Ensuring Environmental Performance of Pharmaceutical Companies of Thailand: Role of Robotics and AI Awareness and Technical Content Knowledge in Industry 4.0 Era

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ABSTRACT

The contradictions regarding the improvements of environmental performance and the factors that possibly might play a very significant role in that case, led this study to happen. So, the study took robotic and artificial intelligence awareness and technical content knowledge to check their impacts on environmental performance. The study also took industry 4.0 implementation as a mediator to check how well it enhances the impacts of robotic and artificial intelligence awareness and technical content knowledge on environmental performance. By reviewing their past literature, the study devised hypothesis. Then to testify them, researcher collected data from 319 individuals from Pharmaceutical Companies of Thailand. The data was analyzed using SPSS and AMOS, though the past relevant studies did not analyze the relevant problem with such modern techniques. The results showed that the impact of robotic and artificial intelligence awareness and technical content knowledge on environmental performance is significant and positive and also role of industry 4.0 implementation as a mediator is significant. The study is beneficial for environmentally friendly organizations to implement robotic and artificial intelligence and use and technical content knowledge to give positivity to the environment. However, the study chose a small sample and lacks generalizability as well.

Keywords: Environmental Performance, Pharmaceutical Companies, Thailand: Robotics Awareness, Technical Content Knowledge, Industry 4.0 Era

Introduction

Environmental performance refers to the performance of government as well as industries in order to preserve the environment and fulfill various objectives related to environmental quality of a country (Jermsittiparsert, Siriattakul, & Sangperm, 2019). Resource use efficiency is also the part of environmental performance. An environmental performance index has been created in order to assess the performance of any country in regard of environment (Auerbach, Concordel, Kornatowski, & Floreano, 2018; Bennett & James, 2017). Many practices can be performed in order to achieve better position in this environmental performance index. These practices include using safer and environment friendly raw materials and equipment to process those raw materials. Proper sanitation of wastes and other harmful chemicals and gases from the industry is also included in this regard.
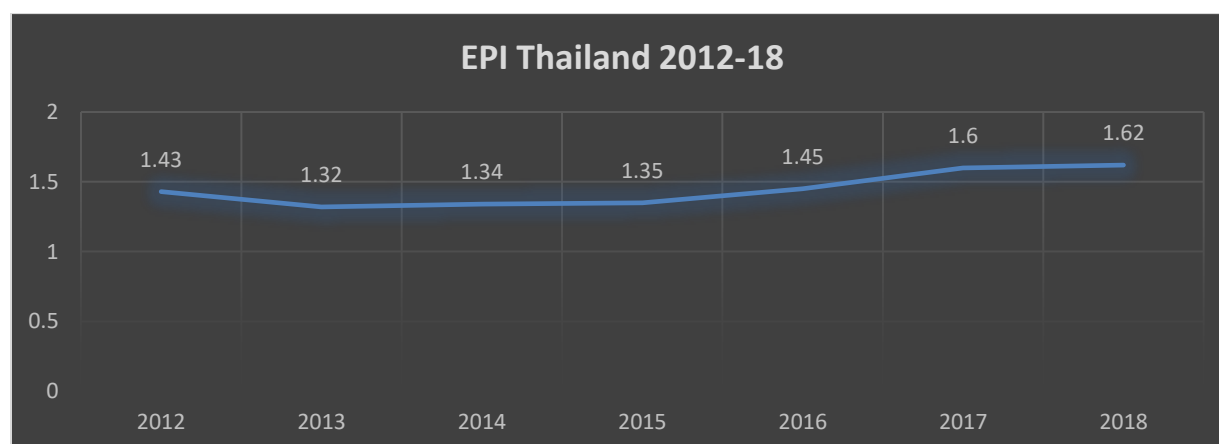

Figure 1: Environmental Performance Index

There have been many changes and advancements in the technological era, automation, robotics, artificial intelligence etc. and these advancements have changed the structure and dynamics of various sectors that are related to industry, business, manufacturing, service etc. This has resulted in the production of huge amount of data and algorithms that are

generally used by different sectors of a particular country in doing various tasks and overcoming different obstacles in the management process of that sector. Artificial intelligence has special place in this regard and has changed many aspects altogether (Berry, 2019). Technical content knowledge has been formed by the combination of two aspects i.e. technology and content knowledge and these two aspects have very strong connection with each other as known by the past studies. There are several fields that involve the use of technical content knowledge such as medicine, archeology, physics and chemistry etc. In all these fields, technology has been utilized effectively in order to demonstrate various concepts that are specifically related to these fields (Cañadas, Ibáñez, & Leite, 2015). Industry 4.0 or I4.0 can be considered as an important up gradation and advancement in communities in various aspects in addition to technology. With the increased use of technology and availability of big and high speed data, it has become necessary for the industries in terms of digitalization. These digitalization processes can be performed and achieved by the use of relevant technologies such as internet of things IoT, CFS and RFID etc. In addition, different hardware and software factors may also be utilized in this context (Björkholm, Andrée, & Carlgren, 2016). This is necessary in order to increase the integration and coordination between different departments and levels of an organization.

Robotic and AI awareness as well as technical content knowledge improve and enhance the environmental performance of the pharmaceutical companies in various regions of the world. But unfortunately, in Thailand, required work has not been done on robotics and AI aspects as well as technical content knowledge. In addition, various other developing and under developed countries are also facing the same situation of decreased enhancement in technological perspective of these countries (Boyd & Holton, 2018). This has resulted into decreased environmental performance of pharmaceutical companies of Thailand and other developing and under developed countries. If the same situation remains for a longer period of time, it may cause serious issues to the environmental performance of such companies therefore steps must be taken in order to improve the technological conditions such as in robotics, artificial intelligence and content knowledge etc. There are many studies that are conducted in order to study the technological aspects such as robotics and AI awareness and technical content knowledge in the past. In addition, few studies have also been conducted to study the impact of these technological aspects on the environmental performance. However, there is no study that discusses the pharmaceutical companies in regard of environmental performance. Moreover, the mediating role of industry 4.0 has also not been considered in the past studies. Therefore, Boyd and Holton (2018) has recommended studying the impact of robotics and AI awareness and technical content knowledge on environmental performance of pharmaceutical companies of Thailand in the presence of mediating role of technical content knowledge. Following are the basic objectives of this study,

- To analyze the significant impact of robotics and AI awareness on environmental performance of pharmaceutical companies of Thailand
- To analyze the significant impact of technical content knowledge on environmental performance of pharmaceutical companies of Thailand
- To analyze the mediating impact of industry 4.0 implementation between robotics and AI awareness and environmental performance of pharmaceutical companies of Thailand
- To analyze the mediating impact of industry 4.0 implementation between technical content knowledge and environmental performance of pharmaceutical companies of Thailand

Pharmaceutical companies involve a large scale of production of different types of medicines and this production revolves around chemicals and solutions. Such production processes result in extraction of different types of harmful substances from the production area and emission of harmful gases too. These aspects are ultimately harmful for the environment and the people living in that environment (Braam, de Weerd, Hauck, & Huijbregts, 2016). This study has described in detail the use of technology in regard of robotics, artificial intelligence and technical content etc. so that the harmful effects of pharmaceutical companies in Thailand may be minimized or preferably eradicated. These points can also be considered as the significance of this study. Researchers and other authors may have access to different technical concepts as discussed in this study and they may use them in their studies. In addition, the policy making officials and departments of government will also be assisted by the use of this study in making favorable policies and regulations for pharmaceutical companies.

Literature Review and Resource Based View RBV Theory

RBV theory revolves around the view that a firm or a company may use various resources contained by the company in order to achieve some competitive advantage over the others. This theory has been considered to be introduced by Barney (1991) in his article named "Firm Resources and Sustained Competitive Advantage". According to this theory, companies contain many different kinds of resources such as human resources, financial resources that may be employed in various areas in order to improve the performance of the company (Dirican, 2015). In the current study, this theory is related in such a way that a company may consume its financial resources in order to shift to industry 4.0 by incorporating different aspects of technology such as robotics, AI and technical content knowledge in order to enhance environmental performance of the industry (Dubey, Gunasekaran, & Ali, 2015). Based on this theory, various hypotheses can be drawn.

Robotic and AI Awareness impact on Environmental Performance

Many researchers have discussed various aspects of technology in the past and robotics and AI are the area of interest for many of the researchers. Erikson and Salzmann-Erikson (2016) and Gilchrist (2016) have explained different functions and domains of these technical aspects in detail in their researches and have found that these technologies and robotics etc. not only help in doing various types of tasks but also increase the

speed of the ongoing tasks that ultimately increases the efficiency of that particular sector in which these are being used. These technical aspects have also increased the customer satisfaction levels as they receive better quality products and services (Gill, 2019). In addition to all these advantages, there are some disadvantages too such as the impact of technology on relationships between co-workers and exchange of human labor with machines. Ignoring these aspects of technology, the author has moved towards studies conducted in the past that describe the impact of latest technology aspects on environmental performance of a company (Xu, Xu, & Li, 2018). According to these studies, the use of heavy machinery and the use of cheap fuels such as oil and gas etc. in the manufacturing companies result in harmful impacts on environment (Ieropoulos, 2019). To explain this phenomenon, consider a company that is using oil as fuel and producing some product through heavy machinery. The burning of oil by the machinery will release harmful gas in the environment that ultimately results in air pollution. This is just one example; there are many other similar examples too in the similar context. In the same way, different measures may also be taken such as disposing off the waste in proper way and providing proper channels through which harmful substances and gases may be emitted from the company. These studies by Lambert and Wagner (2017) and Lee, Bagheri, and Kao (2015) revealed that their results indicate that the awareness about latest technology involving robotics and artificial intelligence must be increased so that all companies adopt such aspects by making one time investment in technology. This is necessary to depict improved environmental performance and enhanced production of that particular company. Based on these studies and their review, it can be concluded that robotics and AI awareness have significant impact on the environmental performance of a company. The following hypothesis can be generated in this regard,

H 1: Robotics and AI awareness has significant impact on the environmental performance of pharmaceutical companies of Thailand.

Technical Content Knowledge impact on Environmental Performance

Technical content knowledge TCK has been the center of attention of many researches and has been utterly discussed in the studies and researches of Lu (2017) and Malik, Rohendi, and Widiaty (2019) as one of the variables. As discussed earlier, technical content education has its applications in different fields and involves the manipulation of different types of data and as a result, a new content based on technology is produced. For example, the discovery of x-rays by Roentgen as well as the carbon dating process can be effectively understood and imagined through the use of technology. In the same way, the processing of heart and functioning of brain can also be viewed in this way (Winfield & Jirotka, 2018). Apart from these aspects, it may find its use in businesses and other related sectors where understanding of various concepts can be taken through the use of technology in the form of TCK (Martos, Pacheco-Torres, Ordóñez, & Jadraque-Gago, 2016). The past researches have indicated the fact that TCK is very significant in understanding and applying different concepts of technology in the industries specially that involve chemicals

and related aspects. It is very important that the companies or industries must understand the implications and uses of a particular technology in context of their particular field or discipline so that a proper and relative technological tool can be produced for the purpose of training and development of the employees. The basic use of TCK in any industry is to present the process or structure of a specific product as well as its production to its employees and workers. The trainers must have the knowledge of these presentations as well as the use of technology involved in these presentations that have been prepared for the training purposes of the employees and workers (Nykvist et al., 2017; Qin, Liu, & Grosvenor, 2016). In this way, the productivity of the organization or the company is increased due to the better understanding of production processes by the employees. This will not only impact the financial performance of the company but also the environmental performance of the company. Based on the review of these past studies, it can be suggested that technical content knowledge has significant impact on the environmental performance of the company. The following hypothesis can be designed in accordance with the above discussion,

H 2: Technical content knowledge has significant impact on the environmental performance of pharmaceutical companies of Thailand.

Mediating Role of Industry 4.0 Implementation between Robotic and AI Awareness and Environmental Performance

The role of implementation of I4.0 has been considered by many researchers in the past and they have related it to various aspects regarding business and technology (Trumpp & Guenther, 2017; Webster & Ivanov, 2020). As the fourth industrial revolution is presented by industry 4.0 or I4.0, it involves the incorporation of different technological aspects such as artificial intelligence and robotics in the industry. As discussed earlier, robotics and AI use in industry and production firms has become very popular due to its great benefits in terms of finance and environment. According to Roblek, Meško, and Krapež (2016), the application of robotics and AI in the industry makes that particular industry the part of the fourth industrial revolution and such an industry becomes I4.0. This type of industry has an ultimate impact on the environmental performance of a firm. In context of robotics, a past study has indicated that in the past robots were the options for only the huge companies having huge budgets and they used them in different processes in their industry. However, these trends have changed and almost every size industry may afford the expense of robots and use them in their industries (Rüßmann et al., 2015; Song, Fisher, Wang, & Cui, 2018). They may perform different tasks such as picking up products and goods and placing them somewhere else and may also be involved in manufacturing or production processes. Artificial intelligence may also be associated with the robotics as they may function through the use of AI in different operations of that industry. In this way, the financial as well as environmental performance is supposed to increase in accordance with the results suggested by the past researches. This discussion indicates that industry 3.0 has significant mediating role between robotics and AI awareness and

environmental performance of a company. The following hypothesis can be produced in this regard,

H 3: Industry 4.0 implementation has significant mediating role between robotics and AI awareness and environmental performance of pharmaceutical companies of Thailand
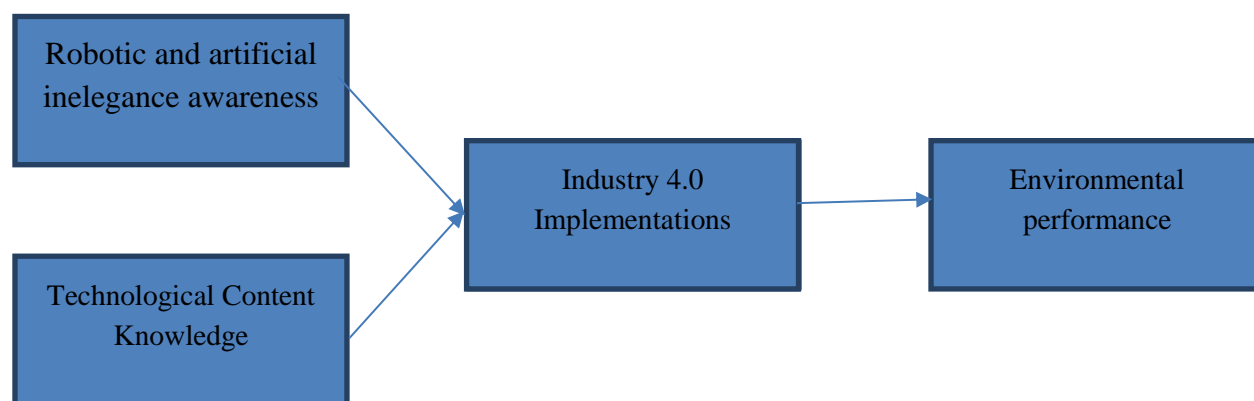
Mediating Role of Industry 4.0 Implementation between Technical Content Knowledge and Environmental Performance

In context of technical content knowledge, the past studies have discussed that the use of technology in providing education or training to the employees of a specific company, technology can be effectively used to demonstrate different processes and procedures that result in the implementation of industry 4.0 in any company. As discussed earlier, the use of technical aspects results in the betterment of productivity of the company as well as the environmental performance of that company. According to Stock and Seliger (2016), technology content may also provide information and presentation about

different ways to prevent pollution of various kinds such as air pollution, water pollution etc. and thus has positive impacts on the environment. This also improves the reputation of that company in context of corporate social responsibility CSR. Industry 4.0 has major role in this regard and according to various researchers, many industries have paid considerable attention towards this aspect and are enjoying the benefits. As technology has become affordable for almost all the sectors and sizes of the companies, therefore technology adoption has become easy and its impact on environment can be observed (Thompson & Hanley, 2017; Tröger, Sumfleth, & Tepner, 2017). Based on the above review of these studies, the author has concluded that industry 4.0 implementation has significant mediating role between technical content knowledge and environmental performance of a company. Therefore the following hypothesis can be generated,

H 4: Industry 4.0 has significant mediating role between technical content knowledge and environmental performance of pharmaceutical companies of Thailand

Research Model

Research Methodology
Population and Sampling

This research study has been taken into consideration for examining the influence of robotic and artificial awareness and technical content knowledge on environmental performance, in mediating role of industry 4.0 implementation. Researcher selects pharmaceutical companies of Thailand as population of study because pharmaceutical sector has been considered major contributor in enhancing GDP of Thailand and Thailand is also famous for drug clinical trials as it provides sophisticated healthcare system. For increasing growth of this sector and for providing excellent facilities to foreign pharmaceutical companies, environmental performance of pharmaceutical sector has to increase. For that reason, researcher proposed research study in which researcher selects Pfizer, Novartis and Roche as sampling frame and collect data about concerned variables from the managerial employees of these companies. Further, convenience sampling technique has been accompanied for selecting sample respondents

because a large no of employees have been working in these companies that's why it is beneficial to collect data only from those individuals which can easily be assessed and who have strong opinions regarding the technical know-how such as role of robotic and artificial intelligence and industry 4.0. For data collection, researcher distributes 400 questionnaires among respondents but he or she attained only 337 responses. Out of which researcher considers 319 valid responses because rest of them have been discarded to invalidity and incomplete responses.

Data Collection Procedure

As researcher requires primary data and for collecting objective, numeric and objective responses, researcher considers survey questionnaire as more appropriate option for data collection. Researcher divides survey questionnaire into two type of closed ended questions such as (1) demographic questions and (2) variable scale-items, in which researcher asked respondents about the impact of concerned variables. All these survey questions have been written originally in English

language but for collecting responses from Thailand, researcher translate it in native Thai language. Researcher has to accompany back translation method for again translating back into English language, which can easily be analyzed statistically. Further, researcher takes into account pretest test approach for checking understandability of survey items and collects feedback from industrial practitioner regarding content validity of measures. Afterwards, self-administering technique has been followed for final administration as it enables researcher to resolve queries of respondents regarding technical terms in questionnaire as soon as possible.

Measures

Due to authenticity and validity of previously used measures for the measurement of role of concerned variables, researcher considers it more suitable and appropriate to adapts these measures from previous literature. In the proposed research study, researcher adapts 4 survey items from research study of (Brougham & Haar, 2018), for measuring robotic and artificial intelligence awareness. Moreover, researcher measures technical content knowledge construct through 5 survey items, which have been adapted from (Hayati, 2019). Mediating effect of industry 4.0 implementation in the proposed study has been measured through 3 measurement items, adapted from (Varela, Araújo, Ávila, Castro, & Putnik, 2019). Further, environmental performance (dependent variable) has been measured through 3 survey items, all these items have been adapted from (Lin, Tan, & Geng, 2013). Researcher accompanied 5-point Likert scale for measurement of all these survey items, in this scale responses have been recorded in range from 1 = strongly disagree to 5 = strongly agree.

Data Analysis Techniques

SPSS and AMOS have been accompanied as most suitable data analysis software, which helps in analyzing authenticity, validity and reliability of collected data. Firstly, SPSS has been taken into account for applying regression test, correlation test and descriptive statistics test, which have been accompanied for statistical analysis of collected responses. Moreover, reliability test has also been performed under SPSS, which has been run under two criteria such as (1) Composite reliability and (2) Cronbach's alpha, researcher has to ensure that values of both criteria must exceed 0.70 threshold limit because above 0.70 value internal consistency and items reliability can be ensure. As far as AMOS is concerned, it helps to run diagnosis of structure equation modeling, which has been taken into consideration for conducting hypothesis testing, under which researcher checked which hypothesis get accepted or which get rejected.

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RESULTS AND ANALYSIS

The author explored the frequency distribution of respondents to examine their shares based on gender, age and education. The valid data size is based on 319 respondents. The frequency distribution indicates that the share of male and female respondents are 52.4 percent and 47.6 percent, respectively. Moreover, the share of individuals having master and post-graduate degree are 33.2 and 43.3 percent, respectively. As far as higher education is concerned, the proportion of respondents older than 50 years have 14.6 percent share in respondents. Hence, it may inferred that author fetched the data majorly from individuals of middle age category.

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
RAIA	319	1.00	5.00	3.5008	1.12373	-.794	.137
TCK	319	1.00	5.00	3.4884	1.15506	-.661	.137
In4.0Imp	319	1.00	5.00	3.5444	1.16526	-.755	.137
EnPr	319	1.00	5.00	3.5705	1.10987	-.795	.137
Valid N (listwise)	319						

The descriptive statistics of variables such as average, maximum, minimum, skewness, and standard deviation of variables' data are presented in table 1. The results indicates that minimum and maximum values of all variables is 1 and 5, respectively. The values denote that responses are recorded on five point Likert scale. The mean values of all the measures are moving around 3.5 that indicate that most of the respondents are slightly agree with statement. Besides, the skewness test confirm the normal distribution in data as its lie in the range of -1 and 1.

Table 2: Factor Loading and Convergent Validity

	TC	RA	II	EP	CR	AVE
TC4	.857				0.951	0.797
TC5	.848					
TC3	.840					
TC2	.839					
TC1	.802					
RA4		.858			0.918	0.738
RA3		.856				

RA2	.830				
RA1	.733				
II3		.895		0.929	0.813
II2		.858			
II1		.836			
EP2			.872	0.905	0.761
EP3			.833		
EP1			.820		

Table 2 presents the results of component factor analysis (CFA) which examine the validity of measures. Table 2 also shows rotated component matrix of variables. The values of CFA test authenticates that all variables have valid construct because the load factors of all variables are higher than 0.7, which is threshold value for validity. The "convergent and discriminant" test also approves the validity of measures. Besides, the issue of cross loading is also not found in variables.

Table 3: Discriminant Validity

	II	RA	TC	EP
II	**0.902**			
RA	0.516	**0.859**		
TC	0.589	0.604	**0.893**	
EP	0.459	0.554	0.582	**0.872**

Table 3 shows the results of "convergent and discriminant" validity. The table also depicts the observed and threshold values of test. The values of AVE and CR confirm convergent validity in variables because the values is less than threshold of 0.75 and 0.7, respectively. The high diagonal values than off diagonal values in table endorse the discriminant validity of indicators.

Table 4: Confirmatory Factors Analysis and KMO

CFA Indicators	CMIN/DF	GFI	IFI	CFI	RMSEA	KMO
Threshold Value	≤ 3	≥ 0.80	≥ 0.90	≥ 0.90	≤ 0.08	0.6 – 1.0
Observed Value	2.719	0.915	0.969	0.969	0.073	0.913

Table 4 shows the results of Kaiser-Meyer-Olkin and Bartlett's Test. The KMO test is used to check how relevant data is for Factor Analysis. The test also evaluates sampling adequacy for model and for each variable. Furthermore, the KMO test also finds the variance proportion among variables that might be common variance. The findings of KMO test validate adequacy in sample data because the value lies under the threshold range of 0.6 - 1.0 standing on 0.91.
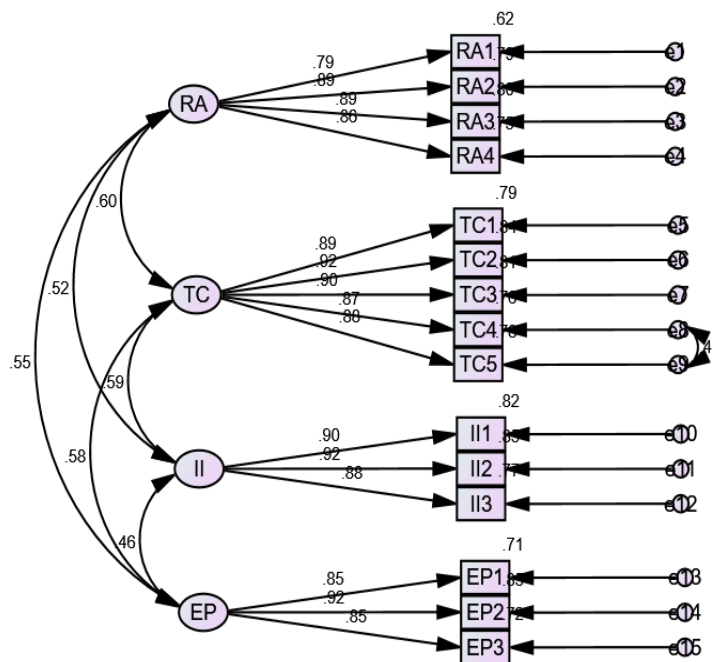
Figure 2: CFA

Table 5 depicts the empirical findings of Structura Equation Model which is estimated by employing AMOS. The model finds the relationships of "Robotic and Artificial Intelligence Awareness" and "Technical Content Knowledge" with the environmental performance of pharmaceutical companies of Thailand. The results indicate that direct and indirect impact of "Robotic and Artificial Intelligence Awareness" and "Technical Content Knowledge" on environmental performance of pharmaceutical is significant and positive, as p-value of coefficients are less than 0.05. The coeffcient of "Robotic and Artificial Intelligence Awareness" shows that one unit increase in "Robotic and Artificial Intelligence Awareness" will improves the enviromental performance of pharmacuticals by 24.7 percent. Likewise, the coeffcient of "Technical Content Knowledge" denotes that one unit incraese

in "Technical Content Knowledge" will improve enviromental performance of pharmacuticals by 41.0 percent. Besides, the indirect impacts of "Robotic and Artificial Intelligence Awareness" and "Technical Content Knowledge" on environmental performance through industry 4.0 implementation are also significant. The mediating coeffcients indicate that one unit increase in industry 4.0 implementation will improve enviromental performance about 8.1 and 13.5 percent through "Robotic and Artificial Intelligence Awareness" and "Technical Content Knowledge" respectively. Therefore, it can be inferred that mediating impact of industry 4.0 implemenattion strengthens the relationships of "Robotic and Artificial Intelligence Awareness" and "Technical Content Knowledge" with environmental performance of pharmacutical in Thailand.

Table 5: Structural Equation Modeling

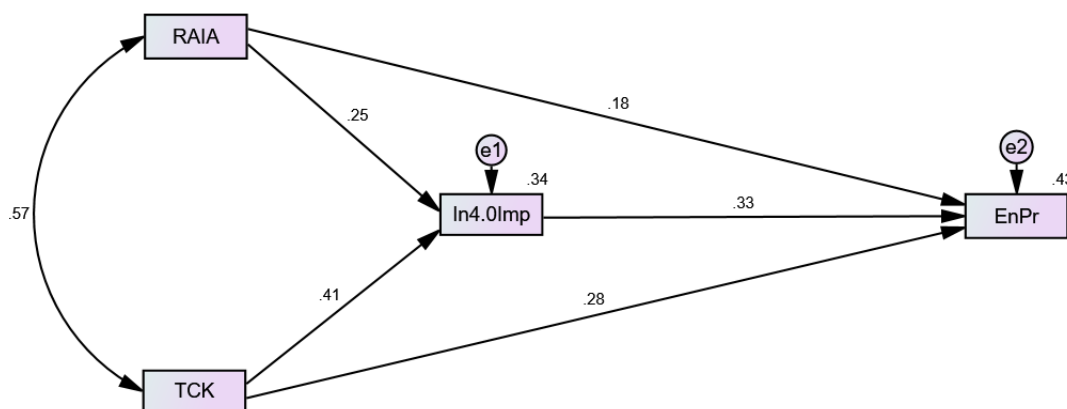| Hypothesis	B-Value	SE	P-Value	Decision
RA→EP	.247	.057	.000	Accepted
TC→EP	.410	.056	.000	Accepted
RA→I4.0I→EP	.081	.032	.010	Accepted
TC→I4.0I→EP	.135	.042	.010	Accepted

Figure 3: SEM

DISCUSSION AND CONCLUSION

Discussion

The reason why the need to conduct this study arise was the contradictions regarding the improvements of environmental performance and the factors that possibly might play a very significant role in that case. So, the study took robotic and artificial intelligence awareness and technical content knowledge to check their impacts on environmental performance. The study also took industry 4.0 implementation as a mediator to check how well it enhances the impacts of robotic and artificial intelligence awareness and technical content knowledge on environmental performance. The first hypothesis that the study proposed was that, the impact of robotic and artificial intelligence awareness on environmental performance is significant." The hypothesis has been accepted according to the study of (Chalongsuk & Sribundit, 2013), robotic and artificial intelligence awareness causes overall work efficiency without much harm to the environment in return, which will cause the environmental performance to increase. The second hypothesis, "The impact of technical content knowledge is significant on environmental performance" is accepted according to the results of the study and research of (Kuek, Phillips, & Kohler, 2011) as well. The third hypothesis proposed by the study was that, "The mediating role of industry 4.0 implementation between robotic and artificial intelligence awareness and environmental performance is significant." This hypothesis has been accepted based on the study of (Pongcharoensuk & Prakongpan, 2012), which states that the industry 4.0 practices and the robotic and artificial intelligence awareness will minimize the waste matter and will maximize the efficiency which means that the environment can be given back positive vibes instead of bringing damage to it. The fourth hypothesis proposed by the study was that, "The impact of industry 4.0 implementation between technical content knowledge and environmental performance is significant." This hypothesis has been accepted by the results of the study and also the research work of (Pothitong & Charoensiriwath, 2011).

Conclusion

The contradictions regarding the improvements of environmental performance and the factors that possibly might play a very significant role in that case, led this study to happen. So, the study took robotic and artificial intelligence awareness and technical content knowledge to check their impacts on environmental performance. The study also took industry 4.0 implementation as a mediator to check how well it enhances the impacts of robotic and artificial intelligence awareness and technical content knowledge on environmental performance. The study collected data from 319 individuals from Pharmaceutical Companies of Thailand. The data was analyzed and results showed that the impact of robotic and artificial intelligence awareness and technical content knowledge on environmental performance is significant and positive and also role of industry 4.0 implementation as a mediator is significant.

Implications of the study

The study has its implications in theoretical section as it has significantly increased empirical evidences regarding the role of robotic and artificial intelligence awareness and technical content knowledge in solving the environmental problems. Moreover, the study has also increased the chances that not only the pharmaceutical industry in Thailand but the industries from around the globe will be implementing robotic and artificial intelligence and will pursue technical content knowledge for betterment of environmental performance by making policies about them as being necessary as well.

Limitations and future research recommendations

The study has its own limitations as well, regarding the size of its sample because taking 319 individuals representing a very large industry is a small sample indeed. Moreover, the study also is very less explanatory about the need of the robotic and artificial intelligence awareness and technical content knowledge in the pharmaceutical industry only and why not in any other industry in specific. The study lacks generalizability to a great extent as well.

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