Volume 11 • Issue 2 • 2019

received: 2 January 2019
accepted: 10 June 2019

pages: 52-69

Fourth industrial revolution: a way forward to attain better performance in the textile industry

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ABSTRACT

The textile industry is one of the fastest growing industries which expressively contributes to the economic growth of Malaysia. However, in recent years, the situation has changed and demonstrates a downward trend. The imports are growing faster compared to the exports, consequently resulting in a low contribution to the gross domestic product (GDP). To address the issue, this study aims to investigate the role of Industry 4.0 on the performance of firms engaged in the production and services of the Malaysian textile industry. To achieve the objective, this study adopted a cross-sectional research design. A survey was carried out to collect data from employees of textile firms. Results of the study found that Industry 4.0 positively contributed to the effectiveness of the production and services of the textile industry. Production and services have a positive role in the performance of textile firms. The current study provides an interesting insight into the future direction of research for studies on organisational performance, which can be extended to different manufacturing-based industries. In addition, it provides the rationale for the adoption and implementation of smart technologies in these industries. It has been found that cyber-physical systems (CPS), interoperability, a smart city and a smart product have a positive effect on production and services. Additionally, it is not possible without the effective implementation of technology. Thus, the current study provides valuable insights into the improvement of the textile industry's performance.

KEY WORDS

Industry 4.0, firm performance, cyber-physical systems, interoperability, smart product; smart city

DOI: 10.2478/emj-2019-0011

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Introduction

The fourth industrial revolution is most significant in having the latest technology, which leads to improved performance. This industrial revolution has a key role in the attainment of higher performance (Lalic et al., 2017; Nagy et al., 2018; Sandengen et al., 2016; Tonelli et al., 2016) by promoting production and services in an organisation. Industry 4.0 provides the latest technology for the manufacturing process, which promotes organisational performance. It can also deliver improved services through the latest and unique technology. Therefore, the fourth industrial revolution is key to the promotion of organisational performance.

Industry 4.0 has important elements, such as big data, cyber-physical systems (CPS), the interoperability, the Internet of Things (IoT) and a smart city. The industrial revolution is mostly based on these five factors. However, the current study examined the effect of three major factors, namely, CPS, the interoperability and a smart city (a smart factory, a smart product) on the production and services of textile companies in Malaysia. These three elements of Industry 4.0 (CPS, the interoperability and a smart city) have a significant role in production and services. It should be mentioned that Industry 4.0 has a major role in boosting the manufacturing process of various industries (Gentner, 2016; Theorin et al., 2017; Zheng et al., 2018; Alaeddin et al., 2018; Ślusarczyk, 2018; Muzekenyi et al., 2019).

This study considered the textile industry of Malaysia. The textile industry is one of the fastest growing industries which expressively contribute to the economic development of many countries, including Malaysia (Pang & Abdullah, 2013; Meyer & Meyer, 2016), where this industry makes a significant contribution to the GDP. In Malaysia, the contribution of the textile and apparel industry to the GDP amounts to approx. 1.2% (Ali & Haseeb, 2019). Therefore, this industry is significantly important for the economy.

However, in recent years, the situation has been changing, and performance has been decreasing. In Malaysia, this industry has been demonstrating the greater growth of imports compared to the exports, which resulted in the decrease of the contribution to GDP between 2015 and 2016 (Ali & Haseeb, 2019). The performance of the Malaysian textile industry from 2006 to 2016 is presented in Tab. 1. This shows the decreasing trend in exports and the increasing trend in imports. The increase in imports and the decrease in exports have a negative effect on the overall performance. Aiming to improve perfor-

Tab. 1. Malaysian textiles and apparels trading (2006–2016)

Year	Import	Export	Balance
2006	6	10.9	4.9
2007	5.6	10.3	4.7
2008	5.4	10.5	5.1
2009	4.4	8.93	4.53
2010	5.65	9.33	3.68
2011	8.17	10.81	2.64
2012	8.91	9.46	0.55
2013	8.78	10.25	1.47
2014	9.1	11.03	1.92
2015	14.93	11.9	***-3.03***
2016	16.4	12.06	***-4.34***

Source: elaborated by the authors based on (Ali & Haseeb, 2019).

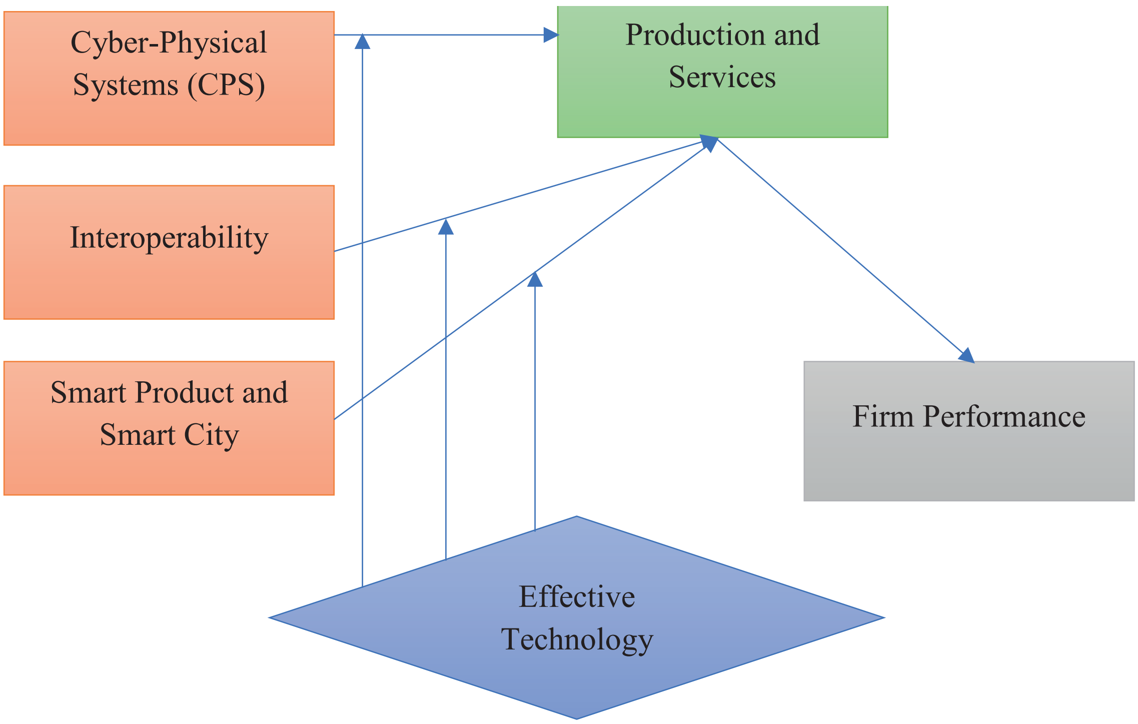

Fig. 1. Theoretical framework of the study showing the relationship between Industry 4.0, production, services, technology implementation and firm performance

mance, a balance should be ensured between exports and imports. In this case, Industry 4.0 has the features to control the decreasing performance of the Malaysian textile industry performance as the features of Industry 4.0, such as CPS, the interoperability and a smart city (a smart factory, a smart product), have a positive effect on the production and services of textile companies.

Many researchers investigate the manufacturing of the textile industry (Bryson & Ronayne, 2014; Cancer, 1990; Dabas et al., 2019; Magnani et al., 1993; Rai et al., 2005); however, studies rarely document the role of Industry 4.0 in the production and services sector of the textile industry. Therefore, a gap exists in the body of literature. Hence, this study investigated the effect that Industry 4.0 has on the performance firms acting in the Malaysian textile industry.

The theoretical framework of the current study is presented in Fig. 1. It shows the relationship between Industry 4.0 (CPS, the interoperability, a smart city, a smart product), production, services, technology implementation and firm performance. The objective of this study is to investigate the role of Industry 4.0 on the performance of firms based on the production and services of the Malaysian textile industry. The selection of the textile industry is further motivated by the literature, which maintains that the adoption of Industry 4.0 solutions tends to give rise to barriers, such as uncertainties, to the potential financial benefit as well as the lack of specialist knowledge (Küsters, Praß & Gloy, 2017). Additionally, this study has two sub-objectives: 1) to examine the mediating role of production and services, and 2) to examine the moderating role of effective technology implementation.

The rest of the paper is organised in the following manner: Section 1 reviews the relevant literature to develop the hypotheses; Section 2 describes the methodology used in the study; Section 3 presents the results of the analysis; and Section 4 provides the implications of the results, which are discussed. The final section concludes the study and discusses its main contributions.

1. Literature review

As an evolving piece of technology, Cyber-Physical Systems (CPS) are likely to provide capable solutions to the conversion of processes in a company as well as play a role in numerous current industrial arrangements (Bondar et al., 2017; Gürdür, El-Khoury et al., 2016; Mao et al., 2016; Yan et al., 2015; Zhai et al., 2016). The present research study has evaluated thirteen articles shown in Tab. 2, which researched CPS — systems related to the industry automation that combine different innovative functions with the support of networking to allow linking of the operations with better computing as well as communication substructures (Bagheri et al., 2015; Branger & Pang, 2015; Jazdi, 2014; Shafiq et al., 2015).

Shafiq et al. (2015) described CPS as "the convergence of the physical and digital worlds by establishing global networks for a business that incorporate their machinery, warehousing systems and production facilities" (p. 1149). Monostori et al. (2016), on the other hand, noted that "CPS are systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the Internet" (p. 621). CPS are comprised of micro-controllers that handle the devices as well as actuators. Data and knowledge are replaced among various embedded terminals of computers, with various applications of wireless, houses, or clouds. The multifaceted, dynamic as well as combined CPS will cooperate to produce an analysis related to planning, various designs of modelling, implementation and preservation in the manufacturing procedure. All these procedures show a positive effect on manufacturing performance. It also positively affects the service performance of a company.

Based on combined information regarding CPS, decentralisation and independence play vital roles in increasing the complete industrial performance (Iva-

Tab. 2. Studies on a smart factory and manufacturing

Research Category	Publication
CPS of Industry 4.0	Bagheri et al. (2015)
	Brettel, Friederichsen, Keller & Rosenberg (2014)
	Harrison, Vera & Ahmad (2016)
	Ivanov, Dolgui, Sokolov, Werner & Ivanova (2016)
	Ivanov, Sokolov & Ivanova (2016)
	Jazdi (2014)
	Kobara (2016)
	Lee, Bagheri & Kao (2015)
	Georgakopoulos, Jayaraman, Fazia, Villari & Ranjan (2016)
	Pérez, Irisarri, Orive, Marcos & Estevez (2015)
	Schuster et al. (2015)
	Shafiq, Sanin, Szczerbicki & Toro (2016)

nov et al., 2016). The systems of CPS are skilled in enhancing output, increasing development, adapting the performance of company workforce, and constructing high-quality goods with minor costs by gathering and examining information (Rüßmann et al., 2015), which positively affects the performance of companies. Jazdi (2014) showed the CPS application by demonstrating its features, work procedures, and various advanced methods. Ivanov, Dolgui et al. (2016) claimed that various frameworks were required in CPS to manage actions in different manufacturing measures and to maximise production. According to the latest grounded features, CPS can improve the management of production and services.

According to Shafiq et al. (2015), the joint structure of Virtual Engineering Objects (VEO), Virtual Engineering Factory (VEF) and Virtual Engineering Process (VEP) is a particular method of CPS. VEO is a process of information conversion and data retrieval, in which one could reuse the experience of engineering objects as well as further advance the process of making key decisions in the industrial design and manufacturing (Schuster et al., 2015; Shafiq et al., 2015). VEO participates in IT classifications at diverse classified levels through a production procedure. Additionally, it can contribute to CPS by providing it with more flexibility as well as readjust the product-making procedure. It is an important arrangement that makes steps towards active knowledge management and plays a significant role in factory management (Posada et al., 2015). VEP is an effective representation of knowledge of a manufacturing procedure with all required operational information, while VEF is a representation of the experience-based information of an engineering factory. According to Shafiq et al. (2015), the three important elements must be combined to build Industry 4.0 as well as to attain an advanced level of smart machines with progressive analytics.

In the future, critical tests should be offered to experts to device CPS and to advance them more consistently. As mentioned in the literature regarding the development of wireless communication and different sensor network know-hows, CPS will develop an immense influence on new and latest ICT. Jazdi (2014) described that further improvement of CPS requires to focus on distributed remote application implemented by software agents. According to Monostori et al. (2016), CPS and the cyber-physical production systems (CPPS) of Industry 4.0 will be initiated and implemented by the development of computational entities. They additionally explained that in production organisations, physical manufacturing would be controlled by integrated CPS as the latest series of industry. CPPS includes humans, different types of machinery and various products, networking with physical procedures used in manufacturing to make the production more cost and time effective with extremely capable services and products (Albers et al., 2016). Therefore, CPS is one of the important systems which can control manufacturing. It is capable enough to handle the production process in organisations and to have a positive effect on performance. Pérez et al. (2015) suggested an agenda for CPPS for health care.

Currently, a forward perspective is focused on the creation of a network of VEO, which has extensive applicability of an engineering artefact integrating dual computerised and real-world representation, including complex multitasking machines (Brettel et al., 2014; Posada et al., 2015). Independent information exchange is activated by real and computer-generated production. A VEO can add, supply, advance, and provide knowledge using an effective manufacturing arrangement (Shafiq et al., 2015).

Cyber-Physical Systems (CPS) play a significant role in an organisation through various facilities, such as production and services (Jiang et al., 2016; Lee et al., 2015; Zhang et al., 2017; Zühlke & Ollinger, 2011). They also have a positive role in the improvement of performance (Mo & Sinopoli, 2016). Therefore, CPS are the most important element of Industry 4.0, which positively affects production and services.

H1. CPS has a relationship with production and services

Industry 4.0 has major elements, including integration and interoperability (Chen, Doumeingts & Vernadat, 2008; Romero & Vernadat, 2016). Combined with various software arrangements, Industry 4.0 will attain unified operations across company limitations and will understand interacted organisations (Smirnov et al., 2013). Interoperability is the main benefit of Industry 4.0. Chen et al. (2008) described that interoperability is "the ability of two classifications to understand each other and to use the functionality of one another". It signifies the competence of two systems to replace data and distribute knowledge. The interoperability related to Industry 4.0 will manufacture software elements, solutions of various types of application, business procedures, and the business framework through the expanded, heterogeneous, as well as autonomous process (Berre et al., 2007).

The construction of the interoperability comprises four different levels: operational, systematic, technical, and semantic interoperability (Gorkhali & Xu, 2016; Sowell, 2006). Precisely, the operational interoperability demonstrates overall structures of ideas, values, languages, as well as associations within CPS and fourth revolution. The systematic interoperability classifies the procedures of different methodologies and various domains. The technical interoperability articulates various tools providing the opportunity for technical development, IT systems and effective communication for support. The semantic interoperability confirms knowledge transfer among different groups of people, applications, and numerous levels of institutions. These different stages of operation make the fourth revolution and CPS more industrious and cost-effective. The interoperability framework of Industry 4.0 is presented in Fig. 2.

Previous studies have shown that Industry 4.0 is based on three major frameworks, namely, "Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR); Interoperable Delivery of European eGovernment Services to public Administrations, Business and Citizens (IDABC); and Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications (ATHENA)" (Sowell, 2006). Various previous studies on interoperability are provided in Tab. 3.

C4ISR Architecture Framework was established by the Department of Defence of the United States in 1996 to assimilate the associations, principles, and various strategies of the US military. It is one of the operational, systematic, as well as technical views on the latest technology. The operational assessment designates the nature of the required information and knowledge transfer in detail for the objective of defining the required degree of information-exchange interoperability (Sowell, 2006). The methodical view first classifies the essential supports for the system, then interprets the essential degree of interoperability in various system competences, and lastly associates executions with the required capabilities (Sowell, 2006). The technical view details the criteria required to administrate the compliant implementation of each essential system capability (Sowell, 2006). The purpose of C4ISR is to guarantee the integration and interoperability of different levels. Eventually, the interoperability could achieve views that are integratable and comparable across international organisational boundaries.

Another part of the interoperability is IDABC. European Interoperability Framework (EIF) Version 1.0 delivers a reference on interoperability for the IDABC program and offers various e-government

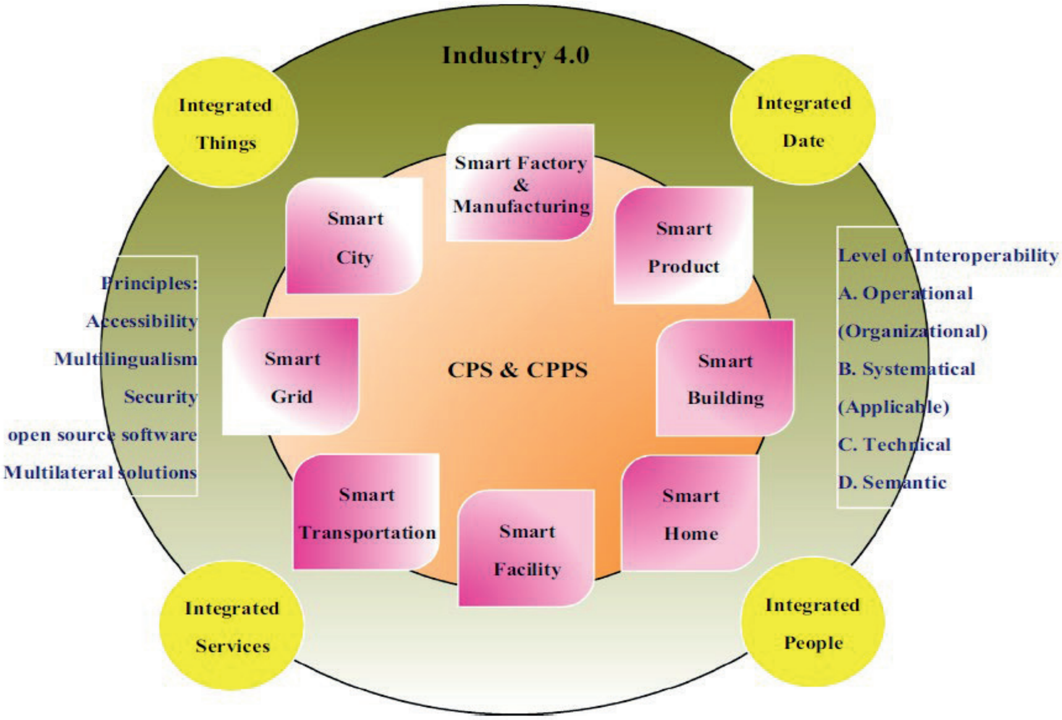

Fig. 2. Framework of interoperability of Industry 4.0
Source: adapted from (Lu, 2017).

Tab. 3. Studies on interoperability

Research Category	Publication
Interoperability of Industry 4.0	Berre et al. (2007) D. Chen et al. (2008) Gorkhali & Xu (2016) Geraci et al. (1991) Lu (2017) Romero & Vernadat (2016) Smirnov et al. (2013) Sowell (2006)

services to peoples as well as enterprises. The EIF framework achieves interoperability with the help of various technical and semantic elements. Organisational interoperability identifies the performers as well as organisational procedures; technical interoperability describes various benchmarks with protocols for the incorporation of technology systems; and semantic interoperability ensures the knowledge transfer among involved people, applications and institutions (Bornman & Puth, 2017). Interoperability has an important role in an organisation through smart products (Schmidt et al., 2015; Thoben et al., 2014; Zug et al., 2015).

These technologies have a positive effect on manufacturing as the latest technology always does (Colombo, Loncan & Caldeira, 2018; Ghani et al., 2003; Hettiarachchi et al., 2007; Hounshell, 1985; Tracey, Vonderembse & Lim, 1999). Consequently, the interoperability of Industry 4.0 also has a positive effect on manufacturing. A positive effect on manufacturing automatically increases organisational performance. Interoperability is based on the latest IT capability and technologies which, in their turn, positively affect the performance. The literature states that the IT capability of the latest technology has a positive effect on organisational performance (Adner & Kapoor, 2010; Aral & Weill, 2007; Benitez-Amado & Walczuch, 2012; Rivard, Raymond & Verreault, 2006; Stoel & Muhanna, 2009).

H2. Interoperability has a relationship with production and services.

A smart city is "a city that comprises six factors in its development policy: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance". Joining the internet, a communications network and the Internet of Things (IoT) will expedite the growth of the latest technology (Roblek, Meško & Krapež, 2016; Tang, 2015). According to Lom, Pribyl and Svitek (2016), a smart city includes a technical discipline and different economic as well as humanitarian aspects. Within a smart city, people change from operators to important stakeholders. In this process, effective technology works like a dynamic enabler and businesses become as partners. The process of production is founded on demand orientation strategies, and transport is one of the smart services with progressive development, effectiveness, and success. The aim of a smart city is to guarantee the sustainability of different cities, to advance the quality of life as well as security and to deliver energy efficiency. Still, the transformation of a traditional city into a smart city takes much time. Additionally, Branger (2015); Branger and Pang (2015) offered a good communication structure for assimilating services in automatic homes. Studies on the smart city are presented in Tab. 4.

Various studies address a smart product — a product related to a smart factory and supported by different sensors and microchips, i.e., various products which make Industry 4.0 smarter (Cao et al., 2015). Industry 4.0 comprises information and communication technology, IoT, CPS, data combination, uniform control and permits humans to interconnect with different products (Schlechtendahl et al., 2015; Schmidt et al., 2015; Thoben et al., 2014). The current manufacturing arrangements require to be combined with Industry 4.0 features. According to Schuh et al. (2015), integrated working and knowledge acquisition is an actual way to improve the performance of Industry 4.0.

Tab. 4. Studies on Smart City

Research Category	Publication
Smart City of Industry 4.0	Lasi, Fettke, Kemper, Feld & Hoffmann (2014) Lom et al. (2016) Tang (2015) Roblek et al. (2016)

Industry 4.0 delivers new technologies in manufacturing (Bagheri et al., 2015; Berre et al., 2007; Schuh et al., 2015). It includes progressive automatic, information and knowledge and real-time accepted production measures (Biao et al., 2016). Therefore, smart products must be shaped based on the latest electronic (digital) technologies and physical procedures (Schmidt et al., 2015). Various features, such as big data, cloud computing, IoT, and improvement in the time of production are offered to control the growth of the fourth revolution (Schmidt et al., 2015). The application in the textile industry has seen the development of clothing capable of measuring various health parameters such as burnt calories, heart

rate, movement etc. (Pang et al., 2015; Roblek et al., 2016).

According to Schlechtendahl et al. (2015), the growth of Industry 4.0 is a procedure that combines the smart production system. As further explained by Gorecky et al. (2014), a cyber-physical construction and user-focused support arrangements offer boundaries to an intelligent user. Additionally, a strategic production preparation procedure is suggested grounded on the central values of integrated design to bring together diverse design, as well as procurement for long-term preparation investment. Another study by Monostori et al. (2016) offered a method grounded on knowledge exchange for evolving production schemes for Industry 4.0.

Therefore, both a smart city and a smart product has a significant role in production and services. A smart factory and a smart product are parts of a smart city. And a smart factory has a significant role in the manufacturing process of a company (Chu et al., 2016; Davis et al., 2012; Kokuryo et al., 2016; Longo, Nicoletti & Padovano, 2017). Previous studies on a smart factory are shown in Tab. 5. Therefore, smart city and smart product have an important role in production and services.

Tab. 5. Studies on a smart factory and manufacturing

Research Category	Publication
Smart Factory and Manufacturing	Chen & Xing (2015) Kolberg & Zühlke (2015) Oses, Legarretaetxebarria, Quartulli, García & Serrano (2016) Paelke (2014) Pisching, Junqueira, Santos Filho & Miyagi (2015) Rüßmann et al. (2015) Wang, Wan, Zhang, Li & Zhang (2016) Sanders, Elangeswaran & Wulfsberg (2016) Scheuermann, Verclas & Bruegge (2015) Thames & Schaefer (2016)

H3. A smart city and a smart product have a relationship with production and services.

The discussion provided above highlighted that Industry 4.0 (the interoperability, Cyber-Physical Systems, a smart city, a smart factory) has a significant relationship with the production and services of a company. A better implementation of Industry 4.0 has a major role in increasing the quality and efficiency of production and services. An increase in the production and services of a company has a direct effect on their performance (Haseebet al., 2019).

Better production and services lead to higher performance. As revealed by previous studies, production and services have a positive relationship with organisational performance (Gray & Hooley, 2002; Hong, Kim & Cin, 2015; Kastalli & van Looy, 2013). Therefore, companies must develop a good production system. Good production also leads to customer satisfaction, and an increase in customer satisfaction improves organisational performance (Saeidi et al., 2015; Sun & Kim, 2013; Zhao, Dröge & Stank, 2001). Thus, as revealed by previous studies, production and services have a major role in organisational performance. In the context of this study, Industry 4.0 factors, such as the interoperability, Cyber-Physical Systems, a smart city and a smart product, have a positive effect on production and services. Besides, production and services improve organisational performance. The implementation of these has also been found to improve energy efficiency in the textile industry, leading to improved organisational performance (Park et al., 2019).

H4. Production and services have a relationship with organisational performance.

H5. Production and services mediate the relationship between CPS and organisational performance.

H6. Production and services mediate the relationship between interoperability and organisational performance.

H7. Production and services mediate the relationship between a smart city, a smart product and organisational performance.

No doubt, Industry 4.0 has the latest technology. However, companies cannot benefit from the latest technology until they implement it properly. Companies must ensure proper implementation of Industry 4.0 to maximise its benefits. According to different studies, the implementation of technology is crucial (Müller, Kiel & Voigt, 2018; Oesterreich & Teuteberg, 2016; Tortorella & Fettermann, 2018; Zawra et al., 2017).

Many companies faced problems related to technology implementation. A successful technology implementation unit offers consistency to the IT unit and makes the complementary view of technology to ensure the best management (Hu & Huang, 2005; Nii, Earl & Ross, 1996; Reich & Benbasat, 2000). Similarly, it fundamentally adds to the influence of business directors in the positioning of the process (Teo & Ang, 1999). For the preparation of business designs, two success features are vital, which are the validation of best management in the IT division, and reliable administrations (Luftman, Lewis & Oldach, 1993). Teo and Ang (1999) theorised that the confirmation of the best management in technology ensures the strategic use of technology, making it bound to distribute assets required for the arrangement as well as the development of IT applications. Furthermore, organisational performance in the textile industry can potentially benefit from technology implementation due to the accelerated design process as well as potential costs savings associated with packaging and transportation (Dilberoglu, Gharehpapagh, Yaman & Dolen, 2017).

H8. Effective technology implementation has a relationship with organisational performance.

H9. Effective technology implementation moderates the relationship between CPS and organisational performance.

H10. Effective technology implementation moderates the relationship between interoperability and organisational performance.

H11. Effective technology implementation moderates the relationship between a smart city, a smart product and organisational performance.

2. Research methods

Research designs are included plans as well as the procedures for research that span the decision from broad assumptions to detailed methods of data collection as well as data analysis techniques. In the area of social science studies, there are three main research approaches in the educational sector, which are 1) quantitative, 2) qualitative, and 3) mixed methods (Creswell, 2009). The current study adopted the quantitative approach. It is one of the most suitable approaches in the case of hypothesis-testing based on primary data. Additionally, this study used a cross-sectional research design.

For this purpose, a survey was carried out to collect the data. Textile companies of Malaysia were used as the population of this study. Data were collected from employees of the textile companies. Only those employees were selected who had direct involvement in new technology adoption events. Aiming to ensure accurate results, employees with no link to the latest technology were not selected as respondents of this study. The latest technology means that technology belongs to the fourth industrial revolution. Therefore, those employees who were involved in Industry 4.0 practices were selected as the respondents. Employees having no experience with Industry 4.0 may not have the required knowledge about this technology and could respond incorrectly.

Different studies provide different methods ensuring the appropriate sample size. This study followed the instructions by Comrey and Lee (1992). According to Comrey and Lee (1992), a "sample having less than 50 participants will observed to be a weaker sample; sample of 100 size will be weak; 200 will be adequate; sample of 300 will be considered as good; 500 very good whereas 1000 will be excellent." Therefore, this study used the 500 sample size to get data from employees of the textile industry. A simple random sampling technique was used in the study to collect the data.

In this study, the survey questionnaires were based on various sections. The first section of the survey questionnaires measured the demographics of the respondents. The second section measured organisational performance. The third section measured CPS, the interoperability, a smart city and a smart product. The fourth section measured the mediating variable, namely, production and services. Finally, the fifth section measured the moderating variable, namely, effective technology implementation.

3. Research results

Results of the study were based on the data collected from Malaysian textile companies. It was expected to have missing values and outliers in the data. Therefore, the analysis was performed to check the missing value issues and outliers. The analysis for missing values and outliers is presented in Tab. 6. It is found that data is free from any case of outliers, missing values and is, therefore, accurate to proceed with further analysis. Skewness and kurtosis can be used as an indicator to check the deviation. Data were said to be normally distributed if the range of skewness and kurtosis lied within + 1.0 and + 3.00, respectively. All the values were under the acceptable range. Maximum and minimum values showed that the data had no outlier.

After the missing value and data outlier analysis, the analysis was made using partial least square (PLS)-structural equation modelling (SEM) techniques. Structural equation modelling (SEM) is a procedure of causal modelling that comprises a varied set of mathematical models, computer algo-

Tab. 6. Missing values and data outlier

	No.	Missing	Mean	Median	Min	Max	SD	Kurtosis	Skewness
CPS1	1	0	3.527	3	1	7	1.852	-0.652	0.371
CPS2	2	0	3.591	3	1	7	1.783	-0.465	0.385
CPS3	3	0	3.555	3	1	7	1.859	-0.725	0.287
CPS4	4	0	3.436	3	1	7	1.758	-0.396	0.432
CPS5	5	0	3.532	4	1	7	1.847	-0.795	0.206
CPS6	6	0	3.455	3	1	7	1.759	-0.507	0.321
INT1	7	0	3.6	4	1	7	1.725	-0.562	0.207
INT2	8	0	2.959	3	1	7	1.399	0.021	0.575
INT3	9	0	3.091	3	1	7	1.339	0.756	0.875
INT4	10	0	3.132	3	1	7	1.295	1.269	0.927
INT5	11	0	3.055	3	1	7	1.4	0.719	0.762
SPSC1	12	0	3.05	3	1	7	1.325	0.985	0.721
SPSC2	13	0	3.1	3	1	7	1.461	0.597	0.732
SPSC3	14	0	3.073	3	1	7	1.409	1.009	0.891
SPSC4	15	0	2.936	3	1	7	1.39	-0.08	0.442
SPSC5	16	0	3.123	3	1	7	1.334	0.773	0.721
SPSC6	17	0	3.027	3	1	7	1.401	0.48	0.68
PS1	18	0	3.005	3	1	7	1.425	0.588	0.75
PS2	19	0	3.136	3	1	7	1.391	0.073	0.549
PS3	20	0	3.041	3	1	7	1.322	0.515	0.578
PS4	21	0	2.95	3	1	7	1.312	0.024	0.543
PS5	22	0	3.068	3	1	7	1.265	0.652	0.617
PS6	23	0	3.032	3	1	7	1.376	0.258	0.722
ETI1	24	0	3.064	3	1	7	1.364	0.419	0.675
ETI2	25	0	3.091	3	1	7	1.262	0.465	0.58
ETI3	26	0	3.209	3	1	7	1.602	-0.488	0.276
ETI4	27	0	3.223	3	1	7	1.735	-0.563	0.405
ETI5	28	0	3.232	3	1	7	1.882	-0.741	0.46
ETI6	29	0	3.25	3	1	7	1.992	-0.988	0.463
FP1	30	0	3.132	3	1	7	2.066	-0.894	0.582
FP2	31	0	3.159	3	1	7	1.935	-0.792	0.535
FP3	32	0	3.268	3	1	7	1.675	-0.429	0.458
FP4	33	0	3.2	3	1	7	1.904	-0.779	0.467
FP5	34	0	3.273	3	1	7	1.873	-0.758	0.502
FP6	35	0	3.241	3	1	7	1.89	-0.739	0.462
FP7	36	0	3.255	3	1	7	2.022	-0.965	0.485

rithms, and statistical procedures that fit networks of constructs to data. Structural equation models are often utilised to measure unobservable "latent" constructs. It is prominent techniques to text the hypotheses in primary data. The procedure is recommended by different prominent authors (F. Hair Jr et al., 2014; J. F. Hair et al., 2006). In this technique, factor loading, composite reliability (CR) and average variance extracted (AVE) must not be less than 0.5, 0.7 and 0.5, respectively (J. Hair et al., 2017; J. F. Hair et al., 2010). These values are shown in Tab. 7 and Tab. 8. Factor loadings in Tab. 7 show the internal consistency

Tab. 7. Factor loadings

	Cyber-Physical Systems	Effective Technology Implementation	Firm Performance	Interoperability	Production and Services	Smart City and Smart Product
CPS1	0.9					
CPS2	0.872					
CPS3	0.906					
CPS4	0.904					
CPS5	0.893					
CPS6	0.874					
ETI1		0.768				
ETI2		0.773				
ETI3		0.849				
ETI4		0.897				
ETI5		0.905				
ETI6		0.863				
FP1			0.932			
FP2			0.921			
FP3			0.872			
FP4			0.922			
FP5			0.916			
FP6			0.907			
FP7			0.901			
INT1				0.66		
INT2				0.863		
INT3				0.893		
INT4				0.888		
INT5				0.893		
PS1					0.844	
PS2					0.9	
PS3					0.854	
PS4					0.885	
PS5					0.894	
PS6					0.909	
SPSC1						0.902
SPSC2						0.914
SPSC3						0.908
SPSC4						0.853
SPSC5						0.869
SPSC6						0.84

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Tab. 8. CR and convergent validity

	Clpha	rho_A	CR	AVE
Cyber-Physical Systems	0.948	0.95	0.959	0.795
Effective Technology Implementation	0.919	0.929	0.937	0.713
Firm Performance	0.965	0.966	0.971	0.829
Interoperability	0.897	0.914	0.925	0.713
Production and Services	0.942	0.942	0.954	0.776
Smart City and Smart Product	0.942	0.943	0.954	0.777

Tab. 9. Discriminant validity

	CPS	ETI	FP	INT	PS	SPSC
Cyber-Physical Systems	0.892					
Effective Technology Implementation	0.621	***0.844***				
Firm Performance	0.604	0.731	***0.91***			
Interoperability	0.66	0.795	0.681	***0.844***		
Production and Services	0.577	0.799	0.671	0.724	***0.881***	
Smart City and Smart Product	0.601	0.821	0.708	0.72	0.722	***0.781***

Tab. 10. Direct effect results

	(O)	(M)	SD	T Statistics	P Values
Cyber-Physical Systems -> Production and Services	0.053	0.05	0.02	2.647	0.004
Effective Technology Implementation -> Firm Performance	0.093	0.092	0.0026	35.794	0
Interoperability -> Production and Services	0.532	0.531	0.061	8.721	0
Production and Services -> Firm Performance	0.203	0.201	0.037	5.544	0
Smart City and Smart Product -> Production and Services	0.464	0.462	0.058	8.064	0

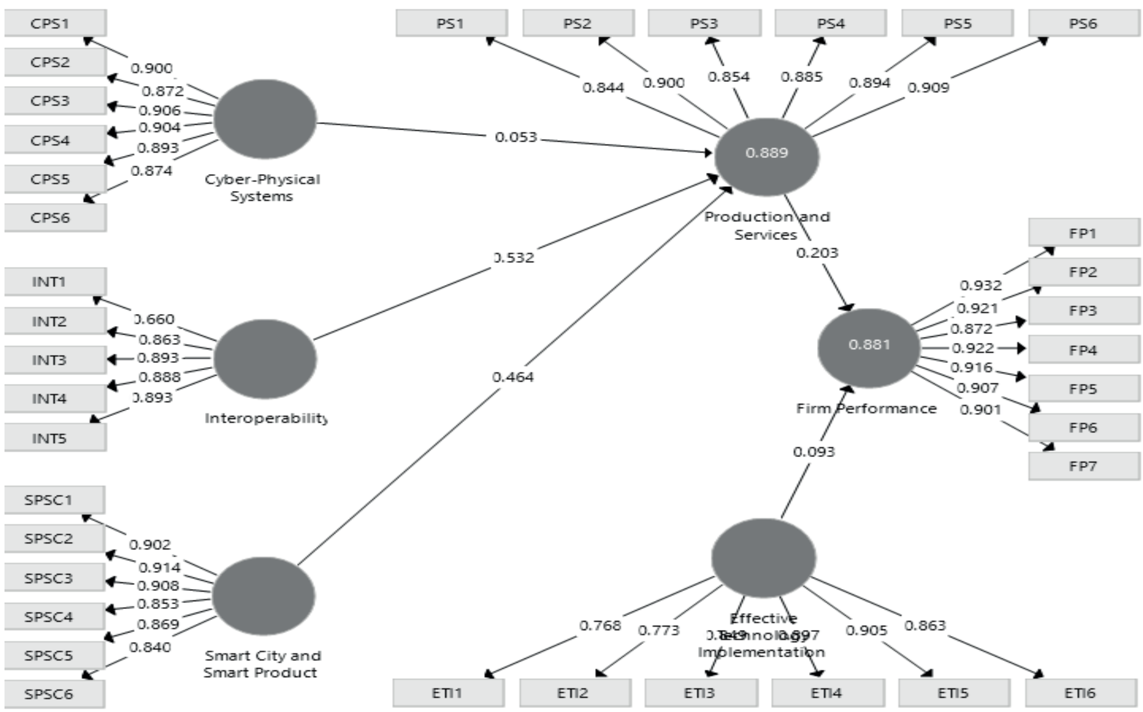

Fig. 3. Measurement model

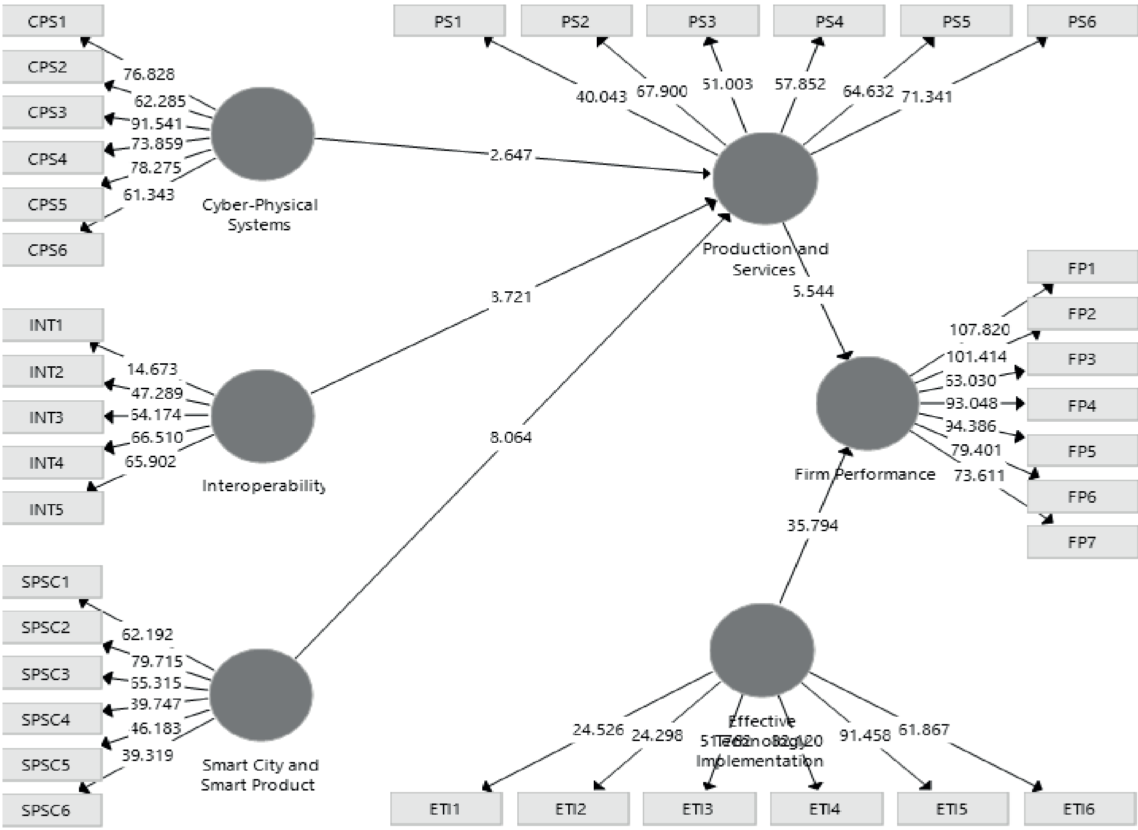

Fig. 4. Structural model

between items. AVE in Tab. 8 shows the external consistency.

All the values of CR, AVE and factor loading is above the minimum threshold level. Additionally, this study examined the discriminant validity by using the criteria of Fornell and Larcker (1981). According to these criteria, the square root of AVE was used to test the discriminant validity. It is given in Tab. 9.

Bootstrapping is one of the good techniques to test the hypotheses. This study also used PLS bootstrapping to test the hypotheses (Fig. 4). A direct effect results are given in Tab. 10. T-value 1.96 was considered for testing the hypotheses. It was found that all the direct effect hypotheses were supported (H1, H2, H3, H4, H8), as the t-value was above 1.96. In Tab. 10, the original sample (O) is given, which shows the beta value (β). The beta value highlighted the direction of the relationship of whether the relationship is positive or negative. SD shows the standard deviation. T-value and p-value show the significance of the relationship.

After a direct effect, an indirect effect was examined by considering the production and services as a mediating variable. The same criteria were followed as the direct effect was examined, and t-value was considered for testing the mediation hypotheses. It was found that the production and services were the mediating variable between interoperability and organisational performance. It was also found that the production and services were a mediating variable between a smart city, and a smart product and organisational performance. However, the mediation effect was insignificant between Cyber-Physical Systems and organisational performance. Therefore, H6 and H7 were supported, and H5 was not.

Additionally, the moderation effect of effective technology implementation was also examined. T-value was considered to check the significance level of the moderation effect. In this study, three moderating effects were examined. Results of the moderation effect of effective technology implementation are shown in Tab. 12. Results of the moderation effect show that effective technology implementation moderates the relationship between interoperability and production and services. The moderation effect is also significant between a smart product, and a smart city and production and services. Thus, H10 and H11 are supported.

Tab. 11. Indirect effect

	(O)	(M)	SD	T Statistics	P Values
Cyber-Physical Systems -> Production and Services -> Firm Performance	0.011	0.01	0.007	1.636	0.103
Interoperability -> Production and Services -> Firm Performance	0.108	0.107	0.024	4.464	0
Smart City and Smart Product -> Production and Services -> Firm Performance	0.094	0.093	0.02	4.819	0

Tab. 12. Moderation Effect

	(O)	(M)	SD	T Statistics	P Values
Moderating Effect 1 -> Production and Services	0.004	0.004	0.037	0.103	0.918
Moderating Effect 2 -> Production and Services	0.059	0.059	0.03	1.961	0.05
Moderating Effect 3 -> Production and Services	0.037	0.033	0.01	3.7	0

4. Discussion of the results

This study focused on Malaysian textile companies. In recent years, the performance of this industry has been decreasing. Aiming to address this issue, this study investigated the role Industry 4.0 has on organisational performance through production and services in the Malaysian textile industry. The current study focused on three key factors of Industry 4.0. It examined the effect of CPS, the interoperability and a smart city (a smart factory, a smart product) on the production and services of textile companies in Malaysia.

The results of the study found that Industry 4.0 makes a major contribution to the production and services of the textile industry as Industry 4.0 has a major role in the manufacturing (Almada-Lobo, 2016; Brettel et al., 2014; Rüßmann et al., 2015; Schumacher, Erol & Sihn, 2016; Durana et al., 2019). Better technologies lead to better manufacturing results. It was found that CPS has a significant positive effect on the production and services with t-value 2.647 and β-0.053. Therefore, an increase in CPS technologies increases the results of the production and services of textile companies operating in Malaysia.

It was found that interoperability has a significant positive effect on the production and services with t-value 8.21 and β-0.532. Consistently with these results, a smart product and a smart factory also had a positive effect on the production and services with t-value 8.064 and β-0.464. Therefore, it was provided that interoperability, a smart product and a smart city have a major role in boosting production and services. Consequently, companies must work to introduce the latest technology related to interoperability, a smart product and a smart factory.

Furthermore, it was found that production and services lead to improved organisational performance. Results of the study demonstrated that production and services had a positive effect on the organisational performance with t-value 5.544 and β-0.203. As it was revealed by the previous studies, production and services have a positive relationship with organisational performance (Gray & Hooley, 2002; Hong et al., 2015; Kastalli & van Looy, 2013; Witkowski et al., 2017).

Therefore, Industry 4.0 leads towards better production and services, improving organisational performance. Additionally, production and services have a positive role in reflecting the effect of Industry 4.0 on organisational performance. However, it is not possible without effective technology implementation. Effective technology implementation strengthens the positive relationship between interoperability and production and services. It also strengthens the positive relationship of smart product and smart city and production and services.

Conclusions

The fourth industrial revolution has the most significant contribution to organisational performance. Major elements of Industry 4.0, such as CPS, interoperability and a smart city (a smart factory, a smart product), have a positive effect on the production and services of textile companies in Malaysia. It is evident that the latest technology is a key contributor to improved performance. Latest techniques in production and services increase efficiency and effectiveness, which shows a significant effect on organisational performance. Additionally, a textile firm cannot benefit from Industry 4.0 unless it implements the technology effectively. Effective technology implementation is a major task for many companies. Introduction of the latest technology is possible; however, the implementation is a tough job. Therefore, proper technology implementation is crucial.

Theoretically, this study has important insights for scholars. The study started a new debate by providing the role of Industry 4.0 in the textile sector using a survey method. This study enhanced the existing literature with a theoretical portion by providing the effect of Industry 4.0 on manufacturing and services. Practically, this study provided valuable insights for practitioners to increase their organisational performance. This study provided valuable insights for the promotion of production and services and reasons why textile companies should introduce Industry 4.0 technologies and ensure effective implementation.

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