The Impacts of Internal and External Factors on Developing Global Digital Innovation: A Case Study of the Provincial Electricity Authority in Thailand

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Abstract— The study aimed to investigate the impacts of internal and external factors on developing global digital innovation by means of a case study of the Provincial Electricity Authority (PEA) in Thailand. The research framework was based on the concepts of disruptive leadership, Thailand 4.0, Industry 4.0, PEA Digital Utility or Electric Utility of the Future, ICT/Digital Innovation, and Sufficiency Economy Principles (SEP). The research sample group comprised 419 PEA employees randomly selected from throughout the country. The research tools consisted of structured questionnaires on content and technical quality validated by five qualified experts. Assumptions of multiple regression analysis- normality, linearity, no multicollinearity, independence, and homoscedasticity were examined. The data verifying the assumptions were analyzed by multiple regression and PEA Digital Utility, Industry 4.0, ICT/Digital Innovation, Disruptive Leadership, and Thailand 4.0 were estimated for the development of global digital innovation. It was also found that most PEA employees, or 51.55 percent, refer to the innovation they know of as PEA Smart Plus. This is because PEA will focus on the use of communication technology to improve efficiency in the distribution system which is the foundation for further development of other parts of the system. Furthermore, most PEA employees identified innovation as being environmentally friendly.

Index Terms— Digital Disruption, Digital Transformation, Global Digital Innovation, Internal and External Factors.

I. INTRODUCTION

Digitization describes the pure analog-to-digital conversion of existing data and documents [1] or involves the conversion of human-driven processes to software-driven processes [2]. Importantly, digitalization increases productivity and efficiency while reducing costs. As Gartner [3] defines it, digitalization is "the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of

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moving to a digital business." The digital transformation converts the world of atoms to a world of bits [4] which are so inexpensive because people can duplicate and move them at no cost and without the loss of the original. In fact, digital or business transformation mainly relates to organizational change [5]; it relates to how organizations transform themselves. In contrast, digital disruption is the 'outside-in' force, mainly changing how business is done in aspects of an industry, and it relates to an external movement targeting existing businesses with the aim of disrupting them [5]. Digital disruption is the change caused either directly or indirectly by the development of new technologies (cloud, big data, mobile, limitless computing and other exponential technologies) that modify business models to make them more valuable; for example, when different technologies come together to offer greater value such as IT (Information Technology) and OT (Operation Technology) in industry. Customer demand can be the most important reason for change, while innovation can also be a reason for digital disruption. Likewise, economic, regulatory, geopolitical and social changes, and natural disasters such as the pandemic can cause digital disruption. Business models are not focused on the masses, but on needs segmented from small groups and are customer-centric. These models incorporate innovations such as collaborative economies, blockchains, and fintechs [6].

However, as Christoph Zohlen [5], [7] stated, "Successful digital transformation is primarily determined by the degree to which people are empowered to actively embrace constant change as an opportunity for growth and innovation." Also, Jack Welch [5], [8] remarked, "When the external change is faster than the internal change the end is near." Generally, people are not used to thinking in exponential terms, and today's organizations are not set-up to work in such an environment [5]. The mindset of individuals usually encompasses the notion that "we have to disrupt ourselves or others disrupt us" - there will never be any transformation unless individuals start their transformation first. The challenge of enabling executives, managers and employees to understand and embrace the risks and opportunities of new digital trends is a fundamental prerequisite for the successful transformation of an organization [5]. Digital disruption is not the only factor that can cause digital transformation. Economic, societal, and regulatory factors also create industry turbulence that influences digital transformation.

Some organizations fear digital disruption and the resulting loss of value, and they try to combat it [2]. Organizations can navigate the challenges and complexities of digital transformation by structuring a digital transformation strategy that forecasts and embraces disruptions by monitoring political, economic, social, and technological trends and researching disruptive innovations on the horizon and using digital platforms to their advantage. The first way to adapt to digital disruption is to get ahead of it [2]. Would-be leaders must create an organization-wide, top-down digital transformation strategy. This must incorporate innovative technology at every level of the supply chain and organizational structure. Organizations should use digital platforms as a means of communication and coordination. It is important to develop a long-term strategy that prioritizes change management and meets the needs and expectations of customers. By understanding digital transformation, organizations can prepare for the loss of value in their industries and, by creating a digital transformation strategy, they can prepare to evolve to become stronger than before.

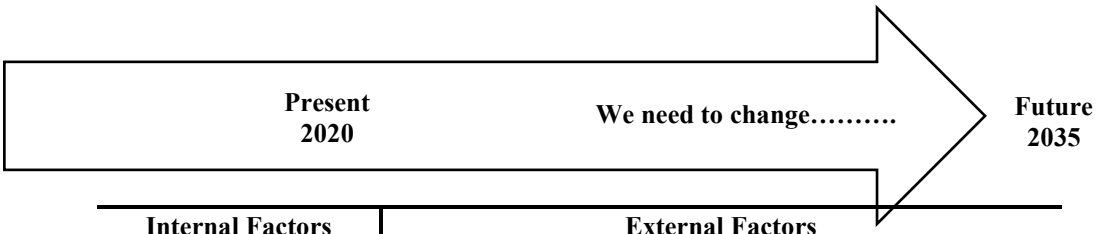
II. OBJECTIVES

The objective of this study is to investigate the impacts of internal and external factors on developing global digital innovation by means of a case study of the Provincial Electricity Authority (PEA) in Thailand.

III. CONCEPTUAL FRAMEWORK

Conceptual framework of the study would consist of the internal and external factors of the Provincial Electricity Authority 2020-2035,

A. The internal and external factors on developing global digital innovation



Internal Factors	External Factors			
PEA Digital Utility (Provincial Electricity Authority)	**Technological Change**		**Environmental Change**	
	Social Change		**Economic Change**	**Politic Change**
	Disruptive Leadership Sufficiency Economy Philosophy	ICT/Digital Innovation	Thailand 4.0 Sufficiency Economy Philosophy	Thailand 4.0
Organizations have to respond to the changing environment and consider the need to change their business/process systems accordingly.				

Fig. I The internal and external factors on developing global digital innovation [9].

As shown in Fig. 1, to develop a global digital innovation during 2020-2035, it needs to follow the guidelines of Thailand 4.0, which is a master plan to get the country ready for Industry 4.0. Industry 4.0 will put an emphasis on digital technology [10], [11], with the support of the sufficiency economy philosophy (SEP) to balance economic progress, environmental protection, and human needs [12].

B. A Digital Innovation Model

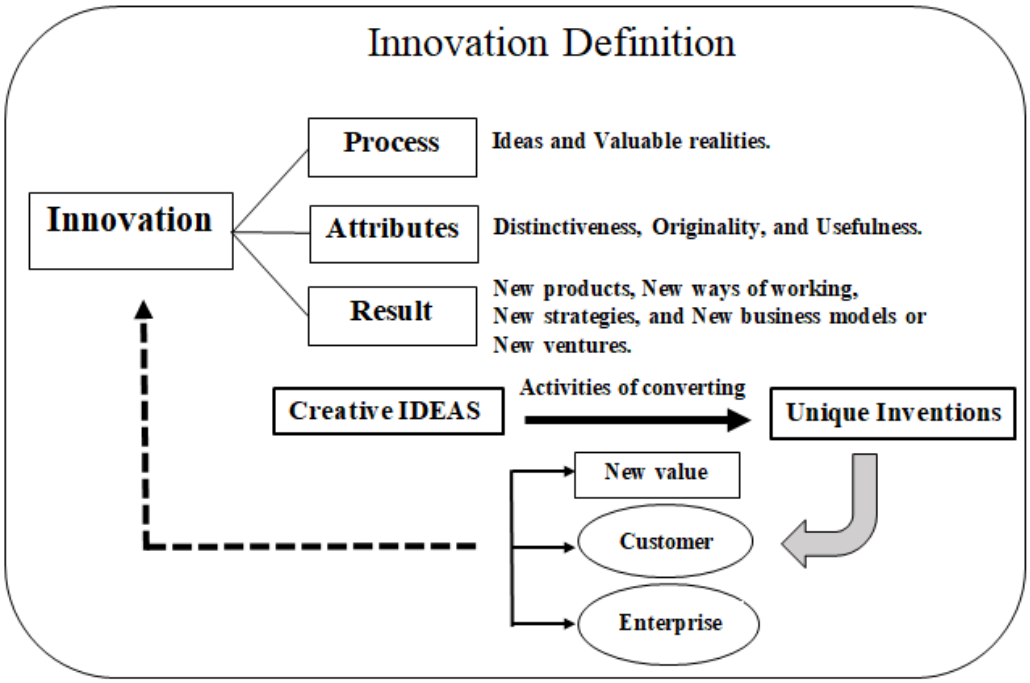


Fig. II A digital innovation model [9].

Fig. II shows that a digital innovation model would consist of as follows:

A. Process: A digital innovation would emphasize ideas, and valuable realities,

B. Attributes: A digital innovation would emphasize distinctiveness, originality, and usefulness.

C. Result: A digital innovation would emphasize new products, new ways of working, new strategies, new business model, and new venture.

D. Unique Inventions: A digital innovation would emphasize on new value, customer, and enterprise.

IV. Research Methodology

A. Population and Sampling Group

The population of the study is 17,170 PEA employees [13]. According to Taro Yamane [14] formula with 95% confidence level, the sample of this research is calculated to determine the sample size which was 390. Then, the research sample group comprised 419 PEA employees using systematic randomly selected throughout the country which are from Provincial Electricity Authority Area 1-4 which are North, Northeast, Central, and South. The number of questionnaires to be sent out via post office with self-addressed envelope as well as online because of COVID-19 pandemic was 525 and the number of questionnaire received 419 or 79.80 percent.

B. Variables

Variables of the study were independent variables and dependent variables. The independent variables are disruptive leadership, Thailand 4.0, Industry 4.0, PEA Digital

Utility, ICT/Digital Innovation, and SEP. While the dependent variable is PEA Global Digital Innovation as shown in Fig. III.

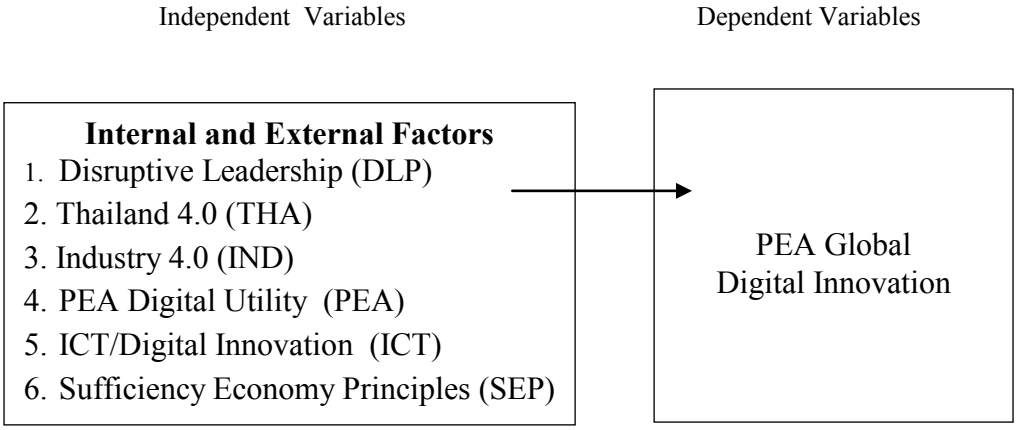


Fig. III Independent and dependent variables

C. Tool for Data Collection

Tool for data collection of this study is a structured questionnaire on content and technical quality validated by five qualified experts is composed of three parts. First part is the demographic or general information of the respondents such as sex, age, and position using checklists. Second part is divided into two subparts: Firstly is concerned with the question of PEA global innovation that the respondents know best because to respond to the second subpart and the third part, the respondents should focus on the one they knew. Secondly, it will be six categories of internal and external factors affecting the PEA global innovation (shown in Fig. I) as in: disruptive leadership, Thailand 4.0, Industry 4.0, PEA Digital Utility, ICT/Digital Innovation, and SEP and subcategories would be 54 items using the 5-point Likert type scale [15] which 5 is strongly agree to 1 is strongly disagree. Then, the value for Cronbach's Alpha [16] for the survey was $\alpha = 0.975$ which is at the excellent level. Lastly, the third part is the questions of PEA global digital innovation related to process, attributes, result, and unique invention (shown in Fig. II) which 5 is strongly agree to 1 is strongly disagree. The total items of the third part question are 24.

D. Data Analysis

Data would be analyzed as follows:

1. To analyze demographic of the respondents using frequency, percentage, mean, and standard deviation.
2. Using multiple regression analysis allows researchers to assess the strength of the relationship between an outcome (the dependent variable) and several predictor variables as well as the importance of each of the predictors to the relationship, often with the effect of other predictors statistically eliminated.
3. Several key assumptions of multiple linear regression would be analyzed as follows [16]:

3.1 There must be a linear relationship between the outcome variable and the independent variables. Scatterplots can show whether there is a linear or curvilinear relationship. The VIF value of disruptive leadership (3.113), Thailand 4.0 (3.445), Industry 4.0 (4.453), PEA Digital Utility (4.852), ICT/Digital Innovation (3.142), and SEP (1.720) which are <= 4 suggests no multicollinearity whereas a value of >= 10 implies serious multicollinearity. Then, the Tolerance value is less than 10 as follows: disruptive leadership (0.321), Thailand

4.0 (0.290), Industry 4.0 (0.225), PEA Digital Utility (0.218), ICT/Digital Innovation (0.318), and SEP (0.581).

3.2 Multivariate Normality-Multiple Regression assumes that the residuals are normally distributed. The error terms must be normally distributed. The general rule is that if n is more than 30, then the sampling distribution of means will be approximately normal. However, if the population is already normal, then any sample size will produce a normal sampling distribution [17].

3.3 No Multicollinearity-Multiple regression assumes that the independent variables are not highly correlated with each other. This assumption is tested using Variance Inflation Factor (VIF) values (see 3.1).

3.4 The Durbin Watson statistic is a test for autocorrelation in a regression model's output. The result of the study is 1.895 which means the value below 2.0; thus, there is a positive autocorrelation. A value above 2.0 would indicate a negative autocorrelation. There should be no correlation between the residual (error) terms. Absence of this phenomenon is known as Autocorrelation. [18].

4. Pearson's Product Moment Correlation Coefficient, and Multiple Regression Analysis would be utilized for data analysis.

V. RESEARCH RESULTS

A. Demographics of Respondents

There were more males (353 or 84.25%) than females (66 persons or 15.75%). Most respondents (151 persons or 36.04%) were aged between <25-30 years, 140 persons (33.41%) were aged between >30-40 years, 81 persons (19.33%) were aged between >40-50 years, and 47 persons (11.22%) were aged 50 years or above. In regard to position ranking within the organization, most respondents or 273 persons (65.16%) had position rankings of levels 4 - 7, 92 persons (21.96%) had rankings of levels 2 - 3, and 54 persons (12.89%) had position rankings of levels 8 - 10.

B. PEA Global Digital Innovation that the Respondents Knew Best

The frequency and percentage of PEA global digital innovation that the respondents knew best is shown in Table I.

Table I
Frequency and percentage of PEA global digital innovation that the respondents knew best.

No.	PEA Global Digital Innovation	n	%
1.	PEA Smart Grid	51	12.17
2.	PEA Smart Plus	216	51.55
3.	PEA Innovation Hub	26	6.21
4.	PEA Care & Service	9	2.15
5.	PEA Smart Home	13	3.10
6.	PEA Smart Electronic Meter	9	2.15
7.	PUPAPLUG	14	3.34
8.	EV & Charging Station	32	7.64
9.	Others*	49	11.69
Total		419	100.00

* PEA global digital innovation was identified for more than one type.

Table 1 shows that most respondents (216 or 51.55%) knew. PEA Smart Plus best which is the application in the form of 'One Touch Service'. This is because during the COVID-19

Variables	Highest-Lowest Variables	$\bar{x}$	Variables	Lowest-Highest Variables	$\bar{x}$
DLP1	In sharing purposes and aspirations, leadership brings forward new ways of being, knowing, and doing.	4.38	DLP6	'Inclusiveness' is the practice or policy of including those who might be excluded or marginalized; those with physical or mental disabilities; and members of minority groups.	4.02
PEA4	Social media and the Internet to be used to communicate with customers as a one-stop service through the PEA Smart Plus application so that they will be impressed by the service.	4.35	THA5	Designing a value-based economy driven by innovation based on the Sufficiency Economy Philosophy (SEP).	4.02
PEA1	Aimed at providing electricity with high quality service and developing the organization (which is continuously responsible for society and environment).	4.34	SEP2	The traditional knowledge and wisdom that has been accumulated in the past but may have been forgotten would be employed to solve problems.	4.06
DLP4	Technological literacy.	4.31	THA3	Its over-arching aim is to transform Thailand into a high-income country with an entirely digitalized economy led by fully digitalized organizations.	4.12

epidemic, it was recommended that electricity users use PEA services or pay electricity bills online through the PEA Smart Plus application in the form of the 'One Touch Service' [19]. Fifty-one, (12.17%) of respondents, knew the PEA Smart Grid Network. The PEA Smart Grid Network deals with the electrical system, service, social media as well as the environment [20], [21]. Other respondents (152 or 36.28%) knew best innovations such as EV & Charging Station and the PEA Innovation Hub. Most of these PEA global innovations are considered to be environmentally friendly [22].

C. The Highest and Lowest Mean of Internal and External Factors in Developing PEA Global Digital Innovation

Table II

Highest and lowest mean of internal and external factors in developing PEA global digital innovation.

Table II (Cont.)

Variables	Highest-Lowest Variables	$\bar{x}$	Variables	Lowest-Highest Variables	$\bar{x}$
DLP5	Recognizing the importance of people in the organization will lead to a sustainable future, or the thought that the customer is a valuable creation will lead to success.	4.31	SEP3	Its goal refers to achieving harmony and stability in financial matters and life.	4.13

Table II shows that most variables affecting developing PEA global digital innovation are identified as follows: the role of disruptive leadership is sharing purposes and aspirations as well as bringing forward new ways of being, knowing, and doing. The PEA Digital Utility deals with social media and the Internet to communicate with customers as a one-stop service through the PEA Smart Plus application so that they will be impressed by the service. The least important variables in developing PEA global digital innovation are exclusive leadership, Thailand 4.0 (which has a value-based economy driven by innovation based on SEP), and SEP which recognizes the traditional knowledge and wisdom that has been accumulated in the past but has been forgotten and can be employed to solve problems.

D. The Highest and Lowest Mean in Developing PEA Global Digital Innovation

Table III
Highest and lowest mean in developing PEA global digital innovation.

Variables	Highest-Lowest Variables	$\bar{x}$	Variables	Lowest-Highest Variables	$\bar{x}$
PEA14	Attributes-usefulness.	4.32	SEP24	Unique inventions concerning Sufficiency Economy Philosophy focus on customers.	4.14
DLP2	Attributes-usefulness.	4.32	THA8	Unique inventions concerning Thailand 4.0 focus on enterprise.	4.18
ICT18	Attributes-usefulness.	4.32	SEP23	Results-new strategies.	4.18
PEA15	Results-focus on new ways of working.	4.29	THA5	Process-value.	4.19
IND10	Attributes-usefulness.	4.29	SEP21	Process-value.	4.20

Table III shows the highest variables of PEA Digital Utility, disruptive leadership, ICT/Digital Innovation, and Industry 4.0 focus on usefulness and new ways of working. The lowest variables were the unique inventions concerning SEP that focus on customers. The unique inventions concerning Thailand 4.0 focus on enterprise.

E. The Impacts of Internal and External Factors on Developing PEA Global Digital Innovation

To find out the impacts of internal and external factors on developing PEA global digital innovation, statistics were utilized for data analysis as follows:

1. ANOVA

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40171.132	6	6695.189	125.521	.000
	Residual	21975.780	412	53.339		
	Total	62146.912	418			

The model was able to predict statistically significant dependent variables, where, from the ANOVA table, the F value of 125.521 indicates that the multiple regression has a proportion explaining the change in the PEA digital innovation model 125.521 times more than the unexplained proportion.

2. Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			Durbin-Watson
					R Square Change	F Change	Sig. F Change	
1	.804	.646	.641	7.303	.646	125.521	.000	1.895

From the Durbin-Watson statistic of 1.895, which is between 1.50-2.50 and indicates that

		PEA Digital Innovation Model	Disruptive Leadership	Thailand 4.0	Industry 4.0	PEA Digital Utility	ICT/ Digital Innovation	Sufficiency Economy Philosophy
Pearson Correlation	Pea Digital Innovation Model	1.000	.660	.680	.713	.715	.704	.662
	Disruptive Leadership		1.000	.772	.765	.744	.685	.551
	Thailand 4.0			1.000	.767	.765	.721	.600
	Industry 4.0				1.000	.843	.763	.596
	Pea Digital Utility					1.000	.794	.577
	ICT/Digital Innovation						1.000	.568
	Sufficiency Economy Philosophy							1.000

the error values are independent, it can be concluded that the group of variables used in the test had no relationship. The value of R is equal to 0.804, which is close to 1. This indicates that the group of independent variables are correlated with the dependent variable which has a correlation size of 0.804. The R^2 value indicates that the group of variables can explain the dependent variables 64.60% or 65%. The Multiple R for the relationship between the set of independent variables and the dependent variable is 0.646 or 64.60% or 65% which would be characterized as strong [23].

3. Correlations

Correlations

Correlations show that the relationship between the two variables. For example, there is a very strong relationship between Industry 4.0 and PEA Digital Utility at 0.843. However, there is a strong relationship between PEA Digital Utility and ICT/Digital Innovation at 0.794; disruptive leadership and Thailand 4.0 which is 0.772; and Thailand 4.0 and Industry 4.0 which is .767.

Coefficients

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	16.773	3.288		5.101	.000		
	Disruptive Leadership	.261	.143	.094	1.823	.069	.321	3.113
	Thailand4.0	.180	.139	.070	1.294	.196	.290	3.445
	Industry4.0	.328	.156	.130	2.106	.036	.225	4.453
	PEA Digital Utility	.402	.163	.154	2.461	.014	.218	4.582
	ICT/Digital Innovation	.483	.122	.205	3.949	.000	.318	3.142
	Sufficiency Economy Philosophy	.596	.080	.285	7.418	.000	.581	1.720

Regression is used to determine the strength and character of the relationship between one dependent variable (usually denoted by Y) and a series of other variables (known as independent variables) [24]. A coefficient refers to a number or quantity placed with a variable [25]. The unstandardized beta (B) represents the slope of the line between the predictor variables and the dependent variable [26]. The constant value is 3.288. The coefficient of ICT/Digital Innovation (0.483) and SEP (0.596) is statistically significant at the 0.01 level, while Industry 4.0 (0.328) and PEA Digital Utility (0.402) are statistically significant at the 0.05 level. Beta values represent constants and regression coefficients of the independent variables which are used to describe the changes in the PEA global digital innovation. The constant value is 16.773. The coefficient of ICT/Digital Innovation (0.205), and SEP (0.285) is statistically significant at the 0.05 level, while Industry 4.0 (0.130) and PEA Digital Utility (0.154) are statistically significant at the 0.01 level. The t-value indicates the causal relationship between the constants and groups of the source variables and the dependent variables. It was found that the t-value of the constant was 5.101 (p value < 0.01), Industry 4.0 was 2.106; PEA Digital Utility was 2.461; ICT/Digital Innovation was 3.949; and SEP was 7.418, respectively. The regression equation can be written as follows:

The raw score formula:

$$\hat{\mathbf{y}} = 16.773 + 0.328\ (\text{Industry 4.0}) + 0.402\ (\text{PEA Digital Utility}) + 0.483\ (\text{ICT/Digital Innovation}) + 0.596\ (\text{Sufficiency Economy Philosophy})$$

The standard formula:

$$Z = 0.130\ (\text{Industry 4.0}) + 0.154\ (\text{PEA Digital Utility}) + 0.205\ (\text{ICT/Digital Innovation}) + 0.285\ (\text{Sufficiency Economy Philosophy})$$

Conclusion and Discussion

The results of study led to the following conclusion and discussion:

1. In terms of the innovations that PEA employees knew most, it seems clear that some of these innovations are directly or indirectly eco-friendly. For example, the Smart Grid Network was introduced to develop Smart System electricity to improve service efficiency for electricity users as well as to encourage electricity users to save energy. It aims to produce energy that is eco-friendly or contribute to a Green Society. The PEA Smart Plus application focused on electricity users during the COVID-19 epidemic, recommending that they use PEA services or pay electricity bills online through the PEA Smart Plus application in the form of the One Touch Service. The PEA Innovation Hub is a collaboration in human resource development between the PEA Innovation Hub and Accenture at iHub Co-working Space, head office, and the PEA [27]. PEA Care & Service provides comprehensive electrical maintenance services such as the inspection, improvement, repair, and maintenance of electrical systems and solar panel equipment with quality standard certification from the PEA [28]. PEA Smart Home is an application of digital and communication technology that controls the electrical system in the home and the operation of smart devices as well as a means of managing renewable energy [29]. The Smart Meter also helps in tracking the status of electricity use [30]. PUPAPLUG is a socket for the electric vehicle business, whereas EV & Charging Station is an electric vehicle charging station [31], [32].

2. When the means of internal and external factors in developing PEA global digital innovation were compared, it was found that the mean of disruptive leadership which focuses on sharing purposes and aspirations, and leadership bringing forward new ways of being, knowing, and doing was the highest ($\bar{x}$ = 4.38). The lowest mean ($\bar{x}$ = 4.02), on the other hand, focuses on 'inclusiveness' which is the practice or policy of including those who might be excluded or marginalized such as those with physical or mental disabilities or members of minority groups. The reason for this is that the electricity provision must be secure, and only professionals can do the job. Risk is the most important function of PEA employees. This can be contrasted with the ideas of diversity which are proven to make communities and workplaces more productive, tolerant, and welcoming [33].

3. Correlations show the relationship between the two variables or internal and external factors and developing PEA global digital innovation. For the relationship in this study, there was a very strong relationship between Industry 4.0 and PEA Digital Utility (r = 0.843) while there was a strong relationship between PEA Digital Utility and ICT/Digital Innovation (r = 0.794); disruptive leadership and Thailand 4.0 (r = 0.772); and Thailand 4.0 and Industry 4.0 (r = 0.767). Thus, this can imply that an external factor such as Industry 4.0 had a relationship with the internal factor of PEA while PEA had a relationship with ICT/Digital Innovation. However, there is also a strong relationship between disruptive leadership and Thailand 4.0 because to develop global digital innovation during 2020-2035 (as shown in Fig II), the PEA needs to follow the guidelines of Thailand 4.0, which is a master plan to get the country ready for Industry 4.0. Furthermore, Industry 4.0 will put an emphasis on digital technology [10], [11].

4. When determining the strength and character of the relationship between internal and external factors and developing PEA global digital innovation, it was found that ICT/Digital Innovation (0.483) and Sufficiency Economy Philosophy (SEP) (0.596) are statistically significant at the 0.01 level while PEA Digital Utility (0.402) and Industry 4.0 (0.328) are statistically significant at the 0.01 level. Surprisingly, SEP seems to be the factor that has a very strong impact on developing PEA global digital innovation. While SEP

seems to be recognized by PEA employees, the traditional knowledge and wisdom that has been accumulated in the past but has often been forgotten can be employed to solve problems. On the contrary, according to Fig. I, SEP could balance economic progress, environmental protection, and human needs [12]. On the other hand, our review on the challenge of enabling executives, managers, and employees to understand and embrace the risks and opportunities of new digital trends is a fundamental prerequisite for the successful transformation of an organization [5]. It seems that SEP cannot go hand in hand with digital transformation. Digital disruption is not the only factor that can cause digital transformation. Economic, societal, and regulatory factors also create industry turbulence that can influence digital transform.

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