An Confirmatory Factor Analysis for Developing TRI 2.0 Structured Model under Internet of Things Context

Kritiya Rangsom
Information Systems dept.
Faculty of Business Administration
Rajamangala University of Technology Thanyaburi
Pathmthani, Thailand
gritiya_r@rmutt.ac.th

Wasun Khan-Am
Information Systems dept.
Faculty of Business Administration
Rajamangala University of Technology Thanyaburi
Pathumthani, Thailand
wasun_k@rmutt.ac.th

บทคัดย่อ บทความฉบับนี้นำเสนอผลการวิเคราะห์องค์ประกอบเชิงยืนยันของโมเดลโครงสร้างความพร้อมในการยอมรับเทคโนโลยีรุ่น 2.0 ภายใต้บริบทของอินเตอร์เน็ตในทุกสรรพสิ่ง ประชากรของงานวิจัยนี้คือ บุคคลทั่วไปที่อาศัยหรือทำงานอยู่ในพื้นที่กรุงเทพมหานครและปริมณฑลผู้ที่มีประสบการณ์การใช้ระบบอินเตอร์เน็ตผ่านโทรศัพท์เคลื่อนที่หรืออุปกรณ์ชาญฉลาด โดยกลุ่มตัวอย่างที่ดำเนินสำรวจทั้งสิ้นจำนวน 402 ตัวอย่าง การคัดเลือกตัวอย่างดำเนินการด้วยวิธีการแบบสะดวก เมื่อเริ่มต้นการวิเคราะห์ตัวบ่งชี้ที่นำมาใช้ในการวิเคราะห์มีทั้งหมด 16 ตัวบ่งชี้ 4 มิติ ได้แก่ การมองเทคโนโลยีในแง่ดี ลักษณะการเป็นนวัตกรรม ความไม่สะดวก และความไม่มั่นคง เมื่อผ่านการวิเคราะห์องค์ประกอบเชิงสำรวจพบว่าสามารถสกัดองค์ประกอบได้จำนวน 3 องค์ประกอบ แต่เมื่อทำการวิเคราะห์ค่าความน่าเชื่อถือขององค์ประกอบทั้งสามพบว่ามีองค์ประกอบที่ผ่านเกณฑ์เพียง 2 องค์ประกอบ และเมื่อนำสององค์ประกอบที่ได้ไปทำการสร้างโมเดลโครงสร้างทำการวิเคราะห์ด้วยการวิเคราะห์องค์ประกอบเชิงยืนยันพบว่ามีความเหมาะสมสามารถนำไปใช้งานได้ ด้วยค่าสถิติคือ ไค-สแควร์ 20.73 องศาความเป็นอิสระ 17 ค่าไค-สแควร์สัมพัทธ์ 1.22 ความเศษที่เหลือ .02 ค่าความเหมาะสมเข้ากันได้ดี .99 และค่านัยสำคัญ .24 โดยเมื่อนำผลลัพธ์ของโมเดลมาคำนวณหาค่าความเที่ยงของตัวแปรแฝง และค่าเฉลี่ยของความแปรปรวนของตัวแปรแฝงที่ถูกสกัด เพื่อแสดงความแกร่งขององค์ประกอบที่สกัดได้พบว่า ค่าความเที่ยงของตัวแปรแฝงขององค์ประกอบแรกเท่ากับ .83 ค่าความเที่ยงของตัวแปรแฝงขององค์ประกอบที่สองเท่ากับ .78 ค่าเฉลี่ยของความแปรปรวนของตัวแปรแฝงที่ถูกสกัดได้ขององค์ประกอบแรกเท่ากับ .50 และค่าเฉลี่ยของความแปรปรวนของตัวแปรแฝงที่ถูกสกัดได้ขององค์ประกอบที่สองเท่ากับ .54

คำสำคัญ ทีอาร์ไอ 2.0, ความพร้อมต่อเทคโนโลยี, การวิเคราะห์องค์ประกอบ, การสกัดตัวบ่งชี้

***Abstract*—This article presents the result of using confirmatory factor analysis of TRI 2.0 structured model under Internet of Things Context. The research population is people who ever use internet by mobile phone or smart devices, the number of sample were chosen by convenient method in Bangkok metropolitan area is 402 volunteer. At the start of analysis, there are sixteen indicators within four dimensions including: Optimism, Innovativeness, Discomfort, and Insecurity. The result of exploratory factor analysis shows that three components were extracted from sixteen indicators. According to reliability analysis, those three components were reduced into two components for the next analysis, one component was eliminated. The confirmatory analysis was conducted at the last part of analyzing; the structured model was constructed and tested. The result structured model was confirmed that model is properly for usage with following statistics as: χ^2 = 20.73, df = 17, χ^2/df =1.22, RMR = .02, GFI = .99, p-value = .24. In additional, the result from fitted model was employed to compute Composition Reliability (CR.) and Average Variance Extracted (AVE.) of component for find out a robustness of component. The result are: CR. of first component = .83, CR. of second component = .78; AVE. of first component = .50, and AVE. of second component = .54.**

Keywords—TRI 2.0, Technology Readiness 2.0, Factor analysis, Extracting indicator

I. INTRODUCTION

Technology Readiness Index is a concept of how to measure trends of people embrace a technology, and contributes in a lot of research since 2000s.

The Internet of Things (IoTs) is a new phrase and a new technology also. This may be a new era of using internet. There are several scholar believes that the Internet of Things will be fully implied in 2020s. The intention of the whole research is how to find out a relationship between behavior

of using Internet of Things and Technology Readiness Index (TRI). However, this article is a first stage of the big research. The first step of finding that relationship is to find out a suitable indicator for creating TRI factor, extracting a proper indicator from sixteen TRI 2.0 indicator, then the researcher will continue implement those factor to find out the relationship next.

The objectives of this article are to identify proper indicator for Technology Readiness Index 2.0 under Internet of Things context, and to analyze them with confirmatory factor analysis.

II. Liturature Review

A. Internet of Things

In 1999, a phrase "The Internet of Things" or IoTs, was originally defined by Kevin Ashton [1] who is an innovator and consumer sensor expert. Follow by his article [2], he insisted that the phrase was first mentioned at the presentation that he made at Procter & Gamble. This phrase was invented to replace the term "Internet like". He described that *Internet of Things make computer and devices can sense things for themselves. There is many billion times more information in the world than people could possibly type in through a keyboard or scan with a barcode by Internet of Things.*

Although Internet of Things is not full implementation now, this research use Internet of Things as an environment of the research, so that each the question of technology readiness index was defined under this circumstance.

B. Technology Readiness Index

The Technology Readiness Indexed, TRI, was developed by Parasuraman in 2000. The definition of this theory is "*people's propensity to embrace and use new technologies for accomplishing goals in home life and at work*" [3]. Therefore, TRI is a list of indicators for measuring an individual's beliefs and thoughts towards a technology.

There are two groups of Component of technology readiness. Grouping has been done on positive and negative beliefs of technology in more complex way. Parasuraman [3] states that person who is optimistic and innovative as well as has lesser discomfort and insecurity feeling will be more ready to use a new technology. Those components of TRI are including Optimism refers to *"a positive view of technology and belief that it offers people increased control, efficiency, and flexibility in their lives*"; Innovativeness is "*a tendency to be an early adopter of technology and opinion leader*"; Discomfort defines as "*a perception of being unable to control the technology and a feeling of being overwhelmed by it*"; and Insecurity is "*suspicion of technology and doubt about its capability to work*" [3-4]. There are a lot of article that involve TRI and TRI 2.0 [5-13] appear in many conference and journal around the world.

According to [3], there are 36 indicators that Parasuraman quote in his first article about TRI [3]. However in [4] those 36 indicators was reduced into 16 questions, this research applies sixteen indicator from technology readiness 2.0 to create a research question and also use them as a main tool for objective archival.

III. Research Design

Refer to the objective, this research intents to find out a good indicator for Technology Readiness Index under Internet of Things context. The research population should be people who were uses to using internet, especially using internet by mobile phone or other smart devices. By qualification of population, the number of population is unknown.

Therefore the number of population is numerous and using cochrans' technique [14] for estimating mean, the number of sample size is defined as 385 ($Z= .05$, $e = 0.1\sigma$) with qualification as follow: they are a volunteer who uses Internet via mobile devices or smart phone and have a willingness to answer the question. The accidental method was employed for collecting data from sample which was selected from people who work or live in Bangkok and outskirt area.

The questionnaire that used as an instrument to collect data were divided into three sections as the next table.

TABLE I. Section in Quesitonnaire

Section	Number of question
Knowledge of Internet of Things	10
Demography	2
Technology Readiness Index	16

The first section is a true-false question. These question use for surveying knowledge as known/unknown about Internet of Things of respondent.

The second section is a demography section. These questions consist of gender and age. The answer type of this question is a nominal question.

The last section of a questionnaire is a technology readiness index, or TRI, consists of 16 indicators and splits into 4 dimensions as the followed table

TABLE II. Section of Technology Readiness Index Quesitonnaire

Topic	Number of question
Optimism (OPT)	4
Innovativeness (INN)	4
Discomfort (DIS)	4
Insecurity (INS)	4

The measurement of the last study section use a five scales of LIKERT-scale. The scale comprise with value as:

0 very low

1 low

2 moderate

3 high

4 very high

The exploratory factor analysis was conducted for reducing indicator to component, then reliability analysis was conducted for deletion component that do not meet a criteria, finally confirmatory factor analysis is used to confirm component suitability [15].

IV. Results

the results of operation were divided into four sections as below.

A. Descriptive Result

By data collecting, there are 432 respondents were collected. After eliminate incomplete and missing questionnaire, the final sample was 402 respondents. A descriptive statistic of collected data is presented in table III.

TABLE III. Number of Knowledge Description

No.	Score	N	Percent
1	0	48	11.9
2	1	4	1.0
3	2	24	6.0
4	3	18	4.5
5	4	45	11.2
6	5	50	12.4
7	6	58	14.4
8	7	57	14.2
9	8	35	8.7
10	9	21	5.2
11	10	42	10.4

In table III, the most respondents have knowledge about Internet of Things at 6 provided questions; there are 58 respondents in this group. Secondly group of respondents has knowledge about Internet of Things at 5 provided questions; there are 57 respondents in this group. The least number of questions that respondent answer known is 1 question, there are only 4 respondents in this group. There are 48 respondents indicate that they do not know anything about Internet of Things knowledge that was provided. When classifying respondents by *yes* answer, they were divided into five groups with criterion:

0	do not know
1 – 3	less
4 – 6	moderate
7 – 9	much
10	very much

TABLE IV. Number of Knowledge Group

No.	Score	N	Percent
1	Do not know	48	11.9
2	Less know	46	10.5
3	Moderate	153	38.1
4	Much	113	28.1
5	Very Much	42	10.4

The previous table shows group of knowledge, the most of respondent has a knowledge about Internet of Things is at moderate level (38.1%). Second group is at much level (28.1%)

TABLE V. Demographies Descriptive Result

Subject	Value	N	Percent
Gender	Male	131	32.6
	Female	271	67.4
Age	< 20	130	32.3
	21 – 30	196	48.8
	31 – 45	55	13.7
	> 46	21	5,2

The above table presents the most of respondents are 231 female (67.4%) and age between 21 and 30 is 196 (48.8%) and most of respondents who answer this questions age under 30 years old, 81.1%.

B. Exploratory Factor Analysis

The number of indicator of TRI 2.0 is sixteen indicators, and the number of research sample is 402 respondents, this circumstance is appropriate to conduct an exploratory factor analysis for extracting suitable component of TRI under Internet of Things context. The result of apply exploratory factor analysis with varimax rotation show in next table.

TABLE VI. Exploratory Factor Analysis Result

variable	Component		
	1	*2*	*3*
opt1	.726	-	-
opt2	.715	-	-
opt3	.796	-	-
opt4	.758	-	-
inn1	-	-	-
inn2	-	-	.732
inn3	-	-	-
inn4	.710	-	-
dis1	-	-	-
dis2	-	-	.700
dis3	-	-	-
dis4	-	-	-
ins1	-	-	-
ins2	-	.863	-
ins3	-	.708	-
ins4	-	.697	-

C. Reliability Test

In previous section, we are using exploratory factor analysis for reducing sixteen TRI 2.0 indicators into three components as: TFAC1, TFAC2, and TFAC3. TFAC1 are including: opt1, opt2, opt3, opt4, and inn4. TFAC2 are including: ins2, ins3, and ins4. TFAC3 are including: inn2, and dis2. Then the next step is to employ reliability test to each component. Reliability test will determine which indicator is a suitable indicator for those components.

TABLE VII. RELIABILITY TEST FOR TFAC1

No.	Variable	Value
1	Delete opt1	.784
2	Delete opt2	.795
3.	Delete opt3	.762
4	Delete opt4	.799
5	Delete inn4	.811
6	Nothing Delete	.825

According to table VII, the reliability test demonstrates value of component which comprise with or without some indicator. The highest value is .825, and consists of all indicator are together. The highest value of this component passes a usage criterion.

TABLE VIII. RELIABILITY TEST FOR TFAC2

No.	Variable	Value
1	Delete ins2	.679
2	Delete ins3	.721
3.	Delete ins4	.685
4	Nothing Delete	.775

According to table VIII, the reliability test demonstrates value of component which comprise with or without some indicator. The highest value is .775. This value consists of all indicator are together. The highest value of this component passes a usage criterion.

TABLE IX. RELIABILITY TEST FOR TFAC3

No.	Variable	Value
1	Nothing Delete	.545

According to table IX, the reliability value is the highest value, .545, when component consists of both indicators together. Although the reliability value is highest when use two indicator, but the highest reliability is less than .7 so that this component is not fitted for implementation.

D. Confirmatory Factor Analysis

After selecting component using reliability value, the structured model was produced from selected component and their indicators. The result of this operation shows in the next figure.

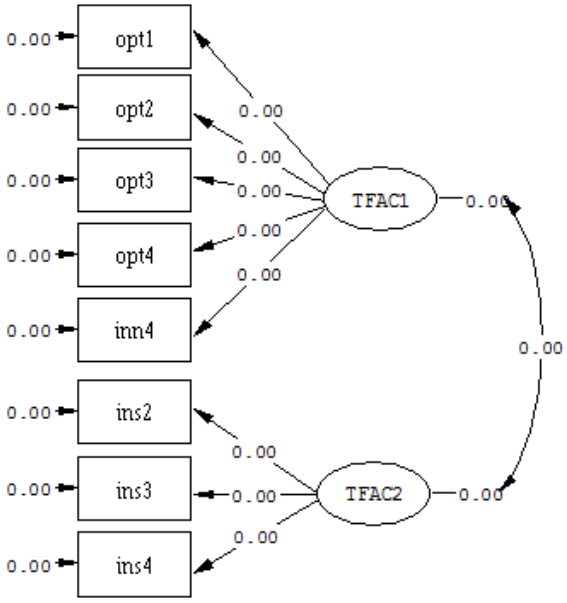

Fig. 1. Initial structured model

By using confirmatory factor analysis with collecting data from respondents, the statistical of fitted model show in the next table.

TABLE X. STATISTICS OF FITTED MODEL

No.	Statistics	Criterion	Value
1	χ^2	-	20.62
2	Df	-	17
3	χ^2/DF	< 2	1.22
4	P-value	> .05	.24
5	RMR	< .05	.02
6	GFI	> .90	.99

Refer to table X, all statistics of structured model passed the criterion of fitted model.

According to fitted model, the factors loading, t-value, and R^2 of all indicators show in the next table.

TABLE XI. FACTOR LOADING,T-VALUE AND R^2 VALUE

No.	Indicator	Factor Loading		t-value	R^2
		TFAC1	*TFAC2*		
1	opt1	.73	-	15.92	.53
2	opt2	.67	-	14.00	.44
3.	opt3	.82	-	18.54	.67
4	opt4	.67	-	14.03	.45
5	inn4	.62	-	12.76	.38
6	ins2	-	.76	15.24	.58
7	ins3	-	.69	13.87	.48
8	ins4	-	.75	14.91	.56

In table XI, all variable have factor loading score more than .5 and t-value greater than 2.54. All variable in above table are proper indicator for each component.

The Composition Reliability and Average Variance Extracted were computed and show in the next table.

TABLE XII. COMPOSITION RELIABILITY AND AVERAGE VARIANCE EXTRACTED

No.	Latent	CR.	AVE.
1	TFAC1	.83	.50
2	TFAC2	.78	.54

In previous table, the values of CR. of both components are greater than .6 that comply a rule of thumb. The values of AVE. of both components are greater than or equal .5 that comply a rule of thumb also.

The fixed model is shown in the next figure.

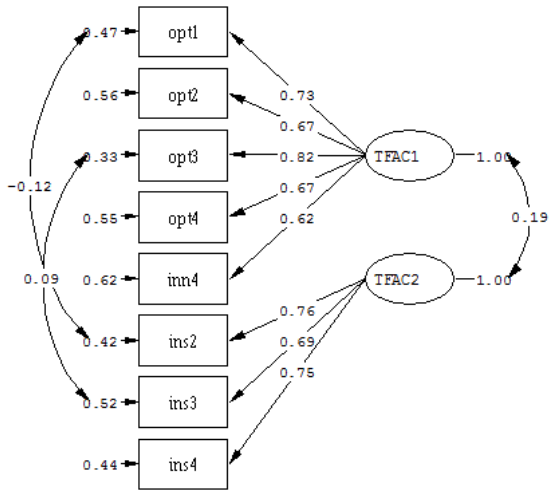

Fig. 2. fixed structured model

V. CONCLUSION

This article state that by using exploratory factor analysis, sixteen indicators TRI 2.0 under Internet of Things can be reduced into three components. Those component names are TFAC1, TFAC2, and TFAC3. In additional, the first component, TFAC1, was constructed by opt1, opt2, opt3, opt4 and inn4; second component, TFAC2, was constructed by INS2, INS3, and INS4; and third component, TFAC3, was constructed by INN2, and DIS2. Due to consideration of reliability value, there are two factors was selected. Finally, the confirmation factor analysis was confirmed that two selecting factors were fitted and properly use in structured model. The structured model is available for other analysis.

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