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INDUSTRY 4.0 and TOTAL QUALITY MANAGEMENT in MALAYSIA

Master's thesis

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DEDICATION

I dedicate this work to my teachers and parents.

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LIST OF ABBREVIATIONS

AGV – Automated Guided Vehicle

TQM- Total Quality Management

SCOR-Supply chain operations Reference

CPS - Cyber-Physical System

GDP - Gross Domestic

Products3D – 3 dimensional

IOTs- Internet of things

ISO- International Organization for Standardization

SPC - Statistical process control

1. INTRODUCTION

Manufacturing companies face critical pressure to make an active green contribution, adopt environmental transformation policies and direct the sustainability-oriented industries. Policymakers can craft industrial policy to eliminate market failure and address social and environmental constraints, paving the way to open new economic development paths. To achieve economic development, it is vital to adopt policies that upsurge prospects due to technological regime changes and changes in market demand owning to the policy intervention (K. Lee & Malerba, 2017). One such technological regime is industry 4.0, representing a new industrial stage that integrates manufacturing systems and information and communication technology (Jeschke, Brecher, Song, & Rawat, 2017).

Emerging technology affects competition rules, industry structure, and customer demands (Bartodziej, 2017; Gilchrist, 2016). Thus, manufacturing companies have come forward to redefine their business models, adopt new technologies, and digitize factories to remain competitive in the market for an extended period. Governments also support the manufacturing companies through innovative policies and set up regulations and institutions to ensure fair competition between the respective competitors (Kuo, Shyu, & Ding, 2019). Governments worldwide have set up programs and strategies to support local manufacturing companies' competitiveness towards Industry 4.0. Industry 4.0 directs the manufacturing organization to integrate the information from all departments, monitor the information closely, and synchronize information accordingly (J. Lee, Bagheri, & Kao, 2014). The adoption of new technology, i.e., industry 4.0 in manufacturing companies, aims to commit innovation through the Triple Helix innovation model. Triple Helix's innovation model promotes cooperation between businesses, academia, and the government (Reischauer, 2018).

Some of the examples of such initiatives are Germany's "High tech strategy 2020", China's "Made in China 2025", "Advanced manufacturing partnership" in the US, Malaysia's "Industry4WRD", Brazil's "Towards industry 4.0", Taiwan's "Productivity 4.0" and Japan's

“Industry 4.1J” (Henning, 2013; Rafael, Jaione, Cristina, & Ibon, 2020; Zhou, 2015). All the programs developed are meant to accelerate industry 4.0 in respective countries.

Malaysia is hardly ahead of other ASEAN countries and targets industry 4.0 to regain Asian Tiger status among the South East Asian countries (Habibu, 2019). The country has shown stagnant productivity growth numbers in 2017 and 2018 (MOREIRA, 2019). The Malaysian government has prioritized boosting productivity in the manufacturing sector to support productivity growth in other sectors further. Manufacturing plays a critical role in the Malaysian economy as it generates over 1/3 of the total GDP. Malaysia had a 22.312 billion euro investment in the manufacturing sectors in 2020 (Business, N. 2020).

The government has received the idea of industry 4.0 from foreign companies like KUKA and ABB (Idrakisyah, 2020). In 2019, the Malaysian government allocated approx. 42 million Euro for the readiness assessment program, approx. 613 million euros for the industry digitization fund, part of the Industry4WRD initiative. In 2020, the government allocated funding for building a 5G system to kick-start local companies to get involved in industry 4.0 (Adilla, 2018; ENG, 2020). Some of the initiatives are the digital transformation acceleration program followed by the industry digitalization transformation fund, automation capital allowance, and soft loan scheme for automation and modernization for industry 4.0 (MITI, 2018). Recent sources pinpoint that the adoption of industry 4.0 technologies has increased manufacturing company revenues from 16 478 000 000 Euros to 20 598 625 000 Euros (Sharon, 2019). Thus, the growth aspects influence the researcher to assess industry 4.0 in Malaysia.

The study's objective was to explore the perceptions of Malaysian manufacturing companies about TQM and Industry 4.0. Malaysian Government implemented Industry4WRD Initiatives to improve the efficiency and TQM in Malaysia. The government has assisted manufacturing companies in helping the transition and conventional to the modern setup of industries through industry 4.0 in Malaysia. All the transition activities have been carried out through readiness assessments by assisting 500 Small and Medium-size Enterprises through industry 4.0 (Ling, Hamid, & Te Chuan, 2020). The initiative directs the firm to evaluate the potentials and readiness to adopt industry 4.0 technologies and processes. To understand the growing operational trends in the manufacturing industry, it is important to understand how companies perceive industry 4.0 and TQM in Malaysia. Thus, the study focuses more on the following questions.

Q1 - How do Malaysian companies perceive Industry 4.0 and TQM?

Q2 - What has been the impact of the Industry4WRD initiative on Malaysian companies?

Managerial staff at manufacturing firms need to clearly understand Industry 4.0. For example, Brettel, Friederichsen, Keller, and Rosenberg (2017) conclude that the industry 4.0 term must be understood first by managers to improve the benefits. Interestingly, scholars have urged to have contemporary research and development in Industry 4.0 (Kamble, Gunasekaran, & Gawankar, 2018). Therefore, it can be generalized that there is a strong need to develop a strong research and development section to improve the understanding of industry 4.0 to achieve higher gains in the manufacturing process. Currently, modernization has become a significant part of managing production structures. Using the latest technologies in the production process can reduce the safety risk for workforce in the production process.

The study is divided into seven sections. The first section is the Introduction, and the second section is the study's theoretical background. It can be treated under four headings: quality management, industry 4.0 in Malaysia, industry 4.0 policy framework in Malaysia, and the studies related to total quality management. The third section examines the methodology. The fourth section is a detailed analysis of primary data outcome is presented with the help of tables and charts. The fifth section summarizes the findings, and the sixth section contains the discussion. Conclusions are drawn in the final section.

2. LITERATURE REVIEW

2.1. Industrial policy

Industrial policy is a national strategy that encourages the government to become involved in revitalizing ailing sectors and assisting them in expanding their market possibilities. A specific activity brings together industrial sectors and government organizations. The major goal of designing industrial policy is to safeguard industries, provide loans, and provide tax benefits to businesses. As a result of the activity, the sectors can gain from the policy (Altenburg, 2011).

It covers any government effort that stimulates a complex economic sector or intervention while also promoting radical transformation (Rodrik, 2009). Industrial policy has always favored the transition beyond farm to industry. However, in recent years, the goal of industrial strategy has been to establish a competitive advantage in experience and understanding businesses. Industrial strategies, on the other hand, direct operations such as salmon farming and viniculture within developing economies. Numerous policy interventions have direct and indirect effects on the economy's balance. As a result, structural reforms influenced other policies (Haeri & Arabmazar, 2019).

It leads enterprises toward increased economic efficiency and market sustainability. The goal of formulating industrial strategy is to make current sectors more productive. It also promotes the creation of new industries to take advantage of better opportunities. For example, distributing grants for research and innovation and giving substantial support for start-ups in launching innovative activities; second, trying to mitigate the social impacts of the declining trend of mature industries, such as having appropriate policies in place for a specific region that relies on significantly reducing industrial events and activities disproportionally low productivity. The third goal is to even out geographical disparities.

It directs the industries to gain economic efficiency and meet competitive advantage in the environment. The objective of framing industrial policy is to strengthen the competitiveness of existing industries. Also, it induces the development of new ones to grab the new economic prospects. For instance, allocating subsidies for research and development and providing consistent support for start-ups in developing new activities, secondly, mitigating the social effects of the decline of mature industries and for example, having respective policies for a particular region that relies on diminishing industrial activities and experiences increasing unemployment rates to a disproportional degree. The third objective is to balance regional inequalities. It offers incentives for investments in impoverished areas, for example. Finally, it compensates for the negative environmental effects of economic activity.. (Altenburg, 2011).

2.2. Industrial revolutions

In 1760, the steam engine was created, kicking off the industrial revolution. It evolved from an ancient way of life, such as farming, to a more contemporary manufacturing one. Coal will be the primary source of energy, while trains will be the primary form of transportation. Textiles and steel were the most important industries in terms of employment, production value, and capital invested. The second industrial revolution began in nineteenth century, with the breakthrough of the internal combustion engine. The move encouraged industrialization, which drove mass production using oil and electricity. The third industrial revolution began in 1960 by employing microchip technology and information technology to computerize the manufacture process, right from screwing to the final product made through automation. The fourth industrial transformation includes simulated product design and 3D printing, which set up solid objects in building up the successive layers of materials. (prisecaru,2016).

Period	Transition Period	Energy Resource	Main Technical Achievement	Main Developed Industries	Transport Means
I: 1760-1900	1860-1900	Coal	Steam Engine	Textile, Steel	Train
II: 1900-1960	1940-1960	Oil Electricity	Internal Combustion Engine	Metallurgy, Auto, Machine Building	Train, Car
III: 1960-2000	1980-2000	Nuclear Energy Natural Gas	Computers, Robots	Auto, Chemistry	Car, Plane
IV: 2000-	2000-2010	Green Energies	Internet, 3D Printer, Genetic Engineering	High Tech Industries	Electric Car, Ultra-Fast Train

Table 1. Four industrial revolutions. Based on (Prisecaru, 2016).

The fourth industrial upheaval integrates technologies that blur the lines among physical, digital, and biological spheres. There is a general view that it disrupts every industry in the country. The breadth and depth of the changes transform the production system,management, and governance (Schwab, 2015).

2.3. Industry 4.0

Industry 4.0 supports the industrial revolution. It refers to a new organization level thatdirects the customer requirements (Rüßmann et al., 2015). The most important phase of the production process is having a clear out understanding of the reasons. (Brettel et al., 2017). The fundamental objective is to address the demands of individual consumers, which has an impact on order management, research, development, and delivery in order to use and recycle items. (Neugebauer, Hippmann, Leis, & Landherr, 2016). The use of internet favors physical goods like sensors, gadgets, and assets, thanks to the Industrial Revolution's paradigm change. (Sipsas, Alexopoulos, Xanthakis, & Chryssolouris, 2016). It has recently attracted numerous stakeholders and businesses since it improves process control significantly. (Gilchrist, 2016). Industry 4.0, according to recent studies, reduces the time to market for new products, improves customer adaptability, allows for tailored mass production with a reduction in overall product cost, increases flexibility, creates a more pleasant work place, and makes more efficient use of resources and vitality. (Rojko, 2017). As per the World Economic Forum’s report, the fourth industrial revolution significantly influenced all industries. Some of the impacts include bringing up rapid speed together with broad, comprehensive, and systematic transformations. With industry 4.0 initiatives, countries have proposed various policies intending to conserve energy, accelerate sustainable development and industry transition (Lin, Shyu, & Ding, 2017).

Industry 4.0 is described as a paradigm shift that coordinates internet of things technologies to create industrial value. Similarly, businesses worldwide are incorporating technological e-business concepts into their manufacturing operations (Sanders, 2007). Also, it helps to interconnect across company boundaries digitally in real-time (Kagermann, Wahlster, &, 2013; Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). It refers to intelligent, vertical, and horizontal networking of people, objects, machines, and communication systems. The main intention of industry 4.0 is to dynamically control the complex system (Liao, Deschamps, Loures, & Ramos, 2017; Müller, Kiel, & Voigt, 2018). It is also formed by a cyber-physical system that contains sensors followed by dataprocessors and actuators. Integrating the system with the real and virtual world enables to transfer of data among people and objects within the entire value chain in real-time (Müller, Buliga, & Voigt, 2018).

The origination of industry 4.0 is from the German “industries 4.0” introduced in 2011. The German government has taken steps to upsurge the German manufacturing industry (Hermann, Pentek, & Otto, 2016; Issa, Hatiboglu, Bildstein, & Bauernhansl, 2018). Industry 4.0 has many prospects that help the company meet the present constraints in industrial value creation (Kiel, Müller, Arnold, & Voigt, 2020). Nine technologies unfold the industry 4.0.

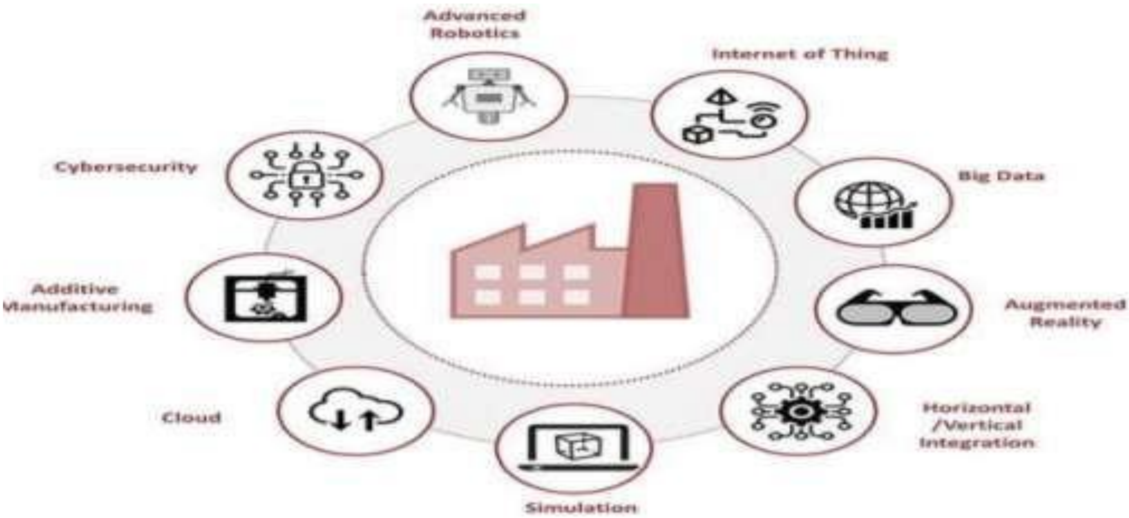

Figure 1. Nine key technologies of Industry 4.0. based on Gázquez et al., 2021

(Rüßmann et al., 2015). It includes big data analytics followed by autonomous robots, simulation, cybersecurity, additive manufacturing, IoT, horizontal integration, vertical integration, and AR (Salkin, Oner, Ustundag, & Cevikcan, 2018; Saucedo-Martínez, Pérez-Lara, Marmolejo-Saucedo, Salais-Fierro, & Vasant, 2018).

In industry 4.0, there are four important components. Cyber-physical systems, the internet of things, services, and smart factories are all included. (Hermann et al., 2016). The cyber-physical system involves the use of physical processes that impact computing, as well as the other way around. Internet of things allows the interaction between things and objects to oblige both to work better. The internet supports services, directing the features through the internet—smart factories direct human being and technologies to execute the tasks.

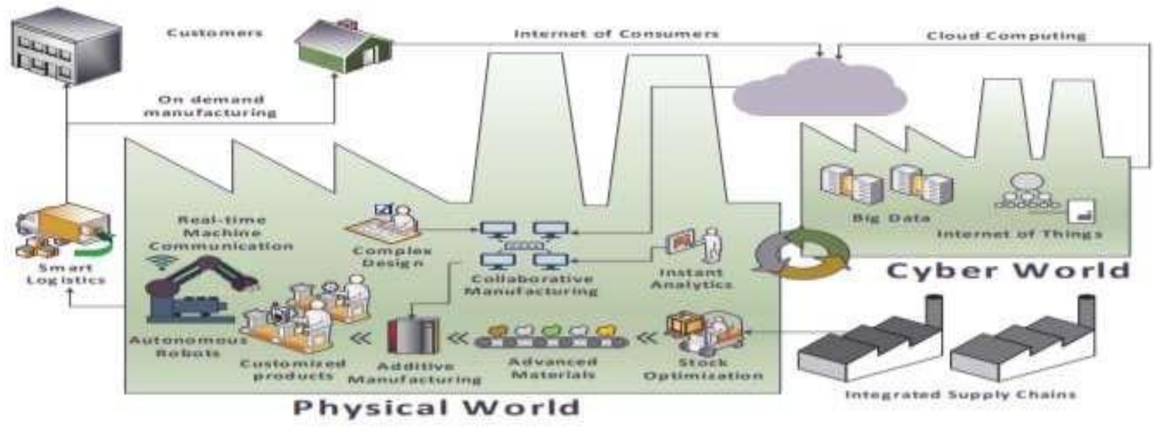

Figure 2. Nine key technologies of Industry 4.0 based on Hermann et al.,2016

A cyber and physical system, as shown in the figure 2. above, is one of the components of industry 4.0. The ultimate objective is to flourish and construct smart factories in a different and new way. The technologies have the potential to create market volatility, increasing demand and increasing the complexity of products and services. Furthermore, it shortens the development cycle. It is anticipated that adaptation and flexibility would improve. The entire efficiency of value production is improved. To encapsulate, industry 4.0 offers prospects that provide ecological and social aids to considerably anticipate industry 4.0.

Nagy (2019) pointed out that the obsolete production system does not help to meet customer expectations and greatly affects the situation. To improve productivity, it is vital to give importance to the quality of manufacturing products and reduce the wastes to a great extent (Paritala, Manchikatla, & Yarlagadda, 2017). All the attributes meet industry 4.0, which positively affects environmentally sustainable manufacturing and the development of green products, processes, and supply chain management (de Sousa Jabbour, Jabbour, Foropon, & Godinho Filho, 2018). Industry 4.0 has the powerto accelerate sales volume and plays an essential role in saving costs and offering micro-levelimprovement in performance (Losonci, Takács, & Városiné Demeter, 2019). Recent studies show that adopting industry 4.0 can decrease production and logistics costs by 10-30% and 10-20% of quality management costs. Industry 4.0 helps manage production planning, scheduling, utilization,energy management, and maintenance (Szalavetz, 2019). It is an essential pillar in manufacturing companies' future competitiveness (Frank, Dalenogare, & Ayala, 2019). By modifying control mechanisms in firm operations, this revolution has improved businesses' quality of products and services. The digitization of the industrial sector via the convergence of the physical and digital worlds and universal connectivity of people and things is the focus of the Industry 4.0 revolution (Pereira & Romero, 2017).

2.4 Total Quality Management

The term "quality" defines the totality of attributes and prerequisites of particular products or services that take on their ability to meet the requirements and satisfy the users (ASQ, 2021). The organization's goal is to produce quality products and processes across the entire product life cycle. Quality defines the competitiveness of the entire manufacturers. To meet high-quality standards requires proper integration of quality processes in the whole manufacturing company. The organization's core basis is to produce high-quality products and processes, especially in research and development and work scheduling areas. The precise concept of quality management is represented below (Garvin & Quality, 1984).

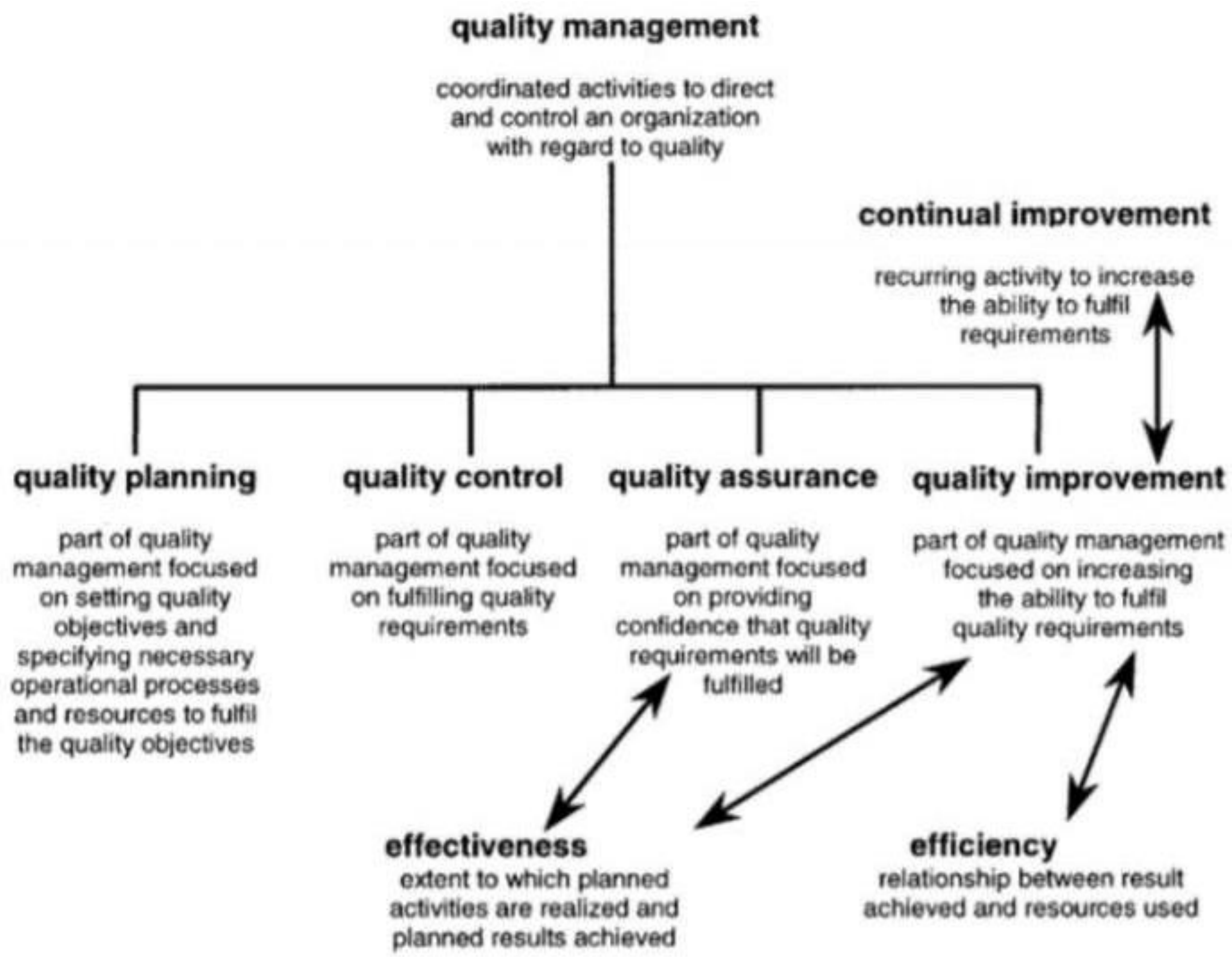

Figure 3.Total quality management system. Based on (Barros, Sampaio, & Saraiva, 2014).

Quality management is an approach or philosophy to management (Barros et al., 2014). The emergence of industry 4.0 brings advancement in quality management. Innovative electronics, which integrates with internal and external data networks, automatically control the process without human intervention. Total quality management (TQM) is a philosophy, a systematic quality and continuous improvement approach in enhancing customersatisfaction, quality, and overall organization management profitability (Gharakhani, Rahmati, Farrokhi, & Farahmandian, 2013). TQM plays a key role in developing management practices (Prajogo & Sohal, 2003). Top management support, employee involvement, continuous improvement, and customer orientation (Hung, Lien, Yang, Wu, & Kuo, 2011; McAdam & Armstrong, 2001). As per ISO, the primary intention is to meet the customer requirement, strive hard to meet customer expectations, and involve all people in accomplishing quality objectives (ISO, 2015).

2.5 Total Quality Management in industry 4.0

TQM matches the second industrial revolution (Canbay, Akman, & Aladağ, 2019). The present emergence of technology paves the way to industry 4.0, keen on optimizing the value chain. It offers autonomous control and dynamic production, which accelerates competitiveness even further in the future, with the comprehensive networking of machines, resources, and products inside the factory incurred with a vast volume of data. Industry 4.0 is characterized by the huge volume of aggregated data (Mayer & Pantförder, 2014). The new emerging potential of huge data quality management like monitoring and tracking the manufacturing process needs tools and methods. With the help of methods, the organization can measure its efficiency and effectiveness as per ISO (Bader & Aehnelt, 2014). Methods must be applied in an industry 4.0 environment (Foidl & Felderer, 2015). It has an excellent prospect for quality management for the organization. Also, it has constraints for the quality management domain in implementing industry 4.0 in the respective organization (*ibid*).

There is a requirement to recognize the TQM principles within the industry 4.0 environment to modify the existing management practices. The best example is leadership. Industry 4.0 and its management and leader competencies must improve because standard markets and product qualifications are ever-changing. Leaders must direct the subordinates with virtual systems and AI. Hence, leaders should have the potential to interact with digital profiles. Digital leadership is the new style to consolidate the subordinates. Still, it is a challenge for industry 4.0 because leaders have to increase the real-time connectivity of human machines, including suppliers, customers, and others (Sniderman, Monahan, & Blanton, 2017). The employee commitment principle is redefined to deal with humans and machines. In this case, commitment and conditions are the new challenging constraints within TQM principles. However, Kaizen implemented these to improve TQM, but industry 4.0 did not allow it to manage TQM in the organizational setup. It is vital to develop a relationship between humans and machines to be organic in time. The Cyber-physical system-based production system must interface both humans and machines. It affects roles, task description, monitoring, controlling methods under cyber-physical security and privacy system principles, and it may also change with industry 4.0 (Axiomtek, 2015; Hofmann & Rüsch, 2017; Mrugalska & Wyrwicka, 2017; Prinz, Kreimeier, & Kuhlenkötter, 2017). According to Rajnai & Kocsis (2018), the fourth revolution improves decision-making and industrial competitiveness.

Müller (2019) has pinpointed the assessment of the present state of industry 4.0 concerningquality management system. The study measures the aspect of the SCOR model perspective using quantitative research methods. It includes the elements of SCOR as plan, source, makes,delivers, and return. Findings of the study show that Make elements evenly distribute the elements among several functions. The study concludes with the implications of traceability, scheduling, and planning tasks reduced significantly. Therefore, more contribution is provided to upsurge lean management.

J. Lee, Azamfar, and Singh (2019) have shown that industry 4.0 urges a new quality management system. The application of industry 4.0 emerges because of technology's advancement to reduce the complexities present in the global business environment. The study applies qualitative research methods in which case studies have been applied. The study's findings indicate that technologies like big data analytics and AI play a key role in industry 4.0. Also, with the help of technology, the authors can perform predictive management that uses to make a helpful analysis, monitor the actual data, and decide at an appropriate time. Additionally, artificial intelligence plays a key role in developing new products in operation management (Huo, Hameed, Haq, Noman, & Chohan, 2020).

Foidl and Felderer (2015) have pointed out the benefits and prospects available for industry 4.0 in quality management. Many manufacturing companies use industry 4.0 to produce high-quality products to satisfy the customers and retain competitiveness. The study assesses industry 4.0 through the smart factory, cyber-physical system, and internet of things and services. All the technologies are offering promising prospects for quality management. However, specific challenges like vertical integration, horizontal and end-to-end engineering integration, and a grounded quality management system approach.

Zaidin, Diah, Yee, and Sorooshian (2018) show the prospects and constraints of quality management of industry 4.0 in the manufacturing sector. The study uses a qualitative approach which shows that the prospects can be seen in strategy, operations, environment, and people. Thus, industry 4.0 has prospects that induce the manufacturing sector.

2.6 Principal components of TQM in industry 4.0

Industry 4.0 brings dramatic innovation to below stated principal components of TQM.

Statistical process control (SPC)

Smart factories must implement sensors to self-inspect, control, and develop the smart process automatically. It will not include humans to do the above-stated activities. It will use robotic production tools to take action (Prinz et al., 2017). Industry 4.0 in SPC automates statistical controls. SPC tools like Pareto and FMEA will be applied easily at the right time to take corrective measures to reduce the failure and take preventive actions whenever required. Therefore, efficiency can be improved in smart factories with industry 4.0.

Information and analysis

Smart factories have a social network that extends the communication channels to other stakeholders. With the help of social networks, internal and external stakeholders, machines can communicate real-time information, which helps to know the process information (Kagermann et al., 2013; Sterev, 2017). Application of CPS and IoT helps to find out the bottlenecks in the process, close them in the social network platform, reduce the quality issues efficiently, and at last, reduce the considerable costs involved in monitoring the process (Axiomtek, 2015).

Just in time (JIT)

The main objective of JIT is to deliver the right product and at the right time, place, quantity, quality at the right costs (Mayr et al., 2018). JIT in industry 4.0 represents technology utilization like AGV, which can automatically transport objects within the material flow. It supplies raw materials to the respective department based on their requirements (Bauernhansl, Ten Hompel, & Vogel-Heuser, 2014; Kaspar & Schneider, 2015). Also, it reduces human bias and empty trips.

Therefore, it reduces search time and improves process transparency, short lead time, and improves flexibility (Künzel, 2016).

Supplier management

With the applications of industry 4.0, the principle of supplier management preserved and increased effectiveness within the smart factory. The best instance for supplier management is that supplier factories are self-sufficient facilities on the supply chain level that acquire raw material from local suppliers. It diminishes the lead time, lowers inventory level, and improves customization and responsiveness significantly (Hofmann & Rüsch, 2017; Radziwon, Bilberg, Bogers, & Madsen, 2014).

Customer orientation

Industry 4.0 provides personalized product design by allowing the client to design and order the product based on their needs and enables last-minute changes to be incorporated if necessary (Kagermann et al., 2013).

Product design

Big data and virtual reality allow us to recognize the customer needs with more improved touchpoints (Ibarra et al., 2018). It helps to develop the products with individualized design.

Process management

CPS with IoT and other technologies helps get real-time information about the process. It helps to gain transparency in knowing about the process in the manufacturing environment. Hence, it helps to do flexible planning that enables dynamic re-engineering processes (Bauer, Hämmerle, Schlund, & Vocke, 2015; Weyer, Schmitt, Ohmer, & Gorecky, 2015).

Strategic quality management

Customer expectations, flexibility, service orientation into a new business model helps develop higher competitive markets. It leads the companies to be more strategic, set up strategic alliances with suppliers and competitors in industry 4.0 (Hecklau, Galeitzke, Flachs, & Kohl, 2016).

Benchmarking

It measures the organization's performance or processes through best class performers. It helps to make continuous improvements and satisfy the customers in accomplishing competitive advantage (Anil & Satish, 2016). Networking horizontal, vertical integration, communications, and smart factory applications strengthen the benchmarking principle (Koch, Kuge, Geissbauer, & Schrauf, 2014; Pagnon, 2017).

System approach in the management

Sensors like RFID can assist in knowing the needs, initiate an order placement with suppliers through a time plan or production schedule. Embedded vision system integrates controller unit with production lines, warehouses, etc. Thus, it increases delivery times and strengthens the process with industry 4.0 developments.

Continuous improvement

High innovation, high-efficiency development made with real-time data, communication, and interaction enables the manufacturing process's continuous development. Continuous improvement can be made through big data, IoT, smart manufacturing systems and robotics, etc.

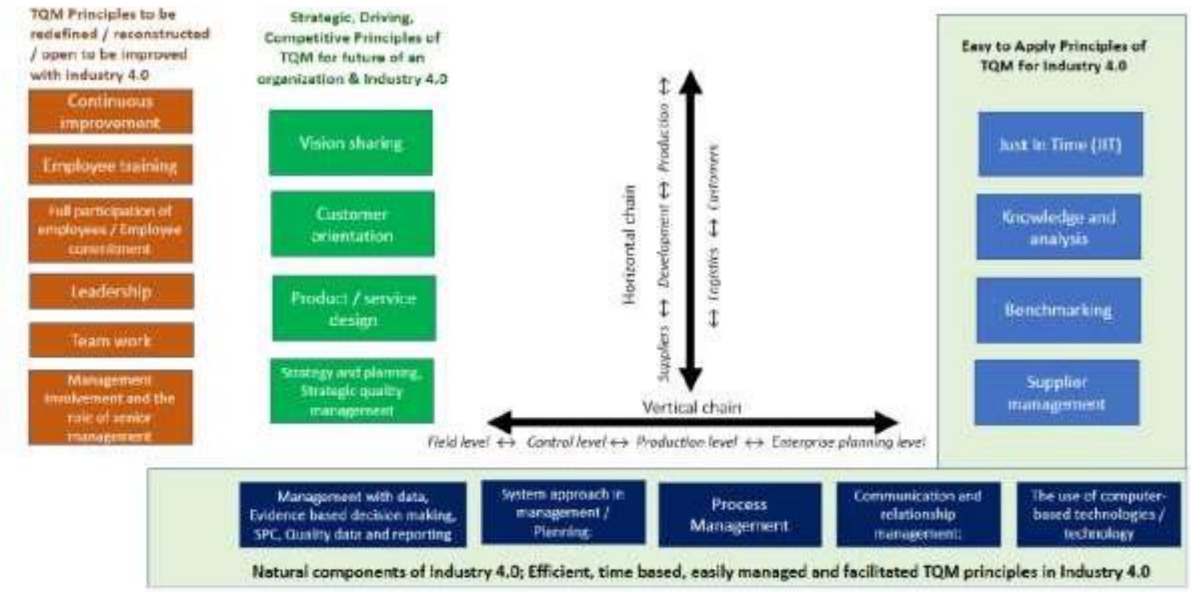

Figure 4. Status of TQM principles within Industry 4.0 Based on (Künzel, 2016).

3. INDUSTRIAL POLICY IN MALAYSIA

Astro Awani news reported that the national industry 4.0 policy framework exhibited a blueprint in 2018. The policy's main intention is to accelerate the digitization and transformation of all sectors in Malaysia (Veno, 2020).

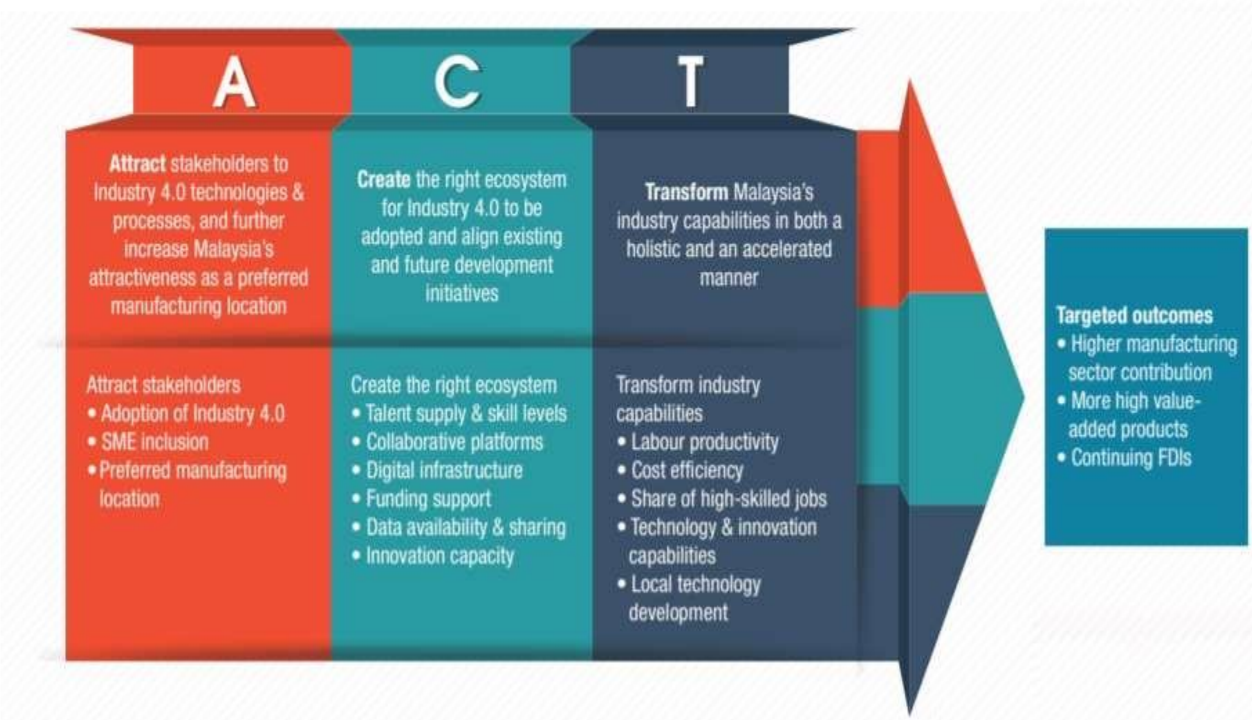

Figure 5. Objectives of the National Policy on Industry 4.0. Based on (Veno, 2020)

The Ministry of International Trade and Industry has set up a Malaysia Productivity Corporation (MPC) to improve productivity through industry 4.0. The government is increasing awareness about industry 4.0 because it addresses manufacturing issues like the hazardous environment, health and safety of labor, reduced wastage, time saving in offering efficient delivery systems, and efficiency in managing supply chain activities. The government of Malaysia believes that the adoption of industry 4.0 relies on three aspects: people, process, and technology. Activities related to people are talent acquisition, human capital development, and retention of existing talent.

The process represents enhancing and assisting innovative and strategic public-private partnerships (PPP). Technology relates to the adoption of intelligent solutions, including advanced hardware integrated with software, sensors, and analytics (Berhad, 2020). Therefore, the Malaysian government indirectly adopts industry 4.0 to increase its quality management of products. It suggests that government support is important in overcoming the initial challenges (Müller, Buliga, et al., 2018). To sum up the policy, the government is taking huge steps to create awareness about industry 4.0 in quality management, and if it is not clearly defined, it may lead to severe problems.

Industry4WRD policy

Between 2018 and 2025, the Industry4WRD policy will focus on reforming manufacturing and their linked service sector. The policy's main goal is to make the Asia Pacific area a significant partner for smart manufacturing and other services. The policy was developed in partnership with various ministries, including the Ministries of Finance, Human Resources, Multimedia and Communication, Power and Energy, Science and Technology, and Education and Climate Change. The policy's main goal is to entice stakeholders to move industries' applications and technology, resulting in Malaysia being a desirable site for smart manufacturing.

In Malaysia, the Industry4WRD initiative transforms the manufacturing sector and its integrated service sector. The main intention is to make smart, stronger technology via people, processes, and technology. The policy can gain an advantage for the firms through industry 4.0. As per Industry4WRD policy, a readiness assessment program helps measure the gaps and readiness to guide the companies properly. In turn, the action paves the way for the country to become the strategic partner for smart manufacturing and its integrated services in the entire Asia Pacific region. The gov ernment has framed the policy to have a collaborative effort of both government and industry. Also, stakeholder consultation has been considered to develop the policy. (MITI, 2021)

Ministry of International Trade and Industry had developed the Industry4WRD policy in 2017. Industry4WRD policy will make a manufacturing sector strong that will pave the way to enhance productivity, create job prospects, innovation capability, attract a highly skilled talent pool, economic prosperity, and social well-being.

4. RESEARCH METHODOLOGY

This study explores the adaptation of Industry 4.0 in total quality management perspectives in Malaysia. Overall, the philosophy of research is positivism. Positivism deals with uncovering reality and presenting it in empirical class. Additionally, positivism underpins the two best methods of understanding behaviour: observation and reasoning (Antwi & Hamza, 2015). Moreover, this is quantitative research in nature and empirically tests the relationship between adaptation of Industry 4.0 and total quality management. The quantitative analysis describes phenomena based on numerical data (Antwi & Hamza, 2015).

Additionally, this study is the cross-sectional type where data is usually gathered at a single point in time. Therefore, this research is survey-based. The data was collected through a self-administered questionnaire. Additionally, the questionnaire was designed in the English language.

Although each data collection method has its method-specific advantages in different settings, this research follows a self-administered questionnaire for data collection in Malaysia. The survey method can further be classified into two types, mailed or via the internet and intercepted in a central location (Blumberg, Cooper, & Schindler, 2014). This research uses a self-administrated questionnaire first type where data was gathered using Google Forms online. The survey method is one of the common methods for collecting data in research. Several compelling advantages of a self-administered questionnaire online, which motivated to choose the survey method. This method expands the accessibility to capture responses from a wide range of audiences and ensures a cost-effective and rapid data collection process, all pluses of a self-administered survey online (Blumberg et al., 2014).

Muller (2019) has proposed the quantitative method and the inspiration behind this design came from the author. The questionnaire was designed based on measurement scales or questions emphasized in previous studies (Schumacher, Erol, & Sihn, 2016; Stentoft & Rajkumar, 2020). Previous research (Schumacher et al., 2016; Stentoft & Rajkumar, 2020) noticed no appropriate and perfect scale to measure these variables. Therefore, our questionnaire is mainly based on the proposed scale used by related research (Schumacher et al., 2016; Stentoft & Rajkumar, 2020). This study modified earlier measurements slightly to fit in current study settings, but this process did not change the overall meaning of questions or measurement. Thus, the questionnaire in this study has two parts, a set of 10 demographic questions and a questionnaire related to the variables used in this study (9 questions for "how company perceive industry 4.0", 14 questions for total quality management, and seven questions for Industry4WRD initiative for TQM principles adaptation). All these questions were combined into a single questionnaire.

The sampling technique used in this study was convenience sampling, where data is collected based on the ease and relevancy of respondents. The purpose of the research is to explore the modification of Industry 4.0 in production processes to improve quality. Therefore, the unit of analysis in the current research was employees from Malaysian manufacturing companies. The link to the questionnaire was shared electronically with 76 employees from manufacturing companies operating in Malaysia. These companies were chosen based on three criteria, as also mentioned in Industry 4WRD Readiness Assessment (Azhar, Omar, & Shaiful, 2021):

- all the respondent companies are the manufacturing companies (automobiles).
- all companies are based in Malaysia.
- all companies have implemented industry 4.0 and are already participating in the industry4WRD initiative.

Industry4WRD readiness assessment has clarified the principles. The readiness was based on three layers, shift factors, thrusts, and dimensions. Further, these layers are subdivided into three shift factors (people, procedure, and smart machinery), eight trusts, and twenty-one dimensions. All layers, shift factors, and dimensions are interconnected. The rating criteria are based on the implementation of these shift factors. In this criterion, technology has 50% weightage, 20% for people, and 30% for the process. Azhar, Omar, and Shaiful (2021) have explained these three layers and thrusts. The technology shift layer includes endowments automation, connectivity, and intelligence. The process shift layer consists of operation management, and production chain management. People shift layer has thrusts such as human capital initiatives and transformational development. In overview, the criteria were defined based on Industry4wrd readiness assessment.

Respondent's eligibility or selection criteria were defined earlier. Two conditions in the criteria must be fulfilled to participate in the survey. Firstly, the respondent must be working on any managerial level designation. Secondly, if he or she is not working currently, then must have worked for at least one year. Recent research has used this benchmark (Hizam-Hanafiah & Soomro, 2021). However, 48 employees sent back filled questionnaires; therefore, 48 responses were chosen for analysis purposes. The response rate was around 63.15% because 48 responses were received out of 76 sent questionnaires.

Additionally, the formulation of the questionnaire was designed in a manner that no employee other than belongs to companies using Industry 4.0 in the production process can fill the questionnaire. Because first ten questions (demographics) were formulated to know whether a company is using Industry 4.0 to maintain total quality management principles in production processes or not. Therefore, only those responses were transmitted for analysis, mainly based on those employees using Industry 4.0. Finally, the CSV sheet was explored from Google forms and encoded into SPSS software and Microsoft Excel for analysis purposes.

The study has utilized various methods like percentage analysis, descriptive statistics, correlation, and regression for analyzing the data. All the data were analyzed using SPSS and Microsoft excel. Researchers have used the SPSS tool extensively to do quantitative analysis. Data from other quantitative findings, tables, and databases can be interpreted and written using SPSS software. When inserting data into the app, choose “variable view” from the drop-down menu. The user can configure the variable view by data category. Overall, the study used ANOVA analysis and regression to check the impact and relationship between constructs.

5. FINDINGS

5.1. Demographic profile of respondents

Particulars		Frequency	Percent
Age	20 to 25 years	16	33.3
	25 to 30 years	8	16.7
	30 to 35 years	4	8.3
	Above 35 years	20	41.7
Gender	Male	40	83.3
	Female	8	16.7
Education qualification	Masters	20	41.7
	Masters in mechatronics	4	8.3
	MBA	4	8.3
	Graduate	4	8.3
	BBA Honors	4	8.3
	Bachelor's degree	8	16.7
	PhD	4	8.3
Work experience	Below five years	24	50.0
	5 to 10 years	12	25.0
	10 to 15 years	8	16.7
	Above 15 years	4	8.3
Designation	Senior software developer	16	33.3
	Electrical design engineer	8	16.7
	Senior manager	8	16.7
	Sales manager	4	8.3
	Operation analyst	8	16.7
	Integrated engineer	4	8.3
Total		48	100.0

Table 2. Demographic profile of respondents. Based on Author's calculations.

Age: Respondents classify age based on respondents' opinions, including 20-25 years, 25-30 years, 30-35 years, and above 35 years. It is inferred that 33.3% of respondents belong to the age categories of 20-25 years, followed by 16.7% of respondents belonging to the age categories of 25- 30 years, 8.3% belonging to the age group of 30-35 years, and 41.7% are above 35 years of age.

Gender: Out of 48 respondents, 40 (83.3%) respondents were male, and 8 (16.7%) were female respondents.

Education qualification: According to the table, the education qualification involves the master's, master's in mechatronics, MBA, graduate, BBA Honors, bachelor’s degree, and Ph.D. Among the 48 respondents, 20 (41.7%) of respondents are masters, 4 (8.3%) are masters in mechatronics, MBA, graduate, BBA Honors, and Ph.D., and 8(16.7%) are bachelor’s degrees.

Work experience: It was observed from the table that 50% of respondents had below five years of experience, followed by 25% having between 5 and 10 years of age, 16.7% having 10-15 yearsof working experience, and 8.3% have more than 15 years.

It was found from the table that 33.3% of respondents are senior software developers,followed by 16.7% are electrical design engineers, senior managers, and operation analysts, and 8.3% are sales managers and integrated engineers.

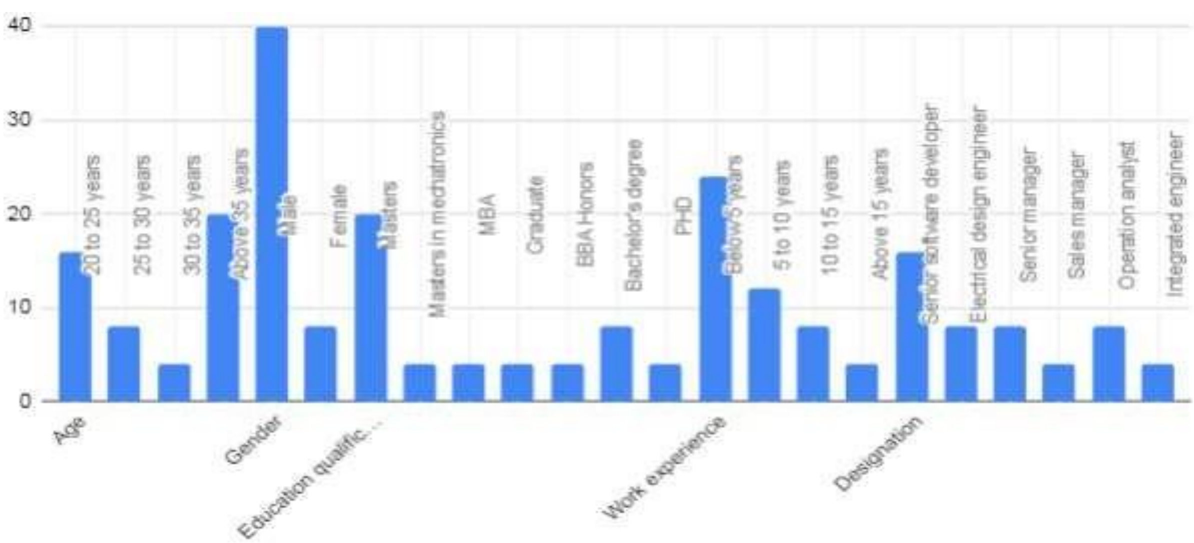

Figure 6. Demographic profile of respondents. Based on Author’s calculations

Particulars		Frequency	Percent
Sector	IT	12	25.0
	Engineering	8	16.7
	Financial	8	16.7
	Manufacturing	16	33.3
	Automobile	4	8.3
Total		48	100.0

Table 3. The frequency of sectors. Based on author's calculations.

The table above shows that 25% of respondents are IT sector, 16.7% are engineering and financial sector, 33.3 is in the manufacturing sector, and 8.3% are automobile sector. Hence, it is evident that many of the respondents who participated in this survey are from the manufacturing sector.

Particulars		frequency	Percent
Sources to know about industry 4.0 initiatives in Malaysia	Internet	24	50.0
	Government campaigns	12	25.0
	Social media	4	8.3
	Newspaper/Magazine	4	8.3
	Friends/Relatives	4	8.3
Total		48	100.0

Table 4. Sources to know about industry 4.0 initiatives in Malaysia. Based on author's calculations.

It has been found from the table that 50% of respondents know about industry 4.0 initiatives in Malaysia by internet, followed by 25% are government campaigns and 8.3% are social media, Newspaper/Magazine, and Friends/Relatives. Thus, it is evident that the highest numbers of respondents who have participated in the survey know about industry 4.0 initiatives in Malaysia by the internet.

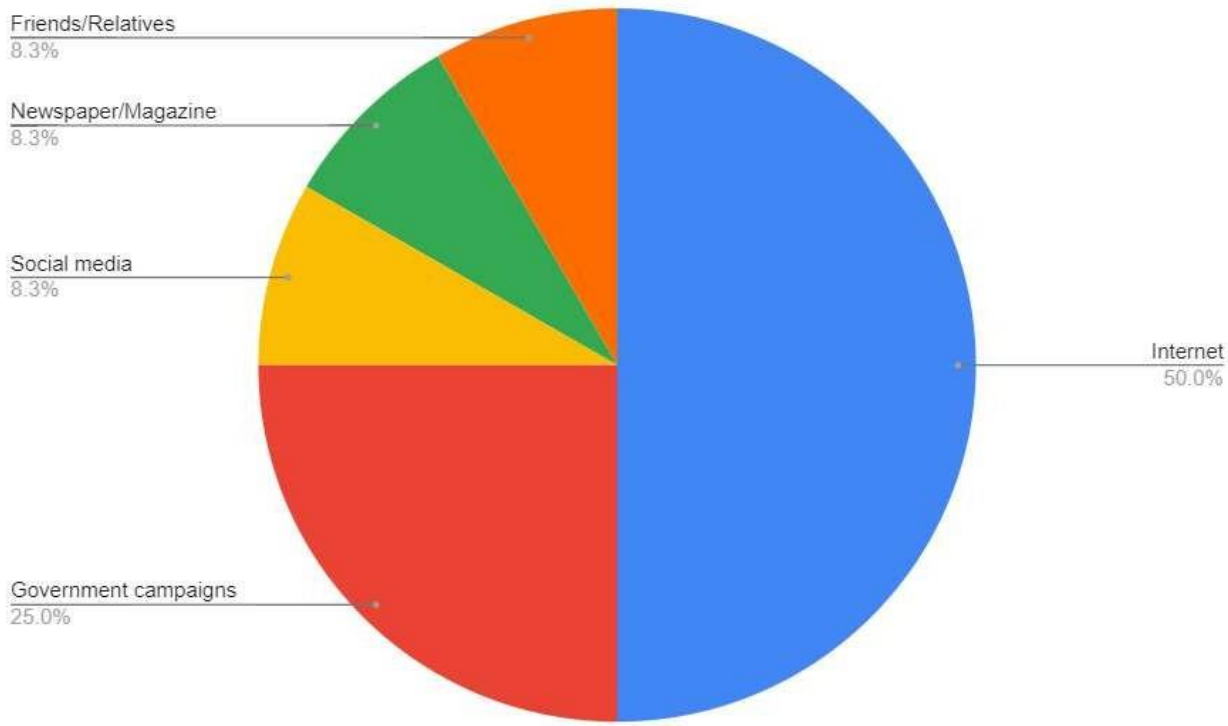

Figure 7. Sources to know about industry 4.0 initiatives in Malaysia. Based on Author's calculations.

Particulars		frequency	Percent
Components using an organization	Cyber-physical system	12	25.0
	Internet of things	16	33.3
	Smart factory	12	25.0
	Others	8	16.7
Total		48	100.0

Table 5. Components of industry 4.0 used in Malaysian organizations. Based on author's calculations.

The table shows that 25% of respondents use cyber-physical systems in the organization, 33.3% are internet of things, 25% are smart factories, and 16.7% are others. Hence, itis inferred that most of the respondents are using the internet of things in an organization.

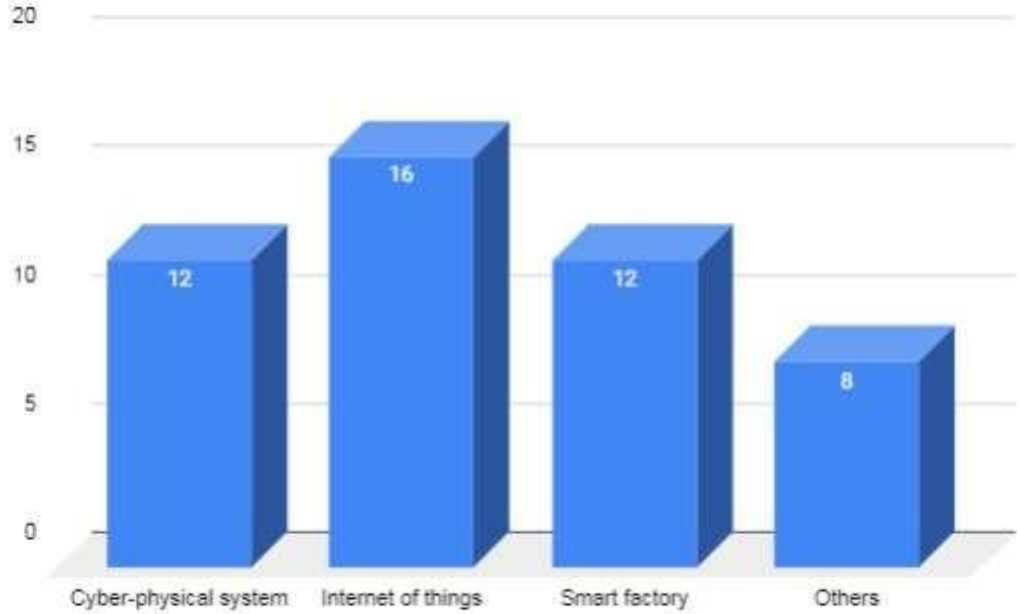

Figure 8.Components used an organization. Based on Author's calculations.

5.2. Descriptive statistics

Perceptions of Malaysian manufacturing industry about industry 4.0 in TQM:

The study analyzed the perceptions of the Malaysian manufacturing industry about industry 4.0 in TQM systems using a five-point Likert scale. It included the statement like "Industry4.0 enables the companies to have flexible manufacturing processes," "Industry4.0 supports to analyses a large amount of data in real-time," "Industry4.0 improves strategic and operational decision making," "Communication between machine and products enable reconfigurable and flexible lines for the production of customized products for small batches," "Industry4.0 assists in adopting several kinds of events like production line breakdown," "Industry4.0 increases productivity, utilizes resource effectively," "Industry4.0 reduces product launch time," "Industry4.0 improves sustainability" and "Industry4.0 optimizes automation processes" which taken into account. The average value varies from 2.4 to 3, and the standard deviation value ranges from 1.15 to 1.45. However, the highest mean value in the statement of "Industry4.0 enables the companies to have flexible manufacturing processes" of 3, and the least mean value represents the statement of "Industry4.0 improves sustainability" of 2.41.

Consequently, the precision can be revealed using standard deviation. The highest precision in the statement of “Industry4.0 improves sustainability” of 1.28 and the least accuracy indicating the statement of “Industry4.0 helps to analyses a large amount of data in real-time” of 1.41.

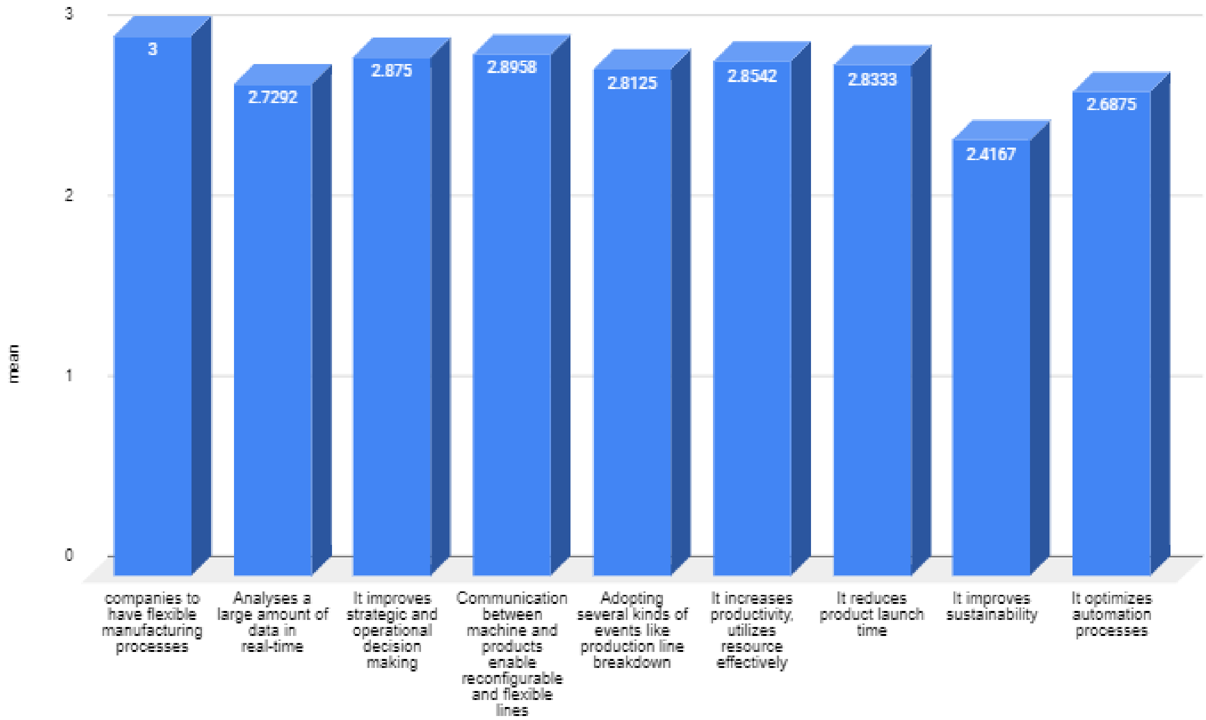

Figure 9. How companies perceive industry 4.0. Based on Author's calculations.

The TQM is rated on a five Likert scale in this study. It includes statements such as "TQM permits firms to provide tailored goods on a consistent basis." "Through TQM, personnel become more motivated to work." "TQM simplifies the process of modifying a mass manufacturing unit," says the author. "TQM combines the process flow and aids ERP systems in supply chain optimization," says the author. "TQM encourages all employees to communicate and collaborate," says the author. "In the firm, TQM promotes openness of business and manufacturing processes," says the author. "TQM enhances process efficient resource planning," says the author". TQM delivers a company with a framework for ongoing improvement at the product, process, and business levels," says the author. "TQM tells us to adopt decisions on the basis of facts," says the author. "New IT technologies (big data, internet of things) supplied a significant potential to improve outcome," says the author. "Industry4WRD initiative need the company to assess its strengths and preparedness to deploy industry 4.0 technology and processes," according to the company. "Industry4WRD initiatives help and accelerate technological change in the manufacturing and services sectors"Industry4WRD Initiative support to identify the status of willingness to accept industry 4.0 technologies," and "Industry4WRD initiative help to determining the difference and improvement opportunities for industry 4.0 as well as chances for output improvement and growth." The standard deviation ranges from 1.25 to 1.45, while the mean score ranges from 2.5 to 3.2.

As a result, "Industry4WRD initiatves assist and stimulate technology innovation in the manufacturing and services sectors" has the greatest mean value, whereas "TQM combines workflows and supports ERP systems in maximizing work process" has the lowest mean value. The reliability, on the other hand, is shown by the standard deviation.

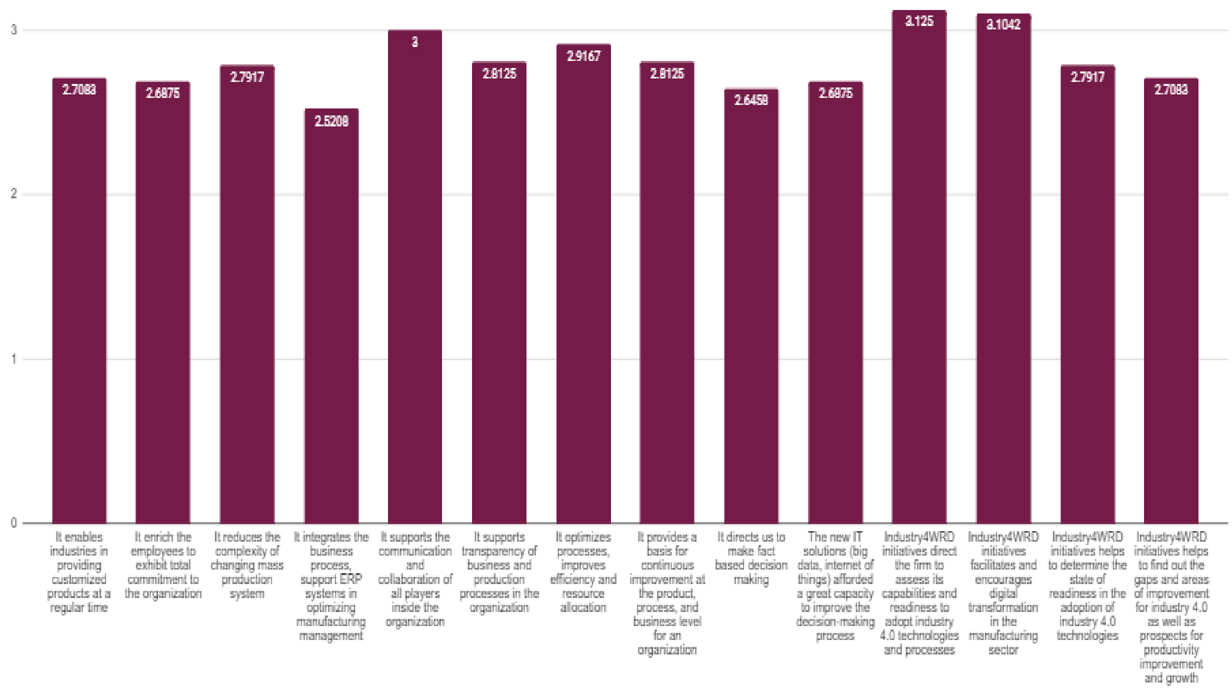

Figure 10. Total quality management. Based on Author’s calculations.

Industry4WRD initiative in Malaysia and its Adoption of TQM principles:

The study measures the statement using a five-point Likert scale. It includes the statement like "Industry4WRD initiative, and TQM practices allow us to improve customer satisfaction by improving the quality of delivered products and services," "Industry4WRD intervention fund assists SME likely to get financial assistance for adoption of industry 4.0 in the respective organization," "Industry4WRD directs the organization to provide transparent production processes, supported leadership capabilities to align and optimize resources effectively," "Industry4WRD initiative induces the organizations to adopt industry 4.0 integrated production system which ensures the production of high-quality products," "Industry 4.0 potentials in the quality management domain helps to monitor, track manufacturing processes," "Industry 4.0 is a good modeling implication business model that enhanced competitiveness" and "Industry 4.0 can trace carbon trail release by using data-centered and also reduce the greenhouse gas emissions." However, the mean value of the statement varies from 2.4 to 2.95, and the standard deviation differs from 1.2 to 1.45.

Simultaneously, it shows that the highest mean value indicates a statement of "Industry 4.0 potentials in the quality management domain helps to monitor, track manufacturing processes," and the least mean value in the statement of "Industry 4.0 is a good modeling implication business model that enhanced competitiveness." Moreover, the standard deviation indicates the precision in the statement. However, the highest precision in the statement of "Industry4WRD intervention fund assists SME likely to get financial assistance for adoption of industry4.0 in the respective organization" and the low accuracy indicates the statement of "Industry 4.0 can trace carbon trail release by using data-centered and reduce the greenhouse gas emissions."

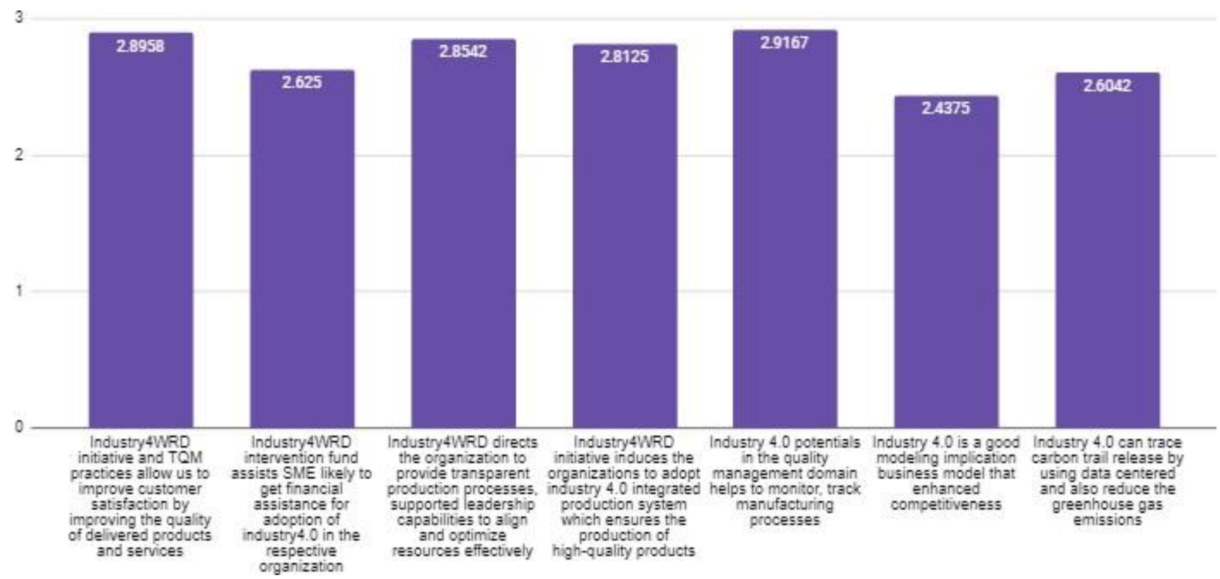

Figure 11. Industry4WRD initiative in Malaysia and its Adoption of TQM principles.

Source: Author's calculations.

5.3. Correlation

The table 6. below describes the correlation between Malaysian industrial policies and overall quality management in Malaysian businesses through its Industry 4.0 project.

In Malaysian businesses, there is a significant connection between how industry 4.0 is seen and total quality management.

Particulars	**r**	**Sig**
How companies perceive industry 4.0	.638**	.000
Industry4WRD initiative in Malaysia and its Adoption of TQM principles	.574**	.000

Table 6. Correlation between the Malaysian industrial policies through its Industry 4.0 initiative and total quality management in Malaysian companies. Based on author's calculations.

The association between perceived firm Industry 4.0 and TQM was determined to be 0.638, with a p-value of less than 5%. As a result, the TQM is favorably connected with the perceived firms

Industry 4.0. It is statistically significant as well. There is a strong link between Malaysia's Industry4WRD effort and the adoption of TQM concepts.

Industry4WRD initiative in Malaysia and its Adoption of TQM principles and TQM revealed that the correlation coefficient is 0.572, and the significance level is 0.000 (p<5%). Thus, it is evident that there is a significant relationship between the variables. Also, it has a positive strength.

5.4. Regression

The below table shows that the perceived companies' industry 4.0 is an independent variable, and TQM is dependent. It is evident that the R-value of the variables is 0.638, and the R-square value is 0.407 indicating a close relationship between the variables. Moreover, the R-square value suggests that the perceived companies' industry 4.0 has a 40.7% impact on TQM.

Particulars	R	r^2	ANOVA		B	t	Sig
			F	Sig			
C					1.036	3.204	.002
How companies perceive industry 4.0	.638[a]	.407	31.533	.000[b]	.635	5.615	.000

Table 7. Impact of industry 4.0 and TQM on manufacturing companies in Malaysia. Based on author's calculations.

However, the F-statistics is 31.533, and the significance level is less than 5%, respectively. Thus, Anova shows that the values are sufficient to predict TQM through perceived companies' industry 4.0. The betavalue of perceived companies' industry 4.0 is 0.638; the t-value is 5.615, and the p-value is 0.000,respectively. Hence, it concludes that industry 4.0 positively affects the TQM of manufacturing companies. Besides, a single unit change in TQM changes to 0.635 units in perceivedcompanies' industry 4.0. The equation for the variables is

TQM = 1.036 + 0.635 (perceived companies' industry 4.0)

Particulars	R	r^2	ANOVA		B	t	Sig
			F	Sig			
C	.574[a]	.329	22.598	.000[b]	1.439	4.843	.000
Industry4WRD initiative in Malaysia and its Adoption of TQM principles					.500	4.754	.000

Table 8. Impact of Industry4WRD initiative in Malaysia and its Adoption of TQM principles on TQM. Based on author's calculations

Industry4WRD initiative in Malaysia and its Adoption of the TQM principle affects the TQM The above table found that the Industry4WRD initiative in Malaysia and its Adoption of the TQM principle and TQM have secured the R-value of 0.574, indicating a strong relationship between the variables. However, the R-square value is 0.329, representing the Industry4WRD initiativein Malaysia and its Adoption of the TQM principle has a 32.9% impact on TQM. Moreover, Anova exhibits that the F-value is 22.598 and sig is 0.000, which is lesser than the significance level. Thus, it finds that the Industry4WRD initiative in Malaysia and its Adoption of TQM principle values are sufficient to predict the TQM with the present data. Also, the study had a beta value of 0.574, the t-value is 4.754, and the p-value is 0.000, which is less than a 5% level of significance. Therefore, it concludes that the Industry4WRD initiative in Malaysia and its Adoption of the TQM principle had a statistical effect on TQM. The regression equation for the variable is presented below

TQM = 1.439 + 0.500 (Industry4WRD initiative in Malaysia and its Adoption of TQM principle)

6. Discussion:

This chapter highlights the study's key results. Various criteria for assessing the results were used during the study, including descriptive statistics, percentage analysis, correlation, and regression analysis. SPSS and Microsoft Excel were used to assess all the statistics. The researcher conducted a thorough assessment of the profile of the respondents, which revealed that the proportion of participants (41.7 percent) are over 35 years old.

A percentage analysis approach was given preference to obtain the result that came from the manufacturing industries. The Manufacturing sector made up most of the questionnaire survey. Among the most striking findings was that respondents in Malaysia learned about industry 4.0 projects via the internet. Furthermore, one of the task's most important results was that the IOTs technology was the most widely deployed component of Industry 4.0 among manufacturing companies.

The statement "industry 4.0 allows enterprises to have flexible production processes" had the lowest sample value, according to descriptive statistics. Furthermore, with a standard deviation of 1.20, the statement "Industry 4.0 fosters sustainability" is closer to the mean value. The remark "Industry 4.0 helps to analyze a large dataset in real time" was, however, very widely distributed. The mean value of the statement "Industry4WRD initiatives fosters and encourages digital transformation in the industrial and manufacturing sector" suggests a relatively minimum value of 3.2 in terms of comprehensive quality management. The sentence "TQM teaches us to make fact-based decisions" has a closer mean when it comes to standard deviation.

The statement "Industry4WRD initiative urges enterprises to examine their skills and readiness to implement industry 4.0 technologies and processes" on the other hand, had a score spread that was significantly different from the mean.

Concerning the Industry4WRD initiative in Malaysia and its Adoption of TQM principles has the highest mean value of the statement was “Industry 4.0 potentials in the quality management domain helps to monitor, track manufacturing process”. With the help of standard deviation value, the researcher observes that’ Industry 4.0 can trace carbon trail release by using data cantered and reduce greenhouse gas emissions has a 1.45 as standard deviation value, indicating that values are more apart from mean. However,' Industry4WRD intervention fund assists SME likely to get financial assistance for adoption of industry 4.0 in the respective organization' has scores that were closer to the mean.

One of the most critical findings observed from correlation analysis was a strong positive correlation between companies perceiving industry 4.0 and total Quality management in Malaysian companies (0.638). Also, the industry4WRD initiative in Malaysia and its Adoption of TQM principles strongly correlated with Total Quality management in Malaysian companies (0.574).

After identifying the relationship, the researcher had made a more detailed analysis through simple linear regression analysis. Which provided the outcome that companies perceived industry 4.0 affected 40.7% on total quality management. Also, one unit of changes made in total quality management can change perceived companies' industry 4.0 to 0.635 units. Moreover, the industry4WRD initiative in Malaysia and its Adoption of TQM principles affected 32.9% of total quality management in Malaysian companies. Besides, one unit of changes made in total quality management system can make changes to 0.500 units in the industry4WRD initiative in Malaysia and its Adoption of TQM principles. To sum up the effect, the industry4WRD initiative in Malaysia and its Adoption of TQM principles on total quality management is inconclusive.

The findings' implications are discussed. According to the findings, many respondents learned about Industry 4.0 via the internet. As a result, industrial organizations have a substantially lower awareness of Industry 4.0.

There is no recognized industry 4.0 education program, according to several responders. As a result, the government should create a separate certification program to encourage responders to actively participate in educational programs to increase their intellectual and empirical expertise. A certified program may also provide society with many competent persons, resulting in a new dimension of job development. It also aids in the development of the economy by promoting social advancement, which increases competitiveness, lowers prices, improves quality, and effectively meets global competition.

Malaysian businesses must adopt Industry 4.0 in all domains, remove unnecessary resource usage. It might steer the firm in the proper path to get a competitive advantage and continue in company's best interest.

7. CONCLUSION

The purpose of this study was to investigate if Malaysian industrial strategy, as embodied in the Industry4WRD development, has had an influence on total quality management in Malaysia, as well as to examine how enterprises in Malaysia view Industry 4.0 and TQM. The Industry4WRD initiative is an industrial policy to shift the structure of economic activity toward innovations that are predicted to lead to economic growth. The researcher used a five-point Likert scale to assess the industry4WRD program and Malaysian enterprises' total quality management.

The industry4WRD project shown a good link with comprehensive quality management, according to the Pearson correlation. In addition, the link between the Industry4WRD initiative and comprehensive quality management was statistically significant.

The data was then reviewed to see how the industry4WRD initiative affected total quality management in Malaysian businesses. The study's key finding is that the industry4WRD initiative has had a 32.9 percent impact on Malaysian enterprises' entire quality management. Furthermore, the study discovered that overall quality management had a linear link with the perceived industry 4.0 of the organization. In addition, perceived firms' industry 4.0 had a 40.7 percent impact on Malaysian companies' total quality management. In conclusion, the study yielded various useful findings, the most noteworthy of which was the existence of a linear connection between the variables (industry 4.0 and total quality management). In addition, industry 4.0 has a significant statistical influence on Malaysian enterprises' comprehensive quality management.

Limitations of the study:

The study's first limitation is that it relied on data from 48 Malaysian small and medium enterprises. In Malaysia, five hundred enterprises are still implementing Industry 4.0. As a result, the 9.6% of the company's views did not represent all Malaysian small and medium businesses. In addition, the findings' scope may be assured to some extent.

The second limitation is that the researcher finds it difficult to contact firms individually and obtain feedback from each one. Due to the covid situation, the personnel took more time to fill the form.

<u>Scope for future Research:</u>

The current study examines how Malaysian organizations view Industry 4.0 and its relationship to the overall total quality management. The study drew input from manufacturing, and automobile industries. As a result, the study's conclusion reflects the overall industry's results. Currently, the study examines the outcomes in a statistical format but does not go into detail about the outcome. As a result, it's a good idea to assess industry 4.0, technology, and components in relation to a certain industry. Future studies could investigate industry 4.0 from a qualitative standpoint.

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APPENDICES

Appendix 1. Questionnaire

1. Name ………………….

2. Age ……………………

3. Education qualification ………………

4. Work experience …………………….

5. Designation ………………………….

6. Sector ……………………………….

7. What are the initiatives available in industry 4.0 in Malaysia? ………………….

8. How do you come to know about industry 4.0 initiatives in Malaysia?

a. Internet

b. Government campaigns

c. Social media

d. Newspaper/Magazine

e. Friends/Relatives

9. Do you think that initiatives disseminate the industry4.0 concepts and technologies to the local firm?

a. Yes

b. No

10. If yes, which of the following components do you use in your organization?

a. Cyber-physical system
b. Internet of things
c. Smart factory
d. Others

How companies perceive Industry 4.0

11. Industry 4.0 enables companies to have flexible manufacturing processes

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

12. Industry 4.0 helps to analyses a large amount of data in real-time

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

13. Industry 4.0 allows for better strategic and operational decision-making.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

14. Communication between machine and products enable reconfigurable and flexible lines to produce customized products for small batches

a. Strongly agree
b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

15. Industry 4.0 supports in the adoption of a range of activities, such as manufacturing process breakdowns.

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

16. Industry 4.0 boosts production and makes efficient use of resources.

   a. Strongly agree

   b. Agree

   c. Neutral

   d. Disagree

   e. Strongly disagree

17. Industry 4.0 speeds up product launch

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

18. Industry4.0 improves sustainability

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

19. Industry4.0 optimizes automation processes

a. Strongly agree

b.

c. Agree

d. Neutral

e. Disagree

f. Strongly disagree

Total quality management

20. TQM enables industries in providing customized products at a regular time

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

21. TQM enrich the employees to display a total commitment to the organization

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

22. TQM reduces the complexity of changing mass production system

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

23. TQM integrates the business process, support ERP systems in optimizing manufacturing management

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

24. TQM endorses the communication and relationship of all players in the organization

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

25. TQM supports transparency of business and production processes in the organization

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

26. TQM optimizes practices, improves efficiency and resource allowance

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

27. TQM provides a basis for continuous improvement at the product, process, and business level for an organization

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

28. TQM leads us to take fact-based decision making

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

29. The new IT way out (big data, internet of things) afforded a great facility to enrich the decision-making procedure.

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

30. Industry4WRD initiative direct the firm to measure its facilities and readiness to embrace industry 4.0 technologies and methods

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

31. Industry4WRD initiative simplify and assist digital change in themanufacturing sector

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

32. Industry4WRD initiatives help to determine the state of readiness in the adoption of industry 4.0 technologies.

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

33. Industry4WR initiative help to notice the variations and areas of improvement for the industry 4.0 as well as prospects for productivity improvement and growth

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

Industry4WRD initiative in Malaysia and its Adoption of TQM principles

34. Industry4WRD initiative and TQM practices allow us to expand consumer satisfaction by upgrading the quality of delivered manufactured goods and services

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

35. Industry4WRD intermediation fund contributions SME likely to get financial backing for adoptionof industry4.0 in the organization

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

36. Industry4WRD directs the organization to provide transparent production processes, supported leadership capabilities to align and optimize resources effectively.

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

37. Industry4WRD initiaive provokes the organizations to embrace industry 4.0 unified production system, which safeguards the production of high-quality manufactured goods

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

38. Industry 4.0 possibilities in the quality management to help, perceive, track process of manufacturing.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

39. Industry 4.0 is a good casting implication corporate model that enhances success

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

40. Industry 4.0 can discover carbon trial issue by applying data- centered and lessen the greenhouse gas discharges

a. Strongly agree

b. Agree

c. Neutral

d. Disagree

e. Strongly disagree

Appendix 2. Tables

Table 8: How companies perceive industry 4.0

Particulars	mean	standard deviation
Industry4.0 enables the companies to have flexible manufacturing processes	3.0000	1.35270
Industry4.0 helps to analyses a large amount of data in real-time	2.7292	1.41029
Industry4.0 improves strategic and operational decision making	2.8750	1.40856
Reconfigurable and flexible lines for the manufacturing of bespoke items in small quantities are made possible through communication between machines and products.	2.8958	1.15297
Industry 4.0 aids in the adoption of a variety of events, such as a manufacturing line failure.	2.8125	1.33139
Industry 4.0 boosts production and makes efficient use of resources.	2.8542	1.35253
Industry4.0 speeds up product launch.	2.8333	1.31008
Industry4.0 boosts long-term viability.	2.4167	1.28549
Automation processes are optimized by Industry4.0.	2.6875	1.35515

Author: own calculation

Table 9: Total quality management

Particulars	mean	standard deviation
TQM helps businesses to deliver customized goods on a consistent basis.	2.7083	1.41359
TQM allows workers to demonstrate a thorough commitment to	2.6875	1.47542

the company.		
TQM simplifies the process of modifying a mass manufacturing system.	2.7917	1.44338
TQM connects corporate processes and aids ERP systems in industrial management optimization.	2.5208	1.30449
TQM encourages internal collaborative efforts among all stakeholders.	3.0000	1.41421
TQM promotes the organization's business and production processes to be transparent.	2.8125	1.43892
TQM raises efficiency and resource allocation by optimizing operations.	2.9167	1.30194
TQM offers a company with a foundation for continuous improvement at the product, process, and business levels.	2.8125	1.42405
TQM promotes us to make decisions based on the information.	2.6458	1.26305
New IT tools (big data, internet of things) provided a significant capability for improving outcome.	2.6875	1.27423

Industry4WRD initiatives direct the firm to assess its capabilities and readiness to adopt industry 4.0 technologies and processes	3.1250	1.49645
Industry4WRD initiatives facilitate and encourage digital transformation in the manufacturing sector	3.1042	1.29220
Industry4WRD initiatives help to determine the state of readiness in the adoption of industry 4.0 technologies	2.7917	1.28756
Industry4WRD initiatives help to find out the gaps and areas of improvement for industry 4.0 as well as prospects for productivity improvement and growth	2.7083	1.28756

Author: own calculation

Table 10: Industry4WRD initiative in Malaysia and its Adoption of TQM principles

Particulars	mean	standard deviation
Industry4WRD initiative and TQM practices allow us to improve customer satisfaction by improving the quality of delivered products and services	2.8958	1.32472
Industry4WRD intervention fund assists SME likely to get financial assistance for adoption of industry4.0 in the respective organization	2.6250	1.23124
Industry4WRD directs the organization to provide transparent production processes, supported leadership capabilities to align and optimize resources effectively	2.8542	1.30449
Industry4WRD initiative induces the organizations to adopt industry 4.0 integrated production system, which ensures the production of high-quality products	2.8125	1.33139
Industry 4.0 potentials in the quality management domain help to monitor, track manufacturing processes	2.9167	1.35007
Industry 4.0 is a good modeling implication business model that enhances competitiveness	2.4375	1.31935
Industry 4.0 can trace carbon trial release by using data-centered	2.6042	1.41029

and also reduce the greenhouse gas emissions		

Author: own calculation