for any organization, as it impacts the direction of organizational performances (Al Khajeh, 2018). It describes a clear strategy to control workers and urges them to assist the leader in achieving organizational goals (Khanzada et al., 2018). Leadership in learning companies is mainly crucial so that the employees can realize them as an effective and inspired person that assists in knowledgeful innovative actions. Moreover, these leaders should be able to recognize and reward those who perform innovative actions (Donate & de Pablo, 2015). Such a leadership style that comprises inspiration and communication components is called knowledge-oriented leadership. However, it's not very well known and much defined (Mohsenabad & Azadehdel, 2016); thus requires further explanation and investigation.

"Knowledge-oriented leadership is based on a mixture of transformational and transactional leadership styles, along with communication and motivational elements. It includes knowledge creation, transfer, storage, and its application" (Donate & de Pablo, 2015, p. 2). It is also defined as a capability that encourages essential information for constructive changes (Mabey et al., 2012). Companies having knowledge-oriented leadership engaged with employees are often more successful than others (Donate & de Pablo, 2015).

Knowledge-oriented leadership is crucial for manufacturing organizations. It sets up the ideal working conditions to maximize the use of knowledge for smart production and innovation performances. This approach is developing quickly in most companies since it helps in improving the processes and efficiency (Mohsenabad & Azadehdel, 2016). Moreover, the companies may consider this factor as useful because it adds value to the organization's performance.

2.6.2. Decentralized Organization Structure

The situations dealt with by most of the companies nowadays are not the same as the situations faced a few decades before when the markets were consistent. Moreover, decisions had not been revised for some time. That old concept is no longer true; therefore, more importance is now given to those organization structures that empower decision-making, standardize the procedures, and integrate work activities (Joseph & Gaba, 2020). Generally, the organization structure is defined as "the formal allocation of work roles and administrative mechanisms to control and integrate work activities" (Lin, 2011, p. 242).

The structure is the most influencing factor and plays an essential role in the success of an organization. A resource may not be used to its full potential if an appropriate structure is not in place. It is well known that a company is made up of employees, and its success is dependent on the workforce. However, the coordination between employees is influenced by the control mechanism (organization structure). In order to get a real advantage, the structure of the organization must be aligned with the organizational objectives (Gupta, 2020).

In this current research, the decentralized organization structure is discussed. This decentralized structure is the opposite of a centralized structure, with both being essential in influencing the successful implementation of organization innovation.

Chi et al. (2021) mentioned that centralization is a major hurdle in adopting organization innovation. It has very low complexity, flexibility, and have specific rules and defined roles. In opposite to that, the decentralized structure promotes creativeness (Dedahanov et al., 2017). It has informal control, more flexibility, and open communication. This kind of structure has few organization levels (hierarchies) that allow the flow of knowledge and ideas (Islam et al., 2015), in addition, to promoting an innovative environment across the organization. According to O'Grady (2019, p. 225), "Decentralized organization structure seeks to reduce the hierarchy and distribute more decision-making authority to a greater number of employees. It enables companies to become more flexible and to handle unanticipated events better".

The idea of creating boundaries in an organization is to handle the coordination of employees within and across all the functioning units (Torfing & Ansell, 2016). It also defines the flow of information and guides the processes (Serrat, 2017). The free flow of information in a business environment, along with the motivational element of employees to bring creativity, can improve innovation performances. A decentralized organization structure assists the flow of information for the employees to achieve the innovation objectives of an organization (Gantino et al., 2017). It is done by providing complete information that directs and guides the employees in performing their tasks efficiently. Thus, it provides the right environment to the employees, where the information is easily accessible by all the employees for their learning and motivation to bring innovation into the organization they are working with (Bianchi, 2018).

2.6.3. Organization Innovation

There are several definitions available for innovation in literature. Baregheh et al. (2009, p. 1326) stated that "*Innovation is the process of transforming ideas into new products or processes to advance and differentiate themselves successfully in the marketplace*". Innovation is also defined as "*non-routine, significant, and discontinuous organizational change that embodies a new idea that is not consistent with the current concept of the organization's business*" (Lam, 2004, p. 12). In short, innovation is any new activity in the organization that is performed for improvement. The important dimensions of organization innovations include products and processes, with an emphasis on technology.

Innovation and versatility are crucial aspects for the success of organizations and workers. The survival of companies is dependent on the level of adoption in innovation. It is an aspect that helps companies to endure the fast-changing world (Direction, 2021) and is recognized as a means of accomplishing success through outperforming opponents and building new product portfolios (Lee et al., 2020). Moreover, it contributes by creating a competitive advantage (Lukes & Stephan, 2017) that is considered an important aspect for the long-term survival of companies (Hassan et al., 2018).

Wahlster (2014) believed that upcoming production systems would be based on innovation, including innovation of intelligent products and services. Therefore, new production techniques should be developed to solve individual and customized needs (Lasi & Kemper, 2014). It can be possible with new information and by thinking outside the box, generally in areas that are irrelevant to current functions (Lee & Kelley, 2008).

Digital transformation in the production industry brings comprehensive disruption to all of the areas and throughout a value chain, leading to efficient manufacturing procedures, more powerful customer-based initiatives, and new products (Özüdoğru et al., 2018). Since it is just the beginning of changes, many innovation studies and policy techniques from all over the world have been following this concept. The principle is "the more, the better", meaning that the companies can spend as much as possible on innovation and then sit back to reap the beneficial results from the manufacturing industry (Buhr, 2017).

The Malaysian government has announced the National Science, Technology, and Innovation Policy (NSTIP 2013-20) that offers guidelines for the Malaysian manufacturing sector to move forward into an innovation economy by 2020 (World Bank & OECD, 2016). However, the implementation is not the only responsibility of government officials but also the stakeholders from the municipal community, businesses, and sciences as well. All these stakeholders have to build a thorough understanding of the innovation development to guide the implementation of extensive digitalization procedures for manufacturing companies (Buhr, 2017).

2.6.4. Readiness for Industry 4.0

"*Industry 4.0 is defined as smart manufacturing*" since it involves the execution of Cyber-Physical Systems (CPS) for production, i.e., connecting the machines to the value chain. Moreover, it is considered as the re-engineering of products that describes extremely personalized items. It adds significance to the real product with an inclusion of economical and effective supply chain (Shamim et al., 2016), as the whole new system of Industry 4.0 concentrates on manufacturing systems that function independently. Different countries have started to adopt the concepts of Industry 4.0 under different initiatives. Industry 4.0 is known as "Smart Manufacturing" in the US, "Made in China" in China, and "Innovation 25" in Japan (Stăncioiu, 2017), while in Malaysia, it is named as "Industry 4.0", as stated in the National Policy 2018 (MITI, 2018).

"*Readiness for Industry 4.0 is referred to as an ability to capitalize on production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown shocks* (Kearney, 2018, p. 5)." According to the definition highlighted by Botha (2018), *"readiness for Industry 4.0 means having enough capabilities in embracing Industry 4.0"* in order to have a potential to meet the pace and challenges that are created due to changes in the business environment.

In the current research, readiness for Industry 4.0 is measured through nine dimensions. The first “strategy” dimension is about the implementation of a road map for a new shift, adaptation of new business models, and availability of resources. Next, the “leadership” dimension of Industry 4.0 deals with building competencies and ensures the central coordination for the organization. The “customer” dimension discusses the digitization of sales/services, digital media competencies, and better utilization of customer data. The “product” aspect covers the customization, digitalization, and product integration to other systems. The fifth dimension, “operation”, handles the decentralization of processes, application of modeling with simulations, and collaboration among different departments. The “culture” dimension outlines and examines the sharing behavior, openness to changes, and cross-organization collaborations. Meanwhile, the “people” dimension discusses the competencies, autonomy, and openness to the technology of employees. The “governance” dimension deals with the regulations of human capital, standards, and intellectual property procedures. Finally, the “technology” aspect verifies the modern ICT, its utilization, and application.

The concept of Industry 4.0 is quite broad and not easy to implement in a short period, but the technology and resources that the organizations can generate under this concept are unlimited (Schwab, 2017). A small example is a machine with the concept of Industry 4.0 that can start processing autonomously and respond to uncommon changes in operation, as well as can predict failure and service the errors automatically (Sung, 2018). Aligning with the supreme vision of Industry 4.0, the manufacturers need to prepare and accept this industrial revolution in order to stay competitive in the strong and hyper-competitive market (Ghobakhloo, 2018).

Many researchers and analysts are placing high expectations on the fourth industrial revolution (a.k.a. Industry 4.0). Nowadays, only about one in every five organizations has a great level of digitization throughout its business processes. In the next five years, it is projected that the number will increase by more than 80% for all of the businesses. A report by Kearney (2018) on the readiness for future production provided an assessment and positioned Malaysia in the "Leader Quadrant" among other 100 countries. This means that Malaysia has a solid current manufacturing base and is thus positioned well in the production sector. Most important, only China and Malaysia, which are from the non-high-income countries, are positioned in the "Leader Quadrant". For each driver of Industry 4.0, Malaysia is ranked between 21^{st} to 30^{th} out of 100 countries, especially in the technology and human capital groups. However, the gap of Malaysia, as compared to other world leaders, such as Japan, Germany, and China, is still very wide, as these countries are moving fast into Industry 4.0 implementation. Therefore, Malaysia has to come up with aggressive plans to catch up on this new world of revolution.

2.6.5. Aging Workforce

The definition of old employees is still not standardized since different companies and agencies are using a wide variety of age groups, usually ranges between 40 to

65 years or more age (Poscia et al., 2016). Hashim and Wok (2013) mentioned that many of the prior studies defined “older workers” as those from between 40 to 75 years old. However, according to the study of Murthy et al. (2019) on aging workforce productivity in Malaysia, the minimum age for the old worker is 55 years. The age of 55 years old is consistent with the definition of the International Labour Organization [ILO] (2015), as this report stated that those between 25 to 54 are at a prime age for work and considered 55 years and above as older workers. Current research considers the aging workforce with employees who are of 55 years of age or older.

The population of Malaysia in 2017 was estimated at 32 million, with 28.7 million are national citizens. According to the Malaysian National Policy, the national aim is to increase the number of citizens to approximately 70 million by 2100 (Manimaran et al., 2017). Moreover, due to the good health facilities that are available in Malaysia, the mortality rate has been decreasing, while the lifespan of an individual has been increasing. The number of older people in Malaysia has doubled in the last 28 years and is expected to make up around 15% of the total population by 2030 (Hamdan et al., 2018). The analysis done by the World Health Organization [WHO] (2015) found that the number of individuals who are older than 60 will increase by 20% to 30% by 2050. Thus, due to the demographics of reducing infertility rate and increasing life span, more and more old-age citizens are going to remain working (Yang & Nie, 2017).

The statistics analyzed by the Department of Statistics Malaysia (DOSM, 2018) indicated that the birth and death ratio in 2018 is not neutral. The live birth rate is approximately three times more than the death rate, thus is creating a gap in industries, especially in manufacturing. This sector is one of the top employment providers. Therefore, it will be more affected by the demographic shift.

On the other hand, as compared to the older generation, male individuals who are 65 years old and above are expected to live 15 years longer, while females are predicted to live 17.2 years longer. Furthermore, the newest trend for newly born babies indicates that boys are expected to live until the age of approximately 73 years old, whereas the girls are expected to live until the age of 78 years old, five years longer than the boys. With a comparison to the past two decades, an increasing trend can be seen in the life expectancy of humans. In the year 2000, the average age of Malaysians was 72.2; this value was increased to up to 73.7 in the year 2008. It showed that in 2018, the individuals are living 2.8 years longer until the age of 75 years old than the individuals in the year 2000 (DOSM, 2018). A summary of the life expectancy of Malaysians is presented in Table 2.4.

Table 2.4
Life Expectancy of Malaysia 2018

Period	Male	Female
At Birth	72.7 Years	77.6 Years
At age 65	15.0 Years	17.2 Years

Note. Abridged life tables, Malaysia. Source: Adapted from DOSM (2018)

All of the above-discussed statistics are indicating that the Malaysian population is heading towards an aging population and will eventually lead to an aging workforce. This aging effect changes the labor market and take the companies into a difficult situation. Consequently, companies should find and apply appropriate strategies in order to manage aging employees so that the company's performance can be maintained (Čiutienė & Railaitė, 2014). Whether and how to retain an old age employee are determined by the actions of the institution and the hurdles the institution may face by doing so. The Eastern and Western countries are in favor of extended working lives. Therefore these nations have legislated the retention of the aging workforce (Beazley et al., 2017). Malaysia has also changed its retirement policy from around 56 or 57 years to 60 years of age (Fong, 2017). Regardless of the facts, the examples discussed above are alarming and will cause more problems for the companies in the near future as more aged people continue working.

2.7. Hypotheses Development

The following section will discuss the relationship between independent and dependent variables to develop hypotheses based on existing literature. In line with research questions, the relationships of *"knowledge-oriented leadership, decentralized organization structure, organization innovation, and readiness for Industry 4.0"*, including *aging workforce* (moderator) and organization innovation (mediator) will be discussed comprehensively.

2.7.1. Knowledge-Oriented Leadership & Organization Innovation

Ability of an individual is exceptionally crucial in developing organization innovation. However, not every employee will step out from their routine roles to get into ad-hoc troubleshooting, as this initiative usually requires dynamic abilities, and these abilities are usually shown by personnel with leader-type mentality (Lee & Kelley, 2008). In fact, for technology-intensive companies, leadership is important in achieving innovation objectives. As a result, individuals possessing leadership capability with the main focus on knowledge are considered useful nowadays. Knowledge-related practices applied by leadership for organization innovation performances are considered as a type of competitive advantage. These practices help in increasing profits significantly. However, the challenges for management include evaluating those who can lead the innovation development and offer supports to them. Leading companies appoint knowledge-oriented leaders to improve the willingness of employees to be involved with innovation performances (Mohsenabad & Azadehdel, 2016).

Knowledge-oriented leadership can play an essential role in promoting innovation (Naqshbandi & Jasimuddin, 2018). The companies can improve the desires of workers for innovation performances with the help rendered by those leaders (Mohsenabad & Azadehdel, 2016). They can develop longer running abilities in employees and improve knowledge management in the businesses that impact innovation positively for an organization (Donate & de Pablo, 2015).

The significance of a leader for organization innovation is not limited to their experiences and technical abilities but also involves knowledge and motivation (Lee & Kelley, 2008). Knowledge-oriented leaders act differently based on the situations for the organizations that want to increase their innovation. They create an environment that is favorable for research, development, and creative learning. Knowledge-oriented leaders communicate the expectations to the workers and ensure that the expectations are aligned with the organizational goals. Moreover, these leaders have an element of motivation in them. They reward actions, for example, knowledge exchange and knowledge transformation, thus stimulating the workers to provide new ideas (Donate & de Pablo, 2015). In other terms, knowledge-oriented leaders guide workers to learn and use the information to accomplish organizational objectives (Serrat, 2017). Thereby, such leadership offers a major role in the organization by generating the opportunities to innovate (Mehmood & Hussain, 2017).

Companies are dependent on the leaders, especially on how they manage, encourage, and develop a structure that maintains the innovation processes (Tuan, 2017). They can set up a culture that encourages continuous innovativeness. On the other hand, the motivation of the organization members also plays a vital part in organization innovation (Tuan, 2017). Motivation is the intrinsic factor that provides the inspiration to engage in innovation. For that, most companies prefer knowledge-oriented leadership because they reward and appreciate new ideas (Naqshbandi & Jasimuddin, 2018) that arouse the employees to show more productivity (Yang et al., 2014).

According to the study of Sadeghi and Rad (2018), there is a significant correlation between knowledge-oriented leadership and organizational innovation. The important role played by a leader is through motivating employees to achieve organization innovation (Naqshbandi & Jasimuddin, 2018), along with the assignment of an appropriate role that ultimately boosts performances (Rosing et al., 2011). Such leaders bring the workers into believing that knowledge development via research and development (R&D) is essential for business growth and competitiveness (Faccin & Balestrin, 2018). Moreover, knowledge-oriented leaders guide the employees to obtain knowledge that leads to an exploration of new knowledge, or in other terms, "innovation".

Based on the literature review discussed above hypothesis below can be formed.

H1: Knowledge-oriented leadership has a positive relationship with organization innovation.

2.7.2. Decentralized Organization Structure & Organization Innovation

Organization structure is highly important in enabling innovation (Waruwu et al., 2020). It is directly enhanced if the organization is putting in efforts to facilitate it, whether formally or informally. There is a need for an effective organization structure to achieve an advanced level of innovation inside the organization. Normally, organization structure in an innovative organization is decentralized, with fewer policies and controls, as well as a high degree of independence (Lin, 2011).

Research conducted by Su et al. (2019) stated that a business structure favorably impacts organization innovation. According to Dedahanov et al. (2017), centralized and decentralized structures affect the flow of knowledge and thus impact organization innovation. However, the companies should have a flexible structure to ensure better innovation (Tuan, 2017). Moreover, horizontally integrated structures are considered more open and fluid. Thus, a decentralized organization structure that has flexibility, openness, and flat structure is more focused on organization innovation (Abouzeedan & Hedner, 2012).

Past researchers that studied organization innovation indicated that centralization is a crucial part of innovation performances (Dedahanov et al., 2017). Centralization is the opposite of decentralization and refers to the level of organization that controls and has decision power, usually under one authority or concentrated at the top of the organization (Dedahanov et al., 2017). In centralization, many rules and regulations are to be obeyed (Janićijević, 2013), therefore may limit the creativity in products and operations (Bianchi, 2018), since most of the decisions are made by the managers, so the employees will just follow the rules (Chen et al., 2010), while communication between associates is low. As a result, the workers are less likely to look for new ideas, and ultimately leading to a low level of innovation.

With the hierarchical structure, the focus is on the top management rather than on lower management employees. Hence most employees are discouraged from bringing new ideas and involved in decision making (Dedahanov et al., 2017). The workers who are omitted from decision-making and have low autonomy might experience some limitations. They are not able to impact their organizational environment and may consequently become hesitant to perform creativeness. This type of structure also reduces the opportunities for individual growth and blocks creative solutions to problems (Liu et al., 2018; Mahmoudsalehi et al., 2012).

Another critical factor for organization innovation is communication. Most organizations cannot bring changes and improvements in a situation with blocked or reduced communication. This is because of the waiting time and procedures following protocols that are required to get approval from the authority at the top. However, easy communication is a requirement for organization innovation. Prajogo and McDermott (2014) confirmed that those companies who stop or limit the free circulation of ideas could also limit the organization's innovation.

Accordingly, appropriate actions are required to deal with the specified circumstances and quicker decision-making. Azar and Ciabuschi (2017) revealed that the improvements in organization structure enhance innovativeness and support the adoption of organization innovation. Therefore, the initial business hierarchies need to be decreased to allow a free flow of communication (Lasi & Kemper, 2014). Moreover, the decision-making power needs to be transferred downwards for a quicker solution. The decentralized companies have fewer hierarchies, free flow of information, and power to make a decision since these are transferred to the lower levels of management (Shamim et al., 2016). It is applied to companies that are using sophisticated technologies and need flexibility, along with high innovation (Janićijević, 2013), because they support new ideas and complicated processes that are associated with innovative activities (Bresman & Zellmer-Bruhn, 2013).

Evidence showed that organization structures, especially those with fewer rules, favorably affect innovation. The results of studies also revealed that innovative organizations usually have fewer hierarchies and inter-functional groups (Bianchi, 2018). This means that as more members are involved in decision-making, then there will be more new ideas proposed (Darvishmotevali, 2019). According to Darvishmotevali (2019), independence is required since it motivates the workers to be involved in idea development. By giving the independence of sharing their ideas, the employees take part in discussions with their best interests and may eventually come up with newer concepts for the organization (Dedahanov et al., 2017).

There are a lot of complexities attached to innovation and new concepts. To overcome such challenges, an organization must proactively set up a structure that supports the whole innovative process (Rubin & Abramson, 2018). Introducing a structure that supports teamwork leads to the improvement of coordination and, as a result, creates a suitable environment for organization innovation (Gunday et al., 2011). Therefore, a decentralized structure that has all such characteristics is suitable for an innovative organization. The existing literature also supports the dependency of decentralized organization innovation on organization structure. Lee et al. (2014) found a significant effect of organization structure on organization innovation. Similarly, Dedahanov et al. (2017) believed that a decentralized structure supports the employees in seeking new techniques and in fostering organization innovation. Thus, a favorable environment for new ideas development can be created by trusting employees and empowering them.

Considering the above discussion subsequent hypothesis is formed.

H2: Decentralized organization structure has a positive relationship with organization innovation.

2.7.3. Organization Innovation & Readiness for Industry 4.0

"Industry 4.0" symbolizes a new shift towards smart ways of manufacturing (Müller et al., 2018; Veza et al., 2015) that resulted in a swifter and better decision-making (Kang et al., 2016). This technology shift also refers to digital innovations that assist in the rise of new industrial technologies (Gilchrist, 2016; Ghobakhloo, 2018). The development has started from the adoption of mechanical systems leading to today's extremely automated assembly lines in reaction to robust market needs. Prominent growth in innovation and introduction of technology have changed perception of customers for the products (Lee et al., 2014).

The use of innovative technologies like artificial intelligence (AI), makes the corporations more responsive and more faster than others, mainly in the customers' needs and technologies (Jones, 2017). Industry 4.0 has the potential to produce innovative products and sometimes amazing work opportunities for businesses that are innovative and adopt smart manufacturing. Industry 4.0 is well developed concept now and has become a reality, as it is already influenced the people and businesses. The idea of Industry 4.0 is significantly impacting companies, systems, and societies.

For getting maximum advantages from Industry 4.0, manufacturing companies require a high level of automization, or in other term, organization innovation. This allows them to create opportunities in the era of Industry 4.0, rather than being threatened by the changes of Industry 4.0 (Müller et al., 2018). Manufacturing companies in developed countries have improved their organization's innovation by shifting themselves from simple products and services to integrated value-added technologies. However, Malaysia is still lagging in technological innovation and Industry 4.0 implementation (MITI, 2018).

Many developed nations, whose economy depends on the manufacturing sector, have made innovative initiatives to convert their existing system and revive the market. Things are changing so rapidly that the developing nations have lesser time to set up the infrastructure and modify guidelines that are required to meet the demands for quick changes. They have to risk themselves in the growing markets and the international production supply chain so that they can aim for maximum benefits. For this reason, the manufacturing companies of these nations are now looking for innovation in production techniques (Lee et al., 2014).

Internationally, Germany is leading towards a transformation that is based on CPS-enabled production and business innovation (Frontoni et al., 2018). From other ASEAN countries, Thailand has also introduced the "Thailand 4.0" strategy for Industry 4.0. Their economic design depends on new technological innovation and high-quality services (Bussi, 2017) that are aimed to improve well-being. Thailand's Prime Minister, Prayut Chan-o-cha, said that the process to achieve this is to discover the use of technology, coupling with innovation, to increase the country's economic system. According to their agenda for Industry 4.0, all the industries will support innovation-driven enterprises through the following developments, (1) the transformation from traditional farmers to "Smart Farmer", (2) a shift from traditional manufacturing to "Smart manufacturing", and (3) switch from traditional services to "High-Value Services" (Jones, 2017).

Malaysia also has announced National Policy on Industry 4.0 with three objectives, namely Attract, Create, and Transform. The purpose of this policy is first to "attract stakeholders to Industry 4.0 technologies & processes, and to increase Malaysia's attractiveness”, then “to create the right ecosystem for Industry 4.0 to be adopted and align existing and future development initiatives”, and finally, “to transform Malaysia’s industry capabilities in both a holistic and an accelerated manner” (MITI, 2018). The target is to make the manufacturing sector the highest contributor to the economy.

So far, it has mainly been big companies that have shown interest in being associated with Industry 4.0. However, many of the Malaysian companies are smaller, so they can only spend lesser funding on research and development as compared to big companies. Their powerful points, however, are collaboration and representation in the industry, with modernization as the innovation in their processes. These small companies are both suppliers as well as customers. For them, it is essential for the diffusion of new technological innovation and methods of Industry 4.0. They could be the market leaders in innovation and deserve the assistance that bigger companies are getting, especially now that the market is under the umbrella of the “high-tech” mania (Buhr, 2017).

The projects of Industry 4.0 are a smaller period in nature. Therefore, the period for development and innovation needs to be decreased. The pace of changes in Industry 4.0 is high-level (Ochs & Riemann, 2017), so the innovation may not last for long. However, this doesn’t mean the companies should ignore long term viewpoints. Instead, they have to maintain innovation performances for a longer period and make it a routine process for the organizations.

The ability of organizations to innovate is the first condition to become successful in the utilization of intensive technologies. The implementation is widely possible through good planning that envisions a step ahead of the digital manufacturing business (Sarvari et al., 2018). Modern-day companies use a strategic road map to assist research and development of future technological innovation inside an organization in order to maintain a competitive edge by preparing themselves for Industry 4.0. However, the introduction of new technologies brings along complexities in operations, and this requires organization innovation to respond promptly (Johansson et al., 2020; Tushman et al., 2011). Therefore, the ultimate success is reliant on organization innovation (Shamim et al., 2016) and is essential for readiness for Industry 4.0 (Lasi et al., 2014).

Hence, the subsequent hypothesis is proposed.

H3: Organization Innovation has a positive relationship with readiness for Industry 4.0.

2.7.4. Knowledge-Oriented Leadership & Readiness for Industry 4.0

This era is fusion of the latest technologies that changed the economies of the world. According to the CEO of the World Economic Forum, the speed of this revolution is faster than the previous three revolutions. The point is, can we cope with the rapid upcoming challenges just like in the last revolutions? Who will prepare the organizations for the abruption of technologies? The literature suggested that the leadership of the organization is important and can be used to align the changes and needs, as well as to predict the challenges (Xu et al., 2018). The traditional leadership styles are obsolete and cannot fit into this new concept of smart production (Peshawaria, 2018). A leadership that is based on knowledge is recommended by the researchers for this change, as it is aligned with the objectives and initiatives that assist the organizations in tackling digital challenges.

This transformation is highly demanding. Hence, this is a great challenge to tackle these technologies, even for knowledge-oriented leaders. Leaders have to think outside the box for the survival of organizations (Shamim et al., 2016). They also need to think long ahead and foresee the changes for a timely solution. Knowledge-oriented leaders have the capability to use their knowledge wisely. By creating, sharing, and application of knowledge, they can come up with smart and effective ways to embrace the changes caused by Industry 4.0 (Donate & de Pablo, 2015). Crucially, such leaders can identify new policies that help them in achieving the required objectives.

There are a few real business examples of leadership that adopted advancements with their effective skills. For instance, the CEO of “Amazon”, Jeffery Preston Bezos, is an early adapter of Industry 4.0, as he anticipated the technological disruption and used the advanced tacit knowledge to become a $150 billion company. Secondly, Kasper Rorsted from “Adidas” introduced AI and 3D printing, as he believes that Industry 4.0 transformation is obligatory (Skinner et al., 2018).

The leadership of Industry 4.0 is not only about power but also about a complete change of basic mindset. It can only be possible for the leaders who believe and depend on new knowledge (Oosthuizen, 2017). Thus, knowledge-oriented leadership develops opportunities brought over by Industry 4.0, primarily through their unique ability to create and share knowledge. In reality, the embracement of new technology is a replacement of functions when the human performance is not up to mark, only knowledge leaders can discover the strengths of humans in this change (Petrillo et al., 2018).

Specifically, Industry 4.0 emphasizes knowledge and innovation. Therefore, knowledge-oriented leadership has been introduced to combine transactional and transformational leadership with the additional element of motivation (Donate & de Pablo, 2015). This new style of leadership plays a crucial role in increasing the development and application of knowledge, in addition to encouraging new ideas by promoting the sharing culture. Most of the companies nowadays are obtaining knowledge from external sources, with the help of integration by knowledge-oriented leaders (Islam et al., 2017; Naqshbandi & Jasimuddin, 2018). Besides that, these leaders excel with knowledge and nurture innovation abilities to embrace Industry 4.0. Moreover, the existing empirical research also suggest a significant positive relationship between these factors (Sadeghi & Rad, 2018; Yang et al., 2014).

Based on above literature the following hypothesis can be proposed.

H4: Knowledge-oriented leadership has a positive relationship with readiness for Industry 4.0.

2.7.5. Decentralized Organization Structure & Readiness for Industry 4.0

Structures are essential in bringing any significant changes in any organization. It has the ability to stop or speed up any new adoption of technologies. However, the implementation of structure is not a single-step process and requires proper effort and time. Therefore, the organizations should apply the structures carefully and according to their operations and requirements. Industry 4.0 has more complex operations, thus requires more flexibility in its processes. Usually, the structure with fewer hierarchies is able to create an environment effective for Industry 4.0 implementation (Sivathanu & Pillai, 2018). The lesser hierarchies are linked to decentralization since fewer hierarchies reduce the communication gap and speed up decision-making. Moreover, the autonomy or power in the decentralized structure is distributed equally and has the ability to adjust according to project requirements. Sivathanu and Pillai (2018) also recommended a decentralized structure for efficient Industry 4.0 implementation and overall growth of the organization.

According to Bartodzieg (2016), volatility is a principal factor of this changing trend that emerged due to Industry 4.0. Such instability is a major concern for the manufacturing sector with the increasing complexities of operations. New management practices required for organizational innovation to master these new challenges. Thus, all organizations require more decentralized structures for their smart production processes. The same need is anticipated by future companies to invest in flexibility because traditional measures are no longer useful for such high volatility (Bartodzieg, 2016). Most investigations agreed that smart factories' inflexible structures are not correct; only decentralized structures are the key to success, meaning that organizations have the ability to change according to their requirements.

Future manufacturing companies are based on decentralization and autonomy. These characteristics are perceived as among the highest productive factors for the system (Bartodziej, 2017). An example of a decentralization idea is shown by a Fraunhofer company. In this company, some engineers were trying to find out the ideal solution for a production system. They had a paper to conceptualize the solutions, but after an intensive discussion, only a corner of a paper had one point, while the rest of the paper was empty. This scenario of emptiness exactly defines the concept of decentralization, showing that the complexity of future systems can only be identified and tackled at the point of encounter (Schuh, 2013). So, the manufacturing sectors should apply a decentralized structure for scenario-based or rapid decision-making processes in Industry 4.0.

According to Cimini et al. (2020), a structure of the organization that is conceptualized on empowerment and decentralization is suitable for innovative changes. Moreover, the structures with high decentralization characteristics are considered as a facilitator for Industry 4.0 (Shamim et al., 2016). Therefore, any changes in the organizations (that are already applying or planning to apply Industry 4.0) can be adopted smoothly with the help of a structure with less hierarchical levels and a wider span of controls, in other words, "decentralization".

Therefore, the researcher proposes that;

H5: Decentralized organization structure has a positive relationship with readiness for Industry 4.0.

2.7.6. Moderating Role of Aging Workforce between Organization Innovation & Readiness for Industry 4.0

Economist Intelligence Unit [EIU] (2015) stated that aging would have a major impact on the structure of the population. It affects many community life areas, including the economy, businesses, social security and etc. In the future, the companies will also face complications in hiring people, as the baby boomers are going to retire in good numbers and employee replacements are lesser. This causes a larger problem when the companies are not able to get successors to remain competitive. Therefore, the shift of aging will affect the economy and the labor workforce (Duxbury & Halinski, 2014; Huang et al., 2019) to become one of the most important challenge faced by countries from all over the world. On the other hand, an increasing number of the aging workforce also opens new opportunities (Čiutienė & Railaitė, 2014; Hertel & Zacher, 2018) because this range of age (aging workforce) has different sets of experiences, skills, and knowledge that are beneficial for companies.

For technology-oriented companies, age is an important variable to consider (Elias et al., 2012), as this demographic factor has a moderating effect on the adoption and acceptance of technologies (Chung et al., 2010; Porter & Donthu, 2006). Several studies found that putting an aging workforce as a moderator increases explanatory prowess. Venkatesh et al. (2016) also mentioned that the aging workforce plays a role as a moderator for technology acceptance or the use of technology (Venkatesh et al., 2016). Moreover, the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) also highlighted the age demographic factor as a moderator to the use or adoption of technology (Tarhini et al., 2014). Hence, the functions of the aging workforce are highly relevant and need to be studied as a moderator in "Industry 4.0" (the new era of technological development and adoption of technologies) that is yet to be widely adopted.

Few researchers studied the impacts of aging demographics on technology usage. The results on new technology adoption indicated the predominance of younger workers as compared to older workers. Studies also found that older workers have a lower inclination towards technology adoption, and they also avoid uncertainty (Laukkanen, 2015). Furthermore, in terms of computer usage, older people have lower self-efficacy due to their beliefs that they are too old to learn new technology (Tarhini et al., 2014).

On the other side, knowledge matures with age and builds experiences, subsequently resulting in wisdom and intelligence. The researchers defined it as a competitive advantage and related it to organizational innovation (Stoffers et al., 2018). However, an aging workforce with outdated knowledge can reduce organization innovation. The research of Park (2018) examined the contrasting effects between the aging workforce and organization innovation. The study observed that due to organization-specific knowledge and experiences, the aging workforce, at some level, contributes to organizational innovation. Older people excel at a task where experiences and knowledge are majorly required. The intellectual and sentimental changes that occur after performing a process many times build expertise, and that is beneficial for job efficiency.

Older employees often have deep knowledge about the system and step-by-step information about their works, thus boosting their abilities in performing knowledge-intensive works. In particular, older employees have the ability to learn and adapt to the jobs, similarly as in the younger workers (Schinner et al., 2017). An aging worker is able to develop strategies and organize projects in different ways, such as by looking further forward, making notes, and trimming choices with the help of their experiences.

The researchers believed that older employees have plenty to offer. Their values consist of knowledge, wisdom, experiences, connections, the skills to detect lies, and also the understanding that violation of rules can cause damages. Moreover, old employees are loyal, trustworthy, dedicated to the job, and are willing to stay more on the job. Hence, at the time of retirement, the industry will face losses (Rahim et al., 2018). Some companies are creating apprenticeships and choosing retired persons to train new employees. This was done as a method to turn the aging market pattern into an advantage by gaining their knowledge through training new staff (McKinsey, 2012). Kocak (2011) revealed that the elements of the aging process should be incorporated into the organization's strategies so that they may concentrate on small level requirements, such as re-training, working conditions, and enhancement of skills needed by old age employees.

Older employees tend to work towards domain specialization, meaning that they may pick the projects where they can make use of intellectual efforts that rely on their expertise. Eventually, an older employee may exhibit high performances in a field of expertise but is disinterested in other fields. Even where a great level of management is required, the aged workers may outshine the younger ones, especially in a situation where they may use more specialized abilities. When motor abilities are needed, the older employees may bypass lower skill sets by thinking forward and pre-planning their projects (Downing et al., 2005; Schinner et al., 2017).

Normally, job performances decrease as age increases. However, some researchers reported uncertain results regarding age, learning, and performance (Ismail et al., 2015). In "*Handling the Ageing Workforce*," it was highlighted that there is no difference in tasks performances between older and younger employees (Hamdan et al., 2018; Hertel & Zacher, 2015). Contrary to that, Gruescu (2007) realized that the aging population is affecting the economy negatively. Particularly, age reduces physical capabilities, as well as decreases the desire to learn new things and to work with the new technology and innovation. Thus, it adversely impacts workability, ultimately decreasing the GDP per capita of the country. For competitiveness, the companies should deal with these changes effectively (Monostori, 2014). They need to focus on the needs of the aging workforce and prepare developmental programs by evaluating organization technologies (Schinner et al., 2017). To conclude, the aging of employees is an issue of a level of human resources. Therefore, it should be resolved tactically.

There is a belief that older workers are not much innovative and are resisting innovation. They are deemed as less flexible, less motivated, and less open to change. However, their positive performances can also be found in the literature. Now the question is whether the extensive knowledge and experiences of older employees put them in a position to implement new ideas and prepare their organizations for the implementation of Industry 4.0? There is limited data available in the literature that can be analyzed to answer this. For example, Rietzschel and Zacher (2015) believed that more research regarding innovation and the moderating role of aging workers in companies are required.

From the literature discussed above researcher proposed a moderating relationship of an aging workforce.

H6: Relationship between organization innovation and readiness for Industry 4.0 is moderated by an aging workforce.

2.7.7. A Mediating Role of Organization Innovation between Knowledge-Oriented Leadership & Readiness for Industry 4.0

The organizational innovation is an application of changing processes and adopting technologies. It also helps in developing competencies for an organization. Moreover, it is considered a solution for organizations to stay updated with the market trends and to remain active in global market competition (Georgy, 2017). In this current situation, Industry 4.0 is bringing disruptions into all the traditional structures and processes; thus, organization innovation is becoming a survival factor. Despite the number of benefits innovations can bring along, the extent to which it supports Industry 4.0 in the availability of knowledge-oriented leadership is unclear, especially in the context of the manufacturing sector of a developing country that is moving forward to embrace Industry 4.0.

Many researchers examined knowledge-related practices for creation, sharing, and application in order to achieve organizational objectives and to become competitive (Darroch, 2005; Nonaka & Takeuchi, 2007). Effective knowledge practices guided by the knowledge leaders can lead to improved organization with different kinds of innovation. Improved or better organization is more resilient since resilience is about adapting to new changes (Industry 4.0) and staying competitive (McManus, 2008).

The organizations that are targeting competitiveness and trying to achieve the readiness level for Industry 4.0 should invest in finding and training knowledge leaders. However, these changes will not appear overnight since it requires continuous struggles and improvements. Hence, the organizations must develop tacit knowledge through the right practices, as well as build innovation by finding new and smarter ways for Industry 4.0 adaptation (Weeks & Feeny, 2008). The same arguments were discussed by Niu et al. (2010) on knowledge, innovation, and adaptation. They believed that the knowledge generated and accumulated by knowledge leader become part of new ideas, while these ideas and creativity speed up the adaptation process.

Mafabi et al. (2012) explained how the knowledge-oriented leaders and their generated tacit knowledge are helpful in timely solutions, such as by predicting the future and adapting new techniques. The leaders use their experiences to analyze the problems and prepare the solution. All of these might involve innovation as a part of their Industry 4.0 adaptation processes. For prediction, knowledge leaders anticipate risks and solutions through their expertise and conceptualize the ideas, concretized with hits and trials, after that implement the perfect changes.

Innovation act as a mediator between leadership and organization overall performances (Zafar & Mehmood, 2019). Leaders have motivational capabilities that can create an innovative environment with their charismatic speeches and can achieve the organization's long-term goals. Their different behavior (such as leading by example) become a driving force in the adoption of changes. The capabilities they transfer to employees, in the form of knowledge management, can generate new knowledge, subsequently contributes to a high level of achievements for the organizations. It will also help in making new products that make them more successful. Based on the discussions above, this research proposes that:

H7: Relationship between Knowledge-oriented leadership and readiness for Industry 4.0 is mediated by organization innovation.

2.7.8. A Mediating Role of Organization Innovation between Decentralized Organization Structure & Readiness for Industry 4.0

Organization structure plays an important role in developing the innovation capacities of the organization. Researchers argued that the decentralized structure favors innovation and assists in achieving the high-performance goals of organizations. It helps in developing an innovation-friendly environment by promoting knowledge sharing, empowerment, decision making, and decentralization of management decision making. Furthermore, innovation helps in the application of abilities to prepare the organizations for any upcoming shifts, currently is referring to Industry 4.0. Now, the understudy question is to determine the extent of indirect influence caused by organization innovation to the readiness of Industry 4.0.

Kaliappen and Abdullah (2014) and Ylijoki et al. (2019) also highlighted the mediating role of organizational innovation for big data and organizational performances. However, it requires the support of organization structure that enable the capability of organization to innovate. Further it strengthen the whole organization system to adopt Industry 4.0 changes smooth. In an argument on the implementation of Industry 4.0 concepts by Sivathanu and Pillai (2018), it is highlighted that organization structure is vital for every organization. It creates a conducive environment for the preparation of Industry 4.0.

Decentralized organization structure brings the function of flat hierarchy, which reduces the communication barrier and fasten the decision-making. With the distribution of power to make decisions enables employees to work autonomously and respond immediately according to the project demand. Hence, organization structure would be required for efficient Industry 4.0 implementation that would all departments to play a more strategic role in the overall organization growth.

Organization structure enables the innovation by promoting the new ideas that brings changes for dynamic business environment. Extant literature has discussed the innovation as bridge between structure and adoption of technology. Hao et al. (2012) examined the mediating role of organization innovation in influencing decentralized organization structure. The results also supported the direct and indirect roles of organization innovation. Based on the discussions above, this research proposes that:

H8: Relationship between decentralized organization structure and Readiness for Industry 4.0 is mediated by organization innovation.

Summary of all hypotheses developed above are presented in Table 2.5 below. Table includes Hypothesis, its number, and proposed relationship based on literature review.

Table 2.5
Summary of Hypotheses

Number	Hypotheses	Proposed
H1	Knowledge-oriented leadership and organization innovation	Positive
H2	Decentralized organization structure and organization innovation	Positive
H3	Organization innovation and readiness for Industry 4.0	Positive
H4	Knowledge-oriented leadership and readiness for Industry 4.0	Positive
H5	Decentralized organization structure and readiness for Industry 4.0	Positive
H6	Aging workforce between organization innovation and readiness for Industry 4.0	Moderates
H7	Organization innovation between Knowledge-oriented leadership and readiness for Industry 4.0	Mediates

H8	Organization innovation between decentralized organization structure and readiness for Industry 4.0	Mediates

2.8. Proposed Research Framework

Based on the literature review of variables and their relationship, research framework has been presented (see Figure 2.1). In application to Learning Organization and Dynamic Capability theories, this framework assists in developing organizational innovation and prepare organizations for new revolution. Figure below presents the figure of hypotheses that are developed.

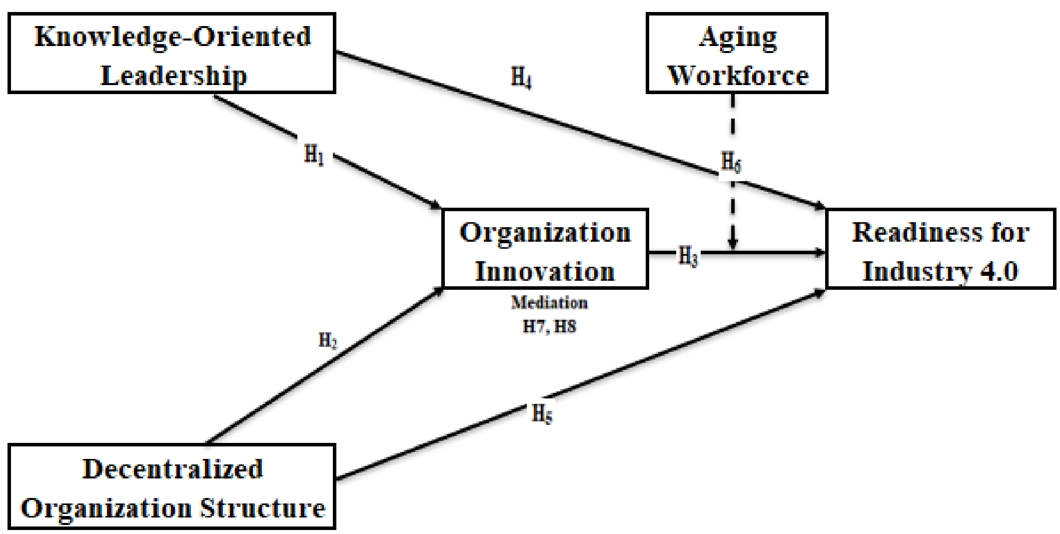


Figure 2.1: Proposed Framework to Readiness for Industry 4.0

2.9. Summary

The literature is reviewed in accordance with the relevant theoretical and empirical background to contextualize the study. The purpose is to examine the readiness of Malaysian manufacturing for Industry 4.0 through appropriate practices and organization innovation. The objective of the literature review was to study the existing relationships between variables and theories in the context of the Malaysian manufacturing industry. However, the task to test the framework is remaining. The following chapter will discuss the methodology of study in the manufacturing sector of Malaysia.

CHAPTER 3

3.0 RESEARCH METHODOLGY

3.1. Introduction

This chapter outline the research methodologies that are organized in different sections. The first section focuses on research paradigm and research approach applied in current research. The second section includes the explanation of research purpose and research design. The third section explains the data collection method, population and sample. The subsequent section describes the operationalization of questionnaire design and development of structure. The fifth section provides the view of data analysis in which the measurement and the structural model of the study are explained. Finally, a summary of the research methodology is provided at the end of this chapter.

3.2. Research Paradigm

Research paradigms talks about the development of knowledge. These are defined as belief-based systems that passes across the generation. It deals with nature, source, and development of knowledge (Saunders et al., 2016). Based on research objectives discussed in the first chapter, current research has adopted an epistemological philosophical view of positivism.

3.2.1. Positivism

Current research follows the epistemological approach of finding the answers to research questions and its type "positivism" that is suitable for research objectives. The positivism approach promotes the method from social science (Bryman & Bell, 2015). It is a study of society that relies upon scientific evidence collected through the survey and later revealed through statistics about how society operates (Burrell & Morgan, 2017). The positivism approach says that there is a fixed stance on reality (Hollway, 2018). The principle is that scientific knowledge that develops from the affirmation of theories by applying scientific methods is authentic. Unlike positivism, constructivism relates the knowledge as human constructs and thus is subjective. That means, it is generated by scientists. Therefore, it rejects the verification of knowledge through scientific methods and not relevant for current empirical research.

Positivist research paradigm believe that there is generally a single reality. It involves a structural approach to develop hypotheses and selection of suitable methodology. Consistent with the past literature, current research tries to keep distinction among science, facts, and experience (Mack, 2010). Hence, a quantitative method is applied to investigate the relationship between "*knowledge-oriented leadership, decentralized organization structure, organization innovation, and readiness for Industry 4.0*". As it applies statistical methods which are the core of positivist research to disclose knowledge of objects (Chen et al., 2011).

Current research follows the progressive schema, moving from eight main research questions, development of hypotheses, data collection, and analysis. Therefore, Positivism, a well-known epistemological position in research philosophy is employed. It can quantify measures, draw inferences about phenomena and explain them objectively. Since the research focuses on the practical meaning of how management practices support for innovation and preparation of companies for Industry 4.0. Thus, the positivist philosophy applies techniques in accordance with the research problem and is considered most suitable for current research.

3.3. Research Approach

Decisions in business research are to be made after getting reliable information. The information must be processed in a logical way to use effectively in the decision-making process. Therefore, a scientific methodology is used to solve the issues systematically through data analysis for drawing a valid conclusion (Creswell & Creswell, 2017). Current research considered the deductive approach of reasoning because it follows a systematic way based on theory.

3.3.1. Deductive Approach

A deductive approach is the basis of developing a hypothesis from theory and collection of data. It also helps in designing a strategy to test the proposed hypotheses (Bryman & Bell, 2015). According to Saunders et al. (2016), deductive approach characteristics include; use of hypotheses to explain the causal relationship. In addition, it requires the operationalization of concepts to measure them quantitatively. Finally, to generalize the findings, the sample should be large enough. Based on the application of a deductive approach, the current research has developed the hypotheses from the literature of Learning Organization and Dynamic Capability theory, followed by data collection process. Further, the relationships between independent and dependent variables are operationalized properly. Finally, the causal relationships are tested, and results revealed are generalized accordingly.

3.4. Research Purpose

The aim of current research is two-fold; to describe the variables of the study and to investigate the relationship between them. Therefore, descriptive and explanatory research designs are applied to fulfil the aim by gathering information about variables. Besides, it explains the phenomena and allows testing the relationship through hypothesis (Sekaran & Bougie, 2016).

The objective of descriptive research study is to provide a complete picture of understudy phenomena. It helps in describing the topic precisely, like events, individuals, or situations (Kowalczyk, 2015). The application of descriptive research technique in the current study will benefit in explaining the statistics of two dependent variables, two independent variables, mediator, and moderator *"knowledge-oriented leadership, decentralized organization structure, organization innovation, readiness for Industry 4.0, and aging workforce*" properly, including their mean and standard deviation. Moreover, the demographic profile of companies and employees can be understood using descriptive technique. Whereas, the explanatory research design allows to test the causal relationship between above mentioned variables.

3.5. Research Design

A research design is associated with the objective and purpose of research originated from research questions. It provides a framework for the collection of data, measurement, and analysis based on research objectives (Cooper & Schindler, 2014). Research design decides how the researcher answers the research questions and identifies the methods for analysis. The researcher employed Quantitative with Cross-sectional research design for research purpose.

3.5.1. Quantitative Study

In line with the positivist philosophy and deductive approach, this research will apply the quantitative research design to answer research questions. The quantitative research is an empirical investigation of phenomena with statistical techniques (Bernard, 2017). It is applied to test the readiness of Industry 4.0 in Malaysian manufacturing sector. This approach provides the researcher with an opportunity to analyse "*knowledge-oriented leadership and decentralized organization structure*" that support "*organization innovation for the readiness of Industry 4.0*", numerically. Since the variables of study can be defined, isolated, and linked for the hypothesis generation, thus the quantitative approach is appropriate for the findings that are generalizable (Hammarberg et al., 2016). Antecedents of organization innovation will be analysed quantitatively to understand the role of management practices. Especially the examination of moderating and mediating effect of the aging workforce and organization innovation respectively are of high interest. Therefore, the quantitative analysis is applied to get a precise measurement of causal as well as moderating and mediating relationships to make evidence-based decisions.

The quantitative method is preferred over qualitative due to the reason that the later would impede a broad investigation. It limits the size of sample that would result in generalizability issues to the population under study (Morgan, 2016). Moreover, a qualitative approach is used while inspecting underdeveloped phenomenon or when there are challenges to identify the target population (Hammarberg et al., 2016; Hammarberg et al., 2014). The constructs of current research can be isolated and connected to develop a hypothesis, therefore the quantitative approach is more relevant for examination (Morgan, 2016).

3.5.2. Cross-Sectional study

Current research applied cross-sectional design that is widely adopted in the management field of research. The cross-sectional design allows the collection of data from defined population at a specific time (Fagerland et al., 2015; Samuel, 2018). It can measure the prevalence of all factors and assist in examining the relationship between variables. Current research contains multiple variables to study and analyse data that were collected from the representative of manufacturing companies at a specific time. Thereby, this design facilitates the empirical investigation of management practices that are useful for developing innovation capacity of manufacturing companies and to measure their readiness for Industry 4.0. Further, it enables the researcher to identify moderating effect of aging workforce and mediating effect of organization innovation. The same design is recommended by Schmidt and Kohlman (2008) to check the causal effect of variables.

3.6. Data Collection Method

Data were facts provided to the researcher from the environment (Cooper & Schindler, 2014). Data collection is the process of gathering it from all the sources that are relevant and available to evaluate them and get a solution for research problem. For the current research purpose, raw data were used to analyse the research problem. The researcher collected primary data from first-hand sources of manufacturing companies in Malaysia by keeping the current research project in mind. Data collected were used specifically for current research (Stephanie, 2018). To collect the data a survey questionnaire strategy was used for data collection purposes. This strategy is widely adopted and considered suitable for management studies.

3.6.1. Survey Questionnaire

A survey is a strategy that is used to collect standardized primary data from respondents. Current research design suggested a quantitative nature of the study and intended to collect data from companies for solving research problems, therefore, survey strategy was adapted to gather standardized data that can be coded and analysed analytically by using statistical techniques (Borges et al., 2017). In the survey, a questionnaire was a method used for collecting data where respondents responded in a predetermined way through written questions, also called items.

Current research has adopted a questionnaire technique that is also popular in survey work. The aim was to collect data from manufacturing company representatives. The questionnaire used in this research consists of closed-ended questions and was self-administered to collect reliable data without the involvement of any other factors. This method enabled researcher to get the required data without any risk of biases (Nardi, 2018). Moreover, it is less expensive, easy to complete, generalizable, convenient, and has low bias features (Saunders et al., 2016). The research questionnaire prepared for current research has two sections. Section “A” includes demographic related questions for respondent and company, whereas section “B” comprises the items related to variables. Further details are discussed in questionnaire design and structure section 3.10.

3.7. Population and Sample

A population is a number of all elements upon which inferences are made (Cooper & Schindler, 2014). Identifying and justifying the target population is an important stage of research (Sekaran & Bougie, 2016). In current research, the population includes the registered manufacturing companies of Malaysia that are 49,101 (DOSM, 2018; MITI, 2018). The target population was selected from the database of Federation of Malaysian Manufacturers [FMM] (2018) which is highlighted by an official department “Malaysian Investment Development Authority [MIDA] (2018)", as the major data source related to manufacturing companies in Malaysia. The FMM is a representative company of Malaysia for manufacturers globally. Moreover, this database has been used in various research and thus considered as an appropriate source (Bakar & Ahmed, 2015; Lee et al., 2019; Long & Khairuzzaman, 2008; Mamoun et al., 2020; Mohd Mokhtar et al., 2009; Ramakrishnan et al., 2015).

Further, the element of a population concerning current research is a single manufacturing company. A unit of analysis is “one individual/representative” from “each company” was requested to answer research questionnaire. That individual can be “Owner, CEO, Director, General Manager, Manager, or Executive”. These individuals are selected due to their significant experience and knowledge of operations along with the better vision of company’s activities ((Bahari et al., 2018; Hambrick & Mason, 1984). The objective was to collect non-biased data that reflects organization practices for innovation and readiness of the manufacturing industry for Industry 4.0.

3.7.1. Sampling Technique and Sample Size

With the help of G*Power software, the sample size was calculated. The minimum size required for research was recorded 107 (Faul et al., 2019). The value is achieved through statistical test “Linear Multiple Regression” with type of power analysis “A priori”. The parameters include medium effect size, 95 percent power and 2 predictors. Researcher was able to collect 155 usable responses which are adequate for structural equation modeling (Hair, 2007). The Simple Random Sampling (SRS) technique was used to select respondents from the list of companies that are available with the (FMM). This technique is deemed least biased, and the finding can be generalized to wider population (Jawale, 2012).

Companies registered with the Federation of Malaysian Manufacturers were contacted through e-mails. A request was sent to fill the questionnaire from an individual that can be “Owner, CEO, Director, General Manager, Manager, or Executive” because they have significant experience, know the operations well and have better vision of company's activities. They also have a great influence on company performance and strategies (Bahari et al., 2018; Hambrick & Mason, 1984). For getting instant response, a Google form link has also been provided through email. Non respondents were contacted and requested twice additionally to ensure the response.

3.8. Development of Measurement Scale

According to Kumar (2005), a measurement scale should have three qualities; all items must be clear and understandable; the scale should be short to avoid respondent fatigue; and a suitable Likert Scale should be selected to avoid hasty and neutral responses (Lindell & Whitney, 2001). Current research has adopted a 5-point Likert scale to measure the perception of respondents (Cox, 1980).

It is highly important to ensure accuracy, persistence, and quality of scale. For the reason, current research has adapted well-adopted scales from existing empirical studies (Bryman, 2015). Further the items were processed through the pre-testing and pilot testing stage. The questionnaire is prepared in English language to increase the quality and better responses. It is also written in a standard font size that is easy to read and includes clear instructions.

3.8.1. Scale for Knowledge-Oriented Leadership

The scale for knowledge-oriented leadership is adapted from the study of Donate and de Pablo (2015). It contains items with a mixture of transformational and transaction style to measure knowledge-oriented leadership. Items seek to measure actions among workers and groups in context of their responsible behaviors (Rosenbloom, 2000), the management role for applying information and evaluating workers to promote learning innovation (Bollinger & Smith, 2001), leading by example (Bryant, 2003) and rewarding those who apply and share knowledge (Haas & Hansen, 2005). For an overview of measurement details, (see Table 3.1).

Table 3.1
Operationalization of Measurement Scale for Knowledge-oriented leadership

Items	**Reference**
Our company managers have been creating an environment for responsible behavior among employees and teams.	Donate and de Pablo (2015)
Our company managers assume the role of knowledge leaders as a mediator for sharing and applying knowledge.	
Our company managers promote learning from experience rather than work output.	
Our company managers behave as advisers, and controls are just an assessment of the accomplishment of objectives.	
Our company managers promote the acquisition of external knowledge.	

Continued next page

Our company managers reward employees who share and apply their knowledge.	

3.8.2. Scale for Decentralized Organization Structure

To measure decentralized organization structure, a scale is adapted from the study of Willem et al. (2007) and Cunningham and Rivera (2001). It helps to examine the decentralization characteristics of organization by reverse coding the items during analysis (Wan et al., 2005). Items measured the flexibility and autonomy of employees for making any decision. The list of items for organization structure are presented (see Table 3.2).

Table 3.2
Operationalization of Measurement Scale for Decentralized Organization Structure

Items	**Reference**
Every matter in our company has to be referred to someone higher up for the final answer.	Willem et al. (2007)
In our company, a person who wants to make a decision on his own is discouraged.	
In our company, any decision employees make needs higher management approval.	
In our company, no actions are performed until the higher management makes a decision.	

3.8.3. Scale for Organization Innovation

Several researchers evaluate organization innovation by using a reliable scale. For current research the researcher has adapted a unidimensional scale from García-Morales et al., (2012). Items presented in Table 3.3 are included in scale to measure the technology and product-based innovation of the company. An overview of the items for organization innovation is presented below.

Table 3.3

Operationalization of Measurement Scale for Organization Innovation

Items	Reference
Our company's emphasis is on developing new products.	García-Morales et al. (2012)
In our company, introduction of new products into the market increased in last 12 months.	
Our company has spent on new product development activities in last 12 months.	
New products of our company have been introduced for the first time in the market in last 12 months.	
Our company invested in developing proprietary technologies in last 12 months.	
Our company's emphasis is on technological innovation.	

3.8.4. Scale for Readiness for Industry 4.0

To check the readiness for Industry 4.0, a reflective second order measurement scale is adapted from the study of Akdil et al. (2018). The items included in questionnaire are measuring the nine high order dimensions of Industry 4.0 including Industry 4.0

Strategy, Industry 4.0 Leadership, Industry 4.0 Customer, Industry 4.0 Products, Industry 4.0 Operation, Industry 4.0 Culture, Industry 4.0 People, Industry 4.0 Governance, and Industry 4.0 Technology. This construct will be measured with a 5-point Likert scale. For an overview of measurement, items (see Table 3.4), whereas the readiness for Industry 4.0 is acting as a dependent variable.

Table 3.4
Operationalization of Measurement Scale for Readiness of Manufacturing Industry for Industry 4.0

Items	Reference
Industry 4.0 Strategy	Akdil et al. (2018)
Our company is using a plan for the implementation of industry 4.0 activities.	
Our company has adopted a business model that is compatible with industry 4.0.	
Our company possesses adequate resources for the realization of industry 4.0.	
Industry 4.0 Leadership	
Our company managers are willing to face the challenges of industry 4.0 activities.	
Our company management possesses adequate competencies to face the challenges of industry 4.0 activities.	
In our company, central coordination for industry 4.0 is available.	
Industry 4.0 Customer	
Our company has digitalized sales and services.	
Our company analyses customer data for sales improvement.	
Our company customers are competent with Information and Communication Technology (ICT).	

Continued next page

Industry 4.0 Product

It is possible to integrate products into other systems that are compatible with industry 4.0.

Our company products have flexibility in their characteristics.

Our company products are digitally compatible.

Industry 4.0 Operation

Our company has decentralized the process of operations.

Our company encourages interdepartmental collaboration.

Our company is adopting modeling and simulation methods in their operations.

Industry 4.0 Culture

Our company encourages open innovation (cross-company collaboration).

Our company encourages knowledge sharing among employees.

In our company, the employees value Information and Communication Technology (ICT).

Industry 4.0 People

Our company employees are having high ICT competencies.

Our company employees are open to accepting new technologies.

Our company employees enjoy autonomy.

Industry 4.0 Governance

Our country business policies have suitable technology standards.

Our country business laws protect the company's intellectual property.

Our country business laws have adequate labour regulation for industry 4.0.

Continued next page

<u>Industry 4.0 Technology</u>
Our company has adopted Information and Communication Technology (ICT).
Our company is utilizing mobile and related devices.
Our company has integrated computers with machines and tools.

3.8.5. Scale for Aging Workforce

To analyse the aging workforce, the following question was asked from the respondent "*What percentage of employees in your company would you estimate to be over the age of 55?"* The responses received were in the range (0% to 20%). It was further divided into two categories with the help of median split approach. Median split is a common technique to dichotomize the data for further analysis (Sörensen et al., 2020). The values below median are categorized as "Low Aging Workforce" that ranges from (0% to 10%) and the value above median is named as "High Aging Workforce" ranges from (11% to 20%) for analysis. The application of median split will help in analysing the moderation as well as the Multi Group Analysis.

3.9. Pre-Test and Pilot Test

Before the original survey, a trial (pre-test) should be carried to check for improvements. It is crucial because of the feedback by experts that can be used to find out the relevance of the research query. It ensures that there are no wording problems, rectifies inadequacies to reduce biases (Hilton, 2017). It also clarifies ambiguities in questions for a clear understanding to interviewee/respondent. This test also helps to ensure that the items reflect the variables of construct.

Since the survey is self-administered so the feedback from experts enhanced the interaction part that made it easier and understandable. For pre-testing of current study, ten experts five each from their respective industry (academics & manufacturing) were requested to review the questionnaire and rate the items. The experts consisted of CEOs and Managers from different manufacturing companies. The rest were professors with relevant research interests and a language expert.

A widely adopted Content Validity Index approach is applied to examine the content validity. Item level (I-CVI) and Scale level (S-CVI) were calculated in the process. The experts rated the instruments for clarity and relevancy as per theoretical definitions on a scale of 4 “Not Relevant to Highly Relevant” as suggested by Zamanzadeh et al. (2015). The items with a rating of 3 and 4 (Quite Relevant or Highly Relevant) were given 1 score in calculation. The average of all responses against each item should be more than 0.78 for I-CVI as suggested by Lynn’s, (1986) to retain the item. Whereas the S-CVI should be more than 0.90. Two items including “I have to ask the boss before I do almost anything” of decentralized organization structure and “Number of new products or services added by the organization and already on the market” of organization innovation were eliminated due to their rating below threshold (Appendix B). Further, the suggestions and corrections especially related to sentence structure were incorporated for overall improvements. The pretesting questionnaire is also presented in Appendix A.

To confirm the validity between constructs and items, a pilot study was conducted. The pilot test is a small-scale preliminary test that is carried out by a group of selected people who responds to every question that is included in the survey. This trial is required for the research before going to the actual study for feedback to improve validity, reliability, and operationalization practicability, to get answers in true manner (Kumar & Kothari, 2018; Xie & Lee, 2013). Moreover, it ascertains the variance item range, scale reliability, factor loadings, and review of the items (Artino et al., 2014; Nunally, 1978). In this research, pilot test was performed in manufacturing companies of Malaysia. Thirty-five respondents were selected as suggested by Connelly (2008) from the same database that was used for the actual study later. Top-level employees from different categories of manufacturing sectors were requested to fill the survey and assess the content of the questionnaire to bring clarity in instrument.

The questions were arranged properly in a chronological manner with their respective constructs in order to avoid any confusion. Each step taken has further enhanced the quality of questionnaire and subsequently supported to yield significant results. A statistical tool SPSS has been employed for pilot study upon the collected data. The value of Chronbach's Alpha was examined to check the internal consistency. A minimum accepted Alpha value was considered at 0.60.

During the pilot study, the individual item Cronbach's value and overall instrument Cronbach's value were checked thoroughly. Initially, the value of Cronbach's Alpha for organization innovation was calculated 0.519 due to the items OI_5 "Our company's Emphasis on creating proprietary technologies" and OI_8 "Our company's emphasis on pioneering technological developments in its industry". Both items variance was abnormal (Appendix C). Thus, the items were deleted to achieve Cronbach's value 0.913. Finally, six items of knowledge-oriented leadership, four items of decentralized organization structure, six items of organization innovation, and twenty-seven items of readiness for Industry 4.0 were confirmed for actual research.

3.10. Questionnaire Design and Structure

An introductory letter was attached at the start of questionnaire that briefly explains the objective of research and to get the consent before beginning the survey. The questionnaire is divided into two sections. Section "A" includes demographics profile of respondent and company. A total number of nine questions were asked in section "A". It includes two options for *Gender*, five ranges for *Age* from "less than 24 years old to more than 55 years old", three main categories for *Position* "Owner/CEO/Director/G.Manager, Senior Manager/Manager, Executive", five categories of *Working Experience* from "less than 5 years to more than 20 years", thirteen states and three federal territories of Malaysia for *Company Location* to be selected, seven categories for manufacturing *Company Products*, two choices

"Local or Foreign" for *Company Ownership*, five categories for *Company Type* based on their registration "Private Limited, Public Limited, Sole Proprietorship, Partnership, or Limited Liability Partnership", and "estimate of employees percentage as per age". Section "B" covers the items of *four variables* that include *"knowledge-oriented leadership, decentralized organization structure, organization innovation, and readiness for Industry 4.0"* (see Appendix D).

The term's definitions are provided in footnotes for respondents' better understanding. A 5-point Likert scale specially designed to measure attitudes or opinions was selected by the researcher due to its fixed choices. It increases the response quality, decreases the level of frustration, and allows the use of statistical tools (Collis & Hussey, 2009). According to Johns (2010), the data becomes less accurate when more than 7 or less than 5 points scale is employed. It lowers the quality of responses with an increase in categories, therefore, 5-Point Likert Scale is considered a better option and hence recommended (Revilla et al., 2014).

3.11. Data Analysis

Current research has applied Smart PLS 3 and SPSS software to conduct data analysis. Smart PLS was employed to test the reliability and validity of survey questionnaire data. It is known for analysis with fewer sample size restrictions and considered a better choice in comparison with covariance-based structural technique (CB-SEM) (Chin et al., 2003). Smart PLS 3 has the capacity of analysing the data efficiently (Henseler et al., 2009). Moreover, due to its higher ability (Afthanorhan, 2013) the measurement and structural model of the framework will be analysed effectively. It is also suitable for model building studies and is considered appropriate for examining the cause-effect relationship (Hair et al., 2012). Importantly, it allows the analysis of higher order construct without the issues of reliability and validities with the provision of latent variable scores. Thus, the relationships of dependent variable (Readiness for Industry 4.0) and antecedents of organization innovation (knowledge-oriented leadership and decentralized organization structure) were assessed by using Smart PLS. Additionally, the moderating effect of aging workforce and mediating effect of organization innovation were also examined. But before the data analysis, data preparation and screening were performed thoroughly.

3.11.1. Data Preparation and Screening

Data were screened to ensure the reliability as well as the validity (Tabachnick & Fidell, 2013). In this process, initially the missing values were checked. Missing data is a common incidence but can have a significant effect on results. More than 10% of the data that is missing can cause a serious issue (Tsikriktsis, 2005). Missing data can be due to a deliberate act of ignoring some questions. But within an acceptable limit, data can be mitigated by the exclusion of that cases of missing data from specific research as suggested by (Hair et al., 2010). Smart PLS 3 offers two approaches to deal with missing data issues, either substitute the mean of overall cases of a variable or case-wise deletion (Temme et al., 2006).

Further the response bias and the outliers within and between variables were tested during the cleaning process by using SPSS. According to Hair et al. (1998), univariate and multivariate are used for the identification of outliers. As suggested by Kline (2005), a univariate outlier is an extreme value of a single variable, and in a multivariate outlier at least two variables have an unusual score. For current research, outliers were tackled by checking the z-score and Mahanalobis. The value of z-score should be less than 4 and Mahanalobis probability must not be ($P<0.001$) (Hair et al., 1998). Finally, the screening of normality assumptions was performed. It is important to have a normal data for appropriate results and precise predictions (Das & Imon, 2016). The indicators including Kolmogorov-Smirnov, Histogram, Skewness and Kurtosis were examined to ensure normality.

3.11.1.1. Multicollinearity

Multicollinearity is the absence of a correlation between variables (Saunders et al., 2016). It thus threatens the measurement model integrity, fitness, and constructs validity. In order to reduce this issue, before creating an inter-item correlation, data should be mean-centered (Kutner et al., 2005). Variance Inflation Factor (VIF) test was performed to check and avoid concerns of multicollinearity. The value <=0.10

or >=5 is considered as problematic and thus to be removed from the analysis (Menard, 2002; Rogerson, 2001).

3.11.2. Measurement Model

The measurement model describes the relationship between constructs. The measurement model for the latent construct must be assessed initially before the presentation of the structural model (Hair et al., 2010). It is also used to perform confirmatory factor analysis (CFA). The reflective measurement model is evaluated for consistency and accuracy through reliability and validity analysis. Initially, the uni-dimensionality test was taken to eliminate any artificial correlation between constructs.

3.11.1.2. Uni-Dimensionality Test

It refers to the measurement of a single ability, construct, skill, or attribute. The factor loading procedure and “Kaiser-Meyer-Olkin (KMO) and Bartlett’s tests of Sphericity” will be applied to check uni-dimensionality. Moreover, for the newly developed item, the criteria of factor loading for a single construct is 0.5 or higher and 0.6 is the minimum score for the established item (Awang, 2012). Items should be deleted and retained one by one with lowest item deleted first. This test helps in finding artificial correlation among constructs.

3.11.1.3. Reliability Analysis

Reliability is the level of getting the same results (consistency) from a test if it is repeated more than once. This test is applied to check the reliability of scales used in this research. It aims that the data is free from error, either it is a random or unstable error. (Cooper & Schindler, 2014).

The internal consistency was examined by using Chronbach's alpha for two reasons. Firstly, it is used to check consistency across time and various items of an instrument. Secondly, it is widely recognized and very common in testing multi-item reliability for a scale (Cooper & Schindler, 2014). The Cronbach's alpha should be between 0 and 1 with a rule "higher the better". The least value considered for this research and believed as strong is 0.70 (Hinton et al., 2004).

3.11.1.4. Validity Analysis

Validity refers to the level at which measurement gets the real meaning of which it is intended to measure. It means that the responses received from the questionnaire represents exactly what is being measured (Saunders et al., 2016). For valid research, the two methods of content validity and construct validity were applied.

Content validity refers to the level to which measurement of study provides adequate coverage of questions. Adequacy can be judge through careful review of definition from literature (Polit & Beck, 2006; Saunders et al., 2016) or by using a panel of the individual to assess measurement questions. Measurement for current research is adapted from previous studies and thorough assessment from experts will be applied during pre-test for content validity purposes.

Construct validity also called composite reliability confirms the questions of measurement, measures the construct exactly as intended. From the types of construct validity, convergent validity checks two measures measuring the same construct and demonstrates that they are related. It is tested through factor loading (Anderson & Gerbing, 1988) within each construct. Additionally, for convergent validity, the value of Average Variance Extracted (AVE) should be greater than 0.5 as suggested by Afthanorhan (2013). Besides, the value of composite reliability (CR) should be greater than 0.7 and factor loadings greater than 0.6 (Yap et al., 2012). Further, discriminant validity which measures the two items that are expected to be unrelated, are unique is tested through correlation analysis (Hair et al., 2010). For the purpose, Heterotrait-Monotrait ratio of correlations (HTMT) test was applied with the maximum threshold of 0.85 (Henseler et al., 2015). For excellent validity, both types of validities are required. The measurement model is completed after establishing all the above validities and reliabilities. Summary of Measurement model tests and criteria is presented below (see Table 3.5).

Table 3.5
Summary of Measurement Model Tests and Criteria

Indicator/Procedure	Purpose	Criteria	Reference
AVE	Convergent Validity	It should be greater than 0.50	Afthanorhan (2013)
CR	Composite Reliability	Greater than 0.70	Yap et al. (2012)
Cronbach's Alpha CA	Internal Consistency	Greater than 0.70	Hair et al. (2010)
Heterotrait-Monotrait (HTMT)	Discriminant Validity	Threshold 0.85	Henseler et al. (2015)

3.11.3. Structural Model

Structural model analysis is performed using Smart PLS bootstrapping technique. But before the application, Pearson's coefficient $(R)^2$ is to be gauged. Current research followed the study of Henseler et al. (2009) which suggested $(R)^2$ 0.25, 0.5, and 0.75 as a weak, moderate, and substantial respectively. The value of $(R)^2$ is achieved by running PLS Algorithm in Smart PLS. Moreover, Stone-Geisser indicator (Q^2-Relevance of predictive validity) was applied to predict the quality of model. It reflects how much the model matches the expectations. The value of Q^2 must be greater than 0. Where $Q^2 = 1$ represents a perfect model without errors. By using the blindfolding module in Smart PLS 3, the value of Q^2 general redundancy can be achieved by eliminating each variable one by one. The formula for q^2 is (q^2 *included* – q^2 *excluded) / (1 -* q^2 *included)*. Additionally, usefulness of each construct is examined by Cohen's indicator f^2 (f^2 *included* – f^2 *excluded) / (1 -* f^2

included)) for adjustment model. It is the ratio of part explains with a part not explained. The required value of Cohen's indicator can be achieved by including and excluding constructs one by one in bootstrapping technique. Whereby, f^2 value 0.02, 0.15, and 0.35 are considered small, medium, and large respectively (Cohen, 1988). The structural model is considered accurate if the entire tests mentioned below in Table 3.6 met the criteria.

Table 3.6
Summary of Structural Model Tests and Criteria

Indicator Procedure	**Purpose**	**Criteria**	**Reference**
Pearson's Determination $(R)^{2*}$	Portion of variances of endogenous variables	Weak 0.25 Moderate 0.50 Substantial 0.75	Henseler et al. (2009)
t-statistics	Significance of correlation and regression	t >= 1.96	Hair et al. (2014)
Cohen's Indicator $(f)^2$	Effect Size	Small 0.02 Medium 0.15 Large 0.35	Cohen (1988)
Stone-Geisser's Indicator $(Q)^2$	Accuracy of Adjusted Model	$Q^2>0$	Hair et al. (2014)
Path co-efficient (Γ)	Causal Relation		Hair et al. (2014)

Note. *R^2 Quality of adjusted model.

3.11.3.1. Hypotheses Testing

A bootstrapping method is applied to test the direct and indirect relationship. Hypotheses are considered accepted if the test statistics value is greater than 1.96 and p-value less than 0.05. Indirect effect results were examined to see the mediation effect of organization innovation for Hypothesis 7 and Hypothesis 8. Further *H1, H2 and H3* were checked to assess the partial or full mediation. On the other side, moderating effect of aging workforce was also tested in Smart PLS. A moderator is introduced in model between "*organization innovation and readiness for Industry 4.0*". The results achieved through bootstrapping were evaluated based on the above test statistics and p-value criteria.

3.11.3.2. Multi-Group Analysis

Multi-Group analysis allows to understand the different groups effect on results (Henseler et al., 2009). A pre-defined data groups is created, and analysis is performed to test significant difference in parameters. To understand the aging workforce effect better on the H3, both lower aging workforce and higher aging workforce groups will be examined by using Multi-Group Analysis. The existing results will be then compared separately with each aging workforce group for noteworthy implications.

3.11.3.3. Importance Performance MAP Analysis (IPMA)

The Importance Performance Analysis (IPMA) will be performed to see the importance of exogenous variable on endogenous variable. Moreover, it will also help in analysing the performance of exogenous variable on map. The results will be used to extend the knowledge of understudy variables relationships. Moreover, it will have an important implication for managers to understand the important factors with their relevant performance and strategize accordingly.

3.12. Supplementary Qualitative Study Design

To strengthen the quantitative research findings and support the sample size of quantitative study, a supplementary qualitative study was applied. This additional research and analysis helped in understanding the findings of main eight research questions and accomplishment of objectives.

The interview was divided into two sections. Section "A" contains the questions related to demographic profile of respondent and company. Following section covers the twelve (open ended) questions related to business awareness. The questions are mainly related to the awareness of industry 4.0 and aging workforce, and the roles of knowledge-oriented leadership and decentralized organization structure. A covering letter including the research information and voluntary consent was also attached at the start of survey (Appendix E).

An ATLAS.ti software was used to analyze the nine interviews of top management from manufacturing organizations. This software is selected because it has ability to show better outcome and organize, retrieve, and analyse the data with precision (Ronzani et al., 2020). The results are explained in section 4.8.

3.13. Ethical Consideration

Research ethics should be considered in research design, data storage, and reporting stage as suggested by Saunders et al. (2016). Several ethical issues like privacy and volunteerism will be taken in to account during current research. For the purpose, current research has obtained ethical approval (U/SERC/36/2019) prior to research from Universiti Tunku Abdul Rahman (UTAR) in accordance with their guidelines, due to the involvement of human subject. The present research used questionnaire for collection of data that contains the cover letter which states the purpose of research, voluntary participation, and confidentiality assurance of data being collected. Moreover, respondents are required to provide their consent and have the right to withdraw from the survey anytime.

3.14. Summary

The current chapter has discussed research paradigm, research approaches, and research design. Additionally, the adoption of research methods and techniques for data collection is presented comprehensively. Finally, measurement model and structural model are explained in the data analysis section. The results of the survey will be evaluated in following chapter.

CHAPTER 4

4.0 RESULTS

4.1. Introduction

The objective of this chapter is to provide the insights of data analysis for assessment of the theoretical model hypothesized in the research. The first section includes descriptive analysis of respondents and constructs. It is followed by the factor analysis that helps researcher to classify the items that can measure constructs properly. The reliability and validity tests are described based on measurement model. Finally, confirmation of hypotheses through structural model is explained.

4.2. Response Rate

Although the G*Power suggested 107 sample size, but researcher tried to get a maximum of 150 responses which is also suggested by Hair (2007, 2010) for structural equation modeling. A total of 2801 companies' representatives were contacted from the database of Federation of Malaysian Manufacturers. An online survey was sent to companies across Malaysia. For getting instant response, a Google form link has also been provided through email. Respondents were contacted twice to ensure better response rate. The data collection process period was counted from 3rd September 2019 to 20th December 2019. Prior studies indicated low response for surveying owner-manager (Anseel et al., 2010;

Bartholomew & Smith, 2006; Hiebl & Richter, 2018; Pielsticker & Hiebl, 2020). In addition, the application of online survey can reduce the response rate further low (Shih & Fan 2008). Abd Aziz and Mahmood (2011) had received the low response rate for mail survey in 5 months from manufacturing companies of Malaysia. The study of Wong and Sam (2011) and Marimuthu and Bidin (2016) also experienced the low response in Malaysia. Whereas a study of Tang et al. (2013) received only 9% response from research conducted in Malaysia.

A total of 163 responses were received which accounted approximately 6% response rate. The response rate is calculated through the ratio of responses received with total distributed survey questionnaire. This response rate is acceptable as it is common in different countries including developed ones. For instance, 6% response rate in USA mail survey (Spencer et al., 1994), and 4% in UK (Wright & Burns, 1998). Generally, the response rate varies between 5% to 10% in online surveys, whereas Malaysia normally has low response rate (Sulaiman et al., 2012). Two of the questionnaires were omitted due to the doubt of bias response that can trouble the interest of research. The omitted respondents only answered the same values for all variables. Six responses were removed from data analysis because they fall in “Others” category of position. It may cause serious issues to the generalizability; therefore, respondents were removed from the sample. A total 155 responses were selected for final analysis.

4.3. Response Bias

Response bias is a common issue in a survey. It deals with the quality of data therefore, it is important to avoid for meaningful responses (Xu et al., 2017). The data is divided into two groups based on early and late responses by using SPSS. Both groups were tested through Paired-Sample t-test. The results of each variable groups must be insignificant to avoid any difference between groups i.e., response bias. Results confirmed that there is no response bias in the data as all the groups have insignificant difference (see Table 4.1).

Table 4.1
Paired Sample Test

		Mean	**Std. Deviation**	**Significance**
Pair 1	KOL_E - KOL_L	1.037	0.146	0.892
Pair 2	DOS_E - DOS_L	1.392	0.196	0.346
Pair 3	OI_E - OI_L	1.359	0.192	0.918
Pair 3	I4.0_E - I4.0_L	1.005	0.142	0.840

Note: "KOL = Knowledge-oriented leadership, DOS = Decentralized organization structure, OI = Organization innovation, I4.0 = Readiness for Industry 4.0, E = Early Responses, L = Late Responses. Std. = Standard"

4.4. Data Cleaning

Prior to the analysis, data were cleaned properly to ensure the validity and reliability. The missing values, normality tests, KMO and Bartlett's and Harman's Single Factor tests were performed. The data validation technique is applied by using Google form to avoid possibility of any missing values.

4.4.1. Assessment of Outliers

The presence of outliers, either it is univariate or multivariate, can affect the estimation as well as the model fit of data. To analyse and resolve the issues of outliers if any, the standardized values "z-scores" for all items were generated (Kline, 2005) and presented in (Appendix F). The range of z-score should be between -4 to +4. The values presented confirms that all the items of variables are within the required range, thus no outliers found. Further, the Mahanalobis probability was calculated by computing variables *(1-CDF.CHISQ(MAH,43)).* The probability values are above the minimum threshold ($P<0.001$) which confirms no multivariate outliers.

4.4.2. Descriptive Statistics

The descriptive analysis has been performed by using SPSS software. The values of mean and standard deviation of all constructs are presented (see Table 4.2). The mean value of each construct shows that the *"knowledge-oriented leadership, decentralized organization structure, organization innovation, and readiness for Industry 4.0"* values are towards medium to a high level due to their scores above midpoint i.e., 2.50. For standard deviation, all variables were reported closer and below 1 which is considered an acceptable range. Additionally, the Skewness and Kurtosis were calculated to test the normality of the data. The values for Skewness are within +2 to -2 and for Kurtosis all the values are within +7 to -7, thus confirms the normal contribution of data (see Table 4.2). The item wise normality, Q-Q plot and Histogram are affixed (see Appendix G and H).

Table 4.2
Descriptive Statistics and Assessment of Normality

	Mean	**Std. Deviation**	**Skewness**		**Kurtosis**	
			Statistic	Std. Error	Statistic	Std. Error
KOL	3.717	0.764	-0.505	0.195	0.217	0.387
OSR	2.671	0.960	0.319	0.195	-0.503	0.387
OI	3.377	0.959	-0.423	0.195	-0.928	0.387
I4.0	3.312	0.704	-0.311	0.195	-0.342	0.387

For achieving the uni-dimensionality of factor analysis, Lowry and Gaskin (2014) has suggested the "Kaiser-Meyer-Olkin (KMO) and Bartlett's tests of Sphericity". The indications of sampling adequacy for both tests were acceptable with KMO (0.789) inside meritorious range and Bartlett's test significant at (0.000) proving an adequate sample for Exploratory Factor Analysis. Finally, a total 155 items were finalized for data analysis. The results presented (see Table 4.3) ascertain the convergence of items and thus emergence of factors.

Table 4.3
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.789
Bartlett's Test of Sphericity	Approx. Chi-Square	6442.708
	df	903
	Sig.	0.000

4.5. Common Method Variance

Common Method Variance explains the measurement error that is compounded due to the respondent who wants to be positive while answering the questions (Chang et al., 2010). It normally arises in cross-sectional design studies. According to Kock (2015), if the factor level value of VIF is greater than 3.3, it indicates that the model is unclean and has a common method bias. Therefore, Common Method Bias was confirmed from Collinearity by connecting variables one by one to each construct and analyzing Variance Inflation Factor (VIF) through Smart PLS 3. All the values are less than required threshold with a maximum recorded value is 1.342 (see Table 4.13), hence, the model is considered free from common method bias. Moreover, Harman's single factor test was performed to verify the issues of common method variance due to the use of self-administered questionnaire in a single survey. Through SPSS software, the exploratory factor analysis was conducted by choosing one fix factor under principal factor axis. A value of one common factor for total variance should be less than 50% to avoid any issues. For current research, the result of Harman's single factor analysis is accounted 36.437%, that means a single factor is extracting 36% of total variance, and thus confirms no major problems (see Table 4.4).

Table 4.4
Harman's Single Factor

Initial Eigenvalues			Extraction Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
16.218	37.716	37.716	15.668	**36.437**	**36.437**

4.6. Demographic Profile

The respondents of current research were (Owner, CEO, Director, General Manager, Manager, and Executives) of manufacturing companies that are operating inside Malaysia. The summary of respondent's demographic profile is presented (see Table 4.5). Interestingly, (55%) respondents are male and (45%) are female. It indicates that there is not much difference between male and female workers in the Malaysian manufacturing industry. More than two-thirds of the respondents were between the age group of 25 to 44 years. While the highest percentage of respondents (35%) were from the age group of 35 to 44 years. Only (6%) respondents belong to a group of workers that are from aging workforce (55 or more) years old. Furthermore, the total number of representatives (74%) are associated with local (Malaysia) companies and (26%) belongs to foreign manufacturing companies operating in Malaysia.

Table 4.5
Summary of Demographic Profile

Demographics		No. of Respondents	Percentage
Gender	Male	85	55
	Female	70	45
Age Group	25 - 34 years old	52	34
	35 - 44 years old	54	35
	45 - 54 years old	40	26
	More than 55 years old	9	6
Company Type	Local	114	74
	Foreigner	41	26

The respondents also provided the data about their company product, type, and ownership while answering to the "Section A" of questionnaire. Most number of responses were from Transport Equipment (19%), Metal & Non-Metallic Mineral (19%), Food, Beverages & Tobacco (17%), Petroleum, Chemical, Rubber & Plastic (16%), and Electrical & Electronics (16%), which accumulates the 87% of total response. Current research is more valuable because of the responses received from major product categories including Electrical & Electronic and Petroleum, Chemical, Rubber & Plastic that are good contributors to the GDP of Malaysia. Whereas, Food, Beverages & Tobacco and Petroleum, Chemical, Rubber & Plastic, that are the fast-growing and leading Malaysian industries respectively (see Table 4.6).

Table 4.6
Summary of Responses Categorized by Company's Products

Company Products	Responses	Percentage
Transport Equipment	29	19
Metal & Non-Metallic mineral products	29	19
Food, Beverages & Tobacco	27	17
Petroleum, Chemical, Rubber & Plastic	25	16
Electrical & Electronics	25	16
Textile, Wearing, Apparel, Leather & Footwear	10	6
Wood, Furniture, Paper & Printing	10	6
Grand Total	**155**	

On the other hand, mostly the respondents (47%) are holding the managerial positions while (37%) belong from top management. Additionally, (72%) of companies included in current research are registered as Private Limited Sendirian Berhad. Followed by (18%) Public Limited Berhad and (6%) Partnership registered companies (see Table 4.7).

Table 4.7
Company Registration Type and Job Position

Position	Responses	Percentage
Owner/CEO/Director/G. Manager	58	37
Senior Manager/Manager	73	47
Executive	24	15
Summary of Responses Categorized by Company Registration Type		

Continues next page

Registration Type	Responses	Percentage
Private Limited Sdn. Bhd.	112	72
Public Limited Berhad	28	18
Partnership	9	6
Sole Proprietorship	6	4

In comparison with respondents to their company location (states), it can be seen in Table 4.8 that most of the companies (30%) are from Selangor. Followed by Kuala Lumpur (17%), Perak (15%), and Penang (12%) sharing (74%) of total responses. These states are also known for business activities and are considered as business hubs of many industries.

Table 4.8
Summary of Responses from States

State	Total	Percentage
Selangor	46	30
Kuala Lumpur	26	17
Perak	24	15
Penang	18	12
Johor	15	10
Kedah	10	6
Negeri Sembilan	8	5
Sarawak	4	3
Kelantan	2	1
Sabah	2	1
Grand Total	**155**	

4.7. Partial Least Squares Structural Equation Modelling (PLS-SEM) Analysis

Before initiating the analysis, the Weighted PLS method was applied to ensure that the sample collected represents the actual population of research. The weights were generated through the ratio of responses received' percentage with the actual percentage of manufacturing products category in Malaysia stated by Department of Statistics Malaysia (DOSM, 2018). Table 4.9 presents the Weighted PLS calculations for representation of population. Additionally, the data collected through questionnaire for decentralized organization structure were coded reverse to analyse the decentralized characteristics. The items have the characteristics of centralized structure which should be reverse to get the real meaning of decentralized organization structure, the other extreme of it. For the further analysis in Smart PLS 3, WPLS and reverse coded values were used for required results.

Table 4.9
Weighted Partial Least Square

Row Labels	Responses	Actual	WPLS
Electrical & Electronics	16.13%	8%	1.941
Food, Beverages & Tobacco	17.42%	18%	0.932
Metal & Non-Metallic mineral products	18.71%	18%	1.035
Petroleum, Chemical, Rubber & Plastic	16.13%	9%	1.794
Textile, Wearing, Apparel, Leather & Footwear	6.45%	19%	0.360
Transport Equipment	18.71%	11%	1.807
Wood, Furniture, Paper & Printing	6.45%	17%	0.365

Moreover, the readiness for Industry 4.0 is representing the second-order of nine first-order constructs including *"Industry 4.0 Customer, Industry 4.0 Product, Industry 4.0 Culture, Industry 4.0 Strategy, Industry 4.0 Leadership, Industry 4.0 Technology, Industry 4.0 Operation, Industry 4.0 Governance & Industry 4.0 People"* was measured through repeated indicators (Chin, 1998; Lallmahomed et al., 2013; Wang & Scheepers, 2012; Wetzels et al., 2009).

After setting the data, the researcher applied a two-step analysis that includes the analysis of measurement model and structural model as recommended by Anderson and Gerbing (1988). Measurement model was checked thoroughly and the scores for validity and reliability of constructs were ensured satisfactory for the establishment of models (Lin et al., 2012; Scott & Walczak, 2009). The tests were conducted by using PLS Algorithm.

Finally, the structural model was assessed to examine the relationship between variables. All the hypotheses were tested in this stage and results were concluded based on analysis. To perform both stages, Smart PLS 3 was used because it allows better results as compared to CBSEM when a model has more items (Chin, 2010). Moreover, it was opted due to the capability of efficient measurement even with small samples (Puschel & Mazzon, 2010). The following sections will present the complete analysis of data.

4.7.1. The Measurement Model

In the first stage of analysis (measurement model) also known as the outer model was validated. The strength of measurement model was examined through measuring the convergent, construct, discriminant validities, and composite reliability of each indicator (Ramayah et al., 2011). The researcher was able to determine the stability (consistency) of instrument with the help of a reliability test and accuracy of instrument (for which it is developed) through a validity test (Sekaran & Bougie, 2010).

4.7.1.1. Convergent Validity

Convergent validity is described as a capability of measurement to produce the same results with alternative measures when applied. Convergent validity is considered valid if factor loadings, Average Variance Extracted (AVE) and Composite Reliability (CR) are more than 0.60, 0.50 and 0.70 respectively (Fornell & Larcker, 1981; Hair Jr., 2006; Leong et al., 2013; Tan et al., 2014).

The Table 4.11 presents the values of Average Variance Extracted (AVE). All values of (AVE) are greater than 0.50, with maximum value of readiness for Industry 4.0 (0.824) and minimum value of organization innovation (0.607) were recorded. The value of readiness for Industry 4.0 was measured manually by dividing the sum of total loadings to the number of standard loadings squared due to its second-order construct characteristics. Whereas knowledge-oriented leadership and decentralized organization structure has values of (AVE) 0.618, and 0.721 respectively.

The total variance explained has also been calculated through SPSS from dimension reduction – factor tab, it shows 77.3% of total variance explained (Appendix I). Besides, the loadings of all remaining items for both models are more than 0.60 (see Figure 4.1 and Table 4.10). The minimum 60% variance also confirms no dimensionality problems (Hatcher, 1994). Hence, the convergent validity has been established.

Table 4.10
Outer Loadings

Items	Loadings	Items	Loadings	Items	Loadings
KOL_1	0.841	OI_6	0.801	I4_PP3	0.690
KOL_2	0.825	I4_St1	0.900	I4_C1	0.810
KOL_3	0.722	I4_St2	0.924	I4_C2	0.881
KOL_4	0.652	I4_St3	0.858	I4_C3	0.727
KOL_5	0.802	I4_OP1	0.785	I4_G1	0.859
KOL_6	0.854	I4_OP2	0.672	I4_G2	0.643
OSR_1	0.824	I4_OP3	0.891	I4_G3	0.886
OSR_2	0.824	I4_CL1	0.818	I4_P1	0.854
OSR_3	0.889	I4_CL2	0.790	I4_P2	0.892
OSR_4	0.857	I4_CL3	0.757	I4_P3	0.783
OI_1	0.726	I4_L1	0.867	I4_T1	0.869
OI_2	0.844	I4_L2	0.943	I4_T2	0.816
OI_3	0.781	I4_L3	0.925	I4_T3	0.808
OI_4	0.740	I4_PP1	0.905		
OI_5	0.775	I4_PP2	0.855		

Loading > 0.60 (Bagozzi & Yi, 1988)

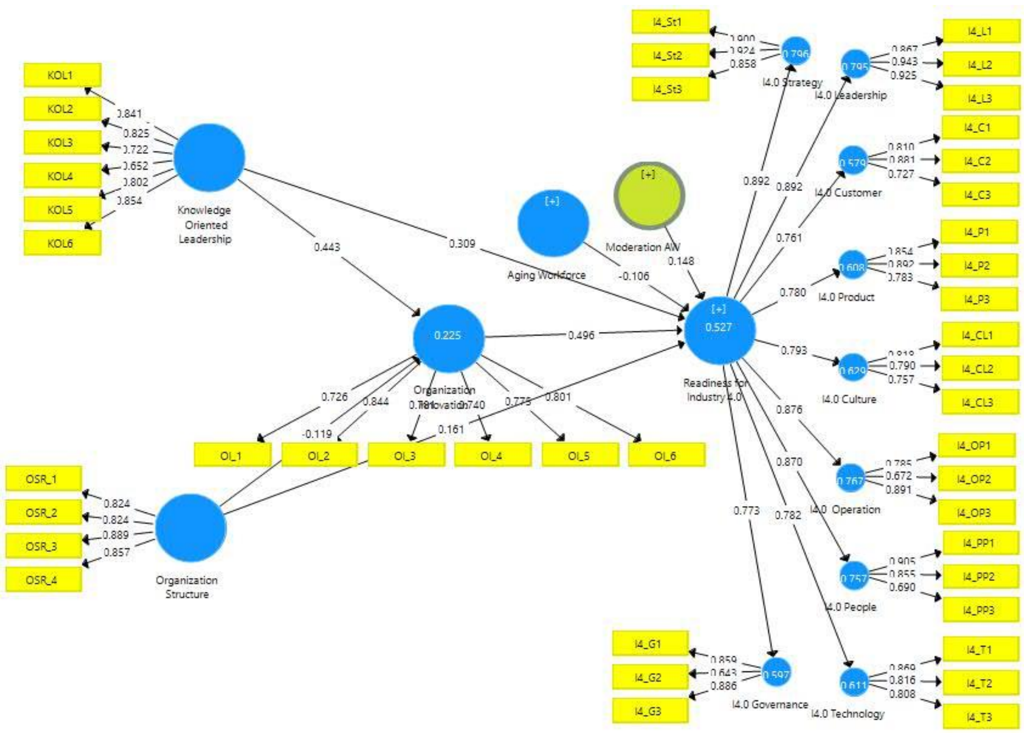


Figure 4.1: PLS-SEM Results of Readiness for Industry 4.0

4.7.1.2. Reliability Analysis

The Composite Reliability (CR) is examined through measurement model analysis. It is calculated through formula: "*(Square of the summation of the factor loadings)/{(Square of the summation of the factor loadings + (summation of error variances)}''* (Chau & Hu, 2001, p. 709). The value of Composite Reliability for knowledge-oriented leadership (0.906), decentralized organization structure (0.912), organization innovation (0.902), and readiness for Industry 4.0 (0.960) are presented (see Table 4.11). All values for CR are achieving the satisfactory grades as recommended by Molina et al. (2007).

In order to keep the internal consistency, the value of Cronbach's Alpha should be between 0.5 and 0.70 for moderate and above 0.7 for strong reliability (Hinton et al., 2004). The values of Chronbach's Alpha for all factors are greater than 0.70 which confirms strong reliability. It includes "*knowledge-oriented leadership and decentralized organization structure*" (0.875), "*organization innovation"* (0.871), "*readiness for Industry 4.0"* (0.956). Hence, the values reported for all constructs are greater than minimum accepted value.

Table 4.11
Construct Reliability and Validity

Variables	**Cronbach's Alpha**	**Composite Reliability**	**Average Variance Extracted**
Knowledge-Oriented Leadership	0.875	0.906	0.618
Organization Innovation	0.871	0.902	0.607
Decentralized Organization Structure	0.875	0.912	0.721
Readiness for Industry 4.0	0.956	0.960	0.824

Cronbach's Alpha > 0.60 (Nunnally, 1978), AVE > 0.50 (Hair Jr., 2006), CR > 0.70 (Fornell & Larcker, 1981).

4.7.1.3. Discriminant Validity

"The degree to which the items of variables differentiate between each other is referred as Discriminant validity" (Thong, 2001, p. 152). It is measured through the ratio of correlation Heterotrait-Monotrait (HTMT). This method has been recommended by Henseler et al. (2015) because of its efficiency in results. In a simulation study of Monte Carlo, HTMT has 95 to 97 percent sensitivity rates with comparison to Fornell-Lacker (Fornell & Larcker, 1981) which only has 20. The criteria for checking validity through HTMT states that the values near to 1 mean a lack of discriminant validity. To establish discriminant validity the recommended value is less than 0.85 (Kline, 2011).

The ratio of correlation among each construct has been presented (see Table 4.12). It can be seen clearly that the ratios are less than 0.85. Meaning that the items highly load with their respective latent construct. The highest value of HTMT recorded is 0.651 between Readiness for Industry 4.0 and organization innovation. Which confirms HTMT values are within the required range and below maximum threshold.

Moreover, the pattern of loading and cross-loadings confirms that each of the item values are more than 0.60 and thus was loaded properly with their respective latent construct. It suggests the existence of convergence between all variables. Hence, with the strong discriminant validity confirms the establishment of measurement model (Venkatesh et al., 2012).

Table 4.12
Discriminant Validity – HTMT

	Aging Workforce	Knowledge-Oriented Leadership	Aging Workforce	Organization Innovation	Dec. Organization Structure
Aging Workforce					
Knowledge-Oriented Leadership	0.144				
Aging Workforce	0.007	0.159			
Organization Innovation	0.110	0.499	0.083		
Dec. Organization Structure	0.124	0.211	0.093	0.188	
Readiness for Industry 4.0	0.184	0.587	0.212	0.651	0.153

HTMT<0.85, Dec. = Decentralized

4.7.1.4. Collinearity

Collinearity occurs if the correlation coefficient is too high between predictors. Variance Inflation Factor (VIF) and Tolerance values were checked for Collinearity issues if there are any. The value of VIF must be less than 5 and Tolerance should be more than 0.10 to avoid the issue of a high correlation coefficient (Menard, 2002; Rogerson, 2001). All the values have met the criteria of VIF less than 5 and Tolerance above 0.10 (see Table 4.13). The maximum value for VIF is 1.342 and minimum Tolerance of minimum 0.701 is recorded between *"knowledge-oriented* *leadership and readiness for Industry 4.0*". Hence, the dataset is clear from any Collinearity problems as well.

Table 4.13
Collinearity - Variance Inflation Factor (VIF) & Tolerance

	Organization Innovation	**Readiness for Industry 4.0**	**Tolerance**
Aging Workforce		1.042	0.950
Knowledge-Oriented Leadership	1.029	1.342	0.701
Organization Innovation		1.317	0.730
Decentralized Organization Structure	1.029	1.061	0.964

VIF<5 (Rogerson, 2001)

4.7.2. The Structural Model

After validating the measurement model, the Structural Model was examined through Smart PLS 3 (Ringle et al., 2005). By using bootstrapping (5000 sub-samples) the path coefficient of indicators and level of significance were assessed (Okazaki et al., 2012). The following sections explains the results of structural model.

4.7.2.1. Path Analysis

The pictorial view of structural model has been displayed in Figure 4.2 and the results of direct effects are concluded (see Table 4.14). Both Figure and Table explain the hypotheses and level of significance for each path. The structural measurement PLS-SEM test was conducted to answer the eight main research questions that are presented in Chapter 1.

The results presented in Figure 4.2 confirms the significance results for *H1* (T-Statistics = 6.274 and P-Value = 0.000) i.e., (Relationship between *knowledge-oriented leadership and organization innovation*). The result answered the first research question in a way that there is a strong positive relationship between knowledge-oriented leadership and organization innovation. Secondly, the result confirms the insignificance of H2 (T-Statistics = 1.217 and P-Value = 0.224) i.e., relationship between "*decentralized organization structure and organization innovation*" and answered the research question two by showing no meaningful relationship between *"decentralized organization structure and organization innovation*". Thirdly, the confirmation of significant results in H3 (T-Statistics = 5.817 and P-Value = 0.000) relationship between "*organization innovation and readiness for Industry 4.0*" answers the research question three that there is a strong positive relationship between organization innovation and readiness for Industry 4.0. Moreover, the results of *H4* (T-Statistics = 3.101 and P-Value = 0.002) approves the positive relationship between "*Knowledge-oriented leadership and* *readiness for Industry 4.0*”. Whereas the *H5* (T-Statistics = 1.682 and P-Value = 0.093) shows the insignificant results in context of positive proposition between “*decentralized organization structure and readiness for Industry 4.0”*, and thus answered the fifth question of the research.

Table 4.14
Structural Model Results, Direct Effects

H	**Relationships**	**Beta**	**T Statistics**	**P-Value**	**Decision**
H1	Knowledge-Oriented Leadership -> Organization Innovation	0.443	6.274	0.000	Supported
H2	Dec. Organization Structure -> Organization Innovation	-0.119	1.217	0.224	Not Supported
H3	Organization Innovation -> Readiness for Industry 4.0	0.496	5.817	0.000	Supported
H4	Knowledge-Oriented Leadership -> Readiness for Industry 4.0	0.309	3.101	0.002	Supported
H5	Dec. Organization Structure -> Readiness for Industry 4.0	0.161	1.682	0.093	Not Supported
H6	Moderator Aging Workforce -> Readiness for Industry 4.0	0.148	2.236	0.025	Moderated

Note: H=Hypotheses, P < 0.05, t > 1.96, Decentralized

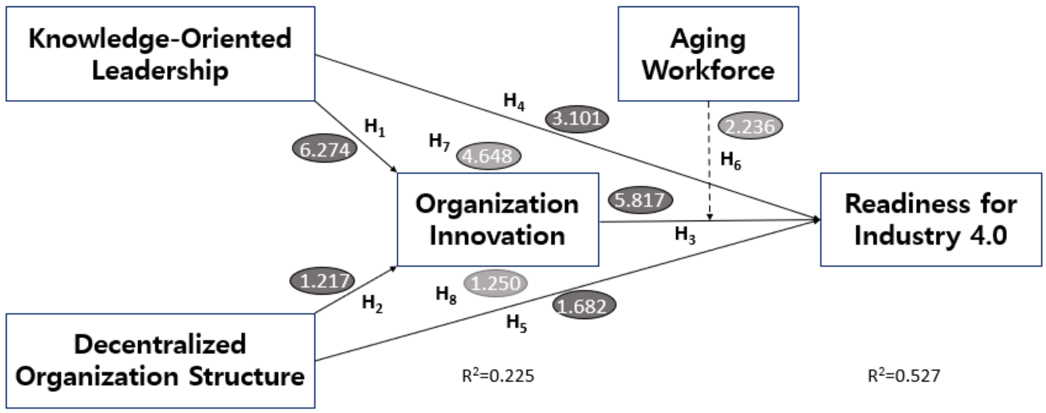


Figure 4.2: Structural Model: Assessment of Readiness for Industry 4.0

Interestingly, for the aging workforce, the result shows an indirect significant impact (T-Statistics = 2.236 and P-Value = 0.025) confirming *H6* (*Aging Workforce moderates* the relationship between *organization innovation and readiness for Industry 4.0*). Thus, answers the research question in a way that aging workforce moderates the relationship positively between "*organization innovation and readiness for Industry 4.0*", exactly same as proposed hypothesis in chapter 2. Figure 4.3 displays the slope for moderating effect between *"organization innovation and readiness for Industry 4.0"*. It explains that the aging workforce strengthens the existing positive relationship between *"organization innovation and readiness for Industry 4.0*". Whereas the high aging workforce influence more in high organization innovation environment. In current research, aging workforce will support companies to become more ready for Industry 4.0.

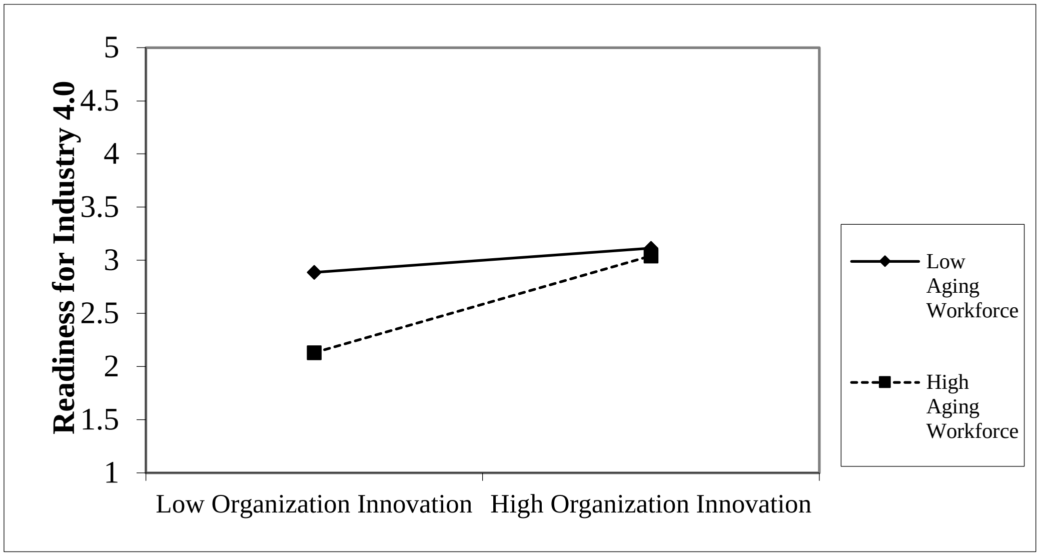


Figure 4.3: Moderating Effect of Aging Workforce

On the other side, the mediating roles of organization innovation have also been tested. The result of *H7* i.e., "*mediation of organization innovation* betwee*n knowledge-oriented leadership and readiness for Industry 4.0"* confirms a partial mediation (T-Statistics = 4.648, P-Value = 0.000) by showing significant results of both direct (H4) and indirect hypotheses (*H7*). However, the result of H8, the "*mediating effect of organization innovation* between *decentralized organization structure and readiness for Industry 4.0"* shows an insignificant result (T-Statistics = 1.250, P-Value = 0.221) and thus no mediation was concluded. A summary of indirect effects is presented (see Table 4.15).

Table 4.15
Structural Model Results, Indirect Effects

H	Relationships	Beta	T Statistics	P Value	Decision
H7	Knowledge-Oriented Leadership -> Organization Innovation -> Readiness for Industry 4.0	0.220	4.648	0.000	Partial Mediation
H8	Dec. Organization Structure -> Organization Innovation -> Readiness for Industry 4.0	-0.059	1.250	0.221	No Mediation

Note: H=Hypotheses, S.D = Standard Deviation, P < 0.05, T > 1.96, Dec. = Decentralized

4.7.3. Multi-Group Analysis

In addition to measurement model and structural model assessment, the Multi-Group Analysis has been performed to understand the interaction of aging workforce more clearly. Multi-Group analysis allows to examine the different groups effect on the results (Henseler et al., 2009). Two groups "High Aging Workforce" and "Low Aging Workforce" were created and tested through MGA technique to compare the significant difference on results. A significant difference has been found for H3 "*organization innovation and Readiness for Industry 4.0*". Further, the contribution of aging workforce (High) and aging workforce (Low) separately have been analyzed to understand their impact more precisely on hypothesis. The results H3 shows a significant impact for high aging workforce with p-Values less than 0.05 and insignificant impact for low aging workforce with p-value 0.218. The results summary of Multi-Group Analysis is presented below (see Table 4.16).

Table 4.16
Multi-Group Analysis

(Aging Workforce High and Aging Wrokforce Low)					
H	**Relationships**	**Path Coefficients**		**p-Values**	
H3	Organization Innovation -> Readiness for Industry 4.0	-0.514		0.002	
		High	**Low**	**High**	**Low**
		0.732	0.218	0.000	0.062

$P < 0.05$; High = High Aging Workforce; Low = Low Aging Workforce

4.7.4. Coefficient of Determination and Effect Size

Pearson Coefficient (R^2) and Effect Size (F^2) values have been posted (see Table 4.17 and Table 4.18). Based on the explanation of Henseler and Ringle (2009) there is weak to moderate value of R^2 for *"organization innovation and readiness for Industry 4.0"*. Both dependent variables "*knowledge-oriented leadership and decentralized organization structure*" contributed approximately 22.5 percent towards organization innovation. Whereas "*knowledge-oriented leadership, decentralized organization structure, organization innovation and aging workforce*" contributes 52.7 percent towards the readiness for Industry 4.0.

Table 4.17
R Square – Coefficient of Determination

	R Square	R Square Adjusted
Organization Innovation	0.225	0.215
Readiness for Industry 4.0	0.527	0.511

Note: R^2 = 0.75, 0.50, and 0.25 are substantial, moderate and weak respectively (Henseler Jr. et., 2009)

The value of F^2 effect size reporting is vital for results interpretation as it presents the understanding of significant and non-significant effects (Fairchild & McQuillin, 2010). Effect size calculates the influence of latent exogenous variables on latent endogenous variables. Table 4.18 highlights the effect size f^2 values, confirming the medium effect size for *"knowledge-oriented leadership with organization innovation"* (0.249), and for *"organization innovation and readiness for Industry 4.0"* (0.425), large effect size. Whereas Decentralized organization structure and moderating effect of aging workforce has a small effect size for their respective endogenous variables (Cohen, 1988).

Table 4.18
Effect Size

Predictor	Endogenous	Effect Size - f^2
Knowledge-Oriented Leadership	Organization Innovation	0.249
Decentralized Organization Structure	Organization Innovation	0.019
Knowledge-Oriented Leadership	Readiness for Industry 4.0	0.131

Continues next page

Decentralized Organization Structure	Readiness for Industry 4.0	0.053
Organization Innovation	Readiness for Industry 4.0	0.425
Moderator Aging Workforce	Readiness for Industry 4.0	0.068

Note: Effect Size impact indicators are according to Cohen (1988) (f^2) values 0.35 (large), 0.15 (medium), and 0.02 (small)

4.7.5. Importance Performance Map Analysis

To extend the results in structural model, Importance Performance Map Analysis (IPMA) was performed through Smart PLS to learn about the variable importance and their performance. This test will help in strengthening the managerial implications, as it will provide a guide to managers of manufacturing companies to reevaluate their strategies based on the importance and performance of specific variables. The current research result displays the important variable that are knowledge-oriented leadership as well as organization innovation. However, decentralized organization structure importance score is average, but aging workforce has the lowest importance impact in this research study. Besides, the performance of both important factors is quite good showing the right direction of the companies (see Figure 4.4).

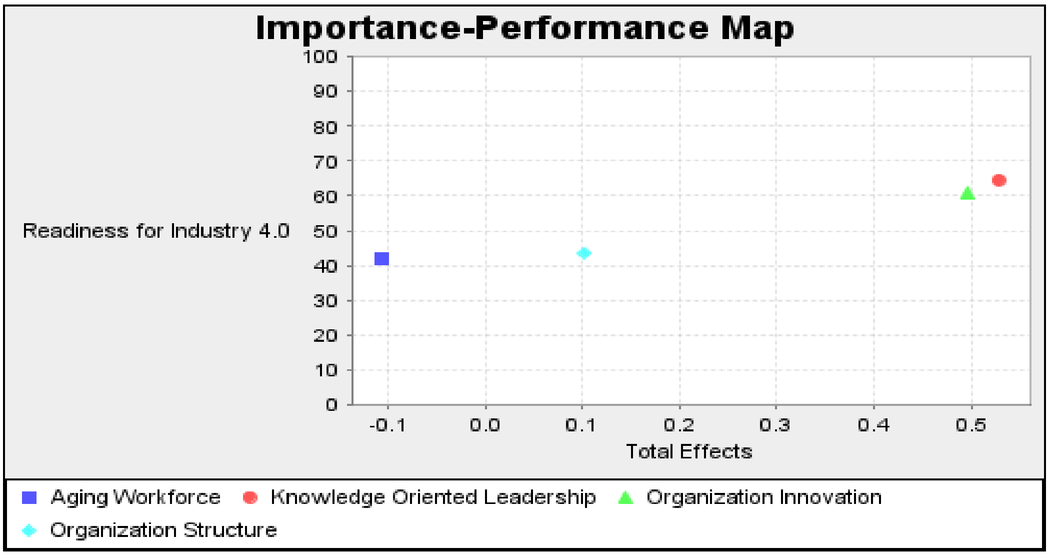


Figure 4.4: Importance Performance Map Analysis

4.8. Supplementary Qualitative Study Analysis

An ATLAS.ti software was used to analyze the nine interviews. The interview questions were responded by manufacturing representatives. The representative belongs from top management including "*CEO/Owner/Director or General Manager/Manager/Supervisor*" position. 78% person respondents are male and 22% are female. Four of the interviewees represents large manufacturing companies "More than 100 employees", while others are from medium scale manufacturing companies "5 to 19" employees". The responses covered the awareness, adoption level and challenges of Industry 4.0, the benefits and challenges of aging workforce, and the roles of knowledge-oriented leadership & decentralized organization structure. The codes for the responses are attached in (Appendix J) and the results are explained in next section.

4.8.1. Industry 4.0

Most of the respondents believe that *Industry 4.0 is about* adoption of advance technologies and development smart manufacturing industries. While other believes that Industry 4.0 is related to Human-Machine integration, Internet of Things, Big Data, Artificial Intelligence, and automation (Appendix K). Besides, from *nine pillars* of Industry 4.0, most companies have applied Cloud Computing, followed by Internet of Things, and System Integration. Whereas Augmented Reality is not applied yet by any of the organization (Appendix L).

While answering to the second question, the majority of the respondents stated that their organizations are not *ready for Industry 4.0* due to lack of control, low awareness and underdeveloped processes. A couple of companies are trying to develop different prototypes on the concepts of Industry to meet their business requirements. 33% of the representatives think that the *level of adoption* of industry 4.0 in their organization is at lowest, while others have just started applying some ideas. However, organizations have started planning for the implementation of it. The planning includes "adoption of new technologies, automation, speedy internet connection, big data applications, research and development, and engaging a special workforce" (Appendix M). During this transformation, the major *challenges* faced by the organizations are but not limited to "less awareness, cost/budget issues, low experience and connectivity, complexity of the concepts, and shortage of skilled employees (Appendix N).

4.8.2. Aging Workforce

Aging workforce is considered an important aspect for organizations. The respondents perceive multiple benefits of aged workers including "practical knowledge and experience, less turnover, assistance in quality improvement and transformation, and provision of training and guidance to young workers (see Appendix O). Nevertheless, the top management also perceive some challenges that are; "resist change, avoid new technologies, conservative and outdated knowledge, and low energy and motivation" (see Appendix P).

4.8.3. Role of Knowledge Oriented Leadership

The respondents from top management of manufacturing sector believed on the important role of knowledge-oriented leadership for organizations that are preparing for industry 4.0. It acted as a "technology leader who train and guide everyone, prepare strategies, motivate others, encourage new knowledge and learning by providing environment, spread awareness, improve communication, assist in adoption of new technologies, educate on industry 4.0, and focus on improving processes". Ultimately, it helps in augmenting innovation and prepare manufacturers for Industry 4.0. Moreover, knowledge-oriented leadership are competent to enhance innovation with their "growth and change mindset, motivational element, guidance, leading role, knowledge sharing, support, and awareness" (see Appendix Q).

4.8.4. Role of Decentralized Organization Structure

The respondents shared the importance of *"decentralized organization structure for organization innovation and readiness for industry"* 4.0. Couple of respondents believe that decentralized structure cannot improve the adoption of industry 4.0. While others believe that this structure is helpful, but it requires time to reach maturity. It is also perceived that decentralized organization structure assist innovation through "flexibility, rapid response, friendly and learning environment, quick decision making, support change, empowerment, decentralization, quick solutions (see Appendix R).

4.9. Conclusion

Current chapter has provided a detailed statistical analysis of causal relationship between independent and dependent variables. Eight research questions were analyzed, and the results of hypotheses are confirmed using PLS-SEM. The result shows that (*H1*) knowledge-oriented leadership is a good contributor to the innovation and preparation for Industry 4.0. While organizational innovation serves the readiness in *direct* as well as *indirect* ways. However, decentralized organization structure shows insignificant impact on manufacturing Industry 4.0s' readiness and innovation. Finally, the moderator (aging workforce) also shows the positive influence between innovation and Industry 4.0. The following chapter will discuss the details about findings of current chapter, contributions, limitations, and future research.

CHAPTER 5

5.0 DISCUSSION, IMPLICATIONS AND CONCLUSION

5.1. Introduction

This chapter has been constructed on the discussion and implications of the research. The first section contains a discussion about the results presented in chapter four. The answers to all eight research questions are well explained in following chapter based on the results revealed during data analysis. The section 5.4 and 5.5 covers theoretical and practical contributions. Finally, the limitations and recommendations for future research are presented at the end.

5.2. Accomplishment of Research Objectives

The current research discussion revolves around the analysis of eight main objectives, that are: (1) *"to examine the positive relationship between knowledge-oriented leadership and organization innovation, (2) to examine the positive relationship between decentralized organization structure and organization innovation, (3) to examine the positive relationship between organization innovation and readiness for Industry 4.0, (4) to examine the positive relationship between knowledge-oriented leadership and readiness for Industry 4.0; (5) to examine the positive relationship between decentralized organization structure and readiness for Industry 4.0; (6) to examine the moderating effect of aging workforce between organization innovation and the readiness for Industry 4.0; (7) to examine the mediating effect of the* *organization innovation between knowledge-oriented leadership and readiness for Industry 4.0; and (8) to examine the mediating effect of the organization innovation between decentralized organization structure and the readiness for Industry 4.0"*; in the Malaysian manufacturing industry.

5.2.1. Discussion on Relationship Between Knowledge-Oriented Leadership and Organization Innovation

Knowledge is considered as a basis for the creation of products and services. Most nations nowadays are more swayed towards a knowledge-based economy. Therefore, it is worthwhile to pursue this meaningful economic concept. The first objective of current research aims to explain *the relationship between knowledge-oriented leadership and organization innovation.* The proposed hypothesis *(H1)* associated with the first objective states a *positive relationship*. The results favors the manufacturing companies that are apprehensive about their innovation objectives and specific leadership styles (i.e., knowledge-oriented leadership). This leadership has a strong positive influence on organizational innovation in the manufacturing sector of Malaysia. It indicates that an increased in organization innovation can be attained by appointing knowledge-oriented leadership in a project or a company. The findings proved significant influences of knowledge-oriented leadership upon organization innovation that was examined through probability and statistical test values. The results were consistent with the research of Sadeghi and Rad (2018) and Yang et al. (2014), as these studies also reported a positive relationship between both variables. By knowing the importance of specific leadership practices, innovation-focused companies are most likely to adopt this practice to fulfil their goals.

Past studies have documented a few management practices that influence organization innovation. Leadership style, abundant knowledge, and HR Practices are among those management practices, highlighted by Shamim et al. (2016). To attain organization innovation, such practices should be managed and controlled properly. The extant literature supported the current research findings by showing statistical evidence about the positive relationship between knowledge-oriented leadership style and organization innovation (Donate & de Pablo, 2015). Because of the reason that knowledge-oriented leaders can clearly communicate the innovative strategies of an organization to the employees (Bertoldi et al., 2018). Likewise, they inspire the team members to heighten organization innovation (Ribiere & Sitar, 2003) and reward the employees for their innovative ideas (Singh, 2008). Safari and Azadehdel (2015) also concluded the same results from an empirical investigation. The study explained that the companies involved in innovation activities use knowledge leadership and advanced information to counter any problems. It also builds the company capacity in generating new ideas and changes for sustainable competitive advantages over competitors.

With the emergence of the “knowledge is a power” notion, the application of knowledge-oriented leadership in companies has become an essential need for the day. Such leadership style is indispensable for manufacturing companies of a country, including Malaysia, that is eyeing to be listed as developed countries soon. The outcomes of the current research study have also emphasized the significance of knowledge-oriented leadership for Malaysian manufacturing companies in today's dynamic business world. These leaders can learn fast and manage the employees, as well as new knowledge. Not limited to that, they also build the right environment and conditions for the formation and application of such knowledge (Naqshbandi & Jasimuddin, 2018).

In parallel to that, the rapid technology shift is challenging every other company and compelling them to make innovation a part of their continuous processes. Subsequently, Industry 4.0 has brought along a fast pace of transformation. Therefore, innovation has become the only survival strategy for manufacturing companies. Here, knowledge-oriented leaders lead with examples by promoting knowledge-sharing and new ideas generation. Few companies across the world have already applied knowledge-oriented leadership to improve their organization's innovation for the provision of better products and services (Sadeghi & Rad, 2018).

The existing literature endorsed the employees that are more open to new knowledge and are more willing to learn and become creative (Užienė, 2015). For innovation-focused companies in Malaysia, knowledge-oriented leadership can communicate strategies clearly to their employees and lead them to achieve the organization's objectives (innovation). Such leaders also motivate their followers to enrich organization innovation by recompensing those who bring new knowledge into the company. Consequently, the study results supported the specific knowledge-oriented leadership for the development of organization innovation in the Malaysian manufacturing sector.

5.2.2. Discussion on Relationship Between Decentralized Organization Structure & Organization Innovation

Second objective aims to illuminate the connection of *"decentralized organization structure and organization innovation".* Hypothesis *(H2)* associated with this research objective proposed a *positive relationship.* But the results of statistical analysis are unlike to what researcher proposed and anticipated. Herewith, decentralized organization structure showed an insignificant effect on organization innovation of Malaysian manufacturing companies. This means that this structure is not of much significance for organization innovation in the Malaysian manufacturing companies' setting. This explanation was articulated from numerical values achieved through statistical analysis that was stated previously in chapter four (i.e., test statistics). In conclusion, the organization that adopts a decentralized structure do not have a significant impact on organization innovation.

The results of the current research are not favorable enough to support the significance, heretofore discussed in the literature part of chapter two. The value of path coefficient and probability are too scant to conclude a positive impact between "*decentralized organization structure and organization innovation*". The extant literature mostly favors the positive influences of decentralized structure on organizational innovation, as this factor supports the employees in achieving the organization's innovation objectives through the structure with loose control, openness to ideas, and experiences that are useful for improving innovation performances. Thus, a decentralized organization structure can reduce communication barriers and create awareness for innovation (Lee et al., 2016).

Interestingly, the discussion of decentralization and innovation performances has a long history but is still far from consensus (Yang et al., 2014). There are some studies available that concluded different results. The study of Hage and Aiken (1967), in particular, indicated that the decentralization structure brings a lot of new information that initiates the discussion of needs and appropriateness. It likely increases the conflicts between competing ideas, thus blocking innovation. Similarly, the studies of Hirst et al. (2011), Dewar and Dutton (1986) and Yang et al. (2014) found an insignificant relationship between the *"decentralized organization structure and organization innovation*". Those studies argued that the impacts of decentralized structure on innovation were affected by the effectiveness, quality, and quantity of information. The impacts were also dependent on the employees' willingness to share important ideas. In short, innovation is possible if the information sharing is properly compensated, and the motivation of employees is adjusted.

Consistently, current study results were insignificant but can be clarified with some specific reasons that are explained next in support. Primarily, the reason for unexpected results is the maturity level of Industry 4.0 in Malaysia. Industry 4.0 brings a lot of technological and procedural changes with the conception of Artificial Intelligence and Smart Manufacturing. Such technical and complex concepts are not easily understandable. For this purpose, Malaysia has initiated some formal efforts for this valuable shift but has only started a couple of years ago (MITI, 2018). Therefore, the manufacturing industry is still not mature enough to follow the standards applied by the developed countries and to get benefits from it. They may require some more time to strategize and prepare themselves for the implementation. Along with further development, there are chances for changes in current results, but at this time, the results do not show enough impacting evidence from specific decentralized structure to organization innovation in the Malaysian manufacturing context.

Most importantly, only a decentralized organization structure was not proven to support innovation goals. There are other factors that have to be considered to understand this. For example, while gathering and sharing the new innovation, it is important to analyze the quality and quantity of that information. Moreover, it is also important to check the feasibility of the idea for the company. Many ideas are attractive but may not be practicable enough due to limited resources and existing strategies or policies of the organization. Additionally, the impact of that innovative idea on the employees are also a point to ponder. A lot of innovations are useful for the organizations but may also be a threat or considered as a threat for the employees. Ergo, the employees may try to block those ideas. Some employees avoid sharing new information because they believe that sharing will help other people instead of themselves.

Besides, with the involvement of internet facilitated services, most of the work is done without physical interaction with humans. This kind of ease in business processes has disrupted the existing processes and driven the companies away from structural boundaries. Accordingly, the present study illustrated the same trend that showed insignificant impacts of decentralized organization structure on organization innovation. These results were also valid to the current pandemic issue of Covid-19, where most of the companies are getting a setback due to the dramatic disruption. This sudden change has forced the companies to bypass their set of rules and duly follow the trend. Therefore, an insignificant impact can be seen in the current research analysis.

In addition, the scope of the study is different from most of the literature and showed that decentralized organization structure influences organization innovation. Current research results are only applicable to the Malaysian manufacturing sector, hence having unique demographic characteristics. First of all, most of the manufacturing companies (approximately 98.5%) are Small Medium Enterprises (SMEs) (MITI, 2018; SMECorp. Malaysia, 2019). These companies are comprised of fewer employees and do not have a formal planned structure that they follow. Usually, they adapt the strategies of bigger companies and are mostly dependent on their policies. Such companies keep on learning, through time by time with hits and trials, without having much focus on their structure. The application of specific structures by the companies with a single owner or multiple owners and having few members inside is hard to consider. Their structure is a mixture of different characteristics that may vary in different situations. Most importantly, the stakeholders of small companies are even not even aware of the structural significance and therefore do not know about the benefits. Moreover, the flexibility and autonomy among the employees during work are not distributed properly or vague. Thus, this investigation concluded that the manufacturing companies of Malaysia are not influenced by a decentralized structure. However, they need to learn and adjust to transforming themselves immediately to adapt to any fast changes that are happening in the business environment.

5.2.3. Discussion on Relationship Between Organization Innovation & Readiness for Industry 4.0

The third objective aims to explain the relationship between *"organization innovation and readiness for Industry 4.0"*. This objective is associated with a *positive* proposition of hypothesis *(H3)*. Data analysis was performed to confirm the above-mentioned hypothesis and achievement of research objective. The outcomes of the analysis endorsed that the readiness of Malaysian manufacturing companies for Industry 4.0 was highly dependent on their levels of innovation. The more innovative the companies are, the more likely they are ready for Industry 4.0. Empirical testing of relationships showed a strong positive influence between *"organization innovation and readiness for Industry 4.0"*. The above discussion was explained based on probability and test statistic values that were generated and presented in chapter four. In Industry 4.0 era, innovation is very much important for organizations (Guimaraes & Paranjape, 2019) and it is highly important for manufacturing companies of Malaysia to prepare them for it. If the companies want to be considered as beneficiary of Industry 4.0, they improve and carry out innovation consistently for their manufacturing process. Consequently, innovation-based strategies will support them in gaining the most advantages from Industry 4.0.

The findings showing a significant relationship between organization innovation and readiness for Industry 4.0 were consistent with existing literature. Therefore, innovation is an important element that demonstrates the organization's orientation, as needed by Industry 4.0 (Prause, 2015; Schumacher et al., 2016). Reddy and Reinartz (2017) also linked Industry 4.0 to values addition or new changes. These new changes in manufacturing processes will augment customer satisfaction, enabling the companies to offer customization (the core concept of the new shift). The same judgments in research of Cachay and Abele (2012) explained that the companies must adopt new innovative production procedures and be capable enough to improve their system continuously for Industry 4.0. Since the companies with the main inclination towards innovation have a higher propensity to be ready for Industry 4.0 (Agostini & Filippini, 2019).

Besides, the modern (innovative) structure of Internet and Communication Technology (ICT) is also considered as core prerequisite of Industry 4.0 (Erol et al., 2016). In the same way, the Internet of Technology (IoT), as technological innovation, is leading to a smart industry known as Industry 4.0 (Metallo et al., 2018). However, the purpose of innovation in today's world is not only limited to new technology deployment but also re-conceptualize the industry to develop superior values (Matthyssens, 2008). Moreover, it builds the capacity of companies for any kind of situation that can occur during business processes.

The notion of Industry 4.0 remained in the interests of researchers and practitioners over the last few years. The companies are trying to embrace the changes of Industry 4.0 as soon as possible. The manufacturing sector of Malaysia is one important sector that is trying to achieve maximum benefit from this paradigm shift. However, the concept of Industry 4.0 is quite broad, as it brings along changes in all levels of the organization. Generally, it is about the adoption of new technologies and improvement in the production processes (Tortorella et al., 2019). The fast pace of changes in Industry 4.0 brings complexities. Therefore, its implementation can only be possible for the companies that can act in a timely manner and can develop innovation rapidly. If a company is well equipped with innovative technologies of the day (such as AI, IoT, and Smart Manufacturing), it can execute complex operations of production processes that are required by Industry 4.0.

The companies must develop short-term and long-term innovation abilities for competitiveness. The higher the levels of technological and process innovations shown by the organizations, the more likely they are considered to be ready for Industry 4.0. For that reason, the results of this research highlighted the imperative role of organization innovation in preparing an organization for a new revolution. Nevertheless, organizational innovation does not only bring in new changes, but it also develops the capacity of employees, as well as the whole system, to efficiently resolve the unexpected challenges that may appear during operations (Nambisan et al., 2019). So, Malaysian manufacturing companies need to deploy an innovatively skilled workforce, adopt new processes, and integrate digital technologies in the processes to attain Industry 4.0.

5.2.4. Discussion on Relationship Between Knowledge-Oriented Leadership & Readiness for Industry 4.0

The fourth objective enabled to explain the relationship *"between knowledge-oriented leadership and readiness for Industry 4.0".* Hypotheses *(H4)* related with this research question proposed a *positive* relationship which is proven by the statistical results. The analysis concluded that knowledge-oriented leadership is useful in making the manufacturing companies of Malaysia ready for Industry 4.0. Companies that deploy knowledge-oriented leader are more likely capable of embracing the Industry 4.0 trend. The same significance was discussed in the study reported by Nazlina et al. (2019). Accordingly, the traditional styles of leadership are not well-suited and well-capable for Cyber-Physical systems. This system integrates humans and machines at a great level. An advanced learning culture is required for this notion. As the name suggests, the idea of knowledge-oriented leadership revolves around knowledge and its management. Accordingly, Industry 4.0 is also about continuous learning. Therefore, this new style of leadership is a perfect match for the companies that are seeking ways for Industry 4.0 implementation.

The limits of Industry 4.0 are beyond the imagination, while the operations are usually in control of machines. Such an environment brings challenges at every level. Hence, the learning of new knowledge becomes a prerequisite. Here, knowledge-oriented leadership plays its role in creating a learning and knowledge-sharing culture in an organization. Individual knowledge is considered as organizational knowledge, and everyone feels motivated while sharing it. Due to the "motivation" factor that is integrated into the characteristics of knowledge-oriented leaders, they are able to set an example by starting from themselves and rewarding those who learn and share. In particular, this type of leadership still contains traditional leadership ways, in combination with transactional and transformational leadership characteristics (Politis, 2001; Sivathanu & Pillai, 2018). Therefore, the mixture of old ways with additional elements of knowledge management and motivation have made the new way of leadership inevitable for Industry 4.0.

Research conducted by Islam et al. (2017) and Naqshbandi and Jasimuddin (2018) stated that the companies are now doing collaborations with other firms to share and gain external knowledge, in addition to implementing knowledge-oriented leadership for internal application of new knowledge to face Industry 4.0. Additionally, knowledge-oriented leadership also plays an important part in the development of infrastructure and as a source for promoting new ideas and cultures to bring positive changes. Moreover, it helps the companies to adopt new technologies faster through learning different ways of innovation. Therefore, it is essential for the companies to foster knowledge capabilities and strive in the challenging environment of Industry 4.0 with the help of knowledge-oriented leaders.

5.2.5. Discussion on Relationship Between Decentralized Organization Structure & Readiness for Industry 4.0

Fifth objective enabled the researcher to understand the relationship between *"decentralized organization structure and readiness for Industry 4.0"*. The hypotheses *(H5)* linked with this objective proposed a *positive* relationship between them, however the results are otherwise. The impact of "*decentralized organization structure on readiness for Industry 4.0*" is not observed to be significant in the case of the Malaysian manufacturing sector. Any favorable changes in such a structure will not influence the Industry 4.0 preparations in a substantial manner. The results were achieved through the values of test statistics while analyzing the data through Smart PLS. These different results opened new approaches and discussion of structure for today's business.

The prior literature stated that the decentralization of management favors the changes by endorsing flexibility and free flow of information (Maria et al., 2017). The employees who are relaxed are more willing to adopt new technologies. In the case of Malaysian manufacturing companies, this research found that the decentralized structure is not appropriate for the adoption of new technologies and processes, including Industry 4.0. The main reason is the maturity level of manufacturing companies for Industry 4.0, as most of the companies are not aware of this new trend. According to MITI (2018) in the National Policy regarding Industry 4.0, manufacturing companies are still not aware of this new shift. They have very little knowledge and have yet to start preparing for it. In 2018, the government of Malaysia had allocated a budget to instil awareness for Industry 4.0 concepts, but still, there is a lot to learn and develop.

Another important factor is the complexity level of Industry 4.0 concepts. Industry 4.0 is a revolutionary change, it cannot be implemented or accepted overnight. Even developed countries took decades to understand and embrace but still are at the improvement stage. Malaysia is still a long way to reach its maturity MITI (2018). Therefore, the traditional perceptions and techniques may produce different results. The complicated processes involved in Industry 4.0 require more than just the decentralization structure. In contrast, it needs a different or hybrid structural model that has the flexibility to change according to different circumstances. As a result, the findings obtained are indifferent to the proposition discussed in chapter two.

5.2.6. Discussion on Moderating Role of Aging Workforce Between Organization Innovation & Readiness for Industry 4.0

Sixth objective aims to understand the moderating role of *"aging workforce between organization innovation and readiness for Industry 4.0"*. The proposed hypothesis *(H6)* associated with this objective state that; *"aging workforce moderates the relationship between organization innovation and readiness for Industry 4.0"*. To answer the research question, moderation analysis was executed by using Smart PLS 3. The results of the study confirmed the moderation effect of an aging workforce between *"organization innovation and readiness for Industry 4.0"*. Based on the literature discussed, in combination with the proven results obtained later, the aging workforce was found to act as a moderator and provides more strength to the existing relationship between *"organization innovation and readiness for Industry 4.0"*.

The relationship between the independent variable (i.e., organization innovation) and dependent variable (i.e., readiness for Industry 4.0) showed a positive and substantial impact. Meanwhile, the inclusion of an aging workforce as a moderator has also strengthened that association. The existing literature mostly discussed the influences of the aging workforce on innovation and organization's performances, especially for technology and innovation-focused companies where the workers' age is considered as an important factor (Elias et al., 2012). It concludes that the success of a company is dependent on the performance of workers and their age, because the employees who are getting older also have more experience and knowledge, accordingly. The knowledge and experiences the age can bring along will eventually be developed into wisdom and intelligence. The researchers claimed that the wisdom that develops over the years becomes a competitive edge for innovative companies and surpasses any negative aspects of age. Thus, the age factor is contributing positively to the direction of innovation (Stoffers et al., 2018). Moreover, Industry 4.0 also requires the same intellectual ability that can only be obtained after processing the tasks so many times. Hence, large companies value the worth of old workers by retaining them and developing customized strategies so that they do not lose the company's assets.

To justify, there are several possible reasons behind the results, and are positive signs for the Malaysian manufacturing industry. As discussed previously in chapter one, the number of aged Malaysian people is increasing. Very soon, the aging workforce will make up 15% of this country's population. This demographic shift will have a mammoth impact on the structures and performances of industries (Bento & Garotti, 2019). Based on present research findings, an aging workforce is vital and has a capacity to bring positive influences in the age of Industry 4.0. By having years of job knowledge and industry experiences with them, the aging workforce (workers above 55 years of age) (Murthy et al., 2019) is regarded as human capital (asset) that provides competitive advantages for the companies. Then, by application of their experiences and knowledge, the aging workforce benefits in increasing the performances of companies and in preparing them for Industry 4.0. Aging Workers prepare strategies to organize works in a way that improves processes, mainly through their ability to look forward in the longer term and to screen the choices with their experiences (Downing et al., 2005). Therefore, the current research results reveal that in the existence of an aging workforce, the companies should be able to be more progressive and innovative to achieve the readiness for Industry 4.0.

The experienced elderly workers may perform knowledge-oriented tasks more efficiently than an average younger inexperienced worker. Moreover, they are eager to learn as a means to prepare for effective long-term strategies that are required by their companies. The time the aging workforce spent in performing their jobs is worth more than anything owned by a company. Most importantly, the competitive advantages they gained throughout their lives and experiences, including knowledge, wisdom, experiences, connections, the skill to detect lies, decision power, patience, strategic planning, loyalty, long term oriented, and efficiency, will lead the companies to embrace the Industry 4.0 in a confident way (Hertel & Zacher, 2018). Hence, based on the statistical results, the researcher can conclude that the aging workforce is constructive for Malaysian manufacturing companies in the preparation of Industry 4.0. Their knowledge and experiences will boost innovation and lay the foundation for Industry 4.0 adoption.

5.2.7. Discussion on The Mediating Role of Organization Innovation Between Knowledge-Oriented Leadership & Readiness for Industry 4.0

Seventh objective aims to comprehend mediation influence of *"organization innovation between knowledge-oriented leadership and readiness for Industry 4.0"*. The hypothesis (*H7*) associated with it proposed a *mediating effect of organization innovation.* An indirect relationship test was performed through Smart PLS 3 to analyze the proposition. The results on the "*indirect effects organization innovation*" were found to be significant, especially between *"knowledge-oriented leadership and readiness for Industry 4.0"*, meaning that the relationship is interconnected to the presence of organization innovation. The results were consistent with the research of Mafabi et al. (2012) who also focused on the mediating effect of organizational innovation. The research explained that innovation indirectly helps in building the capacity of an organization.

The hypothesis *H1*, a significant direct effect of "knowledge-oriented leadership and readiness for Industry 4.0", was also connected to this relationship. It confirmed the partial mediation of organization innovation for this hypothesis and explained that the readiness for Industry 4.0 could be achieved in two ways, either directly through knowledge-oriented leadership support or with the intervention of organization innovation.

The previous works had discussed the importance of knowledge and innovation (e.g., Akbar et al., 2020; Basadur & Gelade, 2006; Carneiro, 2000; du Plessis, 2007; Goh, 2005; Xu et al., 2010) and emphasized the impacts of various knowledge processes through innovation outcomes (e.g., Chan et al., 2019; Chang & Lee, 2008; Chou, 2005; Darroch, 2005; Leiponen, 2006; Matusik & Heeley, 2005; Taminiau et al., 2009). However, these researchers mainly focused on the direct relationships and overlooked the intervening effects of organization innovation. Therefore, the key role of organization innovation is the chief finding in this study. The direct and indirect effects will open a lot of opportunities for researchers and practitioners. Knowledge-oriented leadership is the key that initiates the processes and impacts innovation in a positive way. Activities that focus on knowledge storage and sharing create new information which ultimately brings new ideas and develops innovation. Organization innovation can be triggered by specific leadership, as well as advances the organizations in embracing new technologies and processes that are the prerequisite of Industry 4.0 concepts.

Hither, organization innovation as a mediator supports the organizations to resolve problems by enhancing organizational capacities. If the companies are eager to apply innovation, then these companies can acquire advantages over others and become successful. The ability to seize opportunities enables them to be the lead in the market (Chang, 2011) by providing new solutions. Hence, the innovation works as a bridge and ensures the Industry 4.0 implementation in a smoother way. The presence of organization innovation adds value to the readiness of Industry 4.0, especially when coupled with the support of knowledge-oriented leadership. In other words, knowledge-oriented leadership facilitates innovation and prepares the manufacturing sector of Malaysia for Industry 4.0.

5.2.8. Discussion on The Mediating Role of Organization Innovation Between Decentralized Organization Structure & Readiness for Industry 4.0

The eighth objective aims to explain the the mediating effect of *"organization innovation* between *decentralized organization structure and readiness for Industry 4.0"*. The hypothesis *(H8)* associated with this objective outlines the proposed mediating effect between *"decentralized organization structure and readiness for Industry 4.0"*. The objective is achieved by testing the indirect effects via bootstrapping technique. The indirect effects of *"organization innovation"* between *"decentralized organization structure and readiness for Industry 4.0"* have not been found significant. Results confirmed that there is no mediation effect of organization innovation between the organization structures.

The relationship showed that the presence of organization innovation as an intercessor would not help a manufacturing company with a decentralized organization structure in embracing Industry 4.0. Similarly, the findings further support the objective two argument that a simple decentralized structure is not enough to prepare the organization for Industry 4.0. Even the presence of a mediator that showed direct and indirect impacts on the readiness for Industry 4.0 had not been impacted by a decentralized organization structure. Earlier the insignificant impact of *"decentralized organization structure for organization innovation*" already laid the foundation for insignificance of *H8*.

In an ideal situation, decentralization is an enabler for innovation (Suling et al., 2020), and further innovation can setups the organization for any changes. However, the comprehensive model of this research, with the inclusion of a mediation effect, observed different results, possibly due to the changes caused by Industry 4.0 are so complex and require quite strategic decisions for its adoption. The adaption further involves different drivers that must work together to embrace it. Therefore, all companies require continuous but long-term collective efforts from all the stakeholders.

Consistent to the findings of direct effect of second hypothesis, the results are expectedly same. Just like the relevant hypothesis *H2* suggest that the complexity of Industry 4.0 cannot be overcome by a specific structure, likewise the current hypothesis explains that the availability of innovation for decentralized structure to facilitate Industry 4.0 in the Malaysian manufacturing sector is of no use and need to handle tactfully.

5.3. Multi-Group Analysis

The Multi-Group Analysis (MGA) was performed to understand the significant difference between different groups of data. In this current research, the low aging and high aging groups were created and tested separately for their impacts on relationship. This test was applied to analyze *H3*, and the results were found to be significant (see Table 4.16). This hypothesis proved a significant relationship based on the analysis of a complete set of data. It explained that the association between "*organization innovation and readiness for Industry 4.0*" is influenced by the intensity of the aging workforce. The Multi-Group Analysis demonstrated that *H3* is impacted significantly by a high aging workforce. While exploring it further, the results indicated that *H3* is not influenced by the low aging workforce group. In conclusion, the readiness for Industry 4.0 is achieved differently for a different set of aging workforce groups.

5.4. Theoretical Contribution

Current research helps to fill in the initially identified literature gaps, including: (1) the linkage between the variables in the context of Learning Organization theory and Dynamic Capability Theory, (2) discussion and empirical investigation on the connection between organization innovation and readiness for Industry 4.0, (3) the dual position of organization innovation (4) and empirical analysis of aging workforce as a moderator.

The current research is an earliest attempt to examine the conceptual foundation of the readiness for Industry 4.0 in the Malaysian manufacturing industry setting. It acmes the importance of organization innovation and its role in preparation for Industry 4.0. These efforts are also useful in drawing the attention of the researcher to focus on the management practices that have been ignored before instead of focusing only on the technological aspects of Industry 4.0.

Two organization practices, *"knowledge-oriented leadership and decentralized organization structure"*, were tested. The inference has enriched the body of knowledge as a guide and opened up a new investigation aspect for the other researchers. For instance, the findings recommended that organization practices do contribute to organization innovation as well as the readiness for Industry 4.0. The specific style of leadership (knowledge-oriented leadership) was shown to establish a supportive relationship with both "*organization innovation and the readiness for industry 4.0*". It acted as an enabler for both of these variables, and the results are added to the literature. One unexpected and new result from this study is that decentralized organization structure showed an insignificant influence on "*organization innovation and readiness for Industry 4.0*". Most cited studies prior in hypothesis development, including Marín-Idárraga and Cuartas (2016), supported the relationship between decentralized structure and organization innovation, but the results from the current investigation confirmed otherwise. Subsequently, the other researchers can probe further into this finding.

Most importantly, the results also confirmed the high dependency of readiness for Industry 4.0 on innovation is considered as a new knowledge. The gap filled in by current research helps the other researchers to rectify their directions by considering organization innovation as a precedent to readiness for Industry 4.0 rather than as a part of it. Significantly, the dual role (i.e., direct and indirect) of organization innovation is a lead to contribute to the trending researchers on Industry 4.0. The results supported the mediating effect of organization innovation on knowledge-oriented leadership. In contrast, the findings observed that a decentralized organization structure does not support the readiness for

Industry 4.0 was unsupported, hence opening up new opportunities for arguments and exploration.

Another noteworthy contribution to the extant literature is the indirect effect of the aging workforce. In the context of the Malaysian manufacturing sector, the aging workforce acts as a moderator between *"organization innovation and readiness for Industry 4.0"*, and the effects have not been much investigated before. Empirical analysis approved that the presence of a moderator has a significant impact, and this strengthens the existing positive relationship *"organization innovation and readiness for Industry 4.0*". Findings of current research are a steppingstone for future researchers of the countries that are facing challenges by the aging workforce to extend the knowledge in order to find a solution and prepare themselves for Industry 4.0.

Additionally, the supplementary qualitative analysis has added a significant contribution to literature in multiple ways. It highlighted the understanding of industry 4.0 concepts, the adopted pillars, level of adoption and the challenges that are being faced during transformation. The analysis also shed light on the benefits and challenges of aging workforce. It helps in understanding the quantitative findings better. Lastly, the roles of "*knowledge-oriented leadership and decentralized organization structure*" for innovation as well as for industry 4.0 from the view of top management is of great interest for future researchers.

Finally, the Learning Organization Theory (LO) introduced by Senge (2006), in addition to the Dynamic Capability theory were applied to test the two organization practices that may help the companies to innovate. Previous studies that applied these theories were testing specific values and actions (see section 2.4), that support innovation. To enrich the literature, two major practices (namely knowledge-oriented leadership and decentralized organization structure) that cause the actions discussed in extant literature were introduced as the enablers of organization innovation. Hence, this novel investigation, in the context of Learning Organization and Dynamic Capabilities theories, adds great value to the facts of these theories and helps to better understand the processes of readiness for Industry 4.0 in a better way.

5.5. Practical Contribution

The following section will further discuss two implications of current research concerning a practical perspective. It includes managerial implications that discourses the importance of research findings for manufacturing companies and national implications useful for national stakeholders.

5.5.1. Managerial Implications

Current research is important in providing useful understandings from the managerial perspective to reassess their companies' strategies. Most of the respondents in current research are from the managerial or top positions such as "*Owner, CEO, Director, General-Manager, Senior-Manager, Manager*" of manufacturing companies. Importantly, this tier of job is involved in policy and decision-making. Therefore, current research results portray the actual stance of companies' directions. Hence, the results provide critical insights for the managers to plan accordingly in the current Industry 4.0 transformation. The results of current research can be applied to the examined companies, regardless of their type, ownership, and product categories. Decision-makers from many types of organizations (whether locally or foreignly owned, public or private institutions, etc.) can espouse the results for their Industry 4.0 implementation goals.

The outcomes of current research offer the provision of practices that are supportive in enhancing innovation and Industry 4.0 performances of companies. Decision-makers in the manufacturing companies can use the findings of this investigation to prepare themselves way earlier than their competitors. At present, with a fast shift in technologies and processes, the companies are seeking ways to improve innovation so that they can match the pace of industrial trends. Current research resolved the matter by demonstrating a strong positive relationship of "knowledge-oriented *leadership"* for *"organization innovation and readiness for Industry 4.0"*. Herewith, the companies that are aiming to enrich the innovation and trying to reap most of the benefits from Industry 4.0 can freely deploy knowledge-oriented leadership during their practices. Since this type of leadership helps in promoting the knowledge sharing culture and supporting new ideas (Naqshbandi & Jasimuddin, 2018), eventually will be helpful in mounting organization innovation. The same argument is supported by the Importance Performance Map Analysis (see Figure 4.4), as this analysis also presents knowledge-oriented leadership and organizational innovation as important factors for companies.

The analysis provides a direction for the managers by highlighting major factors that are crucial in planning for their performances and inputting more focuses on Industry 4.0 readiness.

Furthermore, the results of hypotheses *H2* and *H5* confirmed the insignificant effects of "*decentralized organization structure on organization innovation and readiness for Industry 4.0*", respectively. The understandings of these findings help the managers and other stakeholders inside the companies to set their directions by following the recommendations of current research. They must avert their endeavors from a decentralized organizational structure. Instead, they should invest their time and assets in the right organizational practices, for example, in a specific leadership style (knowledge-oriented leadership), to achieve the company's higher objectives.

Even though the Industry 4.0 concept is in the midst of its revolution, most of the companies still have no clue about their future directions in this area. Current research provided the answer to the question of "How to become ready for Industry 4.0?" that every company is seeking. A clear direction was provided through statistics by proving that organization innovation is a precedent and mediator to the readiness for Industry 4.0. Findings approved the notion "the more the better" for organization innovation in relevance to readiness for industry 4.0. Furthermore, the intervening role of organization innovation boosted its prominence for the manufacturers. Hence, the decision-makers in companies should put all their energies into developing innovation that will eventually result in preparation for Industry 4.0. This is crucial with the notion that more innovative technologies in a system will subsequently lead to more adaption of Industry 4.0 practices.

The empirical results concluded the support to moderating hypothesis. A moderating effect of the aging workforce was observed between *"organization innovation and readiness for Industry 4.0"*. With the fear of the increasing number of aging workforce that looms over Malaysia, these imperative findings can help the managers in reviewing and revising the existing strategies (e.g., retirement, recruitment, compensation, and many more) that are related to their workforce. This will also be a sigh of relief for the managers who are involved in human resource management. The application of results suggests the human resource managers to hold the existing aged talent for their companies' well-being and prepare a win-win strategy for workers, as well as for the company. It also helps the companies to retain their human capital (i.e., aged workers) and get the maximum benefits from their experiences as an approach to face the world of Industry 4.0.

The qualitative results portrayed the current understanding, adoption, and challenges of industry 4.0. It also displayed the benefits of aging workforce and importance of leadership and innovation. This allows the managers and strategists for developing better plans for transformation by facilitating change and decreasing hurdles. Most importantly, the review of policies and challenges for Industry 4.0 spread awareness among stakeholders to lead the transformation more smoothly. The HR managers also will get some useful insights while planning a career for aging workforce.

Above all that, the research offered an opportunity to highlight the significance of the new industrial revolution (Industry 4.0) and prepare the company management for its implementation. It does not only clarifies the concept of Industry 4.0 in an easy manner but also spreads awareness to the stakeholders from all over the industrial sectors, especially the manufacturing companies of Malaysia. The results of current research concentrated on the prominence of practices, especially on knowledge-oriented leadership and organizational innovation. So, top managers who are responsible for the performances of companies can get some valuable knowledge from current research. Likewise, it helps the practitioners in preparing their organization for Industry 4.0 based on the application of qualitative and quantitative findings and step into the race of gaining benefits from this new shift before it is too late.

5.5.2. National Policy Implications

The Malaysian manufacturing sector is regarded as a key sector for economic growth that also contributes an attractive percentage of profit to the Gross Domestic Product (GDP) of the country. The government is well aware of the contribution of the manufacturing sector to exports, as this sector alone accumulates 80% of the total exports volume (MATRADE, 2020). Moreover, they are aware of the values of Industry 4.0 and the impacts on the manufacturing industry. Therefore, the officials are working hard to spread awareness for Industry 4.0 concepts. As compared to other ASEAN countries, Malaysia is still lagging, with its initial national policy on Industry 4.0, known as “INDUSTRY4WRD”, has been announced in 2018. This policy highlights the main issues, including unclear understanding about the new shift in the companies. They are unaware of their status in preparation for this industrial trend. For this reason, Malaysia has also prepared a plan in 2021 to measure the readiness of Industry 4.0 for the companies (Malaysia Productivity Corporation [MPC], 2019).

Based on the discussions above, current research has multiple offerings for different ministries, especially those that are directly involved in transforming manufacturing businesses and achieving policy goals (MITI, 2018). For example, Goal 9 of Industry 4.0 policy discusses the development of infrastructure to promote faster innovation, and this study highlights the importance of innovation, hence can lead the Ministry of Finance (MOF) to allocate and manage funds properly in order to achieve the goal. The same policy goal highlights the need for technological solutions by stating that “*without technology and innovation, industrialization will not happen, and without industrialization, the development will not happen*”. Hence, there are also some key highlights that are targeting the Ministry of Science, Technology, and Innovation (MOSTI), so that this Ministry can establish technological and collaborative programs for technology adoption that facilitate smart manufacturing. By considering this as an earlier effort, the Ministry of Education (MOE) can motivate academicians with grants and scholarship programs to conduct more research in the same area but with different industries, as this initiative can prepare these industries for Industry 4.0. Additionally, it assists in finding solutions for the successful implementation of Industry 4.0. Moreover, it creates awareness of this concept. Lastly, the results can be used as supports for the Ministry of Human Resource (MOHR) to ensure the training and employment of the right talent with the right skill sets, in addition, to preparing policies of Industry 4.0 for the aging workforce.

The national policy predicts an increase in the population by 2100 (Peng et al., 2014), mainly because better health facilities are available and more people can survive longer every year. These numbers are predicted to double in the last 28 years, and by 2030, around 15% of the total population will be from the older age category (Hamdan et al., 2018). Such alarming statistics are an eye-opener for the officials. Accordingly, there is a need for policy development that is tailored to the aging workforce. The policymakers, especially MOHR, should start preparing the strategy, as most of the aging workers need to keep working to maintain their livelihood. They will try to remain a part of the workforce for as long as possible. By using the positive findings revealed in current research, the government can plan for an attractive policy (e.g., retirement policy) for the aging workforce with the maximum benefits from Industry 4.0.

In a nutshell, current research aids in developing the forthcoming strategies, especially for the manufacturing sector. The results obtained can be used to direct the officials in the allocation of more resources to important factors that were discussed previously to achieve the required developmental objectives for the industrial sector. The government should pay thorough attention to innovation factors and prepare an awareness campaign on innovation and the importance of Industry 4.0 for the companies so that these can be smoothly transformed for Industry 4.0.

5.6. Limitations and Recommendations for Future Research

The identification of the research gap, development of instruments, data collection, and data analysis was performed to answer the research questions that are laid out at the start of the research. However, there are several limitations that have been presented in this section. A detailed list is provided and proposed future studies to fill the literature gaps are presented based on the best of the researcher's knowledge.

Initially, the current research was executed on the manufacturers only, and this is limited by type of industry, the manufacturing processes, and market structure, as all of these are limited to manufacturing only. Hence, the conclusions cannot be generalized to all industries besides manufacturing. Accordingly, current research presents an opportunity to other researchers to perform the same research in other industries e.g., construction and education, that are also considered as a backbone for the country's development in tangible and intangible ways, respectively.

The stage of data collection for this research was a bit challenging because the target respondents included top management personnel as well. Initially, it was difficult to reach out to this group of respondents and to get their time to complete the survey later. But still, the researcher was able to collect 37% of the responses from the top tier, and 47% from the mid-level of the organization, since both the top and mid-level management are usually involved in decision making. Though the collected responses were sufficient for research, but to increase the response rate, an awareness seminar covering the understanding and significance of Industry 4.0 for their company is suggested prior to the data collection step.

The current research examined the aging workforce (moderator) based on the perception of respondents. There is an opportunity for another research that is based on the responses of the aging workforce itself. This extended version will provide a comparative analysis and with more effective strategic decisions.

The Learning Organization and Dynamic Capability theories applied in this research answered the research questions in the best possible way by identifying the practices that enable innovation and build competencies. For further exploration, other types of variables, such as Human Resource Management, in combination with the concepts from Ability Motivation Opportunity (AMO) (Hughes, 2007), would be a valuable addition to new knowledge.

Current research is based on a model limited to knowledge-oriented leadership and decentralized organization structure that showed 22.5 percent (R^2) for organization innovation. Hence allowing the analysis of other factors that could add value to innovation development. There are several other practices that can be useful (in the context of organization innovation) and are recommended for investigation. Henceforward, it is highly recommended for keen researchers to test other organization practices, like Organization Culture and Human Resource Practices, for the development of organization innovation (Bhatti et al., 2021; Haneda & Ito, 2018).

In the same way, management practices and organizational innovation are contributing half to readiness for Industry 4.0. This report opens an opportunity for future research on the other contributing factors for the readiness of Industry 4.0. An addition of Learning and Knowledge Management (mediator) could be a significant contribution to the existing literature to unveil the mystery of Industry 4.0 (Shamim et al., 2016). Most importantly, with an insignificant result obtained from the analysis of decentralized organization structure upon organization innovation, an opportunity arises for profound researchers to test on the other types of models, for example, formalized, specialized, matrix, and bureaucratic or mix structure, so that further knowledge and understandings can be enhanced.

Large and foreign companies have more resources to invest, as compared to Small Medium Enterprises (SME). Therefore, Multi-National Companies (MNC) and other giant businesses can be more ready for Industry 4.0. However, this research has provided general guidelines to all of the companies, irrespective of their size and type. Future research can be performed separately on SMEs and MNC's to deeply understand their readiness status for Industry 4.0 and their different policy analyses.

Finally, this research used cross-sectional data for analysis. Dramatic changes due to the fast pace of Industry 4.0 and natural disasters (for example, Covid-19) have already affected and impacted a lot of business conditions in Malaysia (KPMG, 2020). Thus, longitudinal research will be helpful for policymakers and other business stakeholders to track the changes and prepare viable strategies for their companies.

5.7. Conclusion

The core objective of current research is to highlight the significance of innovation for manufacturing companies. The research has investigated "*knowledge-oriented leadership and decentralized organization structure*" to enhance the innovation performance of companies. It further analyzed the dual job of organization innovation. Lastly, a significant impact of aging workforce as a moderator between *"organization innovation and readiness for Industry 4.0"* has been studied comprehensively.

Out of eight main hypotheses proposed, five of them including the effect of: "*knowledge-oriented leadership and organization innovation", "organization innovation and readiness for Industry 4.0"* "*knowledge-oriented leadership and readiness for Industry 4.0"* "*organization innovation mediator between knowledge-oriented leadership and readiness for Industry 4.0"*and "*Aging Workforce moderator between organization innovation and readiness for Industry 4.0"* has been supported by showing significance impact among their relations. However, the relationship between "*decentralized organization* *structure and organization innovation"* "*decentralized organization structure and readiness for Industry 4.0"* and "*organization innovation mediator between decentralized organization structure and readiness for Industry 4.0" are* tested insignificant and the proposition is hence not supported.

To conclude, the significance for Industry 4.0 is unquestionable and thus preparation for its adoption for the manufacturing sector is need for the day. Achievement of current research objectives is a small contribution to support companies in fulfilling their performance goals. It has provided a direction for practitioners and policymakers to remarkably consider the development of innovation for nurturing the capacity of companies for Industry 4.0 complexities. Moreover, theoretical, and managerial perspective contributions, limitations, and recommendations for future studies have been discussed extensively in current research.

Overall, the current research has revealed that knowledge-oriented leadership as well as organization innovation are very essential in developing organization and support for preparing organizations for Industry 4.0. Whereas, for Malaysian manufacturing sector, decentralized organization structure is not of much relevance. Moreover, companies that are good in innovation performance are well prepared for Industry 4.0 and the presence of the aging workforce will enrich the organization's readiness for Industry 4.0.

LIST OF REFERENCES

Abd Aziz, S., & Mahmood, R. (2011). The relationship between business model and performance of manufacturing small and medium enterprises in Malaysia, *African Journal of Business Management, 5*(22*),* 8918-8932. http://doi.org/10.5897/AJBM11.474

Abdullah, D. B., Abdullah, M. Y., & Salleh, M. A. M. (2017). A review on the concept of Fourth Industrial Revolution and the government's initiatives to promote it among youths in Malaysia. *Journal of Social Sciences and Humanities*, *14*(7). https://www.semanticscholar.org/paper/A-REVIEW-ON-THE-CONCEPT-OF-FOURTH-INDUSTRIAL-AND-TO-Abdullah-Abdullah/b44b397ada3db4b978add229454ca88a4a0f2658

Abouzeedan, A., & Hedner, T. (2012). Organization structure theories and open innovation paradigm. *World Journal of Science*, *Technology and Sustainable Development*, *9*(1), 6–27. https://doi.org/10.1108/20425941211223598

Adamu, Y. A. (2019). *Development of A 6-DOF 3D printed industrial robot for teaching and learning* [Doctoral dissertation, University of Malaya].

Afthanorhan, W. M. A. B. W. (2013). A Comparison of Partial Least Square Structural Equation Modeling (PLS-SEM) and Covariance Based Structural Equation Modeling (CB-SEM) for Confirmatory Factor Analysis. *Certified International Journal of Engineering Science and Innovative Technology (IJESIT)*, *2*(5), 2319–5967. https://pdfs.semanticscholar.org/65aa/74c17d6ebd4eec4c20769a225a527a768e90.pdf

Agarwal, S., & Lenka, U. (2018). Managing organization effectiveness through e-human resource management tool-e-learning: Indian cases a qualitative approach. *PEOPLE: International Journal of Social Sciences*, *4*(1), 298-312. https://dx.doi.org/10.20319/pijss.2018.41.298312

Agostini, L., & Filippini, R. (2019). Organizational and managerial challenges in the path toward Industry 4.0. *European Journal of Innovation Management*, *22*(3), 406-421. https://doi.org/10.1108/EJIM-02-2018-0030

Akbar, F., Khan, R. A., Wadood, F., & Bon, A. T. B. (2020). Entrepreneurial orientation dimension affects firm performance: A perspective from the Malaysian furniture industry. *Entrepreneurial Business and Economics Review*, *8*(4), 157-181. https://doi.org/10.15678/EBER.2020.080409

Akdil, K. Y., Ustundag, A., & Cevikcan, E. (2018). Maturity and readiness model for industry 4.0 strategy. In *Industry 4.0: Managing the digital transformation* (pp. 61-94). Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-319-57870-5_4

Al Khajeh, E. H. (2018). Impact of leadership styles on organizational performance. *Journal of Human Resources Management Research*, *2018*, 1-10. https:// doi-org/ 10.5171/2018.687849

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological*

Bulletin, *103*(3), 411–423. https://psycnet.apa.org/buy/1989-14190-001

Anderson, N., Potočnik, K., & Zhou, J. (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management, 40*(5), 1297–1333. https://doi-org/10.1177%2F0149206314527128

Anning-Dorson, T. (2018). Customer involvement capability and service firm performance: The mediating role of innovation. *Journal of Business Research*, *86*, 269-280. https://doi.org/10.1016/j.jbusres.2017.07.015

Anseel, F., Lievens, F., Schollaert, E., & Choragwicka, B. (2010). Response Rates in Organizational Science, 1995–2008: A Meta-analytic Review and Guidelines for Survey Researchers. *Journal of Business and Psychology, 25(3), 335–349.* https://doi-org/10.1007/s10869-010-9157-6

Antoncic, B., & Hisrich, R. D. (2001). Intrapreneurship. *Journal of Business Venturing*, *16*(5), 495–527. https://doi-org.libezp2.utar.edu.my/10.1016/S0883-9026(99)00054-3

Arnold, J., Silvester, J., Cooper, C. L., Robertson, I. T., & Patterson, F. M. (2005). *Work psychology: Understanding human behaviour in the workplace*. Pearson Education.

Ashton, T. S. (1997). The industrial revolution 1760-1830. *OUP Catalogue.*

Auh, S., & Menguc, B. (2007). Performance implications of the direct and moderating effects of centralization and formalization on customer orientation. *Industrial marketing management*, *36*(8), 1022-1034. https://doi.org.libezp2.utar.edu.my/10.1016/j.indmarman.2006.02.010

Awang, Z. (2012). Research methodology and data analysis second edition. UiTM Press.

Awang, Z. H. (2010). *Research methodology for business & social science*. Pusat Penerbitan Universiti, Universiti Teknologi MARA.

Azar, G., & Ciabuschi, F. (2017). Organizational innovation, technological innovation, and export performance: The effects of innovation radicalness and extensiveness. *International Business Review*, *26*(2), 324–336. https://doi-org.libezp2.utar.edu.my/10.1016/j.ibusrev.2016.09.002

Bahari, N., Yunus, A. R., Jabar, J. A., & Yusof, S. W. M. (2018). Entrepreneur characteristics and firm performance: A study on Malaysian food manufacturing industry SME's. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, *23*(2), 92-98. https://doi.org/10.9790/0837-2302079298

Bahrin, M. A. K., Othman, M. F., Azli, N. H. N., & Talib, M. F. (2016). Industry 4.0: A review on industrial automation and robotic. *Jurnal Teknologi, 78*(6–13), 137–143. https://doi.org/10.11113/jt.v78.9285

Bal, A. C., Reiss, A. E. B., Rudolph, C. W., & Baltes, B. B. (2011). Examining Positive and Negative Perceptions of Older Workers: A Meta-Analysis. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *66B*(6), 687–698. https://doi.org/10.1093/geronb/gbr056

Bakar, A. R. A., & Ahmed, Z. U. (2015). Technology motivation in e-marketing adoption among Malaysian manufacturers. *Journal of Transnational*

Management, *20*(2), 126-152. https://doi.org/10.1080/15475778.2015.1038949

Baqar, R. (2016). *Leadership 4.0 (Vol. 1).* Frankfurt University of Applied Sciences.

Baregheh, A., Rowley, J., & Sambrook, S. (2009). Towards a multidisciplinary definition of innovation. *Management Decision*, *47*(8), 1323–1339. https://doi.org/10.1108/00251740910984578

Bartholomew, S., & Smith, A. D. (2006). Improving survey response rates from chief executive officers in small firms: The importance of social networks. *Entrepreneurship Theory and Practice*, *30*(1), 83-96. https://doi.org/10.1111%2Fj.1540-6520.2006.00111.x

Bartodziej, C. J. (2017). The concept industry 4.0. In *The concept industry 4.0* (pp. 27-50). Springer Gabler, Wiesbaden.

Basadur, M., & Gelade, G. A. (2006). The role of knowledge management in the innovation process. *Creativity and Innovation Management*, *15*(1), 45-62. https://doi.org/10.1111/j.1467-8691.2006.00368.x

Beazley, A., Ball, C., & Vernon, K. (2017). Workplace age diversity: The employers' perspectives. In *Managing the Ageing Workforce in the East and the West*. Emerald Publishing Limited. https://doi.org/10.1108/978-1-78714-638-920171012

Behun, M., Gavurova, B., Tkacova, A., & Kotaskova, A. (2018). The impact of the manufacturing industry on the economic cycle of European Union countries. *Journal of competitiveness*, *10*(1), 23-39. https:// doi.org/ 10.7441/joc.2018.01.02

Bento, F., & Garotti, L. (2019). Resilience beyond formal structures: a network perspective towards the challenges of an aging workforce in the oil and gas industry. *Journal of Open Innovation: Technology, Market, and Complexity*, *5*(1), 15. https://doi.org/10.3390/joitmc5010015

Bernard, H. R. (2017). *Research methods in anthropology: Qualitative and quantitative approaches*. Rowman & Littlefield.

Bertoldi, B., Giachino, C., Rossotto, C., & Bitbol-Saba, N. (2018). The role of a knowledge leader in a changing organizational environment. A conceptual framework drawn by an analysis of four large companies. *Journal of Knowledge Management. 22*(3), 587-602. https://doi.org/10.1108/JKM-09-2017-0422

Bhatti, S.H., Zakariya, R., Vrontis, D., Santoro, G. and Christofi, M. (2021). High-performance work systems, innovation and knowledge sharing: An empirical analysis in the context of project-based organizations. *Employee Relations*, *43*(2), 438-458. https://doi.org/10.1108/ER-10-2019-0403

Billett, S., Dymock, D., Johnson, G., & Martin, G. (2011). Overcoming the paradox of employers' views about older workers. *The International Journal of Human Resource Management*, *22*(6), 1248–1261. https://doi.org/10.1080/09585192.2011.559097

Bolat, Y., & Bas, M. (2018). The Perception of the Educational Philosophy in the Industrial Age 4.0 and the Educational Philosophy Productivity of

Teacher Candidates. *World journal of education*, *8*(3), 149-161. https://doi.org/10.5430/wje.v8n3p149

Bollinger, A. S., & Smith, R. D. (2001). Managing organizational knowledge as a strategic asset. *Journal of Knowledge Management*, *5*(1), 8–18. https://doi.org/10.1108/13673270110384365

Borges, W. G., Imm, N. S., Cheong, C. B., Chai, L. T., Teik, D. O. L., Nadarajah, D., Mamat, M. N. (2017). *Business Research Methods*. SJ Learning. http://www.sjlearning.com.my/titles/item/Business-Research-Methods-William-G-Bill-Borges-Ng-Siew-Imm-Chew-Boon-Cheong-Lau-Teck-Chai-Derek-Ong-Lai-Teik-Devika-Nadarajah-Lee-Chin-Goi-Mei-Teh-Law-Kian-Aun-and-Mohd-Noor-Bin-Mamat-2017

Botha, A. P. (2018). Rapidly arriving futures: Future readiness for industry 4.0. South African *Journal of Industrial Engineering*, *29*(3), 148–160. https://doi.org/10.7166/29-3-2056

Bresman, H., & Zellmer-Bruhn, M. (2013). The Structural Context of Team Learning: Effects of Organizational and Team Structure on Internal and External Learning. *Organization Science, 24*(4), 1120–1139. https://doi/abs/10.1287/orsc.1120.0783

Briken, K., Chillas, S., & Krzywdzinski, M. (2017). *The new digital workplace: How new technologies revolutionise work*. Macmillan International Higher Education.

Brisson-Banks, C. V. (2010). Managing change and transitions: a comparison of different models and their commonalities. *Library Management, 31*(4/5), 241–252. https://doi.org/10.1108/01435121011046317

Bryant, S. E. (2003). The role of transformational and transactional leadership in creating, sharing and exploiting organizational knowledge. *Journal of Leadership & Organizational Studies*, *9*(4), 32-44. https://doi.org/10.1177%2F107179190300900403

Bryman, A. (2001). *Social research methods*. Oxford University Press. https://books.google.com.my/books/about/Social_Research_Methods.html?id=3ulxQgAACAAJ&redir_esc=y

Bryman, A. (2015). *Social research methods* (5th Ed.). Oxford University Press. https://global.oup.com/ukhe/product/social-research-methods 9780199689453?cc=my&lang=en&

Bryman, A., & Bell, E. (2015). *Business research methods*. Retrieved from https://books.google.com.my/books/about/Business_Research_Methods.html?id=l7u6BwAAQBAJ&redir_esc=y

Buchner, A., Erdfelder, E., Faul, F., & Lang, A. G. (2019). G* Power (Version 3.1. 9.4) [Software]. *Verfügbar über.* http://www. gpower. hhu. de.

Buhr, D. (2017). *Social innovation policy for industry 4.0*. Friedrich-Ebert-Stiftung, Department of Western Europe/North America. https://japan.fes.de/fileadmin/user_upload/events/2017/pdffiles/Social_Innovation_Polcy_for_Industry_4.0.pdf

Burmeister, C., Lüttgens, D., & Piller, F. T. (2016). Business Model Innovation for Industrie 4.0: Why the'Industrial Internet'Mandates a New Perspective on Innovation. *Die Unternehmung*, *2*, *70*(2), 124–152. https:// doi.org/ 10.5771/0042-059X-2016-2-124

Burrell, G., & Morgan, G. (2017). *Sociological paradigms and organisational analysis: Elements of the sociology of corporate life*. Routledge.

Büsch, V., Dahl, S.Å., & Dittrich, D. A. V. (2009). An empirical study of age discrimination in Norway and Germany. *Applied Economics, 41*(5), 633–651. https://doi.org/10.1080/00036840601007344

Bussi. (2017, April 11). *Connecting People Through News*. Press Reader. https://www.pressreader.com/thailand/the-nation/20170411/281767039084357

Cachay, J., & Abele, E. (2012). Developing competencies for continuous improvement processes on the shop floor through learning factories–conceptual design and empirical validation. *Procedia CiRP*, *3*, 638-643. https://doi.org/10.1016/j.procir.2012.07.109

Carneiro, A. (2000). How does knowledge management influence innovation and competitiveness?. *Journal of knowledge management*, *4*(2), 87-98. https://doi.org/10.1108/13673270010372242

Chan, S. W., Ang, S. F., Andleeb, N., Ahmad, M. F., & Zaman, I. (2019). The influence of transformational leadership on organization innovation in Malaysian manufacturing industry. *International Journal of Supply Chain Management*, *8*(2), 971-976. https://www.researchgate.net/profile/Shiau-Wei-Chan-2/publication/332780293_The_Influence_of_Transformational_Leadership_on_Organization_Innovation_in_Malaysian_Manufacturing_Industry/links/5cc93d11299bf120978b9a93/The-Influence-of-Transformational-Leadership-on-Organization-Innovation-in-Malaysian-Manufacturing-Industry.pdf

Chang, C. H. (2011). The influence of corporate environmental ethics on competitive advantage: The mediation role of green innovation. *Journal of Business Ethics*, *104*(3), 361-370. https://doi.org/10.1007/s10551-011-0914-x

Chang, S. C., & Lee, M. S. (2008). The linkage between knowledge accumulation capability and organizational innovation. *Journal of knowledge management*, *12*(1), 3-20. https://doi.org/10.1108/13673270810852359

Chang, S. J., Van Witteloostuijn, A., & Eden, L. (2010). From the editors: Common method variance in international business research. *Journal International Business Studeis, 41,* 178-184. https://doi.org/10.1057/jibs.2009.88

Chau, P. Y. K., & Hu, P. J. H. (2001). Information technology acceptance by individual professionals: a model comparison approach. *Decision Science, 32* (4), 609–719. https://doi.org/10.1111/j.1540-5915.2001.tb00978.x

Chen, C.J., Huang, J.W., & Hsiao, Y.C. (2010). Knowledge management and innovativeness: The role of organizational climate and structure. *International Journal of Manpower, 31*(8), 848–870. https://doi.org/10.1108/01437721011088548

Chen, Y. Y., Shek, D. T., & Bu, F. F. (2011). Applications of interpretive and constructionist research methods in adolescent research: Philosophy, principles and examples. *International Journal of Adolescent Medicine and Health*, *23*(2), 129–139.

Chi, M., Muhammad, S., Khan, Z., Ali, S., & Li, R. Y. M. (2021). Is centralization killing innovation? The success story of technological innovation in fiscally decentralized countries. *Technological Forecasting and Social Change, 168*, 120731. https://doi.org/10.1016/j.techfore.2021.120731

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. *Modern methods for business research*, *295*(2), 295 – 336.

Chin, W. W. (2010). How to write up and report PLS analyses, *In Handbook of partial least squares* (pp. 655-690). Springer.

Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic-Mail Emotion/Adoption Study. *Information Systems Research*, *14*(2), 189–217. https://doi/abs/10.1287/isre.14.2.189.16018

Chiu, W., Chan, A. W., Snape, E., & Redman, T. (2001). Age Stereotypes and Discriminatory Attitudes towards Older Workers: An East-West Comparison. *Human Relations*, *54*(5), 629–661. https://doi.org/10.1177%2F0018726701545004

Choi, Y. H., & Choi, S. H. (2018). A study of crossing the Chasm in applying smart factory system for SMEs. *International Journal of Pure and Applied Mathematics*, *118*(19), 469-487.

Chou, S. W. (2005). Designing good institutional contexts for innovation in a technology-mediated learning environment. *Journal of Computer Assisted Learning*, *21*(4), 269-280. https://doi.org/10.1111/j.1365-2729.2005.00134.x

Chung, J. E., Park, N., Wang, H., Fulk, J., & McLaughlin, M. (2010). Age differences in perceptions of online community participation among non-users: An extension of the Technology Acceptance Model. *Computers in Human Behavior,* *26*(6), 1674–1684. https://doi.org/10.1016/j.chb.2010.06.016

Cimini, C., Boffelli, A., Lagorio, A., Kalchschmidt, M., & Pinto, R. (2020). How do industry 4.0 technologies influence organisational change? An empirical analysis of Italian SMEs. *Journal of Manufacturing Technology Management*, *32*(3), 695-721. https://doi.org/10.1108/JMTM-04-2019-0135

Cingöz, A., & Akdoğan, A. A. (2011). An empirical examination of performance and image outcome expectation as determinants of innovative behavior in the workplace. *Procedia - Social and Behavioral Sciences*, *24,* 847–853. https://doi.org/10.1016/j.sbspro.2011.09.099

Čiutienė, R., & Railaitė, R. (2014). Challenges of managing an ageing workforce. *Procedia-Social and Behavioral Sciences*, *156*, 69-73. https://doi.org/10.1016/j.sbspro.2014.11.121

Cohen, J. (1988*). Statistical power analysis for the behavioral sciences*. New York: Academic.

Cohen, L. Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.

Collis, J., & Hussey, R. (2009). *Business research: a practical guide for undergraduate & postgraduate students*. Retrieved from https://books.google.com.my/books/about/Business_Research.html?id=awLOPAAACAAJ&redir_esc=y

Connelly, L. M. (2008). Pilot studies. *Medsurg Nursing: Official Journal of the Academy of Medical-Surgical Nurses*, *17*(6), 411–412. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19248407

Cooper, D. R., & Schindler, P. S. (2014). *Business Research Method* (12th Ed.). New York: Mcgraw-hill. https://books.google.com.my/books?id=AZ0cAAAAQBAJ

Cornell, WIPO, & INSEAD. (2017). *The Global Innovation Index 2017*. Cornell University. Retrieved from https://www.globalinnovationindex.org/gii-2017-report

Corporation, M. P. (2019). *Industry4WRD Readiness Assessment*. Retrieved from Malaysia Productivity Corporation: http://www.mpc.gov.my/industry4wrd/#:~:text=the%20smart%20factory-,INDUSTRY4WRD%20READINESS%20ASSESSMENT,migrate%20to%20Industry%204.0%20technologies

Corporation, M. P. (2019). *Malaysian Productivity Corporation*. Annual Report.

Court, T. (2011). How the HR function can build the capability to change. *Development and Learning in Organizations: An International Journal*, *25*(1), 16–18. https://doi.org/10.1108/14777281111096780

Cox III, E. P. (1980). The optimal number of response alternatives for a scale: A review. *Journal of marketing research*, *17*(4), 407-422. https://doi.org/10.1177%2F002224378001700401

Craik, F. I. M., & Salthouse, T. A. (2011). *The handbook of aging and cognition*. Lawrence Erlbaum Associates.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Crnjac, M., Veža, I., & Banduka, N. (2017). From concept to the introduction of industry 4.0. International Journal of Industrial Engineering and Management, 8(1), 21-30.

Csaszar, F. A. (2012). Organizational structure as a determinant of performance: Evidence from mutual funds. *Strategic Management Journal*, *33*(6), 611–632. https://doi.org/10.1002/smj.1969

Cunningham, G.B. & Rivera, C.A. (2001), Structural Designs Within American Intercollegiate Athletic Departments, *The International Journal of Organizational Analysis, 9*(4), 369-390. https://doi.org/10.1108/eb028941

Daemmrich, A. (2017). Invention, Innovation Systems, and the Fourth Industrial Revolution. *Technology and Innovation*, *18*(202), 257–265. https://doi.org/10.21300/18.4.2017.257

Dais, S. (2017). *Industrie 4.0–Anstoß, Vision, Vorgehen, In Handbuch Industrie 4.0 Bd. 4* (pp. 261–277). Springer.

Damanpour, F. (1996). Organizational Complexity and Innovation: Developing and Testing Multiple Contingency Models. *Management Science*, *42*(5), 693–716. https://doi.org/10.1287/mnsc.42.5.693

Darroch, J. (2005). Knowledge management, innovation and firm performance. *Journal of Knowledge Management*, *9*(3), 101-115. https://doi.org/10.1108/13673270510602809

Darvishmotevali, M. (2019). Decentralization and innovative behavior: The moderating role of supervisor support. *International Journal of Organizational Leadership, 8*, 31-45.

Davies, R. (2015). *Industry 4.0: Digitalisation for productivity and growth (Briefing).* European Parliamentary Research Service.

Dedahanov, A. T., Rhee, C., & Yoon, J. (2017). Organizational structure and innovation performance. *Career Development International, 22*(4), 334-350. https://doi.org/10.1108/CDI-12-2016-0234

Dedahanov, A. T., Rhee, C., Yoon, J., Dedahanov, A. T., Rhee, C., & Yoon, J. (2017). Organizational structure and innovation performance Is employee innovative behavior a missing link? *Career Development International*, *22*(4), 334–350. https://doi.org/10.1108/CDI-12-2016-0234

Deng, X., Doll, W. J., & Cao, M. (2008). Exploring the absorptive capacity to innovation/productivity link for individual engineers engaged in IT enabled work. *Information & Management*, *45*(2), 75-87. https://doi.org/10.1016/j.im.2007.12.001

Department of Statistics Malaysia. (2020). *National Accounts Malaysia*. https://www.dosm.gov.my

Department of Statistics Malaysia. (2018). *Annual Economic Survey 2018*. https://www.dosm.gov.my/v1/index.php?r=column/cone&menu_id=QmFjRnZZQTRaaFJIVEc2M1pzNTB6Zz09

Dewar, R. D., & Dutton, J. E. (1986). The adoption of radical and incremental innovations: An empirical analysis. *Management Science, 32*(11), 1422-1433. https://doi.org/10.1287/mnsc.32.11.1422

Direction, S. (2021). Firm capacity to manage new trends: business model innovation can increase resilience. *Strategic Direction, 37*(4), 15-18. https://doi.org/10.1108/SD-01-2021-0009

Donate, M. J., & de Pablo, J. D. S. (2015). The role of knowledge-oriented leadership in knowledge management practices and innovation. *Journal of Business Research*, *68*(2), 360-370. https://doi.org/10.1016/j.jbusres.2014.06.022

Downing, R. E., Moore, J. L., & Brown, S. W. (2005). The effects and interaction of spatial visualization and domain expertise on information seeking. *Computers in Human Behavior*, *21*(2), 195–209. https://doi.org/10.1016/j.chb.2004.03.040

Drath, R., & Horch, A. (2014). Industrie 4.0: Hit or hype?[industry forum]. *IEEE Industrial Electronics Magazine, 8*(2), 56–58.

Du Plessis, M. (2007). The role of knowledge management in innovation. *Journal of Knowledge Management*, *11*(4), 20-29. https://doi.org/10.1108/13673270710762684

Duxbury, L., & Halinski, M. (2014). Dealing with the “Grumpy Boomers”: re-engaging the disengaged and retaining talent. *Journal of Organizational Change Management*, *27*(4), 660–676. https://doi.org/10.1108/JOCM-05-2014-0106

Dworschak, B., & Zaiser, H. (2014). Competences for Cyber-physical Systems in Manufacturing – First Findings and Scenarios. *Procedia CIRP*, *25*, 345–350. https://doi.org/10.1016/j.procir.2014.10.048

Department of Statistics Malaysia. (2019). *Economic Performance First Quarter 2020*. https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=100&bul_id=R09wdGZSektvNmw5T1VCeVphNXRqdz09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09

Elias, S. M., Smith, W. L., & Barney, C. E. (2012). Age as a moderator of attitude towards technology in the workplace: work motivation and overall job satisfaction. *Behaviour & Information Technology*, *31*(5), 453–467. https://doi.org/10.1080/0144929X.2010.513419

Erol, S., Jäger, A., Hold, P., Ott, K., & Sihn, W. (2016). Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production. *Procedia CIRP*, *54*, 13–18. https://doi.org/10.1016/j.procir.2016.03.162

Faccin, K., & Balestrin, A. (2018). The dynamics of collaborative practices for knowledge creation in joint R&D projects. *Journal of Engineering and Technology Management*, *48*, 28-43. https://doi.org/10.1016/j.jengtecman.2018.04.001

Fairchild, A. J. & McQuillin, S. D. (2010). Evaluating mediation and moderation effects in school psychology: A presentation of methods and review of current practice. *Journal of School Psychology*, *48* (1), 53 – 84. https://doi.org/10.1016/j.jsp.2009.09.001

Fagerland, M. W., Laake, P., Benestad, H. B., & Olsen, B. R. (2015). *Research in Medical and Biological Sciences*. Academic Press.

Fatorachian, H., & Kazemi, H. (2018). A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework. *Production Planning & Control*, *29*(8), 633–644. https://doi.org/10.1080/09537287.2018.1424960

Feng, S., Sui, B., Liu, H., & Li, G. (2020). Environmental decentralization and innovation in China. *Economic modelling*, *93*, 660-674. https://doi.org/10.1016/j.econmod.2020.02.048

Ferrell, O. C., & Skinner, S. J. (1988). Ethical behavior and bureaucratic structure in marketing research organizations. *Journal of marketing research*, *25*(1), 103-109. https://doi.org/10.1177%2F002224378802500111

Fong, J. H. (2017). Extending Demographic Windows of Opportunity: Evidence from Asia. *Asia-Pacific Journal of Risk and Insurance*, *11*(1), 1–23. https://doi.org/10.1515/apjri-2016-0022

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18* (1), 39 – 50. https://doi.org/10.1177%2F002224378101800104

Frontoni, E., Loncarski, J., Pierdicca, R., Bernardini, M., & Sasso, M. (2018, June). Cyber physical systems for industry 4.0: Towards real time virtual reality in smart manufacturing, In *International Conference on Augmented Reality, Virtual Reality and Computer Graphics* (pp. 422-434). Springer, Cham.

Gantino, R., Ruswanti, E., & Rachman, T. (2017). Performance model: Environmental uncertainty, decentralization of authority and business strategy on managerial performance (property and real estate and food and beverage sectors listed on Indonesia stock exchange). *International Journal of Economic Research, 14*(13), 151-163.

García-Morales, V. J., Jiménez-Barrionuevo, M. M., & Gutiérrez-Gutiérrez, L. (2012). Transformational leadership influence on organizational performance through organizational learning and innovation. *Journal of Business Research*, *65*(7), 1040–1050. https://doi.org/10.1016/j.jbusres.2011.03.005

Garvin, D. A. (1993). Manufacturing strategic planning. *California Management Review*, *35*(4), 85-106. https://doi.org/10.2307%2F41166756

Geissbauer, R., Vedso, J., & Stefan, S. (2016). *Industry 4.0: Building the digital enterprise - PWC 2016 Global Industry Survey*. PWC. https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf?ga=2.1024 15108.46912338.1539346626-1416210707.1534188424

Georgy, U. (2017). Training Course: Certified Specialist in Innovation Management. Retrieved from http://library.ifla.org/id/eprint/1915

Ghobakhloo, M. (2018). The future of manufacturing industry: a strategic roadmap toward Industry 4.0. *Journal of Manufacturing Technology Management*, *29*(6), 910–936. https://doi.org/10.1108/JMTM-02-2018-0057

Gilchrist, A. (2016). *Industry 4.0: the industrial internet of things*. Apress.

Giffi, C. A., Rodriguez, M. D., Gangula, B., Roth, A. V., & Roth, A. V. (2016). Global manufacturing competitiveness index. *Deloitte Touche Tohmatsu Limited (DTTL) Global Consumer & Industrial Products Industry Group and the Council on Competitiveness*.

Goh, P. C. (2005). Intellectual capital performance of commercial banks in Malaysia. *Journal of intellectual capital*, *6*(3), 385-396. https://doi.org/10.1108/14691930510611120

Gringart, E., Helmes, E., & Speelman, C. P. (2005). Exploring Attitudes Toward Older Workers Among Australian Employers. *Journal of Aging & Social Policy*, *17*(3), 85–103. https://doi.org/10.1300/J031v17n03_05

Groot, de B., & Franses, P. H. (2009). Cycles in basic innovations. *Technological Forecasting and Social Change*, *76*(8), 1021–1025. https://doi.org/10.1016/j.techfore.2009.03.007

Gruescu, S. (2007). *Population ageing and economic growth: education policy and family policy in a model of endogenous growth*. Springer Science & Business Media. https://books.google.com.my/books?hl=en&lr=&id=KLF1IdPevJ4C&oi=fnd&pg=PA3&dq=Gruescu,+S.+(2007).+Population+Ageing+and+Economic+Growth+:+Education+Policy+and+Family+Policy+in+a+Model+of+Endogenous.+Berlin,+German:+Physica-+Verlag.&ots=QaC4Y-VbGG&sig=hOFGX

Guimaraes, T., & Paranjape, K. (2019). Competition intensity as moderator for NPD success. *International Journal of Innovation Science*, *11*(4), 618-647. https://doi.org/10.1108/IJIS-07-2018-0072

Gunday, G., Ulusoy, G., Kilic, K., & Alpkan, L. (2011). Effects of innovation types on firm performance. *International Journal of Production Economics, 133*(2), 662–676. https://doi.org/10.1016/j.ijpe.2011.05.014

Gupta, A. (2020). Developing model for Organization Structure and Firm Performance relationship mediated by impacting factors ie, Organization Culture, Strategic Orientation, Environmental Uncertainty and Technology usage in service sector in India. *Journal of Critical Reviews, 7*(3), 1733-1747. http://www.jcreview.com/fulltext/197-1621686556.pdf

Haas, M. R., & Hansen, M. T. (2005). When using knowledge can hurt performance: The value of organizational capabilities in a management consulting company. *Strategic management journal*, *26*(1), 1-24. https://doi.org/10.1002/smj.429

Hadjistavropoulos, T., Craig, K. D., Duck, S., Cano, A., Goubert, L., Jackson, P. L., & Vervoort, T. (2011). A biopsychosocial formulation of pain communication. *Psychological bulletin*, *137*(6), 910. https://psycnet.apa.org/doi/10.1037/a0023876

Hage, J., & Aiken, M. (1967). Relationship of centralization to other structural properties. *Administrative Science Quarterly*, *12*(1), 72-92. https://doi.org/10.2307/2391213

Hage, J., & Aiken, M. T. (1970). *Social change in complex organizations* (Vol. 41). Random House Trade.

Hair Jr, J. F. (2006). *Black, WC/Babin, BJ/Anderson, RE & Tatham, RL (2006): Multivariate Data Analysis.* Auflage, Upper Saddle River.

Hair, J. F., Anderson, R. E., Babin, B. J., & Black, W. C. (2010). *Multivariate data analysis: A global perspective (Vol.7).* Upper Saddle River, New Jersey.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th Ed.). Prentice Hall, Upper Saddle River, New Jersey. https://www.pearson.com/us/higher-education/program/Hair-Multivariate-Data-Analysis-7th-Edition/PGM263675.html

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. (2012). An Assessment of the use of Partial Least Squares Structural Equation Modeling in Marketing research. *Journal of the Academy of Marketing Science (JAMS)*, *40*(3), 414–433. https://doi.org/10.1108/EBR-10-2013-0128

Hair, J. F., Tatham, R. L., Anderson, R. E., & Black, W. (1998). *Multivariate*

Data Analysis (5th Ed.). Prentice-Hall, New Jersey. https://www.pearson.com/us/higher-education/product/Hair-Multivariate-Data-Analysis-5th-Edition/9780138948580.html

Hair, J. J. F., Sarstedt, M., Hopkins, L., & G. Kuppelwieser, V. (2014). Partial least squares structural equation modeling (PLS-SEM) An emerging tool in business research. *European Business Review*, *26*(2), 106–121.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of management review*, *9*(2), 193-206.

Hamdan, A. A., Puteh, F., & Hassim, A. A. (2018). Aging Workforce: A Challenge for Malaysia. *Journal of Administrative Science Special Edition: ICOPS*, *15(3*), 1–13.

Hamid, A. R. A., Muhamad, N., Zakaria, R., Aminuddin, E., Alwee, A. A., & Tok, A. (2018). The challenges of the ageing population on the Malaysian construction industry. *In Journal of Physics: Conference Series, IOP Publishing,* *1*(1049), 012034. https://iopscience.iop.org/article/10.1088/1742-6596/1049/1/012034/meta

Hammarberg, K., Johnson, L., Bourne, K., Fisher, J., & Kirkman, M. (2014). Proposed legislative change mandating retrospective release of identifying information: consultation with donors and Government response. *Human Reproduction*, *29*, 286–292. https://doi.org/10.1093/humrep/det434

Hammarberg, K., Kirkman, M., & Lacey, S. (2016). Qualitative research methods: when to use them and how to judge them. *Human Reproduction*, *31*(3), 498–501. https://doi.org/10.1093/humrep/dev334

Haneda, S., & Ito, K. (2018). Organizational and human resource management and innovation: Which management practices are linked to product and/or process innovation? *Research Policy*, *47*(1), 194-208. https://doi.org/10.1016/j.respol.2017.10.008

Hao, Q., Kasper, H., & Muehlbacher, J. (2012). How does organizational structure influence performance through learning and innovation in Austria and China. *Chinese Management Studies,* 6*(1), 36–52.* https://doi.org/10.1108/17506141211213717

Haraguchi, N., Cheng, C. F. C., & Smeets, E. (2017). The importance of manufacturing in economic development: Has this changed? *World Development*, *93*, 293-315. https://doi.org/10.1016/j.worlddev.2016.12.013

Harteis, C. (2018). Machines, change and work: An educational view on the digitalization of work, In *The impact of digitalization in the workplace* (pp. 1-10). Springer, Cham.

Hashim, J., & Wok, S. (2013). Competence as a moderator of older workers' trainability and performance. *Economics & Management Sciences, International Islamic University Malaysia*. 1-22. https://www.ufhrd.co.uk/wordpress/wp-content/uploads/2013/10/Hashim-Wok-full-paper.pdf

Hassan, M. U., Iqbal, Z., Malik, M., & Ahmad, M. I. (2018). Exploring the role of technological developments and open innovation in the survival of SMEs: an empirical study of Pakistan. *International Journal of Business Forecasting and Marketing Intelligence, 4*(1), 64-85. https://doi.org/10.1504/IJBFMI.2018.088629

Hatane, S. E. (2015). Employee satisfaction and performance as intervening variables of learning organization on financial performance. *Procedia-Social and Behavioral Sciences*, *211*, 619-628. https://doi.org/10.1016/j.sbspro.2015.11.081

Hatcher, L. (1994). *A step-by-step approach to using the SAS system for factor analysis and structural equation modeling*. Cary, NC: SAS Institute Inc.

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic Approach for Human Resource Management in Industry 4.0. *Procedia CIRP*, *54*, 1–6. https://doi.org/10.1016/j.procir.2016.05.102

Henkens, K., & Schippers, J. (2009). Dealing with older workers in Europe: a comparative survey of employers' attitudes and actions. *Journal of European Social Policy*, *19*(1), 47–60. https://doi.org/10.1177%2F0958928708098523

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the academy of marketing science*, *43*(1), 115-135.

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). *The use of partial least squares path modeling in international marketing,* In *New challenges to international marketing* (pp. 277–319). Emerald Group Publishing Limited.

Hermann, M., Pentek, T., & Otto, B. (2016, January). Design principles for industrie 4.0 scenarios. In *2016 49th Hawaii international conference on system sciences (HICSS)* (pp. 3928-3937). IEEE.

Hertel, G., & Zacher, H. (2018). *Managing the Aging Workforce* (2nd ed.). The SAGE Handbook of Industrial, Work, & Organizational Psychology.

Hiebl, M. R., & Richter, J. F. (2018). Response rates in management accounting survey research. *Journal of Management Accounting Research*, *30*(2), 59-79. https://doi.org/10.2308/jmar-52073

Hilton, C. E. (2017). The importance of pretesting questionnaires: a field research example of cognitive pretesting the Exercise referral Quality of Life Scale (ER-QLS). *International Journal of Social Research Methodology*, *20*(1), 21–34. https://doi.org/10.1080/13645579.2015.1091640

Hinton, P., Brownlow, C., McMurray, I., & Cozens, B. (2004). Using SPSS to analyse questionnaires: Reliability. *SPSS explained*, 356-366.

Hirst, G., Van Knippenberg, D., Chen, C. H., & Sacramento, C. A. (2011). How does bureaucracy impact individual creativity? A cross-level investigation of team contextual influences on goal orientation–creativity relationships. *Academy of Management Journal*, *54*(3), 624-641. https://doi.org/10.5465/amj.2011.61968124

Hitt, M. A., Jackson, S. E., Carmona, S., Bierman, L., Shalley, C. E., & Wright,

M. (2017). *The Oxford handbook of strategy implementation*. Oxford University Press.

Ho, C. T. (2009). The relationship between knowledge management enablers and performance. *Industrial Management & Data Systems*, *109*(1), 98-117. https://doi.org/10.1108/02635570910926618

Hollway, W. (2018). *The importance of relational thinking in the practice of psycho-social research: Ontology, epistemology, methodology, and ethics*. Routledge.

Howaldt, J., & Beerheide, E. (2010). Innovationsmanagement im Enterprise 2.0–Auf dem Weg zu einem neuen Innovationsparadigma?. In *Soziale Innovation* (pp. 355-370). VS Verlag für Sozialwissenschaften.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Huang, W. H., Lin, Y. J., & Lee, H. F. (2019). Impact of population and workforce aging on economic growth: case study of Taiwan. *Sustainability, 11*(22), 6301. https://doi.org/10.3390/su11226301

Hughes, J. (2007, January). The ability-motivation-opportunity framework for behavior research in IS. In *2007 40th Annual Hawaii International Conference on System Sciences (HICSS'07)* (pp. 250a-250a). IEEE.

Ibarra, D., Ganzarain, J., & Igartua, J. I. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing*, *22*, 4-10. https://doi.org/10.1016/j.promfg.2018.03.002

Edelman Intelligence. (2018). *GE Global Innovation Barometer 2018 Full Report ONE: Introduction to the GE Global Innovation Barometer (GIB) 2018*. https://s3.amazonaws.com/dsg.files.app.content.prod/gereports/wp-content/uploads/2018/02/12141110/GE_Global_Innovation_Barometer_2018-Full_Report.pdf

International Labour Organization. (2015). *What age means for the labour force*. https://www.ilo.org/global/about-the-ilo/multimedia/audio/WCMS_358943/lang--en/index.htm

Islam, M. Z., Jasimuddin, S. M., & Hasan, I. (2015). Organizational culture, structure, technology infrastructure and knowledge sharing. *VINE*, *45*(1), 67–88. https://doi.org/10.1108/VINE-05-2014-0037

Islam, M. Z., Jasimuddin, S. M., & Hasan, I. (2017). The role of technology and socialization in linking organizational context and knowledge conversion: The case of Malaysian Service Organizations. *International Journal of Information Management*, *37*(5), 497-503. https://doi.org/10.1016/j.ijinfomgt.2017.06.001

Ismail, N. W., Rahman, H. S. W. A., & Hamid, T. A. T. A. (2015). Does population aging affect economic growth in Malaysia. *Prosiding Perkem*, *10*, 205-210. http://www.ukm.my/fep/perkem/pdf/perkem2015/PERKEM_2015_2C1.pdf

Ivanov, D., Dolgui, A., Sokolov, B., Werner, F., & Ivanova, M. (2016). A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0. *International Journal of Production Research*, *54*(2), 386–402. https://doi.org/10.1080/00207543.2014.999958

Jafri, M. H. (2010). Organizational commitment and employee's innovative behavior: A study in retail sector. *Journal of Management Research*, *10*(1), 62-68. https://www.indianjournals.com/ijor.aspx?target=ijor:jmr&volume=10&issue=1&article=005

James, A. T., Kumar, G., Tayal, P., Chauhan, A., Wadhawa, C., & Panchal, J. (2022). Analysis of human resource management challenges in implementation of industry 4.0 in Indian automobile industry. *Technological Forecasting and Social Change*, *176*, 121483.

Janićijević, N. (2013). The mutual impact of organizational culture and structure. *Economic annals*, *58*(198), 35-60. http://www.doiserbia.nb.rs/Article.aspx?id=0013-32641398035J#.YT2RB50zbIU

Jawale, K. V. (2012). Methods of sampling design in the legal research: Advantages and disadvantages. *Online International Interdisciplinary Research Journal*, *2(6*), 183-190.

Johansson, S., Kullström, M., Björk, J., Karlsson, A., & Nilsson, S. (2020). Digital production innovation projects–The applicability of managerial controls under high levels of complexity and uncertainty. *Journal of Manufacturing Technology Management,* *32*(3), 772-794. https://doi.org/10.1108/JMTM-04-2019-0145

Johns, G. (2010). Presenteeism in the workplace: A review and research agenda. *Journal of Organizational Behavio*r, *31*(4), 519–542. https://doi.org/10.1002/job.630

Jones, C., & Pimdee, P. (2017). Innovative ideas: Thailand 4.0 and the fourth industrial revolution. *Asian International Journal of Social Sciences*, *17*(1), 4-35.

Joseph, J., & Gaba, V. (2020). Organizational structure, information processing, and decision-making: a retrospective and road map for research. *Academy of Management Annals*, *14*(1), 267-302. https://doi.org/10.29139/aijss.20170101

Juhary, J. (2019). IR4. 0 Ready and Aware Academics at the National Defence University of Malaysia, *In Redesigning Higher Education Initiatives for Industry 4.0* (pp. 284-303). IGI Global.

Kagermann, H., Helbig, J., & Wahlster, W. (2013). *Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; final report of the Industrie 4.0 Working Group*. Forschungsunion.

Kaliappen, N., & Abdullah, H. H. (2014). Does service innovation act as a mediator in differentiation strategy and organizational performance nexus? An empirical study. *Asian Social Science*, *10*(11), 123-131. http://doi.org/10.5539/ass.v10n11p123

Kamaruddeen, A. M., Yusof, N. A., Said, I., & Pakir, A. H. K. (2012). Organizational factors and innovativeness of housing developers. *American Journal of Applied Sciences*, *9*(12), 1953. https://doi.org/10.3844/ajassp.2012.1953.1966

Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., … Noh, S. Do. (2016). Smart manufacturing: Past research, present findings, and future directions. *International Journal of Precision Engineering and Manufacturing-Green Technology*, *3*(1), 111–128. https://link.springer.com/article/10.1007%2Fs40684-016-0015-5

Kearney, A. (2018). *Readiness for the future of production report 2018*. In World economic forum. http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf

Kelly, M., & Ó Gráda, C. (2019). Speed under sail during the early industrial revolution (c. 1750–1830). *The Economic History Review, 72*(2), 459-480. https://doi.org/10.1111/ehr.12696

Kesting, P., & Ulhøi, J. P. (2010). Employee-driven innovation: extending the license to foster innovation. *Management decision*, *48*(1), 65-84. https://doi.org/10.1108/00251741011014463

Khanzada, B., Naeem, S., & Butt, H. (2018). Impact of transformational leadership on job satisfaction and patient safety outcomes in health sector of Pakistan. *J Heal Educ Res Dev*, *6*(02), 1-10. https://doi.org/ 10.4172/2380-5439.1000251

Kianto, A., Sáenz, J., & Aramburu, N. (2017). Knowledge-based human resource management practices, intellectual capital and innovation. *Journal of Business Research*, *81*, 11-20. https://doi.org/10.1016/j.jbusres.2017.07.018

Kiel, D., Müller, J. M., Arnold, C., & Voigt, K. I. (2020). Sustainable industrial value creation: Benefits and challenges of industry 4.0. In *Digital Disruptive Innovation* (pp. 231-270).

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd Ed.). New York: Guilford. http://psycnet.apa.org/record/2005-03476-000

Kocak, O. (2011). A field study of challenges faced by aging workforce. *Journal of Yaşar University*, *6*(24), 3913–3931. https://dergipark.org.tr/en/pub/jyasar/issue/19136/203063

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration* (ijec), *11*(4), 1-10. https://doi.org/ 10.4018/ijec.2015100101

Kontoghiorghes, C., Awbre, S. M., & Feurig, P. L. (2005). Examining the relationship between learning organization characteristics and change adaptation, innovation, and organizational performance. *Human resource development quarterly*, *16*(2), 185-212. https://doi.org/10.1002/hrdq.1133

Korotayev, A., Zinkina, J., & Bogevolnov, J. (2011). Kondratieff waves in global invention activity (1900–2008). *Technological Forecasting and Social Change*, *78*(7), 1280–1284.

Kowalczyk, D. (2015). Purposes of research: Exploratory, descriptive &

explanatory. *Academic. Psychology*, *105*. https://doi.org/10.1016/j.techfore.2011.02.011

KPMG. (2020). *Our New Reality*. https://home.kpmg/my/en/home/insights/2020/03/the-business-implications-of-coronavirus.html

Kumar, R. (2005). *Research Methodology a step by step guide for beginners*. Sage Publications.

Kumar, S. C., & Kothari, H. (2018). Pilot Test for Reliability and Validity of the Study on Exploring Factors of Training Effectiveness for it Competency among the Employees of Public Sector Banks. *Splint International Journal of Professionals,* *5*(3), 33-44. https://www.proquest.com/openview/21ed05b2f15a3b0328da07dcb2af8bec/1?pq-origsite=gscholar&cbl=2044944

Kuo, C. C., Shyu, J. Z., & Ding, K. (2019). Industrial revitalization via industry 4.0–A comparative policy analysis among China, Germany and the USA. *Global transitions*, *1*, 3-14.

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models*. McGraw-Hill New York.

Lallmahomed, M. Z. L., Rahim, N. Z. A., Ibrahim, R., & Rahman, A. A. (2013). Predicting different conceptualizations of system use: acceptance in hedonic volitional context (Facebook). *Computers in Human Behavior*, *29*(6), 2776–2787. https://doi.org/10.1016/j.chb.2013.07.018

Lam, A. (2004). Organizational Innovation. BRESE, School of Business and Management. *Brunel University. West London. Apr*, (1), 44.

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & information systems engineering*, *6*(4), 239-242. https://doi.org/10.1007/s12599-014-0334-4

Laukkanen, T. (2015, January). How uncertainty avoidance affects innovation resistance in mobile banking: The moderating role of age and gender, *In 2015 48th Hawaii International Conference on System Sciences* (pp. 3601-3610). IEEE.

Lee, H., & Kelley, D. (2008). Building dynamic capabilities for innovation: An exploratory study of key management practices. *R and D Management*, *38*(2), 155–168. https://doi.org/10.1111/j.1467-9310.2008.00506.x

Lee, J. H., Phaal, R., & Lee, S.-H. (2013). An integrated service-device-technology roadmap for smart city development. *Technological Forecasting and Social Change*, *80*(2), 286–306.

Lee, J. Y., Kozlenkova, I. V., & Palmatier, R. W. (2015). Structural marketing: Using organizational structure to achieve marketing objectives. *Journal of the Academy of Marketing Science*, *43*(1), 73-99. https://doi.org/10.1016/j.techfore.2012.09.020

Lee, J., Kao, H., & Yang, S. (2014). Service innovation and smart analytics for Industry 4 . 0 and big data environment. *Procedia CIRP*, *16*, 3–8. https://doi.org/10.1016/j.procir.2014.02.001

Lee, J., Min, J., & Lee, H. (2016). The effect of organizational structure on open innovation: a quadratic equation. *Procedia Computer Science, 91*, 492-501. https://doi.org/10.1016/j.procs.2016.07.128

Lee, J., Park, J. S., & Lee, J. (2020). The impact of multimarket competition on innovation strategy: Evidence from the korean mobile game industry. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(1), 14. https://doi.org/10.3390/joitmc6010014

Lee, W. L., Chong, A. L., & Ramayah, T. (2019). The effects of entrepreneurial orientation on the performance of the Malaysian manufacturing sector. *Asia-Pacific Journal of Business Administration*, *11*(1), 30-45. https://doi.org/10.1108/APJBA-06-2018-0099

Leiponen, A. (2006). Managing knowledge for innovation: the case of business-to-business services. *Journal of product innovation management*, *23*(3), 238-258. https://doi.org/10.1111/j.1540-5885.2006.00196.x

Leong, L. Y., Hew, T. S., Tan, G. W. H., & Ooi, K. B. (2013). Predicting the determinants of the NFC-enabled mobile credit card acceptance: a neural networks approach. *Expert Systems with Applications, 40* (14), 5604 – 5620. https://doi.org/10.1016/j.eswa.2013.04.018

Leroy, H., Segers, J., Dierendonck, D. Van, & Hartog, D. Den. (2018). Managing people in organizations: Integrating the study of HRM and leadership. *Human Resource Management Review*, *28*(3), 249–257. https://doi.org/10.1016/j.hrmr.2018.02.002

Li, L. (2018). China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0". *Technological Forecasting and Social Change*, *135*, 66-74.

Liao, Y., Deschamps, F., Loures, E. D. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal. *International journal of production research, 55(12)*, 3609-3629.

Lien, B. Y. H., Hung, R. Y. Y., Yang, B., & Li, M. (2006). Is the learning organization a valid concept in the Taiwanese context?. *International Journal of Manpower,* 27*(2), 189-203.* https://doi.org/10.1108/01437720610666209

Lin, L. (2011). Electronic human resource management and organizational innovation: The roles of information technology and virtual organizational structure. *International Journal of Human Resource Management*, *22*(2), 235–257. https://doi.org/10.1080/09585192.2011.540149

Lin, R. J., Chen, R. H., & Chiu, K. K. S. (2010). Customer relationship management and innovation capability: an empirical study. *Industrial Management & Data Systems, 110*(1), 111-133. https://doi.org/10.1108/02635571011008434

Lin, T. C., Hsu, J. S. C., Cheng, H. L., & Chiu, C. M. (2012). Exploring Individuals' Loyalty To Online Support Groups From the Perspective Of Social Support. In *PACIS* (p. 103). http://aisel.aisnet.org/pacis2012/103

Lindell, M. K., & Whitney, D. J. (2001). Accounting for common method variance in cross-sectional research designs. *Journal of Applied Psychology*, *86*(1), 114–121. https://doi.org/10.1037/0021-9010.86.1.114

Liu, Y., Lv, D., Ying, Y., Arndt, F., & Wei, J. (2018). Improvisation for innovation: The contingent role of resource and structural factors in explaining innovation capability. *Technovation, 74*, 32-41. https://doi.org/10.1016/j.technovation.2018.02.010

Long, C. S., & Khairuzzaman, W. (2008). Human Resource Competencies: A Study of the HR Professionals in Manufacturing Firms in Malaysia. *International Management Review*, *4*(2), 65–76.

Loskyll, M. (2013). *Entwicklung einer Methodik zur dynamischen kontextbasierten Orchestrierung semantischer Feldgerätefunktionalitäten*. Techn. Univ.

Lowry, P. B., & Gaskin, J. (2014). Partial least squares (PLS) structural equation modeling (SEM) for building and testing behavioral causal theory: When to choose it and how to use it. *IEEE transactions on professional communication*, *57*(2), 123-146. https://ieeexplore.ieee.org/abstract/document/6803892

Lukes, M., & Stephan, U. (2017). Measuring employee innovation. *International Journal of Entrepreneurial Behavior & Research*, *23*(1), 136–158. https://doi.org/10.1108/IJEBR-11-2015-0262

Lynn, M. (1986). Determination and quantification of content validity. *Nursing Research, 35*(6), 382–385. https://doi.org/10.1097/00006199-198611000-00017

Maaß, F., & Führmann, B. (2012). *Innovationstätigkeit im Mittelstand: Messung und Bewertung* (No. 212). IfM-Materialien. https://www.econstor.eu/handle/10419/55666

Maavak, M., & Ariffin, A. S. (2018). Is Malaysia Ready for the Fourth Industrial Revolution?: The Automotive Sector as an i4. 0 Springboard. In *Analyzing the Impacts of Industry 4.0 in Modern Business Environments* (pp. 41-64). IGI Global.

Mabey, C., Kulich, C., & Lorenzi-Cioldi, F. (2012). Knowledge leadership in global scientific research. *The International Journal of Human Resource Management*, *23*(12), 2450–2467. https://doi.org/10.1080/09585192.2012.668386

MacDougall, W. (2014). *Industrie 4.0: Smart manufacturing for the future*. Germany Trade & Invest. https://doi.org/10.1007/978-3-642-36917-9

Mack, L. (2010). The Philosophical Underpinnings of Educational Research. *Polyglossia, 19,* 5-11.

Mafabi, S., Munene, J., & Ntayi, J. (2012). Knowledge management and organisational resilience: Organisational innovation as a mediator in Uganda parastatals. *Journal of Strategy and Management, 5*(1), 57-80. https://doi.org/10.1108/17554251211200455

Mahmoudsalehi, M., Moradkhannejad, R., & Safari, K. (2012). How knowledge management is affected by organizational structure. *The Learning Organization*, *19*(6), 518–528. https://doi.org/10.1108/09696471211266974

Malaysia, D. O. S. (2019, September 12). Department of Statistics Malaysia, Official Portal. *https://www. dosm. gov. my/v1*.

Mamoun, Y., Wafa, S. A., & Hassan, R. A. (2020). The Impact of HR Strategy on Knowledge Capability in The Malaysian Electrical and Electronics firms. *Journal of the Asian Academy of Applied Business (JAAAB),* 31. https://doi.org/10.51200/jaaab.v0i0.2013

Manimaran, K. K., Vikneswaran, S., Ng, S. Y., & Chiew, W. L. (2017). Sexual and reproductive health implementation in Malaysia. *International Journal of Public Health and Clinical Sciences*, *4*(6), 12-21. http://publichealthmy.org/ejournal/ojs2/index.php/ijphcs/article/view/525

Federation of Malaysian Manufacturers. (2018). *Member List*. *http://www.fmm.org.my/Member_List.aspx?SearchType=Company*

Marimuthu, M., & Bidin, Z. (2016). Awareness, attitude and probable area of difficulties towards the proposed goods and services tax in Malaysia. *International Review of Management and Marketing*, *6*(S8), 175-180. http://repo.uum.edu.my/20777/

Marín-Idárraga, D. A., & Cuartas, J. C. (2016). Organizational structure and innovation: Analysis from the strategic co-alignment. *Academia Revista Latinoamericana de Administración*, *29*(4), 388-406.

Marques, M., Agostinho, C., Zacharewicz, G., & Jardim-Gonçalves, R. (2017). Decentralized decision support for intelligent manufacturing in Industry 4.0. *Journal of Ambient Intelligence and Smart Environments*, *9*(3), 299-313. https://content.iospress.com/articles/journal-of-ambient-intelligence-and-smart-environments/ais436

Martins, E. C., & Terblanche, F. (2003). Building organisational culture that stimulates creativity and innovation. *European Journal of Innovation Management*, *6*(1), 64–74. https://doi.org/10.1108/14601060310456337

MATRADE. (2020, January 1st). *Malaysia's Exports by Main Sectors*. Retrieved January 16, 2020, from http://www.matrade.gov.my/en/malaysian-exporters/services-for-exporters/trade-market-information/trade-statistics/28-malaysian-exporters/trade-statistics/5083-malaysias-exports-by-main-sectors-2020

Matthyssens, P. (2019). Reconceptualizing value innovation for Industry 4.0 and the Industrial Internet of Things. *Journal of Business & Industrial Marketing*, *34*(6), 1203-1209. https://doi.org/10.1108/JBIM-11-2018-0348

Matusik, S. F., & Heeley, M. B. (2005). Absorptive capacity in the software industry: Identifying dimensions that affect knowledge and knowledge creation activities. *Journal of Management*, *31*(4), 549-572. https://doi.org/10.1177%2F0149206304272293

McKinsey, G. I. (2012). *Manufacturing the future: The next era of global growth and innovation*. McKinsey Global Institute.

McManus, S. T. (2008). *Organisational resilience in New Zealand* (Dissertations, University of Canterbury). University of Canterbury. http://dx.doi.org/10.26021/1351

Mehmood, K., & Hussain, A. (2017, November). Knowledge-oriented leadership and innovation: A mediating role of knowledge creation: A case of software industry. In *2017 4th International Conference on Systems and Informatics (ICSAI)* (pp. 1647-1651). IEEE.

Menard, S. (2002). *Applied logistic regression analysis* (Vol. 106). SAGE.

Metallo, C., Agrifoglio, R., Schiavone, F., & Mueller, J. (2018). Understanding business model in the Internet of Things industry. *Technological Forecasting and Social Change*, *136,* 298-306. https://doi.org/10.1016/j.techfore.2018.01.020

Malaysian Investment Development Authority. (2018). *Malaysian Exports.* http://www.mida.gov.my/home/useful-links/posts/

Ministry of International Trade & Industry. (2018). *National industry 4.0 Policy Framework.*

Ministry of International Trade and Industry. (2018, July 1). *Funding the Transformation of Industrial Revolution 4.0 in Malaysia*. https://www.miti.gov.my/miti/resources/15._F1_._Funding_the_Transformation_of_Industrial_Revolution_4_.0_in_Malaysia_.pdf

Ministry of International Trade and Industry. (2018, August 1). *National Policy on Industry 4.0*. https://www.miti.gov.my/miti/resources/National Policy on Industry 4.0/Industry4WRD_Final.pdf

Mohd Mokhtar, S. S., Yusoff, R. Z., & Arshad, R. (2009). Market orientation critical success factors of Malaysian manufacturers and its impact on financial performance. *International Journal of Marketing Studies*, *1*(1), 77-84. http://repo.uum.edu.my/2836/

Mohelska, H., & Sokolova, M. (2018). Managemetn Approaches for Industry 4.0 - The Organizational Cultural Perspective. *Technological and Economic Development of Economy, 24*(6), 2225–2240. https://doi.org/10.3846/tede.2018.6397

Mohsenabad, A. S., & Azadehdel, M. (2016). The impact of knowledge-oriented leadership on innovation performance of manufacturing and commercial companies of Guilan province. *International Journal of Humanities and Cultural Studies Issn, 3*(1), 2356–5926. http://www.ijhcs.com/index.php/ijhcs/article/view/1389

Moktadir, M. A., Ali, S. M., Kusi-Sarpong, S., & Shaikh, M. A. A. (2018). Assessing challenges for implementing Industry 4.0: Implications for process safety and environmental protection. *Process safety and environmental protection*, *117*, 730-741.

Molina, L. M., Montes, J. L., & Ruiz-Moreno, A. (2007). Relationship between quality management practices and knowledge transfer. *Journal of Operations Management*, *25* (3), 682 – 701. https://doi.org/10.1016/j.jom.2006.04.007

Monostori, L. (2014). Cyber-physical Production Systems: Roots, Expectations and R&D Challenges. *Procedia CIRP*, *17,* 9–13. https://doi.org/10.1016/j.procir.2014.03.115

Mudin, D. K. D., How, S. E., Rahman, M. M., Ibrahim, P., & Jopony, M. (2018). Industrial revolution 4.0: Universiti Malaysia Sabah perspective, *In E3S Web of Conferences* (Vol. 48, p. 03005). EDP Sciences.

Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Technological Forecasting & Social Change Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting & Social Change, 132*, 2–17. https://doi.org/10.1016/j.techfore.2017.12.019

Murthy, U., Abdullah, N., & Abdullah, H. (2019). Participation of Aging Workkers and Their Productivity in Malaysia Labour Market. *Journal of Social Sciences and Humanities*, *16*(1), 1–10. https://ejournal.ukm.my/ebangi/article/view/31739

Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy*, *48*(8), 103773. https://doi.org/10.1016/j.respol.2019.03.018

Naqshbandi, M. M., & Jasimuddin, S. M. (2018). Knowledge-oriented leadership and open innovation: Role of knowledge management capability in France-based multinationals. *International Business Review, 27*(3), 701-713. https://doi.org/10.1016/j.ibusrev.2017.12.001

Nardi, P. M. (2018). *Doing survey research: A guide to quantitative methods*. Routledge.

Nguyen, H. N., & Mohamed, S. (2011). Leadership behaviors, organizational culture and knowledge management practices: An empirical investigation. *Journal of Management Development*, *30*(2), 206–221. https://doi.org/10.1108/02621711111105786

Niu, P., Xie, F., & Leonard, T. (2010). Empirical study of the relations between the knowledge base and innovation performance of an economy. *Journal of Knowledge-based innovation in China*, *2*(2), 171-185. https://doi.org/10.1108/17561411011054805

Nonaka, I., & Takeuchi, H. (2007). The knowledge-creating company. *Harvard business review*, *85*(7/8), 162. https://memberfiles.freewebs.com/84/90/65819084/documents/The%20Knowledge-Creating%20Company.pdf

Nonaka, I., & Takeuchi, H. (2011). The wise leader. *Harvard Business Review*, *89*(5), 58–67. http://www.ncbi.nlm.nih.gov/pubmed/21548419

Nunnally, J. C. (1978). *Psychometric theory*. New York: McGraw-Hill, Inc.

O'Grady, W. (2019). Enabling control in a radically decentralized organization. *Qualitative Research in Accounting & Management*, *16*(2), 224-251. https://doi.org/10.1108/QRAM-07-2017-0065

Obeidat, B. Y., & Abdallah, A. B. (2014). The relationships among human resource management practices, organizational commitment, and knowledge management processes: A structural equation modeling approach. *International Journal of Business and Management*, *9*(3), 9.

Ochs, T., & Riemann, U. (2017). Industry 4.0: How to manage transformation as the new normal, *In The Palgrave Handbook of Managing Continuous Business Transformation* (pp. 245-272). Palgrave Macmillan, London.

Okazaki, S., Castañeda, J. A., Sanz-Blas, S., & Henseler, J. (2012). Factors affecting mobilebased diabetes monitoring adoption: initial responses from

Japanese physicians. *Journal of Medical Internet Research*, *14* (6), e183. https://doi.org/10.2196/jmir.2159.

Olinsky, A., Chen, S., & Harlow, L. (2003). The comparative efficacy of imputation methods for missing data in structural equation modeling. *European Journal of Operational Research, 151(*1), 53-79. https://doi.org/10.1016/S0377-2217(02)00578-7

Olsson, J. G., & Yuanjing, X. (2018). Title: Industry 4.0 Adoption in the Manufacturing Process. Multiple case study of electronic manufacturers and machine manufacturers. *Linneuniversitetet Kalmar Vaxjo*. https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1213259&dswid=5139

Oosthuizen, J. (2017, September). The determinants of fourth industrial revolution leadership dexterity: A proposed framework for 4ir-intelligence and subsequent 4ir leadership development. In *4th International Conference on Responsible Leadership* (pp. 243-259).

Özüdoğru, A. G., Ergün, E., Ammari, D., & Görener, A. (2018). How Industry 4.0 Changes Business: A Commercial Perspective. *International Journal of Commerce and Finance*, *4*(1), 84–95. http://ijcf.ticaret.edu.tr/index.php/ijcf/article/view/72

Paauwe, J., & Boselie, P. (2005). HRM and performance: what next?. *Human resource management journal*, *15*(4), 68-83. https://doi.org/10.1111/j.1748-8583.2005.tb00296.x

Palazzeschi, L., Bucci, O., & Di Fabio, A. (2018). Re-thinking innovation in organizations in the industry 4.0 scenario: New challenges in a primary prevention perspective. *Frontiers in psychology*, *9*, 30. https://doi.org/10.3389/fpsyg.2018.00030

Pandiyan, M. V. (2017, September 6). *Industry 4.0: The future is here - Along The Watchtower | The Star Online.* The Star. https://www.thestar.com.my/opinion/columnists/along-the watchtower/2017/09/06/industry-40-the-future-is-here-malaysia-cannot-afford-to-lag-in-a-world-facing-swift-exponential-cha/

Park, J. (2018). Aging workforce and organization innovation: curvilinearity and the moderating role of age diversity. *Journal of the Korea Academia-Industrial Cooperation Society*, *19*(6), 440–446. https://doi.org/10.5762/KAIS.2018.19.6.440

Pease, G. (2017). Optimize Your Greatest Asset-Your People. *Personnel Psychology*, *70*(3), 717–719.

Peng, T. N., Tho, N. S., & Pei, T. P. (2014). Population projection for development planning in Malaysia. *Revisiting Malaysia's Population–Development Nexus, 39*. http://www.statistics.gov.my

Petrillo, A., De Felice, F., Cioffi, R., & Zomparelli, F. (2018). Fourth industrial revolution: Current practices, challenges, and opportunities. *Digital transformation in smart manufacturing*, 1-20. https://dx.doi.org/10.5772/intechopen.72304

Pielsticker, D. I., & Hiebl, M. R. (2020). Survey response Rates in family business research. *European Management Review*, *17*(1), 327-346.

https://doi.org/10.1111/emre.12375

Pohlmann, E. G. (2008). *Methodik zur prozessorientierten Planung serviceorientierter Fabriksteuerungssysteme*. Techn. Univ.

Polit, D. F., & Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? critique and recommendations. *Research in Nursing & Health*, *29*(5), 489–497. https://doi.org/10.1002/nur.20147

Politis, J. D. (2001). The relationship of various leadership styles to knowledge management. *Leadership & Organization Development Journal*, *22*(8), 354-364. https://doi.org/10.1108/01437730110410071

Porter, C. E., & Donthu, N. (2006). Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics. *Journal of Business Research*, *59*(9), 999–1007. https://doi.org/10.1016/j.jbusres.2006.06.003

Poscia, A., Moscato, U., La Milia, D. I., Milovanovic, S., Stojanovic, J., Borghini, A., ... & Magnavita, N. (2016). Workplace health promotion for older workers: a systematic literature review. *BMC health services research*, *16*(5), 415-428. https://link.springer.com/article/10.1186/s12913-016-1518-z

Posthuma, R. A., & Campion, M. A. (2009). Age Stereotypes in the Workplace: Common Stereotypes, Moderators, and Future Research Directions†. *Journal of Management*, *35*(1), 158–188. https://doi.org/10.1177%2F0149206308318617

Prajogo, D., & McDermott, C. M. (2014). Antecedents of service innovation in SMEs: Comparing the effects of external and internal factors. *Journal of Small Business Management*, *52*(3), 521-540. https://www.tandfonline.com/doi/abs/10.1111/jsbm.12047

Prause, G. (2015). Sustainable business models and structures for Industry 4.0. *Journal of Security & Sustainability Issues*, *5*(2). https://dx.doi.org/10.9770/jssi.2015.5.2(3

Prause, M. (2019). Challenges of industry 4.0 technology adoption for SMEs: the case of Japan. *Sustainability*, *11*(20), 5807.

Prince, K. A. (2017). Association for Information Systems AIS Electronic Library (AISeL) Industrie 4.0 and Leadership. *Iceb*, 132–139.

Pundt, A., Martins, E., & Nerdinger, F. W. (2010). Innovative Behavior and the Reciprocal Exchange between Employees and Organizations. *German Journal of Human Resource Management*, *24*(2), 173–193. https://doi.org/10.1177%2F239700221002400205

Puschel, J., & Mazzon, J. A. (2010). Mobile banking: proposition of an integrated adoption intention framework. *International Journal of Bank Marketing*, *28* (5), 389 – 409. https://doi.org/10.1108/02652321011064908

Rajagopal, P., Leong, J. T. C., & Khuan, L. S. (2018). The impact of industry 4.0 on supply chain. In L. S. Khuan & S. R. Raman (Eds.), *Emerging Technologies for Supply Chain Management* (62-74). WouPress. Http://www.wou.edu.my

Ramakrishnan, P., Haron, H., & Goh, Y. N. (2015). Factors influencing green purchasing adoption for small and medium enterprises (SMEs) in Malaysia. *International Journal of Business and Society*, *16*(1). https://doi.org/10.33736/ijbs.552.2015

Ramayah, T., Lee, J. W. C., & In, J. B. C. (2011). Network collaboration and performance in the tourism sector. *Service Business*, *5*(4), 411-428. https://link.springer.com/article/10.1007/s11628-011-0120-z

Reddy, S. K., & Reinartz, W. (2017). Digital transformation and value creation: Sea change ahead. *Marketing Intelligence Review*, *9*(1), 10-17. https://doi.org/10.1515/gfkmir-2017-0002

Reischauer, G. (2018). Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing. *Technological Forecasting and Social Change*, *132*, 26-33. https://doi.org/10.1016/j.techfore.2018.02.012

Rehman, H. M., Au Yong, H. N, & Choong, Y. O. (2021). Impact of management practices on organisational innovation in the digital age: A study of the manufacturing industry in Malaysia. *International Journal of Management Studies*, *28*(2), 73-101. doi:10.32890/ijms2021.28.2.4

Rehman, H. M., Au Yong, H. N, & Choong, Y. O. (2019). Organization innovation for Industry 4.0 in management perspective. In *International Conference on Business, Accounting, Finance and Economics (BAFE, 2019)* (pp. 226-233).

Revilla, M. A., Saris, W. E., & Krosnick, J. A. (2014). Choosing the Number of Categories in Agree-Disagree Scales. *Sociological Methods & Research*, *43*(1), 73–97. https://doi.org/10.1177%2F0049124113509605

Ribiere, V. M., & Sitar, A. S. (2003). Critical role of leadership in nurturing a knowledge-supporting culture. *Knowledge Management Research & Practice*, *1*(1), 39-48. https://link.springer.com/article/10.1057/palgrave.kmrp.8500004

Rietzschel, E. F., & Zacher, H. (2015). Workplace creativity, innovation, and age. *Encyclopedia of geropsychology*. https://doi.org/10.1007/978-981-287-080-3_202-1

Ringle, C. M., Wende, S., & Will, A. (2005). *Smart PLS 2.0*. Hamburg: University of Hamburg.

Ronzani, C. M., da Costa, P. R., da Silva, L. F., Pigola, A., & de Paiva, E. M. (2020). Qualitative methods of analysis: an example of Atlas. TI™ Software usage. *Revista Gestão & Tecnologia*, *20*(4), 284-311.

Rogerson, P.A. (2001). *Statistical Methods for Geography*. London: Sage.

Romero, D., Stahre, J., Wuest, T., Noran, O., Bernus, P., Fast-Berglund, Å., & Gorecky, D. (2016, October). Towards an operator 4.0 typology: a human-centric perspective on the fourth industrial revolution technologies, *In proceedings of the international conference on computers and industrial engineering (CIE46), Tianjin, China*, pp. 29-31. https://www.researchgate.net/profile/David-Romero-32/publication/309609488_Towards_an_Operator_40_Typology_A_Human-Centric_Perspective_on_the_Fourth_Industrial_Revolution_Technologies/links/58e435e7a6fdccc85bdf36fa/Towards-an-Operator-40-Typology-A-

Human-Centric-Perspective-on-the-Fourth-Industrial-Revolution-Technologies.pdf

Rosenbloom, R. S. (2000). Leadership, capabilities, and technological change: The transformation of NCR in the electronic era. *Strategic Management Journal*, *21*(10-11), 1083-1103. https://doi.org/10.1002/1097-0266(200010/11)21:10/11%3C1083::AID-SMJ127%3E3.0.CO;2-4

Rosing, K., Frese, M., & Bausch, A. (2011). Explaining the heterogeneity of the leadership-innovation relationship: Ambidextrous leadership. *The Leadership Quarterly*, *22*(5), 956–974. https://doi.org/10.1016/j.leaqua.2011.07.014

Rubin, G. D., & Abramson, R. G. (2018). Creating Value through Incremental Innovation: Managing Culture, Structure, and Process. *Radiology*, *288*(2), 330–340. https://doi.org/10.1148/radiol.2018171239

Sadeghi, A., & Rad, F. (2018). The role of knowledge-oriented leadership in knowledge management and innovation. *Management Science Letters*, *8*(3), 151-160.

Safari, A., & Azadehdel, M. R. (2015). The key role of knowledge-oriented leadership in innovation performance of manufacturing and commercial companies of Guilan province. *International Letters of Social and Humanistic Sciences*, *62*, 1-7. https://www.learntechlib.org/p/176665/

Samuel, O. (2018). *The effects of trustworthiness on the impact of organisational culture on employee creativity: The Nigerian manufacturing industry* (Doctoral dissertation, UTAR). Universiti Tunku Abdul Rahman.

Sarvari, P. A., Ustundag, A., Cevikcan, E., Kaya, I., & Cebi, S. (2018). Technology roadmap for Industry 4.0. In *Industry 4.0: Managing the digital transformation* (pp. 95-103). Springer, Cham. https://doi.org/10.1007/978-3-319-57870-5_5

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for Business Students* (5th Ed.). Pearson.

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for business students* (7th Ed.). Nueva York: Pearson Education.

Schinner, M., Valdez, A. C., Noll, E., Schaar, A. K., Letmathe, P., & Ziefle, M. (2017, July). 'Industrie 4.0'and an aging workforce–a discussion from a psychological and a managerial perspective. In *International Conference on Human Aspects of IT for the Aged Population* (pp. 537-556). Springer, Cham.

Schmidt, C. O., & Kohlmann, T. (2008). When to use the odds ratio or the relative risk? *International journal of public health*, *53*(3), 165–167.https://doi.org/10.1007/s000 -00 -7068-3

Schröder, C. (2016). The challenges of industry 4.0 for small and medium-sized enterprises. *Friedrich-Ebert-Stiftung: Bonn, Germany*.

Schuh, G. (2013). *Lean innovation*. Springer-Verlag.

Schumacher, A., Erol, S., & Sihn, W. (2016). A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises.

Procedia CIRP, *52*, 161–166. https://doi.org/10.1016/j.procir.2016.07.040

Schwab, K. (2017). *The fourth industrial revolution*. Crown Business.

Scott, J. E., & Walczak, S. (2009). Cognitive engagement with a multimedia ERP training tool: Assessing computer self-efficacy and technology acceptance. *Information & Management*, *46*(4), 221-232. https://doi.org/10.1016/j.im.2008.10.003

Sekaran, U., & Bougie, R. (2010). Research methods for business: a skill building approach. *Language*, *20*(468p), 25.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley & Sons.

Senge, P. M. (1990). The art and practice of the learning organization.

Senge, P. M. (2006). *The fifth discipline: the art and practice of the learning organization*. Doubleday/Currency.

Serban, I. D. (2021). From organisational learning and knowledge acquisition to the learning organisation: the case of the *European Commission through DG DEVCO. European Politics and Society*, 1-18.

Serrat, O. (2017). Innovation in the public sector. In *Knowledge Solutions* (pp. 559-568). Springer, Singapore. https://doi.org/10.1007/978-981-10-0983-9

Shamim, S., Cang, S., Yu, H., & Li, Y. (2016, July). Management approaches for Industry 4.0: A human resource management perspective. In *2016 IEEE Congress on Evolutionary Computation (CEC)* (pp. 5309-5316). IEEE. http://doi.org/10.1109/CEC.2016.7748365

Sharma, P., Davcik, N. S., & Pillai, K. G. (2016). Product innovation as a mediator in the impact of R&D expenditure and brand equity on marketing performance. *Journal of Business Research*, *69*(12), 5662-5669. https://doi.org/10.1016/j.jbusres.2016.03.074

Shih, T. H., & Fan, X. (2008). Comparing response rates from web and mail surveys: A meta-analysis. *Field methods*, *20*(3), 249-271. https://doi.org/10.1177/1525822X08317085

Sigala, M., & Chalkiti, K. (2015). Knowledge management, social media and employee creativity. *International Journal of Hospitality Management*, *45*, 44–58. https://doi.org/10.1016/j.ijhm.2014.11.003Get rights and content

Simoes, A. (2017). OEC - Malaysia (MYS) Exports, Imports, and Trade Partners. Atlas Media. https://atlas.media.mit.edu/en/profile/country/mys/

Singh, S. K. (2008). Role of leadership in knowledge management: a study. *Journal of Knowledge Management, 12*(4), 3–15. https://doi.org/10.1108/13673270810884219

Sivathanu, B., & Pillai, R. (2018). Smart HR 4.0–how industry 4.0 is disrupting HR. *Human Resource Management International Digest*. https://doi.org/10.1108/HRMID-04-2018-0059

Skinner, J., Smith, A. C., & Swanson, S. (2018). *Fostering innovative cultures in sport: leadership, innovation and change*. Springer.

SME Corp. Malaysia, (2019). [Online] Available: https://www.smecorp.gov.my/images/SMEAR/latest/2/Economic%20Cen sus.pdf

Smith, M., Busi, M., & Ball, P. (2008). Factors Influencing an Organization's Ability to Manage Innovation. *International Journal of Innovation Management*, *12*(04), 655–676. https://doi.org/10.1142/9781786346520_0004

Sony, M., Antony, J., Mc Dermott, O., & Garza-Reyes, J. A. (2021). An empirical examination of benefits, challenges, and critical success factors of industry 4.0 in manufacturing and service sector. *Technology in Society*, *67*, 101754.

Soomro, M. A., Hizam-Hanafiah, M., Abdullah, N. L., Ali, M. H., & Jusoh, M. S. (2021). Industry 4.0 Readiness of Technology Companies: A Pilot Study from Malaysia. *Administrative Sciences*, *11*(2), 56. https://doi.org/10.3390/admsci11020056

Soomro, M. A., Hizam-Hanafiah, M., Abdullah, N. L., Ali, M. H., & Jusoh, M. S. (2021). Embracing Industry 4.0: Empirical Insights from Malaysia. *In Informatics, Multidisciplinary Digital Publishing Institute*, *8*(2), 30. https://doi.org/10.3390/informatics8020030

Sörensen, A., Carles, M., Bunea, H., Majerus, L., Stoykow, C., Nicolay, N. H., ... & Mix, M. (2020). Textural features of hypoxia PET predict survival in head and neck cancer during chemoradiotherapy. *European journal of nuclear medicine and molecular imaging*, *47*(5), 1056-1064. https://doi.org/10.1007/s00259-019-04609-9

Spencer, M. S., Rogers, D. S., & Daugherty, P. J. (1994). JIT systems and external logistics suppliers. *International Journal of Operations & Production Management*, *14*(6), *60-74.* https://doi.org/10.1108/01443579410062095agement.

Stachová, K., Papula, J., Stacho, Z., & Kohnová, L. (2019). External partnerships in employee education and development as the key to facing industry 4.0 challenges. *Sustainability*, *11*(2), 345.

Stăncioiu, A. (2017). The Fourth Industrial Revolution Industry 4.0". *Fiabilitate Şi Durabilitate*, *1*(19), 74-78.

Stephan, P. (2014). Industrie 4.0: Auswirkungen auf die Arbeitswelt aus Sicht eines Anwenders. *Präsentation anlässlich des FES-Fachgesprächs Industrie*, *4*(12.11).

Stephanie. (2018). *Primary Data, Secondary Data: Definition Example - Statistics How To*. Data Science Central. https://www.statisticshowto.datasciencecentral.com/primary-data-secondary/

Stock, T., & Seliger, G. (2016). Opportunities of sustainable manufacturing in industry 4.0. *Procedia Cirp*, *40*, 536-541. https://doi.org/10.1016/j.procir.2016.01.129

Stoffers, J., Heijden, V. der, & Béatrice I. J. (2018). An innovative work behaviour enhancing employability model moderated by age. *European Journal of Training and Development*, *42*(1–2), 143–163. https://doi.org/10.1108/EJTD-10-2016-0074

Su, Z., Chen, J., & Wang, D. (2019). Organisational structure and managerial innovation: the mediating effect of cross-functional integration. *Technology Analysis & Strategic Management, 31*(3), 253-265. https://doi.org/10.1080/09537325.2018.1495324

Sulaiman, S., Umar, U. A., Tang, S. H., & Fatchurrohman, N. (2012). Application of radio frequency identification (RFID) in manufacturing in Malaysia. *Procedia Engineering*, *50*, 697-706. http://doi.org/10.1016/j.proeng.2012.10.076

Sung, T. K. (2018). Industry 4.0: a Korea perspective. *Technological forecasting and social change*, *132*, 40-45. https://doi.org/10.1016/j.techfore.2017.11.005

Szozda, N. (2017). Industry 4.0 and its impact on the functioning of supply chains. *Logforum, 13*(4), 401-414. https://doi.org/10.17270/J.LOG.2017.4.2

Taminiau, Y., Smit, W., & De Lange, A. (2009). Innovation in management consulting firms through informal knowledge sharing. *Journal of Knowledge Management*. https://doi.org/10.1108/13673270910931152

Tan, G. W. H., Ooi, K. B., Chong, S. C., & Hew, T. S. (2014). NFC mobile credit card: the next frontier of mobile payment?. *Telematics and Informatics*, *31* (2), 292 – 307. https://doi.org/10.1016/j.tele.2013.06.002

Tang, Y. H., Amran, A., & Goh, Y. N. (2013). Environmental Management Practices of Hotels in Malaysia: Stakeholder Perspective. *International Journal of Tourism Research, 16(6), 586–595.* https://doi.org/10.1002/jtr.1952

Tarhini, A., Hone, K., & Liu, X. (2014). Measuring the Moderating Effect of Gender and Age on E-Learning Acceptance in England: A Structural Equation Modeling Approach for An Extended Technology Acceptance Model. *Journal of Educational Computing Research*, *51*(2), 163–184. https://doi.org/10.2190/EC.51.2.b

Malaysian Industry Government Group for High Technology. (2018). https://www.might.org.my/

Tay, S. I., Alipal, J., & Lee, T. C. (2021). Industry 4.0: Current practice and challenges in Malaysian manufacturing firms. *Technology in Society*, *67*, 101749.

Teece, D. (2018). Dynamic capabilities as (workable) management systems theory. *Journal of Management & Organization*, *24*(3), 359-368. http://doi.org/10.1017/jmo.2017.75

Teece, D. J. (2009). *Dynamic capabilities and strategic management: Organizing for innovation and growth*. Oxford University Press on Demand.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Teh, P. L. (2010). *Role conflict as mediator of the relationship between total* *quality management practices and role ambiguity* (Doctoral dissertation, Multimedia University). Multimedia University.

Temme, D., Kreis, H., & Hildebrandt, L. (2006). *PLS path modeling: A software review* (No. 2006, 084). SFB 649 discussion paper. http://sfb649.wiwi.hu-berlin.de

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. (2005). PLS path modeling. *Computational Statistics & Data Analysis, 48,* 159–205. https://doi.org/10.1016/j.csda.2004.03.005

The Economist Intelligence Unit. (2015). *Engaging and Integrating a Global Workforce Global Trends Impacting the Future of HR Management Engaging and Integrating a Global Workforce Engaging and Integrating a Global Workforce Engaging and Integrating a Global Workforce*. https://www.shrm.org/hr-today/news/hr-magazine/documents/3-15 eiu theme 2 report-final.pdf

Theriou, G. N., & Chatzoglou, P. D. (2008). Enhancing performance through best HRM practices, organizational learning and knowledge management: A conceptual framework. *European Business Review, 20*(3), 185–207. https://doi.org/10.1108/09555340810871400

Teixeira, J. E., & Tavares-Lehmann, A. T. C. (2022). Industry 4.0 in the European union: Policies and national strategies. *Technological Forecasting and Social Change, 180*, 121664.

Torfing, J., & Ansell, C. K. (Eds.). (2016). *Handbook on theories of governance*. Edward Elgar Publishing. https://play.google.com/store/books/details?id=g3ZmDAAAQBAJ&rdid=book-g3ZmDAAAQBAJ&rdot=1&source=gbs_vpt_read&pcampaignid=books_booksearch_viewport

Tortorella, G. L., Giglio, R., & van Dun, D. H. (2019). Industry 4.0 adoption as a moderator of the impact of lean production practices on operational performance improvement. *International Journal of Operations & Production Management, 39*(6/7/8), 880-886. https://doi.org/10.1108/IJOPM-01-2019-0005

Tsikriktsis, N. (2005). A review of techniques for treating missing data in OM survey research. *Journal of Operations Management*, *24*(1), 53–62. https://doi.org/10.1016/j.jom.2005.03.001

Nam, T. H., Tuan, N. P., & Van Minh, N. (2017). Critical successful factors for innovation in vietnamese firms. *Journal of Industrial Engineering and Management*, *10*(3), 522-544. http://doi.org/10.3926/jiem.2020

Tushman, M., Smith, W. K., Wood, R. C., Westerman, G., & O'Reilly, C. (2011). Organizational designs and innovation streams. *Industrial and Corporate Change*, 19(5), 1331–1366. https://doi.org/10.1093/icc/dtq040

Umrani, A. I., & Johl, S. K. (2018). How Different Ownership Structures Perform in Industry 4.0: A Case of Malaysian Manufacturing SMEs. In *SHS Web of Conferences, EDP Sciences, 5,* 04003. https://doi.org/10.1051/shsconf/20185604003

Economic Planning Unit. (2015). *Eleventh Malaysia plan, 2016-2020:*

Anchoring growth on people. Putrajaya: Prime Minister’s Department. http://epu.gov.my/en/rmk/eleventh-malaysia-plan-2016-2020

Užienė, L. (2015). Open innovation, knowledge flows and intellectual capital. *Procedia-Social and Behavioral Sciences*, *213,* 1057-1062. https://doi.org/10.1016/j.sbspro.2015.11.525

Uzkurt, C., Kumar, R., Kimzan, H. S., & Eminoğlu, G. (2013). Role of innovation in the relationship between organizational culture and firm performance. *European Journal of Innovation Management, 16*(1), 92-117. https://doi.org/10.1108/14601061311292878

Veal, A. J. (2017). *Research methods for leisure and tourism*. Pearson UK.

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly, 36* (1), 157 – 178. https://doi.org/10.2307/41410412

Venkatesh, V., Thong, J. Y., & Xu, X. (2016). Unified theory of acceptance and use of technology: A synthesis and the road ahead. *Journal of the Association for Information Systems*, *17*(5), 328-376. http://ais.site-ym.com/?SeniorScholarBasket

Veza, I., Mladineo, M., & Gjeldum, N. (2015). Managing Innovative Production Network of Smart Factories. *IFAC-PapersOnLine, 48*(3), 555–560. https://doi.org/10.1016/j.ifacol.2015.06.139

Vilkaite-Vaitone, N. (2019). Workforce Ageing Issue and Its Management in the Baltic States. *Central Asian Review of Economics and Policy, 1*(1), 24–32. http://www.journalcarep.org/index.php/carep/article/view/18

Wahlster, W. (2014). Semantic technologies for mass customization. In *Towards the Internet of Services: The THESEUS Research Program* (pp. 3-13). Springer, Cham. https://doi.org/10.1007/978-3-319-06755-1_1

Wan, D., Ong, C. H., & Lee, F. (2005). Determinants of firm innovation in Singapore. *Technovation*, *25*(3), 261-268. https://doi.org/10.1016/S0166-4972(03)00096-8

Wang, Z., & Scheepers, H. (2012). Understanding the intrinsic motivations of user acceptance of hedonic information systems: towards a unified research model. *Communications of the Association for Information Systems, 30*, 17. https://doi.org/10.17705/1CAIS.03017

Waruwu, H., Asbari, M., Purwanto, A., Nugroho, Y. A., Fikri, M. A. A., Fauji, A., ... & Dewi, W. R. (2020). The Role of Transformational Leadership, Organizational Learning and Structure on Innovation Capacity: Evidence from Indonesia Private Schools. *EduPsyCouns: Journal of Education, Psychology and Counseling, 2*(1), 378-397.

Watkins, J. (2002). *Information Technology, Organizations and People: Transformations in the UK Retail Financial Services*. Routledge. https://doi.org/10.4324/9780203023280

Weeks, M. R., & Feeny, D. (2008). Outsourcing: From cost management to innovation and business value. *California management review, 50*(4), 127-

146. https://doi.org/10.2307/41166459

Wetzels, M., Odekerken-Schroder, G., & van Oppen, C. (2009). Using PLS path modeling for assessing hierarchical construct models: guidelines and impirical illustration. *MIS Quarterly*, *33* (1), 177 – 195. https://doi.org/10.2307/20650284

Wheeler, B. C. (2002). NEBIC: A Dynamic Capabilities Theory for Assessing Net-Enablement. *Information Systems Research*, *13*(2), 125–146. https://doi.org/10.1287/isre.13.2.125.89

Willem, A., Buelens, M., & Jonghe, I. De. (2007). Impact of organizational structure on nurses' job satisfaction: A questionnaire survey. *International Journal of Nursing Studies*, *44*(6), 1011–1020. https://doi.org/10.1016/j.ijnurstu.2006.03.013

Wong, L. P., & Sam, I. C. (2011). Knowledge and attitudes in regard to pandemic influenza A (H1N1) in a multiethnic community of Malaysia. *International Journal of Behavioral Medicine*, *18*(2), 112-121. https://doi.org/10.1007/s12529-010-9114-9

World Bank & OECD. (2016). *Malaysia | Innovation Policy Platform*. https://www.innovationpolicyplatform.org/content/malaysia

World Health Organization. (2015). *World report on ageing and health*. https://apps.who.int/iris/handle/10665/186463

Wright, D. T., & Burns, N. D. (1998). New organisation structures for global business: an empirical study. *International Journal of Operations & Production Management, 18 (9/10), 896-923.* https://doi.org/10.1108/01443579810225513

Xie, K. L., & Lee, J.-S. (2013). Toward the Perspective of Cognitive Destination Image And Destination Personality: The Case Of Beijing. *Journal of Travel & Tourism Marketing*, *30*(6), 538–556. https://doi.org/10.1080/10548408.2013.810993

Xu, J., Houssin, R., Caillaud, E., & Gardoni, M. (2010). Macro process of knowledge management for continuous innovation. *Journal of knowledge management*. https://doi.org/10.1108/13673271011059536

Xu, M., Fralick, D., Zheng, J. Z., Wang, B., Tu, X. M., & Feng, C. (2017). The differences and similarities between two-sample t-test and paired t-test. *Shanghai Archives of Psychiatry, 29*(3), 184. http://doi.org/10.11919/j.issn.1002-0829.217070

Yadav, G., Luthra, S., Jakhar, S. K., Mangla, S. K., & Rai, D. P. (2020). A framework to overcome sustainable supply chain challenges through solution measures of industry 4.0 and circular economy: An automotive case. *Journal of Cleaner Production*, *254*, 120112.

Yang, E., & Nie, Y. (2017). An Aging Workforce and Work Environment: A Hotel Case Study in China. *Journal of Facility Management Education and Research*, *1*(2), 59-64. https://doi.org/10.22361/jfmer/81608

Yang, L. R., Huang, C. F., & Hsu, T. J. (2014). Knowledge leadership to improve project and organizational performance. *International Journal of Project Management*, *32*(1), 40-53.

https://doi.org/10.1016/j.ijproman.2013.01.011

Yang, Z., Zhou, X., & Zhang, P. (2014). Centralization and innovation performance in an emerging economy: testing the moderating effects. *Asia Pacific Journal of Management*, *32*(2), 415–442. http://doi.org/10.1007/s10490-014-9394-8

Yap, B. W., Ramayah, T., & Shahidan, Wa. N. W. (2012). Satisfaction and trust on customer loyalty: a PLS approach. *Business Strategy Series*, *13*(4), 154–167. https://doi.org/10.1108/17515631211246221

Ylijoki, O., Sirkiä, J., Porras, J., & Harmaakorpi, V. (2019). Innovation capabilities as a mediator between big data and business model. *Journal of Enterprise Transformation*, 1–18. https://doi.org/10.1080/19488289.2018.1548396

Zafar, H., & Mehmood, K. K. (2019). Innovation as a mediator between innovative culture, transformational leadership, knowledge management, learning orientation, and performance. *Innovation*, *17*(1). https://doi.org/10.31384/jisrmsse/2019.17.1.9

Zakaria, N., Nasir, A., & Akhtar, A., (2019). Are the Leaders Ready to Embrace Industry 4.0?. *Journal of Advanced Research in Dynamical and Control Systems*, *11*, 543-549.

Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H., & Nikanfar, A. R. (2015). Design and implementation content validity study: development of an instrument for measuring patient-centered communication. *Journal of Caring Sciences*, *4*(2), 165. https://doi.org/10.15171/jcs.2015.017

Zhou, K., Liu, T., & Zhou, L. (2015, August). Industry 4.0: Towards future industrial opportunities and challenges. In *2015 12th International conference on fuzzy systems and knowledge discovery (FSKD)* (pp. 2147-2152). IEEE.

APPENDIX

Appendix A: Pre-Test Questionnaire

UNIVERSITY TUNKU ABDUL RAHMAN

QUESTIONNAIRE FOR VALIDATION - PRE TESTING

Dear Sir/Madam,

Greetings,

I am Doctor of Philosophy student at UTAR doing a research on assessing the readiness of Malaysian manufacturing sector for Industry 4.0. The idea of Industry 4.0 is to strengthen the manufacturing sector with the use of innovation and technology. In order to encourage manufacturing firms to become competitive it is important to know about their state of readiness for Industry 4.0. Therefore, this research is vital for manufacturing sector to be conducted.

I have managed to prepare an instrument with measurement items adapted from previous studies to measure the variables. The current stage is to **face validate** and **content validate** the measurement items to establish whether they matched their operational definition. I would be grateful if you could spend some time to read through the questionnaire and assess and provide feedback on face validity and specifically read the measurement items and assess their content validity.

Yours Sincerely,

Hafiz Mudassir Rehman

Ph.D. Student, ID: 18ABD07059
Faculty of Business & Finance
Universiti Tunku Abdul Rahman, Kampar Campus
E-mail: mudassir@1utar.my, Phone: 013-5903202

Knowledge Oriented Leadership "Knowledge-oriented leadership is based on a mixture of transformational and transactional leadership styles, along with communication and motivational elements. It includes knowledge creation, transfer, storage and application."					
No	**Measurement Item**	**Not Relevant**	**Somewhat Relevant**	**Quite Relevant**	**Highly Relevant**
1	Leadership has been creating an environment for responsible employee behavior and teamwork.	**1**	**2**	**3**	**4**
2	Managers are used to assuming the role of knowledge leaders, which is mainly characterized by openness, tolerance of mistakes, and mediation for the achievement of the firm's objectives.	**1**	**2**	**3**	**4**
3	Managers promote learning from experience, tolerating mistakes up to a certain point.	**1**	**2**	**3**	**4**
4	Managers behave as advisers, and controls are just an assessment of the accomplishment of objectives.	**1**	**2**	**3**	**4**
5	Managers promote the acquisition of external knowledge.	**1**	**2**	**3**	**4**
6	Managers reward employees who share and apply their knowledge.	**1**	**2**	**3**	**4**
Organization Structure "This structure seeks to reduce the hierarchy and distribute more decision-making authority to a greater number of employees. It enables companies to become more flexible and to better handle unanticipated events."					
No	**Measurement Item**	**Not Relevant**	**Somewhat Relevant**	**Quite Relevant**	**Highly Relevant**
7	There can be little action here until the supervisor make a decision.	**1**	**2**	**3**	**4**
8	A person who wants to make a decision on his or her own would be quickly discouraged.	**1**	**2**	**3**	**4**
9	Even small matters have to be referred to someone higher up for a final answer.	**1**	**2**	**3**	**4**
10	I have to ask the boss before I do almost anything.	**1**	**2**	**3**	**4**
11	Any decision I make have to have my boss boss's approval.	**1**	**2**	**3**	**4**
Organization Innovation "Organization Innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a pre-emptive action to influence the environment. Hence, innovation includes new product or new service and new process or new technology."					
No	**Measurement Item**	**Not Relevant**	**Somewhat Relevant**	**Quite Relevant**	**Highly Relevant**
12	Organization's emphasis on developing new products or services.	**1**	**2**	**3**	**4**
13	Rate of introduction of new products or services into the market.	**1**	**2**	**3**	**4**
14	Organization's spending on new product or service development activities.	**1**	**2**	**3**	**4**

15	Number of new products or services added by the organization and already on the market.	**1**	**2**	**3**	**4**
16	Number of new products or services that the organization has introduced for the first time on the market.	**1**	**2**	**3**	**4**
17	Investment in developing proprietary technologies.	**1**	**2**	**3**	**4**
18	Emphasis on creating proprietary technologies.	**1**	**2**	**3**	**4**
19	Organization's emphasis on technological innovation.	**1**	**2**	**3**	**4**
20	Organization's emphasis on pioneering technological developments in its industry.	**1**	**2**	**3**	**4**

Readiness of Industry 4.0

"Industry 4.0 refers to recent technological advances where the internet and supporting technologies (e.g., embedded systems) serve as a backbone to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form a new kind of intelligent, networked and agile value chain." Whereas "readiness is the ability to capitalize production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown shocks"

No	Measurement Item	Not Relevant	Somewhat Relevant	Quite Relevant	Highly Relevant
21	The company is using a road map for the planning of industry 4.0 activities.	**1**	**2**	**3**	**4**
22	The company adapted a business model that is compatible to industry 4.0.	**1**	**2**	**3**	**4**
23	The company possess adequate resources for realization of industry 4.0.	**1**	**2**	**3**	**4**
24	The leaders are willing to face the challenges of industry 4.0 activities.	**1**	**2**	**3**	**4**
25	The management possess adequate competencies and methods in order to face the challenges of industry 4.0 activities.	**1**	**2**	**3**	**4**
26	The existence of central coordination is available in within the company for industry 4.0.	**1**	**2**	**3**	**4**
27	The company do digitalize the sales or services.	**1**	**2**	**3**	**4**
28	The company do utilize the customer data for sales improvement.	**1**	**2**	**3**	**4**
29	The customer's do possess digital media competence.	**1**	**2**	**3**	**4**
30	The company do digitalize the products.	**1**	**2**	**3**	**4**
31	The company do individualize each product.	**1**	**2**	**3**	**4**
32	The company encourage product integration into other systems that is compatible to industry 4.0.	**1**	**2**	**3**	**4**
33	The company is decentralized the process of operations.	**1**	**2**	**3**	**4**

34	The company encourage interdepartmental collaboration.	**1**	**2**	**3**	**4**
35	The company adopting modeling and simulation methods in their daily operation.	**1**	**2**	**3**	**4**
36	The company is encouraged open innovation and cross company collaboration.	**1**	**2**	**3**	**4**
37	The company encourage knowledge sharing among employees.	**1**	**2**	**3**	**4**
38	The employees value the ICT in company.	**1**	**2**	**3**	**4**
39	The member of organisation are having high ICT competencies.	**1**	**2**	**3**	**4**
40	The member of organisation are openness to new technology.	**1**	**2**	**3**	**4**
41	The member of organisation enjoy a considerable degree of autonomy.	**1**	**2**	**3**	**4**
42	The country business regulation does possess a suitable technological standard.	**1**	**2**	**3**	**4**
43	The country business regulation does protect the company intellectual property.	**1**	**2**	**3**	**4**
44	24. The country business regulation does possess adequate labour regulation for industry 4.0.	**1**	**2**	**3**	**4**
45	The company is adopted modern ICT.	**1**	**2**	**3**	**4**
46	The company is utilizing mobile devices or technology.	**1**	**2**	**3**	**4**
47	The company is adopting machine to machine communication for production efficiency.	**1**	**2**	**3**	**4**

Perceived Age Composition:
What percentage of employees in your company would you estimate to be under the age of 24? ________
What percentage of employees in your company would you estimate between the age of 25 and 54 years? _________
What percentage of employees in your company would you estimate to be over the age of 55? ______

Section B: Respondent's Demographical Profile
Please indicate your gender:
[   ] Male
[   ] Female

Age Group:
[   ] Less than 24 years old
[   ] 25 – 34 years old
[   ] 35 – 44 years old
[   ] 45 – 54 years old
[   ] More than 55 years old

Position: __________
Company Location (State)_______

Working Experience:

[ ] Less than 2 years
[ ] 2 years – 4 Years
[ ] More than 4 years – 6 years
[ ] More than 6 years – 8 years
[ ] More than 8 years

Please select the category of industry your company is associated with:

[ ] Petroleum, Chemical, Rubber & Plastic
[ ] Food, Beverages & Tobacco
[ ] Electrical and Electronics
[ ] Textile, Wearing, Apparel, Leather and Foot wear
[ ] Transport Equipment
[ ] Wood, Furniture, Paper products and Printing
[ ] Metal Products and Non-Metallic mineral products
Others (please specify): _____________

Please select the type of your company:

[ ] Private Limited Sdn Bhd
[ ] Public Limited Berhad
[ ] Foreign

Thank you for your valuable time. If you have any suggestion or comments regarding above instrument, please mention here:

Appendix B: Content Validity

Item	ICVI	Result	Item	ICVI	Result	Item	ICVI	Result
1	1	Added	17	0.8	Added	33	1	Added
2	1	Added	18	1	Added	34	0.9	Added
3	1	Added	19	1	Added	35	1	Added
4	0.9	Added	20	1	Added	36	1	Added
5	0.9	Added	21	1	Added	37	1	Added
6	1	Added	22	0.9	Added	38	1	Added
7	1	Added	23	1	Added	39	1	Added
8	1	Added	24	1	Added	40	1	Added
9	1	Added	25	1	Added	41	1	Added
10	0.7	Deleted	26	1	Added	42	1	Added
11	1	Added	27	1	Added	43	1	Added
12	0.9	Added	28	1	Added	44	1	Added
13	0.9	Added	29	0.9	Added	45	1	Added
14	1	Added	30	1	Added	46	0.9	Added
15	0.6	Deleted	31	1	Added	47	0.9	Added
16	1	Added	32	1	Added			
SLCVI = 0.96								

Appendix C: Pilot Study

Cronbach's Alpha Value if Item Deleted

Item	Value	Item	Value	Item	Value	Item	Value
OI_1	.331	KOL_1	.847	I4_Ldr2	.638	I4_Pp1	.661
OI_2	.236	KOL_2	.839	I4_Ldr3	.622	I4_Pp2	.655
OI_3	.260	KOL_3	.879	I4_Cst1	.660	I4_Pp3	.628
OI_4	.301	KOL_4	.859	I4_Cst2	.658	I4_Gvr1	.665
OI_5	.771	KOL_5	.867	I4_Cst3	.654	I4_Gvr2	.654
OI_6	.370	KOL_6	.845	I4_Prd1	.631	I4_Gvr3	.644
OI_7	.339	OSR_2	.794	I4_Prd2	.620	I4_Tec1	.643
OI_8	.709	OSR_3	.919	I4_Prd3	.643	I4_Tec2	.648
OI_1	.901	OSR_4	.813	I4_Opr1	.635	I4_Tec3	.685
OI_2	.879	OSR_5	.824	I4_Opr2	.636		
OI_3	.909	I4_Str1	.662	I4_Opr3	.643		
OI_4	.906	I4_Str2	.666	I4_Clt1	.652		
OI_6	.889	I4_Str3	.653	I4_Clt2	.634		
OI_7	.898	I4_Ldr1	.649	I4_Clt3	.659		

Value: Cronbach's Alpha if Item Deleted. The correlation values of OI_5 and OI_8 was negative (-0.805 and -0.537).

Reliability Statistics

Variable	No. of Items	Items Deleted	Cronbach's Alpha	Cronbach's Alpha New

Knowledge-Oriented Leadership	6	0	0.877	NA
Decentralized Organization Structure	4	0	0.827	
Organization Innovation	8	2	0.519	0.913
Readiness for Industry 4.0	27	0	0.657	0.657

Appendix D: Study Questionnaire

SURVEY ON READINESS OF MALAYSIAN MANUFACTURING SECTOR FOR INDUSTRY 4.0

Dear Sir/Madam,

Greetings,

I am Doctor of Philosophy student at UTAR doing a research on assessing the readiness of Malaysian manufacturing sector for Industry 4.0[1]. The idea of Industry 4.0 is to strengthen the manufacturing sector with the use of innovation and technology. In order to encourage manufacturing firms to become competitive it is important to know about their state of readiness for Industry 4.0. Therefore this research is vital for manufacturing sector to be conducted.

This data collection is part of research project funded by UTAR. Your responses to this survey will be invaluable for analyzing the readiness of your company for Industry 4.0. Moreover, this research will help to identify appropriate management practices that are required to support change in dynamic business environment for Industry 4.0.

An individual (representative) of your company who is at managerial position or above is requested to complete this survey. The participation in survey is entirely voluntary. The responses will be anonymous and kept confidential. All responses and findings will be used for academic purpose only.

I shall be grateful if you could spare about 10 minutes from your valuable time. Your kind cooperation is very much appreciated. If you have any questions regarding this research or need a copy of results, you may contact my supervisor Dr. Au Yong Hui Nee at auyonghn@utar.edu.my.

Yours Sincerely,

Hafiz Mudassir Rehman

Ph.D. Student, ID: 18ABD07059
Faculty of Business & Finance
Universiti Tunku Abdul Rahman, Kampar Campus
E-mail: mudassir@1utar.my, Phone: 013-5903202

I give my consent to participate in this survey.

YES [ ] **NO [ ]**

(If yes, please proceed to next page or if no, you may return the questionnaire to researcher.)

[1] *Industry 4.0 refers to recent technological advances where the internet and supporting technologies serve as a backbone to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form a new kind of intelligent, networked and agile value chain.*

SECTION A: Demographical Profile

Instructions: Please mark (√) appropriate answers and fill in the blanks.

1) Gender:

[ ] Male [ ] Female

2) Age:

[ ] Less than 24 years old [ ] 25 – 34 years old
[ ] 35 – 44 years old [ ] 45 – 54 years old
[ ] More than 55 years old

3) Position:

[ ] Owner/CEO/Director/G. Manager [ ] Senior Manager/Manager
[ ] Executive [ ] Others (please specify): __________

4) Working Experience:

[ ] Less than 5 years [ ] 6 years – 10 Years
[ ] 11 years – 15 years [ ] 16 years – 20 years
[ ] More than 20 years

5) Company Location (State):

[ ] Johor [ ] Kedah [ ] Kelantan [ ] Kuala Lumpur [ ] Labuan
[ ] Malacca [ ] Negeri Sembilan [ ] Pahang [ ] Penang [ ] Perak
[ ] Perlis [ ] Putrajaya [ ] Sabah [ ] Sarawak [ ] Selangor
[ ] Terengganu

6) Company Products:

[ ] Petroleum, Chemical, Rubber & Plastic [ ] Transport Equipment
[ ] Food, Beverages & Tobacco [ ] Wood, Furniture, Paper & Printing
[ ] Electrical & Electronics [ ] Metal & Non-Metallic mineral products
[ ] Textile, Wearing, Apparel, Leather & Footwear [ ] Others (please specify): __________

7) Company Ownership:

[ ] Malaysia (Local) [ ] Foreign

8) Company Type:

[ ] Private Limited (Sdn Bhd) [ ] Partnership
[ ] Public Limited (Berhad) [ ] Limited Liability Partnership (LLP)
[ ] Sole Proprietorship [ ] Others (please specify): __________

9) Age of Employees:

Note: The total below must be equal to 100% (a+b+c).

What percentage of employees in your company would you estimate…?

a) to be under the age of 24 years ________%
b) between the age of 25 and 54 years ________%
c) to be the age of 55 years and above ________%

SECTION B:

Instruction:

Please circle how strongly you disagree or agree with the statement ranging from 1 to 5.

1=Strongly Disagree (SD), 2=Disagree (DA), 3=Neutral (N), 4=Agree (A), 5=Strongly Agree (SA).						
No	**Measurement Item**	**(SD) 1**	**(DA) 2**	**(N) 3**	**(A) 4**	**(SA) 5**
	Knowledge Oriented Leadership					
1	Our company managers have been creating an environment for responsible behaviour among employees and teams.	1	2	3	4	5
2	Our company managers assume the role of knowledge leaders as a mediator for sharing and applying knowledge.	1	2	3	4	5
3	Our company managers promote learning from experience rather than work output.	1	2	3	4	5
4	Our company managers behave as advisers, and controls are just an assessment of the accomplishment of objectives.	1	2	3	4	5
5	Our company managers promote the acquisition of external knowledge.	1	2	3	4	5
6	Our company managers reward employees who share and apply their knowledge.	1	2	3	4	5
	Organization Structure					
7	Every matter in our company has to be referred to someone higher up for the final answer.	1	2	3	4	5
8	In our company, a person who wants to make a decision on his own is discouraged.	1	2	3	4	5
9	In our company, any decision employees make needs higher management approval.	1	2	3	4	5
10	In our company, no actions are performed until the higher management makes a decision.	1	2	3	4	5
	Organization Innovation					
11	Our company's emphasis is on developing new products.	1	2	3	4	5
12	In our company, introduction of new products into the market increased in last 12 months.	1	2	3	4	5
13	Our company has spent on new product development activities in last 12 months.	1	2	3	4	5
14	New products of our company have been introduced for the first time in the market in last 12 months.	1	2	3	4	5
15	Our company invested in developing proprietary technologies in last 12 months.	1	2	3	4	5
16	Our company's emphasis is on technological innovation.	1	2	3	4	5
	Readiness for Industry 4.0					
	Strategy					
17	Our company is using a plan for the implementation of industry 4.0 activities.	1	2	3	4	5
18	Our company has adopted a business model that is compatible with industry 4.0.	1	2	3	4	5
19	Our company possesses adequate resources for the realization of industry 4.0.	1	2	3	4	5

Page **3** of **4**

1=Strongly Disagree (SD), 2=Disagree (DA), 3=Neutral (N), 4=Agree (A), 5=Strongly Agree (SA).						
No	**Measurement Item**	**(SD) 1**	**(DA) 2**	**(N) 3**	**(A) 4**	**(SA) 5**
	Leadership					
20	Our company managers are willing to face the challenges of industry 4.0 activities.	1	2	3	4	5
21	Our company management possesses adequate competencies to face the challenges of industry 4.0 activities.	1	2	3	4	5
22	In our company, central coordination for industry 4.0 is available.	1	2	3	4	5
	Customer					
23	Our company has digitalized sales and services.	1	2	3	4	5
24	Our company analyses customer data for sales improvement.	1	2	3	4	5
25	Our company customers are competent with Information and Communication Technology (ICT).	1	2	3	4	5
	Product					
26	It is possible to integrate products into other systems that are compatible with industry 4.0.	1	2	3	4	5
27	Our company products have flexibility in their characteristics.	1	2	3	4	5
28	Our company products are digitally compatible.	1	2	3	4	5
	Operation					
29	Our company has decentralized the process of operations.	1	2	3	4	5
30	Our company encourages interdepartmental collaboration.	1	2	3	4	5
31	Our company is adopting modeling and simulation methods in their operations.	1	2	3	4	5
	Culture					
32	Our company encourages open innovation (cross-company collaboration).	1	2	3	4	5
33	Our company encourages knowledge sharing among employees.	1	2	3	4	5
34	In our company, the employees value Information and Communication Technology (ICT).	1	2	3	4	5
	People					
35	Our company employees are having high ICT competencies.	1	2	3	4	5
36	Our company employees are open to accepting new technologies.	1	2	3	4	5
37	Our company employees enjoy autonomy.	1	2	3	4	5
	Governance					
38	Our country business policies have suitable technology standards.	1	2	3	4	5
39	Our country business laws protect the company's intellectual property.	1	2	3	4	5
40	Our country business laws have adequate labour regulation for industry 4.0.	1	2	3	4	5
	Technology					
41	Our company has adopted Information and Communication Technology (ICT).	1	2	3	4	5
42	Our company is utilizing mobile and related devices.	1	2	3	4	5
43	Our company has integrated computers with machines and tools.	1	2	3	4	5

Thank you for your consideration and participation in this research project.

Appendix E: Interview Questionnaire

THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE

Dear Sir/Madam,

Greetings,

I am Doctor of Philosophy student at UTAR doing a research on assessing the readiness of Malaysian manufacturing sector for Industry 4.0. The idea of Industry 4.0 is to strengthen the manufacturing sector with the use of innovation and technology. In order to encourage manufacturing firms to become competitive it is important to know about their state of readiness for Industry 4.0. Therefore, this research is vital for manufacturing sector to be conducted.

This data collection is part of research project funded by UTAR. Your responses to this survey will be invaluable for analyzing the awareness of your company for Industry 4.0 and aging workforce. Moreover, this research will help to identify appropriate management practices that are required to support change in dynamic business environment for Industry 4.0.

An individual (representative) of your company who is at managerial position or above is requested to complete this survey. The participation in survey is entirely voluntary. The responses will be anonymous and kept confidential. All responses and findings will be used for academic purpose only.

I shall be grateful if you could spare about 5-10 minutes from your valuable time. Your kind cooperation is very much appreciated. If you have any questions regarding this research or need a copy of results, you may contact my supervisor Dr. Au Yong Hui Nee at auyonghn@utar.edu.my.

Yours Sincerely,

Hafiz Mudassir Rehman

Ph.D. Student, ID: 18ABD07059
Faculty of Business & Finance
Universiti Tunku Abdul Rahman, Kampar Campus
E-mail: mudassir@1utar.my, Phone: 013-5903202

I give my consent to participate in this survey.

YES [ ] **NO [ ]**

SECTION A: Demographical Profile

Instructions: Please mark (√) appropriate answers and fill in the blanks.

1) **Gender:**

[ ] Male [ ] Female

2) **Industry Type:** ___________________

3) **Company Location:** ________________

4) **Please estimate the size of your company's domestic workforce:**

[ ] Less than 5 employees [ ] 05 employees – 19 employees

[ ] 20 employees – 99 employees [ ] More than 100 employees

5) **Please indicate your job position:**

[ ] CEO/Owner/Director General Manager

[ ] Manager/Supervisor

SECTION B: Business Awareness

Instructions: You are encouraged to provide the answer in detail.

Awareness of Industry 4.0

1) What do you understand about the concept "Industry 4.0"?

Readiness for Industry 4.0

2) Do you think your organization is ready for Industry 4.0? (Why?)

3) Which pillars of Industry 4.0 your organization have applied?

[ ] Augmented Reality [ ] System Integration [ ] Cloud Computing

[ ] Big Data [ ] Internet of Things (IOT) [ ] 3D Printing

[ ] Cyber Security [ ] Autonomous Robots [ ] Simulations

Challenges of Industry 4.0

4) What are major challenges your organization face for Industry 4.0?

Strategies for Industry 4.0

5) What plans are your organization implementing for Industry 4.0?

6) What is the actual level of Industry 4.0 that your organization is currently employing??

[ ] We are not currently employing any of Industry4.0 because it is not relevance to business

[ ] We have adopted part of Industry4.0 because it is somewhat relevance to business

[ ] We have adopted part of Industry4.0 in the past 2 years because it is relevance to business

[ ] We have using Industry4.0 in the past 3 years because it is very relevance to business

[ ] We have fully employed Industry4.0 in the past 5 years because it is strongly relevance to business.

Benefits of Aging Workforce

"A worker with an age of 55 years or above is called aging worker".

7) What benefits do you perceive of an aging worker for your organization?

Challenges of Aging Workforce

8) What challenges do you perceive of an aging worker for your organization?

Role of Knowledge Oriented Leadership

"Knowledge-oriented leadership is based on a mixture of transformational and transactional leadership styles, along with communication and motivational elements. It includes knowledge creation, transfer, storage and application."

9) What role of knowledge oriented leadership could play in your organization to facilitate the adoption of industry 4.0?

10) How knowledge oriented leadership enhance the innovation of the organization?

Role of Decentralized Organization Structure

"This structure seeks to reduce the hierarchy and distribute more decision-making authority to a greater number of employees. It enables companies to become more flexible and to better handle unanticipated events."

11) Is the decentralized organization structure able to improve the effectiveness of Industry 4.0 adoptions?

12) How could decentralized organization structure contribute to the innovation of the organization?

Thank you for your valuable time.

Appendix F: Z-Scores

Z-Scores

Variables	N	Min	Max	Variables	N	Min	Max
Zscore(KOL1)	155	-1.996	1.319	Zscore(I4C1)	155	-1.980	1.347
Zscore(KOL2)	155	-1.932	1.265	Zscore(I4C2)	155	-3.037	1.373
Zscore(KOL3)	155	-2.395	1.345	Zscore(I4C3)	155	-2.510	1.352
Zscore(KOL4)	155	-1.711	1.472	Zscore(I4P1)	155	-2.340	1.438
Zscore(KOL5)	155	-2.843	1.354	Zscore(I4P2)	155	-2.237	1.442
Zscore(KOL6)	155	-2.993	1.283	Zscore(I4P3)	155	-2.096	1.638
Zscore(OS1)	155	-1.284	2.384	Zscore(I4O1)	155	-1.979	1.651
Zscore(OS2)	155	-1.785	1.599	Zscore(I4O2)	155	-2.647	1.288
Zscore(OS3)	155	-1.389	2.323	Zscore(I4O3)	155	-2.079	1.690
Zscore(OS4)	155	-1.799	2.486	Zscore(I4Cl1)	155	-1.951	1.372
Zscore(OI1)	155	-2.365	1.220	Zscore(I4Cl2)	155	-3.224	1.225
Zscore(OI2)	155	-1.924	1.199	Zscore(I4Cl3)	155	-2.136	1.411
Zscore(OI3)	155	-2.026	1.288	Zscore(I4Pp1)	155	-1.947	1.378
Zscore(OI4)	155	-1.669	1.411	Zscore(I4Pp2)	155	-2.658	1.391
Zscore(OI5)	155	-1.813	1.656	Zscore(I4Pp3)	155	-1.649	1.280
Zscore(OI6)	155	-2.144	1.345	Zscore(I4G1)	155	-2.193	1.385
Zscore(I4S1)	155	-1.898	1.553	Zscore(I4G2)	155	-2.328	1.501
Zscore(I4S2)	155	-1.809	1.674	Zscore(I4G3)	155	-2.431	1.676
Zscore(I4S3)	155	-1.718	1.590	Zscore(I4T1)	155	-2.355	1.341
Zscore(I4L1)	155	-2.281	1.220	Zscore(I4T2)	155	-2.526	1.257
Zscore(I4L2)	155	-2.136	1.616	Zscore(I4T3)	155	-2.503	1.570
Zscore(I4L3)	155	-1.783	1.650				

Accepted Range = (-4.0 to +4.0) 3.29

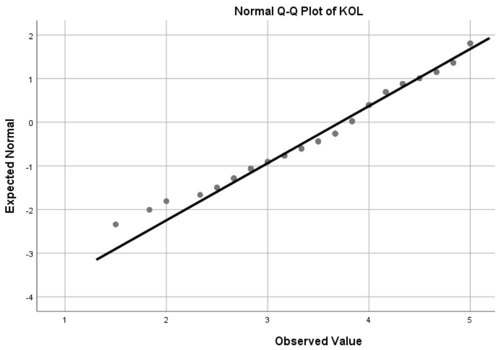
Appendix G: Descriptive Statistics

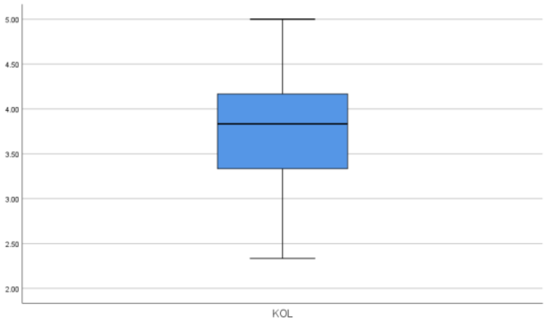
Descriptive Statistics and Assessment of Normality (Items)						
	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
KOL1	3.81	.905	-.617	.195	-.269	.387
KOL2	3.81	.938	-.381	.195	-.720	.387
KOL3	3.56	1.070	-.404	.195	-.412	.387
KOL4	3.61	.942	-.237	.195	-.810	.387
KOL5	3.71	.953	-.481	.195	-.250	.387
KOL6	3.80	.936	-.746	.195	.202	.387
OSR1	2.40	1.091	.701	.195	.085	.387
OSR2	3.11	1.182	-.119	.195	-.988	.387
OSR3	2.50	1.077	.671	.195	-.046	.387
OSR4	2.68	.934	.224	.195	-.620	.387
OI1	3.64	1.116	-.667	.195	-.449	.387
OI2	3.46	1.281	-.568	.195	-.797	.387
OI3	3.45	1.207	-.465	.195	-.884	.387
OI4	3.17	1.298	-.190	.195	-1.096	.387
OI5	3.09	1.153	-.281	.195	-.937	.387
OI6	3.46	1.147	-.420	.195	-.742	.387
I4ST1	3.20	1.159	-.221	.195	-.899	.387
I4ST2	3.08	1.148	-.309	.195	-.626	.387
I4ST3	3.08	1.209	-.083	.195	-.869	.387
I4L1	3.61	1.142	-.610	.195	-.456	.387
I4L2	3.28	1.066	-.185	.195	-.808	.387
I4L3	3.08	1.165	-.077	.195	-.758	.387
I4C1	3.38	1.202	-.658	.195	-.458	.387
I4C2	3.75	.907	-.657	.195	.220	.387
I4C3	3.60	1.036	-.627	.195	-.372	.387
I4P1	3.48	1.059	-.688	.195	-.240	.387
I4P2	3.43	1.087	-.499	.195	-.265	.387
I4P3	3.25	1.071	-.312	.195	-.542	.387
I4OP1	3.18	1.102	-.247	.195	-.642	.387
I4OP2	3.69	1.017	-.473	.195	-.559	.387
I4OP3	3.21	1.061	-.290	.195	-.573	.387
I4CL1	3.35	1.204	-.429	.195	-.758	.387
I4CL2	3.92	.879	-1.125	.195	1.364	.387
I4CL3	3.81	.846	-.401	.195	-.337	.387
I4PP1	3.34	1.203	-.438	.195	-.774	.387
I4PP2	3.63	.988	-.663	.195	.295	.387
I4PP3	3.25	1.366	-.202	.195	-1.215	.387
I4G1	3.45	1.118	-.372	.195	-.599	.387

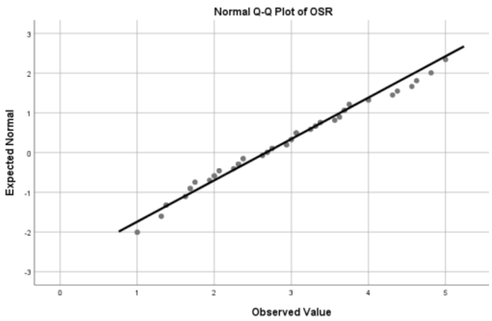
I4G2	3.43	1.045	-.424	.195	-.348	.387
I4G3	3.37	.974	-.326	.195	-.138	.387
I4T1	3.55	1.082	-.578	.195	-.226	.387
I4T2	3.67	1.058	-.442	.195	-.756	.387
I4T3	3.46	.982	-.236	.195	-.347	.387

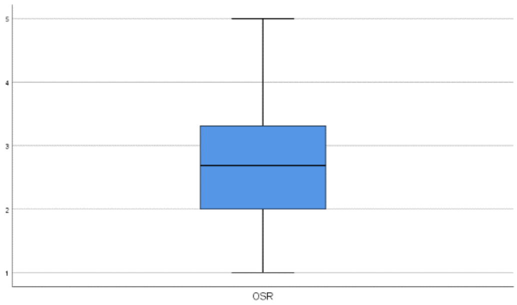
Appendix H: QQ-Plot, Box Plot & Histogram

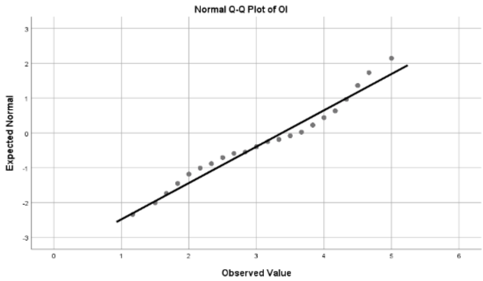
QQ-Plot

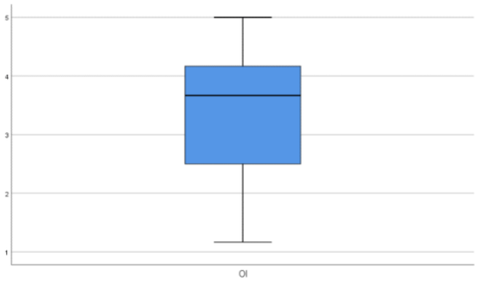


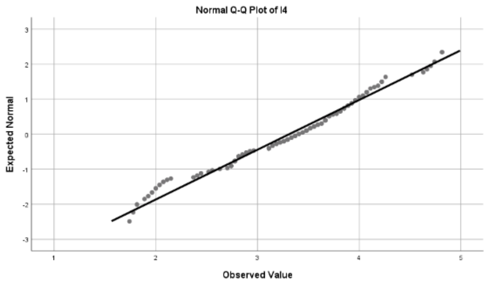


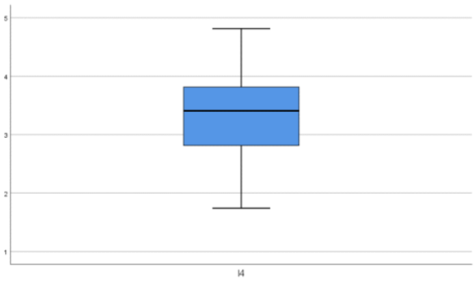




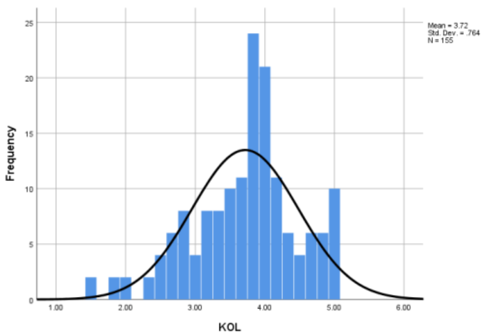

Normal Q-Q Plot of OI
Expected Normal
Observed Value

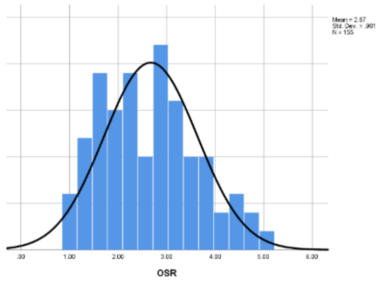

OI

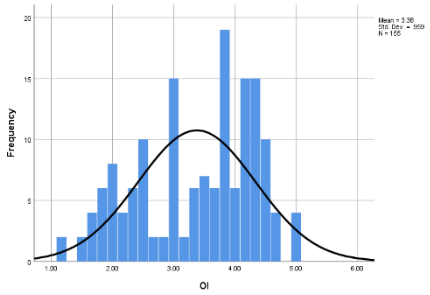

Normal Q-Q Plot of I4
Expected Normal
Observed Value

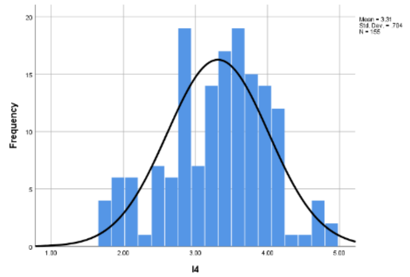

I4

Histogram


Mean = 3.72
Std. Dev. = .764
N = 155
Frequency
KOL


OSR





Appendix I: Total Variance Explained

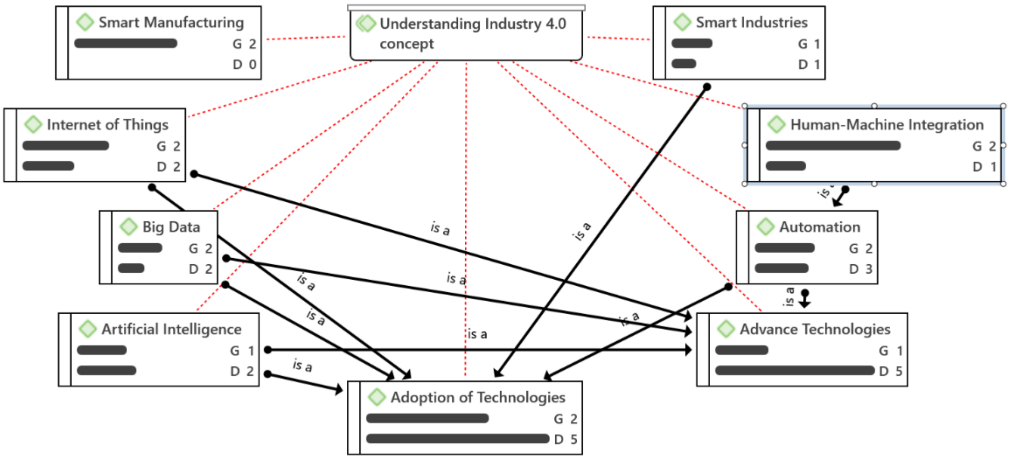
Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	16.218	37.716	37.716	16.218	37.716	37.716
2	3.926	9.129	46.845	3.926	9.129	46.845
3	2.567	5.970	52.815	2.567	5.970	52.815
4	2.248	5.227	58.043	2.248	5.227	58.043
5	1.785	4.151	62.194	1.785	4.151	62.194
6	1.521	3.536	65.730	1.521	3.536	65.730
7	1.412	3.284	69.014	1.412	3.284	69.014
8	1.326	3.084	72.099	1.326	3.084	72.099
9	1.214	2.822	74.921	1.214	2.822	74.921
10	1.040	2.420	77.340	1.040	2.420	77.340

Appendix J: Responses and Coding

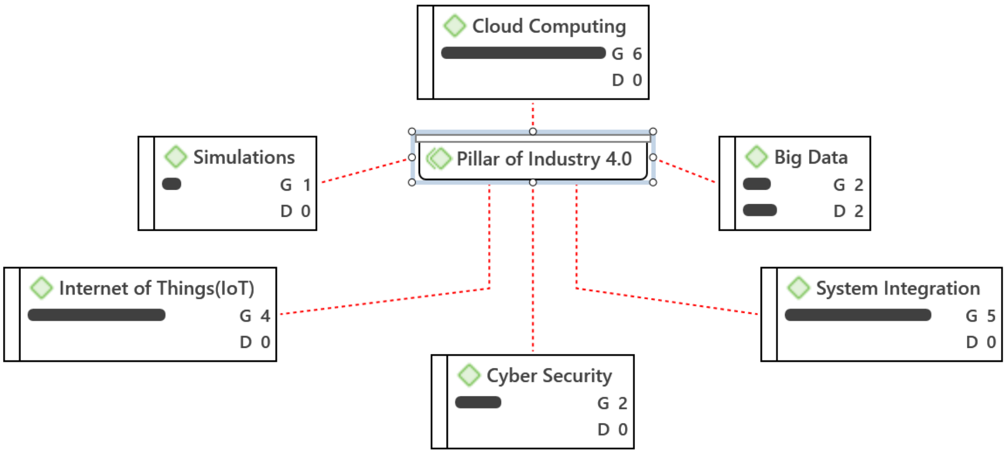
Response	1. What do you understand about the concept "Industry 4.0"?	3. Which pillars of Industry 4.0 your organization have applied?	4. What are major challenges your organization face for Industry 4.0?	5. What plans are your organization implementing for Industry 4.0?
Response	CODING			
1	Automation, Artificial Intelligence, Big Data	Cyber Security, Cloud Computing	Cost, Competency	Engaging Workforce
2	Advace Technologies	System Integration	Budget, New Technologies	Adopting Technologies
3	Adoption of Technologies	Cloud Computing, Internet of Things (IOT)	Awareness, Connectivity	Working on ICT
4	Internet of Things, Human-Machine Integration	Cloud Computing, Big Data, Internet of Things (IOT)	Skillset, Experience	Automation, Big Data
5	Automation	Simulations	Awareness	Research & Development
6	Human-Machine Integration	Cloud Computing, Internet of Things (IOT), 3D Printing, Cyber Security	Awareness, Education	Engaging Workforce
7	Adoption of Technologies	System Integration, Cloud Computing	Awarenss	Adopting Technologies
8	Smart Industries, Smart Manufacturing	System Integration, Cloud Computing, Internet of Things (IOT), Autonomous Robots	Cost, Complexity	Research & Development, Adopting Technologies, Engaging Workforce
9	Internet of Things, Smart Manufacturing	System Integration, Cloud Computing	Budget, Readiness, Time	Research & Development

Response	7. What benefits do you perceive of an aging worker for your organization?	8. What challenges do you perceive of an aging worker for your organization?	9. What role of knowledge oriented leadership could play in your organisation to facilitate the adoption of industry 4.0?	12. How could decentralized organization structure contribute to the innovation of the organization?	10. How knowledge oriented leadership enhance the innovation of the organization?
Response	CODING				
1	Experience	Fitness	Technology Leader	Through Flexibility	Through Knowledge, Change in Mindset
2	Low Risk, Quality Improvement	Understanding of Technology	Communication	Decentralization	Planning, Feasiblity Analysis
3	Nothing	Understanding of Technology	Training & Development	Learning Environment	Motivation
4	Training, Experience, Guidance	Conservative, Low Knowledge	Motivation, Learning, Support	Flexibility	Leading Role, Lead by Example
5	Experience	Avoid Technologies, Not Ready for Change	Awareness	Quick Decisions, Quick Solutions	Creating Awareness
6	Helps Transformation	Learning Capacity	Awareness, Education	Support Change	Motivation, Rewards
7	Nothing	-	Adoption of Technologies	Rapid Response	Support in Change
8	Easy to handle, Low Cost, Less Time	Low Knowledge, Avoid Technologies	Preparing Strategy, Prepare Environment, Improvement in Processes	Empowerment, Rapid Response	Effective Decisions
9	Knowledge, Experience	Low Energy, Low Motivation	Knowledge, Awareness	Efficient Operations, Friendly Environment	Knowledge Sharing

Appendix K: Concept of Industry 4.0



Appendix L: Pillars of Industry 4.0 Applied



Appendix M: Plan for Industry 4.0

Appendix N: Challenges in Industry 4.0

Appendix O: Benefits of Aging Workforce

Appendix P: Challenges of Aging Workforce

Appendix Q: Role of Knowledge Oriented Leadership

Appendix R: Role of Decentralized Organization Structure

SUBMISSION SHEET

FACULTY OF BUSINESS AND FINANCE
UNIVERSITI TUNKU ABDUL RAHMAN

Date: June 2022

SUBMISSION OF THESIS

It is hereby certified that Hafiz Mudassir Rehman (ID No: 18ABD07059) has completed this thesis entitled "THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE" under the supervision of Associate Professor Dr. Au Yong Hui Nee from the Department of Economics, Faculty of Business and Finance and Assistant Professor Dr. Choong Yuen Onn from the Department of Business and Public Administration, Faculty of Business and Finance.

I understand that the University will upload softcopy of my thesis in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

Hafiz Mudassir Rehman

Universiti Tunku Abdul Rahman			
Form Title: TURNITIN ORIGINALITY REPORT VERIFICATION FOR POSTGRADUATE PROGRAMME DISSERTATION/THESIS			
Form Number: FM-IPSR-PSU-022	Rev No.: 1	Effective Date: 06/12/2021	Page No.: 1 of 1

Name of Candidate	Hafiz Mudassir Rehman
Candidate ID.	18ABD07059
Name of Main Supervisor	Dr. Au Yong Hui Nee
Programme	Ph.D.
Title of Dissertation / Thesis	THE READINESS FOR INDUSTRY 4.0 OF THE MALAYSIAN MANUFACTURING SECTOR: THE ROLES OF ORGANIZATION INNOVATION AND AGING WORKFORCE

The following are the required parameters of originality and limits approved by UTAR:

(i) Overall similarity index is 20% and below
(ii) Matching of individual sources listed must be less than 1% each
(iii) Matching texts in continuous block must not exceed 8 words
(iv) Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words

Note: Attach a copy of the originality report with this form.

VERIFICATION BY MAIN SUPERVISOR

Overall similarity index (%)	**12**	Supervisor's Comments (Compulsory if parameters of originality exceed the limits approved by UTAR)
Similarity by source (%):		
• Internet Sources	**9**	
• Publications	**5**	
• Student Papers	**1**	
Number of individual sources listed with more than 1% similarity	**0**	

17 June 2022

(Signature of Main Supervisor) (Date)

VERIFICATION BY INSTITUTE OF POSTGRADUATE STUDIES AND RESEARCH (IPSR)

Parameters of originality and limits are in line with the requirements of UTAR **YES** ☑ **NO** ☐

Signature: ____________________

Name: Nurul Akmar

Date: 19/07/2022