1st International Conference on
Digital Innovation for Global Growth (DIGG)

Date : August 19th, 2021 (Thu)
Time: 8:45 am KST (GMT +9)
Venue : zoom

DIGG CONFERENCE AGENDA

2021

Telephone: +82-42-350-6845(6393) Fax. +82-42-350-6858
http://ittp.kaist.ac.kr

SESSION 1
Social Infrastructure & Growth-driven Digital Innovation

- Moderated by: Prof. Min Jae Park, Ph.D., Associate Professor, School of e-business, Ajou University (South Korea)

SESSION 2
GovTech for Development

- Moderated by: Dr. Hyeon-Suk Lyu, Public Policy, Senior Research Fellow, Division of Disaster & Safety Research, Korea Institute of Public Administration (KIPA) (South Korea)

SESSION 3
Industry Transformation: Smart Agriculture & Fintech

- Moderated by: Prof. Christian Libaque, Ph.D., Associate Professor, School of Engineering, Universidad del Pacífico (Perú)

SESSION 4
Smart Digital Technologies & Capabilities for Global Growth

- Moderated by: Prof. Tumennast Erdenebold, Ph.D., Assistant Professor, Woosong University (Mongolia)

Conference Agenda

Session	Manuscript
Session 1 Social Infrastructure & Growth-driven Digital Innovation	Assessing the effect of absorptive capacity and economic grants on innovation: Evidence from Peruvian MSMEs, Presented by Libaque-Saenz C. (Peru), Universidad del Pacifico (UP).
	Teaching Entrepreneurship to Scientists and Engineers, Presented by Correa A. (USA/Mexico), University of Texas at El Paso (UTEP).
	Electrical Vehicles – Substitute or Complimentary Goods an Analysis from the Cross Elasticity Concept, Presented by Camacho H. (Colombia), Seoul National University (SNU).
	Paving the way towards 6G: Andean Community Status, Presented by Saavedra C. (Ecuador), Korea Advanced Institute of Science and Technology (KAIST).
Session 2 GovTech for Development	Proposing Deployment Model to Promote the Adoption of Cloud Computing in the Public Sector of Myanmar, Presented by San S. (Myanmar), Korea Advanced Institute of Science and Technology (KAIST).
	The Critical factors and barriers to the adoption and use of Technology for an Early Warning System: The case of Nicaragua, Presented by Rivas A. (Nicaragua), Korea Advanced Institute of Science and Technology (KAIST).
	Proposing a Linked Open Data solution to Enable Innovative Data Services: A Case of BPS-Statistics Indonesia, Presented by Widodo E. (Indonesia), Korea Advanced Institute of Science and Technology (KAIST).
Session 3 Industry Transformation: Smart Agriculture & Fintech	Proposing IoT and cloud-based architecture for Smart Irrigation A Case for Tanzania, Presented by Mwakasege E. (Tanzania), Korea Advanced Institute of Science and Technology (KAIST).
	Digital Transformation of Financial Institutions and its Impact on Their Profitability, Presented by Shreshtha M. (Thailand), Asian Institute of Technology (AIT).
	Proposing a Strategy to Reduce the Number of Illegal Fintech P2P Lending Platforms in Indonesia, Presented by Vidyani F. (Indonesia), Korea Advanced Institute of Science and Technology (KAIST).

Session 4 Smart Digital Technologies & Capabilities for Global Growth	The impact of the COVID-19 pandemic on the blockchain implementation project in Brazil's public health system, Presented by Lorenzon I. (Brazil), Solbridge International School of Business (SISB).
	(The Customized Gripper Design for Exploratory-purpose Robots: A Prototype of the Remotely Operated Underwater Vehicle (ROV) for Pollutio Canals, Presented by Tumphasuwan K. (Thailand), Chiang Mai University (CMU).
	Organizations' Readiness for Digital Innovations: Evidence from Ethiopia, Presented by Melesse S. (Ethiopia), Adama Science & Technology University (ASTU).
	The study of Required competence for ICT workforce in the digital transformation: the case of northern industry Thailand, Presented by Areeprayolkij W. (Thailand), Chiang Mai University (CMU).

TABLE OF CONTENT

SESSION 1: SOCIAL INFRASTRUCTURE & GROWTH-DRIVEN DIGITAL INNOVATION

ASSESSING THE EFFECT OF ABSORPTIVE CAPACITY AND ECONOMIC GRANTS ON INNOVATION: EVIDENCE FROM PERUVIAN MSMEs

Maria Fernanda Ricalde-Chahua[1], Christian Fernando Libaque-Saenz[2]

[1] *Engineering School, Universidad del Pacifico, Lima-Peru, m.ricaldechahua@alum.up.edu.pe*

[2] *Engineering School, Universidad del Pacifico, Lima-Peru, cf.libaques@up.edu.pe*

ABSTRACT

Micro, small and medium-sized enterprises (MSMEs) have been recognized as key players in promoting countries' economic development through innovation. In Peru, 99.5% of the formal companies are MSMEs; however, their efforts to innovate are low, representing just 0.12% of the gross domestic product (GDP). Not surprisingly, Peru is at the bottom of the region in terms of innovation indicators. Then, strengthening these companies' innovation capabilities could have a positive effect on the Peruvian economy. The government has launched some initiatives through Innovate Peru (Peru's national innovation agency) to achieve this goal, but there is no evidence of their impact yet. These initiatives focused on MSMEs aims to build capabilities in these companies. Among the main capabilities to innovate, literature suggests that absorptive capacity (AC) is necessary to acquire, assimilate, transform, and exploit external knowledge for commercial purposes. Accordingly, the present study will assess the impact of absorptive capacity on innovation in the case of MSMEs that received a grant from Innovate Peru. We gathered data from 85 MSMEs that participated in the program 'technological missions' between 2014 and 2016. AC was theorized as a concept made up of three dimensions: external knowledge acquisition (acquire), human resources training (assimilate), and internal R&D (transform and exploit). Preliminary results support that the three dimensions of AC has a positive impact on innovation, while the impact of the innovation grant was found to be non-significant. These results are expected to have both theoretical and practical implications (for Peruvian MSMEs and Innovate Peru).

Keywords: absorptive capacity; innovation; Peruvian MSMEs; public grant

1. INTRODUCTION

The Organization for Economic Cooperation and Development (OECD) recognizes micro, small and medium-sized enterprises (MSMEs) as an engine of inclusive and sustainable economic development, which provides employment and decent work, reduces economic inequality, promotes industrialization, and encourages innovation [1]. In terms of innovation, it can be internally created or adopted, as long as the innovation differs significantly from the company's previous products or business processes [2]. In the case of MSMEs, these companies are characterized by the adoption of externally generated innovations [1].

An internationally accepted indicator for measuring the degree of innovation in a country is the expenditure in innovation as a percentage of gross domestic product (GDP). The average of this

indicator in OECD countries is 2.58% [3]. In these countries, MSMEs represent 99% of all companies [1], while represent between 50% and 60% of value-added products and services [4]. It should be noted that the percentage of MSMEs in Latin America is similar to that of the OECD countries – 99% of all companies; however, they represent only 25% of value-added products and services [5]. In fact, Latin American countries invest substantially less in innovation than the average of 2.58% reached by the OECD countries [3]. In the case of Peru, it is even worse because it is one of the countries that invests the least in innovation in the region, barely 0.12% of GDP [3].

The context described above is important for the economic growth of Peru because in the country 99.5% of formal companies are MSMEs [6]. In order to increase the competitiveness of this type of companies, the National Innovation Program for Competitiveness and Productivity – Innóvate Perú – was created in 2014, becoming the most recent innovation agency in the region. However, MSMEs in Peru still present low levels of innovation – 46.63% of MSMEs did not make any effort to innovate in the period from 2015 to 2017 [6]. This context suggests that there is a great opportunity to grow economically in Peru through the promotion of innovation in MSMEs.

The literature indicates that for a company to benefit from the adoption of an innovation, it requires certain internal capacities that allow it to take advantage of the new product, technology or practice within its organization, and thus generate a sustained competitive advantage [7], [8]. This capacity is known in the literature as absorption capacity, and it is defined as the ability of the company to recognize the value of external knowledge, assimilate it and apply it for commercial purposes [9].

Therefore, the present study aims to analyze the impact of absorptive capacity on innovation in the context of MSMEs that were beneficiaries of Innovate Peru. The results are expected to highlight strategies to promote innovation as a mechanism to improve the competitiveness of Peruvian MSMEs, thus contributing to the productivity of the national economy. Within innovation activities, we will focus on the adoption of technologies, since MSMEs in emerging economies must invest in technological updating processes (technological cath-up) to stay competitive [10].

2. LITERATURE REVIEW

1. Gaps in the Literature

From a literature review, we found mixed results regarding the impact of absorption capacity on innovation. Literature review has been divided into 3 sections: 1) studies on absorptive capacity in sectors other than MSMEs in non-Latin American countries, 2) studies on absorption capacity in sectors other than MSMEs in Latin American countries, and 3) studies on absorption capacity in MSMEs. Regarding the first theme, there are studies that found a positive relationship between absorption capacity and innovation, as in the case of [11], who analyzed 461 general Greek companies from the manufacturing and services sectors. In contrast, other studies found no evidence

of a significant relationship. For example, [12], who focused on 138 Finnish companies in the manufacturing, commerce, construction and services sectors.

Regarding the second theme, there are also mixed results from previous research. For example, a reference study is that of [13], which studied the absorption capacity in Brazilian manufacturing companies. In their study, the authors found a significant impact of absorptive capacity on innovation [13]. In contrast, in a study carried out also in Brazil, based on general manufacturing companies, it was found that the assimilation of external knowledge, as a dimension of absorptive capacity, has no effect on innovation [14].

Finally, as for the last theme. Some studies found a positive relationship between absorptive capacity and innovation. For example, [15] used a sample of 215 MSMEs worldwide from knowledge-intensive and labor-intensive industries. In contrast, [16] do not find a positive relationship between absorptive capacity and innovation, based on 403 Colombian MIPYMEs in manufacturing, construction, commerce and services. It should be noted that the latter is the only identified study that analyzes the impact of absorptive capacity on innovation in Latin American MSMEs.

Another field of study related to this study is the role of innovation agencies in the innovation achieved by companies. Studies also show mixed effects of the impact of innovation subsidy on innovation. For example, [17] studied 1,039 German companies in the service sector, finding a positive impact of the subsidy on organizational innovation and marketing. In contrast, there are studies that do not find a significant impact. Is the case of [18], which analyzed 284,662 Swedish manufacturing companies finding that the innovation subsidy does not have a significant impact on long-term business performance. However, to the best of our knowledge there are no studies about this relationship in Latin American countries.

Based on the above discussion, our study seeks to contribute in filling the following gaps identified in the literature review: 1) lack of empirical studies on the role of absorptive capacity in MSMEs' innovation, 2) little evidence about the role of absorptive capacity in companies from developing countries (there are non-conclusive results), and 3) gap in the study of companies subsidized by innovation agencies in Latin American countries, which generates a lack of knowledge about the effectiveness of these agencies in the region.

2. Conceptualization of Absorptive Capacity

Absorptive capacity is classified into two groups: potential and realized [7]. The first group is made up of two dimensions: acquisition and assimilation. The objective of potential absorptive capacity is to prepare the company to acquire and assimilate external knowledge. The second group –

realized absorptive capacity – encompasses the transformation and exploitation of the knowledge, and reflects the company's ability to take advantage of the knowledge that has been absorbed [7].

3. METHODS

1. Variables Measurement

Inovation is our dependent variable. This variable was measured asking respondents to specify, in a 5-point Likert scale, the contribution of the mission in the business innovation [19]. As for the independent variables: 1) Acquisition of external knowledge was measured asking respondents to specify, in a 5-point Likert scale, the degree of external knowledge acquired during the technological mission [19]; 2) assimilation of external knowledge was conceptualized as a dichotomous variable, which measures whether or not the company has carried out personnel training activities [13]; 3) transformation and explotarion was conceptualized as a dichotomous variable, which measures whether or not the company has carried out internal R&D activities [13]; and 4) innovation grant was measured in a 5-point Likert scale with respect to the perception of the respondents about the contribution of economic resources they received from Inovate Peru [17].

2. Sample Description

Data were collected from the Innovate Peru database; specifically, from the program of technological missions. This program is a policy instrument that subsidizes local enterprises for visiting international markets and pertners to facilitate technology transference and, subsequently, these companies can commit to technological innovations.

The MSMEs forming the sample were beneficiaries of a technological mission between 2014 and 2016. It should be noted that the Oslo Manual recommends a period of at the least three years to observe effects of innovation activities on business performance [2]. In this sense, the selected time frame is adequate since the survey was conducted in 2019. Our final sample size is 85 MSMEs. It should be noted that the sample responds to a proportional stratified sampling.

3. Data Analysis

To assess the impact of absorptive capacity and subsidy on innovation, considering the latter is a metric variable, we will use multiple lineal regression, which is a technique widely used in the innovation field [20].

4. EXPECTED RESULTS

Preliminary results found that all the independent variables referring to absorptive capacity have a positive and significant impact on innovation. However, regarding the impact of the subsidy on innovation, a significant result was not found. Table 1 presents the details of this preliminary results.

Table 1. Preliminary Results of Multiple Lineal Regression

Dependent Variable: Innovation	B	SE B	β	R^2	F
Model				0.523	9.121*
Acquisition	0.592	0.110	0.508*		
Assimilation	0.464	0.214	0.188*		
Transformation & Explotation	0.893	0.333	0.217*		
Subsidy	0.029	0.080	0.034^{ns}		

ns = non-significant; * *p*-value < 0.05

5. DISCUSSION

The present research has limitations, which may lead to future studies in the absorptive capacity and innovation fields. First, the sample size was 85 cases made up of beneficiary MSMEs. While this is an accepted sample size, future studies may seek to expand the sample size. Second, the study has limitations in terms of its external validity because it has only considered Peruvian MSMEs. Through the literature review, it has been possible to verify that empirical studies on absorptive capacity may have different results according to the research context, such as the sector, country, type of company, and size, among other criteria. Therefore, future studies may seek to extend this study to other Latin American economies, in order to validate the generalization of the results. Third, the beneficiary MSMEs of Innovate Peru have been used as the unit of analysis. In a future study, it is possible to analyze both beneficiaries and non-beneficiaries of public funds, and evaluate the impact of absorptive capacity on innovation in each of them. Fourth, the instrument analyzed has been technological missions, which focus above all on the potential absorptive capacity. A future study may seek to evaluate other innovation instruments granted to MSMEs by innovation agencies.

6. CONCLUSION

MSMEs represent the main engine of development, both in developed and developing economies [1]. Likewise, they play an important role in the generation of innovation in an economy [4]. In Peru, 99.50% of formal companies are MSMEs; however, only 46.63% of them innovated between 2015 and 2017 [6]. This context suggests a great opportunity for economic growth through the promotion of innovation in MSMEs, so it is relevant to study the factors that impact innovation in these types of companies.

1. Theoretical implications

Since our study focuses on the effect of absorptive capacity and grant on the innovation of Peruvian MSMEs, it is expected that our results help to bridge the three identified gaps in literature: 1) lack of empirical studies on the role of absorptive capacity in MSMEs' innovation, 2) little evidence about the role of absorptive capacity in companies from developing countries (there are non-conclusive results), and 3) gap in the study of companies subsidized by innovation agencies in Latin American countries.

2. Practical implications

Our results are expected to help in drawing recommendations for both MSMEs and Peruvian government. In the case od MSMEs, this type of companies may be aware of the impact of each dimension of absortive capacity to focus their resources and strategies wisely. In the case of Peruvian government, it can assess the impact of the grants and resources they are investing through Innovate Peru. Accordingly, the Peruvian government can priorize its efforts in those dimensions that have more impact.

AUTHOR CONTRIBUTIONS

Maria Fernanda Ricalde-Chahua: Collected the data, performed the analysis, wrote the paper.
Christian Fernando Libaque-Saenz: Conceived and designed the analysis, wrote the paper.

REFERENCES

[1] OECD, *Enhancing the Contributions of SMEs in a Global and Digitalised Economy*. Paris: OECD Publishing, 2017.

[2] OECD and Eurostat, *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*. Paris: OECD Publishing, 2018.

[3] World Bank, "Research and Development Expenditure (% of GDP)," 2018. https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS (accessed Apr. 25, 2021).

[4] OECD, *OECD SME and Entrepreneurship Outlook 2019*. Paris: OECD Publishing, 2019.

[5] M. Dini and G. Stumpo, *MIPYMES en América Latina: Un Frágil Desempeño y Nuevos Desafíos para las Políticas de Fomento*. Santiago, Chile: Comisión Económica para América Latina y el Caribe (CEPAL), 2018.

[6] Ministry of Production, "Encuesta Nacional de Innovación en la Industria Manufacturera y de Servicios Intensivos en Conocimiento," Lima, Peru, 2019.

[7] S. A. Zahra and G. George, "Absorptive Capacity: A Review, Reconceptualization, and Extension," *Acad. Manag. Rev.*, vol. 27, no. 2, pp. 185–203, 2002, doi: https://doi.org/10.5465/amr.2002.6587995.

[8] J. Barney, "Firm Resources and Sustained Competitive Advantage," *J. Manage.*, vol. 17, no. 1, pp. 99–120, 1991, doi: https://doi.org/10.1177/014920639101700108.

[9] W. M. Cohen and D. A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Adm. Sci. Q.*, vol. 35, no. 1, pp. 128–152, 1990, doi: https://doi.org/10.2307/2393553.

[10] C. Petti, Y. Tang, and A. Margherita, “Technological Innovation vs Technological Backwardness Patterns in Latecomer Firms: An Absorptive Capacity Perspective,” *J. Eng. Technol. Manag.*, vol. 51, pp. 10–20, 2019, doi: https://doi.org/10.1016/j.jengtecman.2019.02.002.

[11] K. Kostopoulos, A. Papalexandris, M. Papachroni, and G. Ioannou, “Absorptive Capacity, Innovation, and Financial Performance,” *J. Bus. Res.*, vol. 64, no. 12, pp. 1335–1343, 2011, doi: https://doi.org/10.1016/j.jbusres.2010.12.005.

[12] P. Ritala and P. Hurmelinna-Laukkanen, “Incremental and Radical Innovation in Coopetition—The Role of Absorptive Capacity and Appropriability,” *J. Prod. Innov. Manag.*, vol. 30, no. 1, pp. 154–169, 2013, doi: https://doi.org/10.1111/j.1540-5885.2012.00956.x.

[13] P. F. Bittencourt and R. Giglio, “An Empirical Analysis of Technology Absorption Capacity of the Brazilian Industry,” *CEPAL Rev.*, 2013.

[14] R. M. Engelman, E. M. Fracasso, S. Schmidt, and A. C. Zen, “Intellectual Capital, Absorptive Capacity and Product Innovation,” *Manag. Decis.*, vol. 55, no. 3, pp. 474–490, 2017, doi: https://doi.org/10.1108/MD-05-2016-0315.

[15] V. Scuotto, M. Del Giudice, and E. G. Carayannis, “The Effect of Social Networking Sites and Absorptive Capacity on SMES’ Innovation Performance,” *J. Technol. Transf.*, vol. 42, no. 2, pp. 409–424, 2017, doi: http://10.1007/s10961-016-9517-0.

[16] C. H. González-Campo and A. H. Ayala, “Influencia de la Capacidad de Absorción sobre la Innovación: Un Análisis Empírico en las MIPYMES Colombianas,” *Estud. Gerenciales*, vol. 30, no. 132, pp. 277–286, 2014, doi: https://doi.org/10.1016/j.estger.2014.02.015.

[17] S. A. Basit, T. Kuhn, and M. Ahmed, “The Effect of Government Subsidy on Non-Technological Innovation and Firm Performance in the Service Sector: Evidence from Germany,” *Bus. Syst. Res.*, vol. 9, no. 1, pp. 118–137, 2018, doi: http://10.2478/bsrj-2018-0010.

[18] A. Gustafsson, A. Stephan, A. Hallman, and N. Karlsson, “The ‘Sugar Rush’ from Innovation Subsidies: A Robust Political Economy Perspective,” *Empirica*, vol. 43, no. 4, pp. 729–756, 2016, doi: http://10.1007/s10663-016-9350-6.

[19] B. Forés and C. Camisón, “The Complementary Effect of Internal Learning Capacity and Absorptive Capacity on Performance: The Mediating Role of Innovation Capacity,” *Int. J. Technol. Manag.*, vol. 55, no. 1/2, pp. 56–81, 2011, doi: https://doi.org/10.1504/IJTM.2011.041680.

[20] M. Dziallas and K. Blind, “Innovation Indicators Throughout the Innovation Process: An Extensive Literature Analysis,” *Technovation*, vol. 80, pp. 3–29, 2019, doi: https://doi.org/10.1016/j.technovation.2018.05.005.

TEACHING ENTREPRENEURSHIP TO SCIENTISTS AND ENGINEERS

Alberto M. Correa, B. Sc., M. Sc., Ph. D.
North America Coordinator – Science and Culture. The Global Network of Mexicans Abroad.
An initiative of the Secretary of Foreign Affairs of the Mexican Government
qrwinc@aol.com

ABSTRACT

The article describes the outcomes of teaching the course: Entrepreneurship for Scientists and Engineers, to freshmen, senior and graduate students at the Colleges of Science and Engineering at the University of Texas at El Paso, during 2006 to 2020. In parallel to studying the topics to commercialize emerging technologies, from market analysis and marketing plan, to the legal structure, operations, costs and investments, financial statements, the intellectual property valuation, and the Prospectus for venture capitalists, the students formed working teams to write business plans on technologies by them selected. The outcomes demonstrated that teaching entrepreneurship in science and engineering, allows students expanding their overall view on how technological advances, and their future professional development, should be oriented on solving real life problems. During the period 2019-2020, out of ten business plans written by student teams, it was estimated that most of them were patentable and some of them keep pursuing filling the patent. A short version of the course was offered to professors from the Technology Institute at Juarez, Mexico, to discuss commercializing their research, following the same business plan writing model. Out of six business plans, it is estimated that five are patentable. These results demonstrate that training science and engineering professors on entrepreneurship, allows focusing their research on developing patentable technologies to solve real life problems. A call is made to professionals on entrepreneurship dissemination to focus on science and engineering schools, not only to follow the example of top universities like Stanford, MIT and Harvard, and their financial success, but to contribute to the technology expansion that should be oriented to solving the many problems the humanity faces nowadays.

Keywords: Technology entrepreneurship; business plans; science-based entrepreneurship education.

PREFACE

During the last three decades the United States lived the "entrepreneurship craze" due to the explosion in the demand of entrepreneurial learning and practice by different population's segments: business students, mom-and-pap small business, individuals not willing to be employees but to start up their businesses, even professionals like engineers, architects and physicians that needed to start practicing their careers in their own offices, but did not know how to start and run a business. This craze arrived to the University of Texas at El Paso (UTEP). A grant was received from the Kauffman Foundation to make entrepreneurship education widely available on campus, changing the way entrepreneurship was viewed, taught, and experienced. A Research Center was created to pursue this objective. The author became part of the initial group of six persons that started the grant's operation. All the members of this group were long time professors in the college of Business Administration, with the exception of the author, who was not a professor of business, but a physicist with a M. Sc. and a Ph. D. in Materials Science and Engineering from Stanford University. The author had experience on start-ups and operating tech-

based companies in Mexico and the USA. The author's contribution was participating in the design of the new programs, and to teach a course called "Entrepreneurship for Scientists and Engineers", as described as follows.

1. INTRODUCTION

Can entrepreneurship be taught? This question has been on the table for decades ever since the 90's. Several questions arose: Is entrepreneurship an innate ability or an acquired skill? Can the entrepreneurial knowledge be acquired and enhanced through education? Entrepreneurs are "born" to be entrepreneurial? How being entrepreneurial is based on personal instincts and not on training?

The published literature pretends to answer these questions, most of them resulting on contradictory results depending on who provided those answers: economist, business administration experts, management theorists, social scientists, even human behaviorists. Klein and Bullock (1) mentioned that in management literature, entrepreneurship is associated to certain psychological characteristics of the entrepreneur, where some individuals are particularly well equipped to perform and specialized in communication (2). For labor economists, entrepreneurship is identified as self-employment. The economic theory of entrepreneurship focusses not on the individual or the business, but on the role entrepreneurship plays in the economy.

2. INNOVATION AND ENTREPRENEURSHIP

Schumpeter, a Marxist? Joseph Schumpeter's economic theories are intimately linked to the conceptualization of innovation and entrepreneurship. His intellectual legacy still causes controversy among scholars. Croitoru (3) pointed out that hundreds of papers are annually published about his theories, and citations of his works exceed 10,000 per year. While his view on entrepreneurship is considered dominant, there is still a stream of papers against the Schumpeterian mainstream. Nevertheless, Schumpeter is still considered "the Father of Entrepreneurship", but why?

Croitoru (3) comments that although "Capitalism, Socialism and Democracy" (1942) became Schumpeter's most cited book, "The Theory of Economic Development" (4) has emerged as his *magnus opus*, because in this book Schumpeter establishes how economic development is dependent of "change", ln which the enterprises present "adaptive responses" to the market conditions. But another business strategy can be based on "creative responses" where innovation and novelty are key elements for understanding successful strategies in the market. Creative responses are the results of conducting research and development to create products and services to satisfy the market's needs.

Entrepreneurial innovation is, for Schumpeter, the central cause of economic development, and capital accumulation is a major result. For Marx, by contrast, capital accumulation is itself the primary force in the development process. This is the main difference between Marx's and Schumpeter's economic development doctrines. Economic development is caused by "entrepreneurial innovation". This is the answer to the question why Schumpeter is *the father of entrepreneurship*, and why he is not a Marxist.

Schumpeter's distinction between innovation and invention is noted in his book: "(…) *the inventions of the antique world and the middle ages for centuries failed to affect the current of life. As soon, however, as an invention is put into business practice, we have a process which arises from, and is an element of, the economic life of its time, and not something that acts on from without. Therefore, invention is an external factor*." (4).

When teaching entrepreneurship to scientists and engineers, the difference between innovation and invention should be completely clear. Scientists in many instances claim to be involved in the innovation process, but pure research is the process of invention, which may turn into an innovation when it is launched into the marketplace.

Schumpeter establishes that the "methods of supplying commodities" are directly associated with innovation: "*Technological change in the production of commodities already in use, the opening up of new markets or of new sources of supply, …, improved handling of material, the setting up of new business organizations such as department stores – in short, any 'doing things differently' in the realm of economic life – all these are instances of what we shall refer to by the term of* ***Innovation****."* (4).

Schumpeter conceptualizes innovation as the driving force of the economic evolution: *"In a system in which the process of evolution goes on strongly, it is presumably not very far from the truth to say that practically all new plant that is being constructed beyond replacement, and much of what is being constructed by way of replacement, either embodies some innovation or is a response to situations traceable to some innovation."* (4).

Schumpeter's "Theory of Economic Development" (4) emphasizes that between innovation and entrepreneurship there is an indissoluble relationship: *"For actions which consist in carrying out innovations we reserve the term Enterprise; the individuals who carry them out we call Entrepreneurs. This terminological decision is based on a historical fact and a theoretical proposition, namely, that carrying out innovations is the only function which is fundamental in history and essential in theory to the type usually designed by that term* (4). The paternity of entrepreneurism belongs to Schumpeter.

Again, it is very important to have these concepts clear, since this course assumes that **innovation happens when entrepreneurs launch into the marketplace the inventions, to become innovations.**

Schumpeter (p. 102) introduces several elements which deserve a special attention by the entrepreneurs-to-be: *"the entrepreneur performs but also routinized tasks or 'non-entrepreneurial work' within the company framework"; "the entrepreneur is not necessarily 'the inventor of the good or process he introduces', but s/he is the one who imposed it in the market context"; "the entrepreneur may, but need not, be the person who furnishes the capital. This is a very important point…* ***It is leadership rather than ownership that matters****".* Innovation consists in: a) Introduction of a new good, b) Introduction of a new method of production, c) The opening of a new market, d) The discovery of a new source of supply of raw materials or semi-manufactured goods, and e) Introduction of a new organization in an industry.

Schumpeter states that the economic and social foundations of capitalism will crumble on account of the decay of the entrepreneurial function: "*The decay of the entrepreneurial function decays when the entrepreneurs make their business grow so big, that innovation itself becomes a routine, and technological progress now becomes the province of specialists; marketing and administration become automatic. Innovation thus degenerates into a depersonalized routine activity carried on in big business through a bureaucracy of highly trained managers*" (4).

We question: Are we living this phenomenon by observing Google and Apple?

When teaching entrepreneurship the students must understand basic economic theory from where entrepreneurship derives, to develop a panoramic view on the role they play in the economic framework of capitalism and society. Schumpeter states that in capitalism, innovation continually displaces things: "*the opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory…illustrate the same process of industrial mutation,* ***that incessantly revolutionizes the economic***

structure from within, incessantly destroying the old, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism" (5) (p 83).

3. ENTREPRENEURSHIP EDUCATION

Teaching Entrepreneurship. The teaching of skills and cultivation of talents that students need to start businesses, identify opportunities, manage risk, and innovate in the course of their careers, is now an essential of USA higher education. As recently as the 90's, that was far from true. In the past two decades the university teaching of entrepreneurship has shown an unprecedented explosion.

Evolution. Teaching entrepreneurship is not new. Observers trace it back to 1947, when Harvard University offered a course in "**new enterprises**" for returning veterans (6). The field entered its start-up phase in the 70's, began developing curricula in the 80's, and a rapid growth in the 90's.

A *Kauffman Foundation* research report found in 2008 that "*Entrepreneurship* is *one of the fastest growing subjects in today's undergraduate curricula*" (6). In 1975, colleges and universities in the United States offered over a hundred formal programs (majors, minors, and certificates) in entrepreneurship. The number had more than quadrupled by 2006, reaching more than 500 (6). "*Studies suggest that college campuses in the United States offered approximately 250 entrepreneurship courses in 1985. By 2008, more than 5,000 entrepreneurship courses were being offered in two-year and four-year institutions*" (6). Today, well over 400,000 students a year take courses in the subject, and almost 9,000 faculty members teach it. Universities have become correspondingly important to the nation's start-up infrastructure (7). Of the 1,250 or so business incubators in the United States, about one-third is based at universities, up from one-fifth in 2006 (8). During the 90's to 2000's period, entrepreneurship programs traditionally were the domain of the business school. Schools became inspired by the 2003 launch of the "Kauffman Campuses Initiative (KCI)". The Ewing Marion Kauffman Foundation launched $25 million program in matching grants to eight U.S. universities that committed to make entrepreneurship education more widely available on campus, changing the way entrepreneurship was viewed, taught, and experienced (9). Out of fifteen finalist schools the eight winners were: Florida International University, Howard University, the University of Illinois at Urbana-Champaign, the University of North Carolina at Chapel Hill, the University of Rochester, **the University of Texas at El Paso (UTEP)**, Wake Forest University, and Washington University in St. Louis. And here is where the story begins.

Upon winning the contest, UTEP started working on implementing the means to accomplish the objective. A highly specialized Research Center was created to pursue this objective. The author became part of the initial group of six persons that started the grant's operation. All the members of this group were professors in the College of Business Administration, with the exception of the author, who was not a UTEP professor, neither in business nor in another college, but had a B. Sc. in Physics from the National University of Mexico (UNAM), and a M. Sc. and a Ph. D. in Materials Science and Engineering from Stanford University. The author had the experience of starting-up and operating several tech-based companies in Mexico and the USA. The author's participated in the design of teaching, research and developing programs, and teach a course he designed and called "Entrepreneurship for Scientists and Engineers".

Universities all over are trying to become more effective at entrepreneurial education**,** by generating new income from commercializing research and intellectual property. Important initiatives to fostering entrepreneurship are patenting and licensing**,** creating incubators**,** science parks**,** university spin-offs**,** and investing equity in start-ups.

4. SCIENCE, TECHNOLOGY AND ENGINEERING ENTREPRENEURSHIP

Technology Entrepreneurship. Technology has gone from novelty to necessity, empowering speed and effectiveness in the workplace, and reducing the potential for human error. That happens when knowledge generation (invention) is launched into the marketplace to become an innovation. Entrepreneurs are those that commercialize technologies. Accordingly, teaching entrepreneurship to those individuals in charge of technology development, fosters creativity and enhances the ability to develop commercially viable ideas.

Engineering Entrepreneurship. As Nelson and Byers pointed out (10), it is no longer enough to come out of school with a purely technical education; engineers need to be entrepreneurial in order to understand and contribute in the context of market and business pressures. For engineers who start companies soon after graduation, entrepreneurship education gives them solid experience in product design and development, prototyping, technology trends, and market analysis (10). In many US universities, entrepreneurship is no longer confined to business schools. It is one of the fastest growing subjects in undergraduate education, with formal programs from 1975 to 2006 (11). High impact entrepreneurial ventures have three characteristics: they are innovative; value-creating and growth-oriented. These are the premises that lead the educational programs of those universities that offer Technology and Engineering Entrepreneurship.

Science Entrepreneurship. University-industry technology transfer has long been perceived as the Holy Grail in science and innovation policy. Universities and companies strive to collaborate in research projects, enhancing their mutual innovative potential. Innovation policies assume that a lack of university-industry technology transfer is due to a lack of collaboration between scientists and external parties (12).

University to industry technology transfer has been based on the research done by professor and students. However, in the last two decades, it became clear that in order accelerate this process; universities should teach entrepreneurship to their science and engineering students to learn to develop an entrepreneurial attitude in the mindset of the students, and how to turn scientific innovations into business opportunities.

This was the motivation of the author to offer a course on entrepreneurship to science and engineering students, through the Colleges of Science and Engineering at the University of Texas at El Paso (UTEP). Ever since the first course, the results were not only satisfactory, but astonishing.

5. ENTREPRENEURSHIP FOR SCIENTISTS AND ENGINEERS AT UTEP

Origins. The Kauffman Foundation launched the **Kauffman Campuses Initiative** (**KCI**) in 2003 to encourage new, interdisciplinary entrepreneurship education programs throughout American colleges and universities. As mentioned before, eight universities were part of KCI when it launched in 2003. In 2006, five more universities and five Northeast Ohio liberal arts colleges were selected. UTEP formed the Center for Entrepreneurship, Development, Advancement, Research and Studies (CEDARS) on 2004.

By 2006 there were at UTEP three undergraduate courses in entrepreneurship (entrepreneurship, franchising, small business management), one masters level course (corporate entrepreneurship), and one doctoral level (international entrepreneurship), and some experimental course, among them **Entrepreneurship for Science and Engineering Majors**, and several sections on the **Entering Students Program** on various entrepreneurship topics.

The Course-First Stage. The first course was proposed for the fall semester of 2006. This first stage was effective for three semesters at the College of Science.

Objectives: This course was designed to create in the student the awareness of the value of entrepreneurial education in the world of science and engineering, and to describe how the intellectual capital generated by university research, and the resulting new scientific and technological discoveries, can be commercialized. The attendees learned to identify opportunities derived from scientific and technological research activities, and working as teams will develop a profile of a technology venture.

Prerequisites: Senior-level undergraduate student, or graduate students status.

Team Project 1: Identifying a technology from university research. Senior Science and Engineering students are much aware and capable to understand the research and development projects in different fields. Students were asked to form teams to analyze the research in universities, or UTEP.

Team Project 2: Organizing a technology venture. Once the research project is selected, the student teams were asked to organize a technology venture by writing a *business profile* on how successful that product/technology would be if commercialized.

Content: The student learned the how to write a business profile: market analysis, marketing and sales plans, start-up legal structure, equipment for a manufacturing plant if such were the case, investments, plant lay out, operations, production and administration personnel, raw materials, inventories, packing and shipment of finished products, costs and expenses, financial statements, five-year pro-forma financial forecast, potential venture funding by equity position, owners and venture capitalists equity, company valuation, intellectual property filling and valuation, shares structure, and the Prospectus.

Evaluation and testing. As reported by Torrance, Wendy (13): "*The schools also created numerous centers for entrepreneurship, innovation, and creativity, and countless students were encouraged to share their ideas through competitions*." That was the case for this course. The course had no midterm and no final exam. The students were asked to give presentations of their work advances on the midterm, and a final presentation and a written report for the final exam. For the final presentation, business owners from the local community and professors were invited to act as jurors evaluating the quality of the work. But the final exam was also a contest. The jurors were asked to select the best presentation, and a price was given to the first place.

Course population: the course became popular among students in Electrical Engineering and Computer Sciences, College of Engineering, and among Biologists and Bioengineers, College of Science. During three semesters the total population had an average of 20 students per group.

Outcome: the course was offered for three semesters, student teams selected a wide variety of technologies as their team projects: In renewable energies, the students developed the business plan for a local company commercializing state of the art photovoltaics.

On two consecutive semesters international students coming from the neighbor city of Juarez, Mexico that were studying Computer Science, formed teams and prepared business plans of companies designing videogames. Upon graduation they started their companies in Juarez.

A student studying bioengineering developed a company that would develop computer simulation models for the medical sciences.

The Course-Second Stage. As reported by Torrance, Wendy (13) on the KCI "*Several schools incorporated entrepreneurship into courses required for all students. Campuses as diverse as UTEP, Arizona State, … introduced large numbers of students to the principles of entrepreneurship and innovation... UTEP, likewise, incorporated entrepreneurship into* ***University Studies 1301****, an introductory course that is required for all entering freshmen*". Accordingly, the second stage consisted on switching the course offering to senior science and engineering students, to the first semester for entering students; that is University Studies 1301, part of the "**Entering Students Program**".

Content: the Entering Students Program Course is divided into two parts. In the first part the student receives an introduction to the university on topics like "Academic resources"; "Money matters"; and so no. In the second part, the student received in parallel to the first part, an introduction to their major topics, in this case "**Knowledge Entrepreneurship" (**for Scientists and Engineers), following a similar content than then one described before, but not as detailed since these were students that were taking their first college courses, and they only had one half of the time available. However the content was enough for the students to prepare a business profile on their ideas.

Duration. This course was offered once a year to two or three groups of an average of 40 students per course per year, during the period 2009-2016.

Outcome. Since the students were registered on science and engineering mayors, it became evident that ever since the beginning of their college education, courses on entrepreneurship will perfectly supplement their technical and scientific orientation. There were several cases that after taking the course, the students decided to switch to a business mayor. Some of them decided to open up ever at their young age, their own small business, or to dedicate their energies to learning the management of the family business, since they would inherit it.

The course-third stage. The third stage was on the 2019-2020 period. It was offered for three semesters having an average audience of 10 students per course. In this period, half of the students were in the M.Sc. and Ph. D. programs from the Department of Electrical Engineering and Computer Science. As graduate students were participating, some topics like business finances and Intellectual Property valuation were discussed in deeper detail.

Outcome. Having graduate students registered in the course significantly raised the level and sophistication of their projects. Out of ten projects presented, the judging committees and the students agreed that most of them were patentable, so that some of the student teams proceeded to establish contact with patent law firms for filling preliminary patents. Some of those projects were:

1. "Dim-Brid, Inc.". An *Augmented Reality* company specialized in manufacturing **smart glasses** and **wearable technology** as applied to the Manufacturing Industry. The product "**Mercury I"** provides cost-effective solutions for applications like: Fast Communication, Inventory Management, Failure detection, and To-Do lists. **Mercury I** supports a range of accessories making it easily adaptable for operations within warehousing, field service, training and design. Features include two HD Cameras to provide "Stereo Vision"; microphones and speakers to allow communication; an AMLCD screen for AR functionality; an abundance of software to accommodate hardware. **Status**: students started negotiations with a patent law firm.
2. Multi_Key, Inc. a Company developing local control of multiple computers from a single mouse and keyboard. Features: Easily add multiple computers to the same keyboard and mouse. Configuration and

setup handled by the keyboard, no need to install software or setup up the computer. Cross computer clipboard allows for easy transfer of smaller files as well as images and text. **Status**: initiated approach to patent law firms.

All the business plans presented on this Course-Third Stage included similar innovative ideas, and the financial projections demonstrated that they are not only financially feasible, but the Prospectus offered a very attractive alternative to venture capitalist. Unfortunately the course could no longer be offered due to lack of funding, since the grant available became to an end.

The course-fourth stage. A short 20 hr. course was offered to the Ciudad Juarez, Mexico, Technology Institute on March 2021. In this case, the audiences were the Professors, and some senior and graduate students, covering about the same topics, but focused on selecting the faculty research projects on technologies that could have a real life application and solve real life problems. Again, the outcomes were outstanding. The selected projects were prepared by professor-students teams, some of them on research already in-course. The course allowed them to acquire an overall view of their technologies' market opportunities and financial feasibility. Similar courses are offered to other Institutes in Mexico.

6. CONCLUSIONS

1. Evidence obtained from the experience of offering this course to students at different levels of their careers, demonstrate that teaching entrepreneurship in science and engineering, allows students expanding their overall view on how technological advances, and their future professional development, should be oriented on solving real life problems.
2. Bringing technology to the market place is not only a matter of forming profitable businesses that have a rapid growth and that create high-paid jobs to regional development, but is also a matter of social responsibility to raise the socioeconomic level of the communities where courses are being offered, because these technology-based start-ups have a concomitant effect in terms of products and services required for operation, a cascade of regional socioeconomic proportions.
3. When offered to professors, the course demonstrated that orienting their research to solve current problems, is a matter of social responsibility as well, because the investments done on grants and R&D programs are in this way focused to satisfy market needs.
4. A call is made to professionals on entrepreneurship dissemination to focus on science and engineering schools, not only to follow the example of top universities like Stanford, MIT and Harvard, and their financial success, but to contribute to the technology expansion that should be oriented to solving the many problems the humanity faces nowadays, and the potential collapse of our civilization due to natural phenomena like global warming, or the environmental degradation produced by humans in their efforts to profit without considering collateral effects.
5. Author contribution**.** The reported experiences on a 14 year period demonstrate that the course readily provides elements for students and professors to work on technologies that are designed to solve specific problems, with the advantage of being eligible for filling the intellectual property either as patents or trade secrets.

REFERENCES

1. Peter G. Klein and J. Bruce Bullock. **Can Entrepreneurship Be Taught?** Journal of Agricultural and Applied Economics, Volume 38, Issue 2, August 2006 , pp. 429 - 439
2. Witt, U. "**Imagination and Leadership: the Neglected Dimension of an Evolutionary Theory of the Firm**." Journal of Economic Behavior and Organization 35 (1998): 161–77.
3. Alin Croitoru. "**Schumpeter, Joseph Alois, 1939, Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process**" Journal of Comparative Research in Anthropology and Sociology, Volume 8, Number 1, Summer 2017. pp 67-80.
4. Joseph A. Schumpeter, 2008. **The Theory of Economic Development. An inquiry into Profits, Capital, Credit, Interest, and the Business Cycle**, New Brunswick: Transaction Publishers. Library of Congress Catalog Number: 79-67059.
5. Joseph A. Schumpeter. Professor of Economics in Harvard University. "**Capitalism, Socialism, and Democracy**". 1942. Harper and Brothers Publishers. New York and London.
6. Kauffman Foundation. "**Entrepreneurship in American Higher Education: A Report from the Kauffman Panel on Entrepreneurship Curriculum in Higher Education**". July 2008. kauffman.org/uploadedfiles/entrep_high_ed_report.pdf
7. https://www.kauffman.org/wp-content/uploads/2019/12/eshipedcomesofage_report.pdf
8. Laura Pappano, "**Got the Next Great Idea?**" New York Times, July 19, 2012.
9. https://philanthropynewsdigest.org/news/kauffman-foundation-awards-25-million-to-transform-entrepreneurship-on-campus
10. Nelson AJ, Byers T. "**Challenges in University Technology Transfer and the Promising Role of Entrepreneurship Education"**. Kauffman: Emerging Scholars Initiatives. 2010. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1651224
11. Byers T, Sheppard S, Seelig T, Weilerstein P. "**Entrepreneurship: Its Role in Engineering Education**". The Bridge, summer 2013. p 35. National Academy of Engineering. https://www.nae.edu/File.aspx?id=88638
12. Blankesteijn M., Bossink B., van der Sijde P. "**Science-based entrepreneurship education as a means for university-industry technology transfer**" International Entrepreneurship and Management Journal (2021) 17:779–808. https://link.springer.com/content/pdf/10.1007/s11365-019-00623-3.pdf
13. Torrance W. "**ENTREPRENEURIAL CAMPUSES: Action, Impact, and Lessons Learned from the Kauffman Campus Initiative**" Ewing Marion Kauffman Foundation. August 2013. https://www.kauffman.org/wp-content/uploads/2019/12/entrepreneurialcampusesessay.pdf

IS THE FOURTH INDUSTRIAL REVOLUTION LEADING THE WORLD TO THE BRINK OF A NEW CLIMATE HYPER-CRISIS WITH ELECTRICAL VEHICLES?

Heiner Camacho
GRC-ITPP, College of Engineering, Seoul National University
ITTP, KAIST

ABSTRACT

Based on historic evidence related to technology developments that arise into the society with the promise of cutting-edge energy-efficient goods and the puisne consequences the present paper intends to evaluate the Electric Vehicles new demand as a new technology intended to displaced the ICE and determine if a new raw material market arises with the Co2 footprint of this industry and the links with the fossil fuel derivates (Xing et al., 2019). The methodology (cross-price elasticities of demand) intends to evaluate consistently all the data and evidence in order to determine if, besides the main benefits of the massive use and implementation of BEV, the impact of this new industry will cause a non-reversible effect in humanity as once was caused by the gasoline even when at that time they were provided with enough proofs relating its poisonous with several humans deceases. Nowadays the relation is given the current world industry infrastructure and its emissions/contamination can beard a new industry demand that will duplicate (or more) the raw materials demand in case of the BEV end-up as a complementary good. Exist from the governments committed and involved in this new industry clear guidelines to determine the most accurate and responsible extraction of raw materials and production from developed countries.

Keywords: Battery Electric Vehicle; Internal Combustion Engine; Demand Cross Elasticity; Climate Change; Substitute Goods, Raw Materials, Mining, Co2 Footprint.

1. INTRODUCTION

The thesis of this paper is to determine if BEV are more likely to be a complementary good for the fossil fuel vehicles (FFV) in which case the reduction of the production and consequently the sales of fossil fuel vehicles will not be showing a drastic reduction, therefore the impact over the GHG emissions and the climate change will not be as expected. In this scenario, it will need to evaluate in deep the global policies and evaluate actuarially the impact of the new production of EV due to the world will be in a new production scheme where the demand of vehicles is compound by the total sum of BEV demanded units plus the total sum of FFVs demanded units increasing with this the demand of raw materials and petroleum derivates (Lasse Fridstrøm, 2018). This is a big concern due exist large evidence of the levels of contamination in the transformation process of the raw materials but also in the extraction process which includes deforestation and contamination of the nearest water sources, also air pollution and a human component of exploitation of the manpower.

An analysis of the current raw materials suppliers will provide a big picture of how much will increase the demand according to the EVs sales projections up to 2030 and the effect this may cause in the countries with the most of the mines which in the most of the cases are developing countries. Even more in the particular case of EV, a huge tread is arising linked with the batteries technology based in the lithium and the biggest reserves of this mineral (Notter et al., 2010a). According to the International Energy Agency, the demand for lithium will increase 42 times by 2040 (Energy Agency, 2021). In this aspect, Latin America is a key player by being the main source of raw materials and one important source of petroleum, but also for being the home of the most important ecosystems and sweet water sources of the world. Just in terms of lithium, the main world reserves in million tons (t / a) are Bolivia (21), Argentina, (19.3), Chile (9.6), Australia, (6.4), China (5.1), Canada (2.9), Germany (2.7), Mexico (1.7) (USGS, 2021).

In terms of global emissions, no matter the level of emissions of the BEV the GHG will be increased by the creation of a new industry boosted by demand for a new and complementary good as it may be BEV. On the other hand, if the datasets demonstrate BEV are a substitute good for FFV this will reinforce the accuracy of the current industry trend and will have a positive effect on the GHG reduction. This will be achieved by discouraging the FFV demand and will be evidenced by a reduction in the production and sales levels.

LITERATURE REVIEW

The goal of this literature review is to evaluate three different approaches to the emissions problem evaluation in the EV market and their associated incidence of exploitation of raw materials and petroleum derivates which the suppliers are mostly based in developing countries from LAC. Using a Cross-Price Elasticity of the Demand Function Lasse Fridstrøm and Vegard Østli and Jianwei Xing, Benjamin Leard, and Shanjun Li described the phenomenon of technology displacement/replacement, reporting signs of great substitution on ICE with an EV in the vehicles market by clean emerging technologies. Anna Stamp, Dominic Notter, Hans-Jörg Althaus, Marcel Gauch, Patrick Wäger, Rainer Zah, and Rolf Widmer makes a great contribution in the general understanding of the environmental impacts of the BEV production as a frequent problem in the GHG emissions by describing a methodology based in the Ecoindicator to measure the damage caused by the battery industry demand of copper and aluminium for the production of the anode and the cathode (Notter et al., 2010b). Troy R. Hawkins, Bhawna Singh, Guillaume Majeau-Bettez, Anders Hammer Strømman states that the overall rate found on EVs powered by electricity in the European Union offer a 10% to 24% decrease in global warming potential (GWP) relative to conventional ICE vehicles (Hawkins et al., 2013).

2. METHODS

The main purpose of the vehicles is transportation, no matter the power source. Thus, if the technology is BEV or ICE doesn't affect the end-user perception of the utility of the vehicle. In the case of both technologies, they will achieve "almost" the same performance. The cross-price elasticity of demand will show the relationship between ICE and BEV, by capturing the responsiveness of the demanded quantities of one vehicle technology to a change in the price of another vehicle technology. The fact that one ICE is substitutable for BEV has immediate economic consequences: insofar as one can be substituted for another, the demands for the two vehicles will be interrelated by the fact that customers can trade off one vehicle for the other if it becomes advantageous to do so. An increase in the price of a vehicle x will (ceteris paribus) increase demand for its substitutes, while a decrease in the price of goods, will decrease demand for its substitutes (Curtis & Irvine, 2017).

Price dynamics: To build up the demand function curve the information is arranged according to the methodology. In this first step, the approach is to determine the responsiveness in the period 2016-2021. As the information for 2021 is not complete the analysis is elaborated with data from the Q3 of 2021. The vehicles ICE and BEV datasets were collected in 2016 Q3 and 2020 Q3 (*GCBC*, 2021).

Brand	Model	# 16	Price 16	# 20	Price 21
Nissan	Versa	132,214	10,600	48,272	14,930
Volkswagen	Golf	13,764	18,000	21,927	23,195
Chevy	Spark	35,511	16,660	33,480	13,400
Mitsubishi	Mirage	26,966	16,000	19,135	16,490
		52,113	**15,315**	**30,703**	**17,003**

Figure 1 Prices for ICE 2016-2021

For each brand is calculated the mean of both datasets, price and sold units for both years, 2016 and 2020*.

$$\sum_{1}^{\infty} P_1 = \frac{P_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_1 = \frac{Q_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} P_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} P_1 = \frac{P_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_1 = \frac{Q_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} P_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} P_1 = \frac{P_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_1 = \frac{Q_{16}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} P_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

$$\sum_{1}^{\infty} Q_2 = \frac{P_{21}(Nice + Vice + Cice + Mice)}{n}$$

ICE Demand Curve 2016-2021: In the year 2016, the market reaches a mean of 52,113 units of vehicles from the sample with a mean price of $ 15,315 per unit. This price increase to $ 17,003 per unit, seems to cause a reduction in the units sold by 2020 which drops to 30,073 units. The prices of the selected brands and models expose a reduction in the number of sold units in five years: $\Delta Q=q2-q1= -21{,}410$ units. A total reduction in sales of 21,410. Despite the reduction in terms of sold units, the price had a positive variation: $\Delta P=p2-p1=1{,}698$ USD. This variation means that the final price of the selected brands and models experimented with a mean increase of USD 1,698 per unit. Therefore, a new curve of demand is expected to appear providing the accurate level of Q units of vehicles at the price that consumers were willing to pay before losing payment capacity of 1,698 USD in the last 5 years.

Brand	Model	# 16	Price 16	# 21	Price 21
Nissan	Leaf	14,006	34,200	9,559	31,620
Volkswagen	e-Golf	2,482	28,995	19,044	36,720
Chevy	Spark	7,400	25,510	7400	26,000
Mitsubishi	i-MiEV	94	22,995	94	20,700
		5,995	27,925	9,024	28,760

Figure 2 Prices for BEV 2016-2021

For each brand is calculated the mean of both datasets, price and sold units for both years, 2016 and 2020*. In the year 2016, the market reaches a mean of 5,995 units of vehicles from the sample

with a mean price of USD 27,925 per unit. This price increases up to $ 28,760 per unit, seems to be a good not sensitive with the price or is a market which in terms of technology update is willing to pay the new price: ΔQ=q2-q1= 3,029 units. A total increase in sales of 3,029. Despite the increase in the price: ΔP=p2-p1=835 USD. This variation means that the final price of the selected brands and models experimented with a mean increase of USD 835 per unit, in this case, a new curve of demand is *not* expected due to the willingness of the customers with a new price rising.

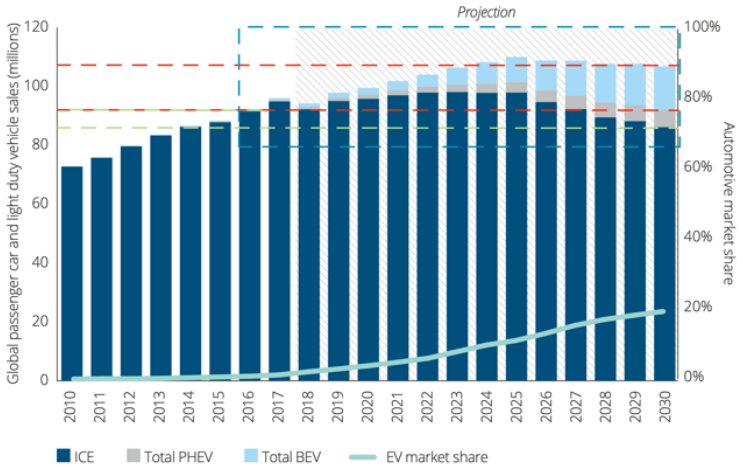
Cross-Price Elasticity of Demand Function ICE-BEV: In this case, the cross-price elasticity may be a positive or negative value, depending on whether the vehicles are complements or substitutes. If ICE-BEVise complements, an increase in demand for one is accompanied by an increase in the quantity demanded of the other. Therefore, the value of the cross-price elasticity for complementary goods will thus be negative. The output from the cross-price analysis is 0,887 which determines a positive slope. This also means ICE is not a complimentary good for BEV.

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\ ICE}{\%\Delta\$\ BEV} = \frac{\frac{30{,}703}{52{,}113}}{\frac{5{,}995}{9{,}024}} = \frac{0{,}589}{0{,}664} = 0{,}887$$

Electrical Vehicles Vs. Fuel Based Vehicles Demand: A cross-price Elasticity of the Demand Function on the BEV-ICE up to the year 2030 Pin terms of price and sales projections will be performed. The method proposed to evaluate the price of the vehicles in 2030 and determine its future price is to select a base brand and model which meet that both brand and model still in the market from 2016 to 2020 and have in the same line of the vehicle the option for ICE and BEV. In this regard, the selected brand is the manufacturer Hyundai with the representative model for ICE "Azera" and the representative model for BEV "Ioniq":

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\ BEV}{\%\Delta\$\ ICE} = \frac{\left(\frac{5{,}995}{9{,}024}\right)}{\left(\frac{30{,}703}{52{,}113}\right)} = \frac{0{,}664}{0{,}589} = 1.12$$

Sales extraction from Deloitte: The data relating to the sales projection will be extracted from the Passenger Global Car Sales study developed by Deloitte in 2017.



ICE sales in 2016: 90.000.000 units.

BEV sales in 2016:100.000 units.

ICE sales in 2030: 85.000.000 units.

BEV sales in 2030:18.00.000 units.

Vehicles Price Projection: To get a basis for calculating the projections up to 2030 due to the lack of price projections in the vehicles market, we suggest using the same price variation evidenced in the period 2016-2020 and estimate under the same percentage the variation for 2030. This implies applying the same step 2,25 times, due to the period analysed comprehends four years and the period to analyse is of nine years. Calculating the price variation ⟨ 2016-2020 for Hyundai Azera: %Δ=p2- p1 ∴ %Δp2 = 0.14. Calculating the price variation ® 2016-2020 for Hyundai Ioniq: %Δ=p2- p1 ∴ %Δp2=0.12.

	2016	2020
Hyundai Azera	$ 24,186	$28,150
Hyundai Ioniq	$ 28.834	$33,045

Reversing prices for 2030 and substituting with the price variations.

Brand	**Model**	**# 16**	**Price 16**	**# 30**	**Price 30**
Hyundai	Azera	90.000.000	24,186	85.000.000	31,620
Hyundai	Ioniq	100.000	28,834	18.000.000	33,045

Cross-Price Elasticity of the Demand Function BEV-ICE 2030

$$\varepsilon_{ICE,BEV} = \frac{\%Q\Delta\, BEV}{\%\Delta\$\, ICE} = \frac{\left(\frac{18.000.000}{100.000}\right)}{\left(\frac{31,620}{24,186}\right)} = \frac{180}{1.307} = 137{,}7$$

3. EXPECTED RESULTS

1. *Electrical Vehicles Vs. Fuel Based Vehicles Demand.:* The outcomes of the is expected to state according to with the trends in the industry and market that BEV is not a substitutive good, therefore, is a complimentary good which explains the projections in the vehicle industry with an increase in the trends of production.
2. *Electrical Vehicles/ Electrical Vehicles Batteries – Raw Materials Demand:* (ongoing) This may be caused by a new industry incumbent which will create additional stress in the raw materials demand with all negative effects summarized in an increase of the Co2 emissions. To determine the impact, the projections of the BEV will be calculated according to the projections of the future raw material demand up to 2030. An analysis from the raw materials derivates from petroleum will be tackle as well.

4. DISCUSSION

In the present research, not intend to evaluate the impact of PHEV- HFCV or evaluate this technology as EV due to the complexity of the data at the moment of determining which amount of the energy came from clean sources and how much the owners use the electric option instead of the combustion engine also to not analyse the impact on the GHG by the power sources for BEV and the energy sources like thermoelectrical plants powered by nuclear-atomic energy and fossil fuels as petroleum, diesel and coal. It is also important to mention that ICE includes not just fossil fuel but hydrogen as well. In this regard worth mentioning that the impact of HFCV corresponds to less than 1% of the market shares. A last restriction in the research scope does not include the pollution and Co2 emissions related to the infrastructure both to provide the energy supply and for the extraction and manufacturing process.

5. CONCLUSION

The Cross-Price Elasticity of the Demand Function ICE-BEV in all cases end up with positive results, which also means positive slopes. Despite the present findings, the results are not determinants due to the inner character of the emergent market of BEV, the accuracy of the databases and the lack of evaluation of different methodologies to project values and quantities in the future. The result from this research is intended to turn into a new scientific insight that provides trustable information related to the transition from ICE to BEV as the main driver in the race against climate change. This will allow policymakers to determine if investing in BEV infrastructure or other technologies like electric trains, cable cars or other electric transport technology.

AUTHOR CONTRIBUTIONS

Heiner Camacho - GRC-ITPP, College of Engineering, Seoul National University.

ACKNOWLEDGEMENT

Professor Hwang Junseok (Seoul National University), Professor Jeong Dong Lee (Seoul National University), Professor Jörn Altman (Seoul National University), ITPP-SNUm Global R&DB Centre, Korea Ministry of Science and ICT Scholarship.

REFERENCES

1. Curtis, D., & Irvine, I. (2017). *Macroeconomics Theory, Models & Policy an Open Text BASE TEXTBOOK Creative Commons License (CC BY-NC-SA)*. Lyryx. https://openlibrary-repo.ecampusontario.ca/jspui/handle/123456789/573
2. Energy Agency, I. (2020). *The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions*. Retrieved August 18, 2021, from www.iea.org/t&c/
3. Geological Survey, U. (2021). *MINERAL COMMODITY SUMMARIES 2021*.
4. Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2013). Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles. *Journal of Industrial Ecology*, *17*(1), 53–64. https://doi.org/10.1111/J.1530-9290.2012.00532.X
5. Lasse Fridstrøm, V. Ø. (2018). *The demand for new automobiles in Norway-a BIG model analysis*. www.toi.no
6. *Nissan LEAF Sales Figures | GCBC*. (n.d.). Retrieved April 7, 2021, from https://www.goodcarbadcar.net/nissan-leaf-sales-figures/
7. Notter, D. A., Gauch, M., Widmer, R., Wäger, P., Stamp, A., Zah, R., & Althaus, H.-J. (2010a). Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles. *Environmental Science and Technology*, *44*(17), 6550–6556. https://doi.org/10.1021/ES903729A
8. Notter, D. A., Gauch, M., Widmer, R., Wäger, P., Stamp, A., Zah, R., & Althaus, H.-J. (2010b). Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles. *Environmental Science and Technology*, *44*(17), 6550–6556. https://doi.org/10.1021/ES903729A
9. Xing, J., Leard, B., & Li, S. (2019). *What Does an Electric Vehicle Replace?*

PAVING THE WAY TOWARDS 6G: Andean Community Status

Carlos Andres Saavedra Arancibia[1]

[1] *Korea Advanced Institute of Science and Technnology*

ABSTRACT

The upcoming 6G era in the 2030s will face new challenges from the radio spectrum management and regulation point of view due to an increasing variety of spectrum bands involved in this technology. In addition, regulators in the 6G era must introduce a new set of spectrum management approaches that facilitate and encourage telecommunication operators the deployment of new cellular networks.

This paper aims to study the secondary market and sharing spectrum issues from a regulatory point of view in the countries of the Andean Community. The paper considers the sharing spectrum mechanisms and the secondary market definition described by the International Telecommunication Union (ITU) and discusses their implementation status in each country. This study provides a baseline about the current secondary market and sharing spectrum status in the region, that can be used for both scholars and policymakers, the former can use the results to conduct further research, while the latter could consider the outcomes into account to design, execute and evaluate new policies in the telecommunication sector.

Keywords: 6G, Telecommunication sector, Sharing Spectrum, Radio Spectrum management, regulation.

1. INTRODUCTION

In order to catch up the needs of an eager super-connected and globally data driven society, the wireless communication industry have kept an intensive and fast-growing evolution trend during the last 40 years. Consequently, this industry have evolved from the first generation (1G) of wireless communications to the current fifth generation (5G). However, 21th century society is becoming more and more data-centric, data-dependent, digitized, and automated. Moreover, new services and applications such as 3D gaming and extended reality plus the rapid development of data centers and automated processes will require a throughput on the order of Terabits per second (Tbps), that might superpass the 5G networks capabilities [1]. Therefore, researchers have devoted their efforts beyond-5G solutions, i.e., the sixth generation (6G) of wireless communications [2-4], aiming to meet the future demands of the 2030 era, thus the first 6G White Paper was launched in 2019 [5]. It is expected that 6G provides hyper-fast links with peak throughput exceeding the Tbps rate with ultra-high reliability and ultra-low latency [6]. In addition, 6G will not only require wider bandwidth which is available at sub-THz and THz bands but also it will use all the existing bands in lower frequencies [7]. Thus, this novel technology will face new challenges due to a vast range of radio spectrum bands with different propagation characteristics and fragmentation of spectrum management approaches. Because spectrum management will continue to play an important role in the deployment of 6G networks, this paper discuss the spectrum management regulatory strategies in the countries of the Andean community: Ecuador, Colombia, Peru, and Bolivia, focusing on sharing spectrum mechanisms and telecommunication secondary market based on the International Telecommunication Union (ITU) framework. This papers aims to encourage policy makers to realize in these acountries about modern mechanisms that allow new telecommunication operators to get ready for early adoption of the 6G technology. To run the analysis, the

paper proceeds as follows. Section II shows a general review of spectrum management strategies. Section III presents a brief overview of the Andean community countries in particular their telecommunication infrastructure status. The IV section presents the found results, while discussion and conclusion are listed in sections V and VI, respectively.

2. LITERATURE REVIEW

This chapter aims to explain spectrum sharing management strategies and telecommunication secondary market approaches, we also present spectrum management decisions in different countries. Due to scarceness nature of the radio spectrum , spectrum management decisions intent to maximize benefits towards society and the efficient utilization of this resource [8]. On the other hand, secondary frequency markets allow mobile networks operators (MNOs) to sell or exchange frequency bands without governmental perimissions or following some few restrictions.

The literature review stands out the evolution of spectral management approaches throughout the years from administrative allocation, to market-based models, and the unlicensed commons approach [9].

For the first generation of mobile celular networks the administrative allocation represented the major spectrum management approach. In this mechanism, the central government grants usage licenses within a primary market, the national regulators used to define rules and conditions for spectrum access rights, this method is also named command and control model because regulators have the unique decision power [10]. Due to growing criticism over the time, the regulators have opened the telecommunication sector to market-based mechanisms [11]. This second approach includes holding auctions, secondary markets and sharing models, that replaces the centralised model by endowing MNOs with higher flexibility. As a consequence, spectrum auctions have became a key tool [12] in the 3G and 4G era for regulators in several countries, being the most commom types single round or simple (open or closed) auctions; and multiple round (successive or simultaneous) auctions.

Regarding secondary spectrum trading, it treats the spectrum assignments in a similar way to property rights allowing parties i.e., MNOs to buy and sale equipment licenses or spectrum utilization. Thus, the original spectrum property rights obtained from the regulator can be traded or leased following geography or bandwidth parameters for a given period of time [13]. For instance, by 2010 according to ITU, 11 countries possessed a spectrum secondary market and another 12 countries were planning to implement it. In Latin America, countries like Chile, Mexico, and Uruguay allow spectrum trading among MNOs while in the European and North American side Spain, Finland, United Kingdom, Canada, and The United States are countries that possess secondary markets as well. The combination of spectrum from various licensed operators designed in New Zealand under the name of “licensed spectrum parks” [14] helps to boosts up the secondary market ecosystem, here the government assigns bands for cooperative use in restricted geographic areas encouraging small operators to join the cellular network ecosystem. Finally, another advanced mechanism in the spectrum sharing regulation is trough the use of small cell, where the primary licensee uses spectrum in remote areas, this spectrum can be reused by small cells in high-demand urban areas that are far away from the remote location in order to improve the spectral efficiency.

In regards the third major apporach, unlicensed commons approach models assume full liberalization in the use of spectrum from the MNOs, only subjected to no interference principles [8]. By making the spectrum Access posible to any stakeholder the ecosystem becomes more competitive and successful solutions as WiFi, Bluetooth, and ZigBee arise [15]. Although typically cellular mobile operators were not interested in these bands, the 5G networks consider sharing radio frequency bands with those of WiFi i.e., open access, and it is expected that 6G networks also take benefits from these unlicensed frequency bands to provide ultra-high-speed, ultra-high-reliability and, ultra-low-latency services and applications.

3. METHODS

This research aims to study current telecommunications policies in regards to Andean Community countries, listed as Ecuador, Colombia, Bolivia, and Peru. These neighboring countries not only face similar issues in economy, educational, and political areas but also share similar cultural facts. Thus the underlying goal of this intra-countries institution is to set up tight links seeking peaceful and equilibrated development among the members [16].

This paper takes into account findings regarding spectrum management from the 6G Wireless Summit held in 2019. Additionally, in order to explore the radio spectrum policies, this study uses definitions described by the ITU in its publication “Policy Guidelines and Economic Aspects” about secondary market, auctions mechanisms, and spectrum sharing mechanisms as combination of spectrum from various licensed operators, and spectrum-sharing model using small cells. The information collected and here shown follows an bibliographical review i.e., it comes from official public web sites and official documents from public institutions and regulators in each country.

It is to be said that this paper does not aim to evaluate the policies adopted by this countries rather to examine and highlight decisions made so far.

4. EXPECTED RESULTS

1. Ecuador

In Ecuador the ministry of telecomunications and information society is the major public institution in regards of ICT. Under it, the Telecommunications Regulation and Control Agency (Agencia de Regulacion y Control de las Telecommunicaciones - ARCOTEL) is the body responsible for managing the spectrum. Although the telecommunications laws have changed through the last 20 years, the Organic Law of Telecommunications (LOT) released in February 2015 is the one that rules the radiofrequency espectrum nowadays. The ARCOTEL grants operators with frequency bands through concessions of it (art. 37), additionally, article 44 prohibits to transfer, lease or alienate the spectrum bands by any means without the permission of the ARCOTEL. In regards of spectrum allocation mechanisms, the ARCOTEL states both direct administrative allocation and public contests (art. 50). Nonetheless, the last time the Ecuadorian government signed a spectrum contract was in 2015, giving the operators Movistar and Claro 50 MHz and 60 MHz respectively, following a direct allocation mechanism. This method was possible because the Ecuadorian regulations allow direct spectrum allocation in case the telecomm operator is established in the country already. In contrast, when the stated-own company CNT was granted with spectrum for LTE deployment by 2012, the central

government gave them 30 MHz and 40 MHz in the 700 MHz and 2100 MHz bands respectively, by giving an *authorization* which is the official mechanism among public institutions. Finally, the regulatory body in Ecuador does not describes mechanisms as shared sprectum from various licensed operators nor spectrum-sharing model using small cells. Although, the article 51 states the direct allocation model for 'band sharing' it does not provide details about how to get shared access to that spectrum.

2. Colombia

The country divide the spectrum management according to the service provided, thus the *Autoridad Nacional de Television* (ANTV) oversees TV broadcasting and grants licenses related to that service. Meanwhile, the agency on charge of sprectrum regulation management for mobile communications is the Agencia Nacional del Espectro (ANE) that also provides technical support to the Ministry of ICT (MinTIC, for its Spanish acronym). Regarding the secondary spectrum market, as part of the *Plan Vive Digital 2014 -2018* (Live Digital Plan 2014 - 2018), the ANE and MinTIC, each one within the framework of their competences, they engage to use the spectrum more efficiently through the implementation of secondary market, unlicensed use, and light licensing, in order to accelerate the development of the telecommunication sector. Thus, by 2014 ANE began a secondary spectrum market test in the 23 Ghz , and another test in the 18 GHz band by 2018. However, according to the Spectrum Public Policy 2020-2024 report launched in June 2020, these mechanisms have been barely used due to a missing regulation so that stakeholders can easily adopt this strategy. In regards to the most recent awarded spectrum, there were public auctions in December 2019, in the 700 MHz and 2500 MHz frequency bands where *Tigo, Claro,* and UK-based partners were awarded 40 Mhz, 50 Mhz, and 50 MHz, respectively. Finally, the regulatory body in Colombia does not describe mechanisms for shared sprectum from various licensed operators and spectrum-sharing model using small cells. Table 1 shows a summary of spectrum management mechanisms status in Ecuador and Colombia.

Table 1. Summary of spectrum management mechanisms status in Ecuador and Colombia

Spectrum Management Mechanisms	**Ecuador**	**Colombia**
Spectrum assignment model used in the last contracts	Direct Allocation	Public Auctions
Spectrum Secondary Market	Prohibited without the regulator permission	Allowed by the regulator, barely used
Shared spectrum from various licensed operators	Not described	Not described
Spectrum-sharing model using small cells	Not described	Not described

Reference: author's elaboration

5. DISCUSSION

The goal of this essay is to highlight the importance and the key role of spectrum management in the 6G era from a regulatory point of view. This papers considers the ITU recommendations about shared spectrum machenisms in order to identify the current status of this regard in the selected countries. The Framework can be used as baseline to study the economic impact when late and not optimal decisions about spectrum management are taken and also to detect the gaps when compared with developed countries.

Additionally, for the best of author's knowledge, the ITU has no released and fixed the standards for 6G communications, thus as soon as these parameters are released, a more accurate spectrum management study can be carry on. Finally, this essay takes into account two out of four Andean community country, therefore it can be expanded in order to make a broader and meaningful analysis in the region.

6. CONCLUSION

Around 30 years back, countries, especially central government and decision makers have seen the radio spectrum as another mechanism two collect money simply. However over the past years, this approach have changed and radio spectrum management is well recognized as a key role specially in the deployment of wireless high-speed communications. In the case of Ecuador, its policies allow spectrum trading by operators however the ARCOTEL takes the fully control by allowing or rejecting the trade, as the bibliographical review indicates this mechanism lead to absence of spectrum secondary market in Ecuador. Moreover, the Ecuadorian LoT as well as the Colombian laws do not provide advanced mechanisms as shared spectrum from various licensed operators and spectrum-sharing model using small cells, that aim to improve the coverage area in rural areas and improve spectral efficiency. Therefore, both countries must update their regulations so those advanced spectrum sharing models can boost the local telecommunication ecosystem by adding new operators that come around with high-end technologies. In regards to Secondary spectrum market in Colombia, the country had run several test bed during the last 10 years at different frequency bands.Nonetheless, the results are still poor and that market has no that much activity as desired. Lack of national evaluation systems and accurate data from official sources stand as a barrier in analyzing the impact of the policies taking in each country. A micro-level evaluations of the regulations is needed to better understand the positive and negative effects of the policies.Policy makers can used the findings to design, execute and asses the regulations applied so far.

AUTHOR CONTRIBUTIONS

Only one author who was on charge on the full paper elaboration.

ACKNOWLEDGEMENT

KAIST, Global ITTP program. Daejeon, South Korea.

REFERENCES

1. Dang, S., Amin, O., Shihada, B., & Alouini, M. S. (2020). What should 6G be?. Nature Electronics, 3(1), 20-29.
2. David, K., & Berndt, H. (2018). 6G vision and requirements: Is there any need for beyond 5G?. IEEE vehicular technology magazine, 13(3), 72-80.
3. Yastrebova, A., Kirichek, R., Koucheryavy, Y., Borodin, A., & Koucheryavy, A. (2018, November). Future networks 2030: Architecture & requirements. In 2018 10th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT) (pp. 1-8). IEEE.
4. Saad, W., Bennis, M., & Chen, M. (2019). A vision of 6G wireless systems: Applications, trends, technologies, and open research problems. IEEE network, 34(3), 134-142.
5. Latva-Aho, M., & Leppänen, K. (2019). Key drivers and research challenges for 6G ubiquitous wireless intelligence (white paper). Oulu, Finland: 6G Flagship.
6. Rappaport, T. S., Xing, Y., Kanhere, O., Ju, S., Madanayake, A., Mandal, S., ... & Trichopoulos, G. C. (2019). Wireless communications and applications above 100 GHz: Opportunities and challenges for 6G and beyond. IEEE access, 7, 78729-78757.
7. Tripathi, S., Sabu, N. V., Gupta, A. K., & Dhillon, H. S. (2021). Millimeter-wave and Terahertz Spectrum for 6G Wireless. arXiv preprint arXiv:2102.10267.
8. Matinmikko-Blue, M., Yrjölä, S., Seppänen, V., Ahokangas, P., Hämmäinen, H., & Latva-Aho, M. (2019). Analysis of spectrum valuation elements for local 5G networks: Case study of 3.5-GHz band. IEEE Transactions on Cognitive Communications and Networking, 5(3), 741-753.
9. Matinmikko-Blue, M., Yrjölä, S., & Ahokangas, P. (2020, March). Spectrum management in the 6G era: The role of regulation and spectrum sharing. In 2020 2nd 6G Wireless Summit (6G SUMMIT) (pp. 1-5). IEEE.
10. Levin, H. J. (1970). Spectrum allocation without market. The American Economic Review, 60(2), 209-218.
11. Valletti, T. M. (2001). Spectrum trading. Telecommunications Policy, 25(10-11), 655-670.
12. Cramton, P. (2013). Spectrum auction design. Review of industrial organization, 42(2), 161-190.
13. Berry, R., Honig, M. L., & Vohra, R. (2010). Spectrum markets: motivation, challenges, and implications. IEEE Communications Magazine, 48(11), 146-155.
14. Goodwin, I. (2014). Proposed methodology and rules for engineering licences in managed spectrum parks. New Zealand Ministry of Business, Innovation and Employment, Technical Report.
15. Carter, K. R. (2006). Policy lessons from personal communications services: Licensed vs. unlicensed spectrum access. CommLaw Conspectus, 15, 93.
16. Andina, C., MIEMBROS, S., & BOLIVIA, S. (1999). Comunidad Andina de naciones. Santafé de Bogotá, DC.

SESSION 2: GOVTECH FOR DEVELOPMENT

PROPOSING DEPLOYMENT MODEL TO PROMOTE THE ADOPTION OF CLOUD COMPUTING IN THE PUBLIC SECTOR OF MYANMAR

Sapal San

sapalsan.san@kaist.ac.kr

Master Candidate, Global Information and Telecommunication Technology Program, Korea Advanced Institute of Science and Technology

ABSTRACT

Using the right technology in an organization can increase business processes and productivity as a competitive advantage. The utilization of cloud Computing is growing up in all government and private institutions by reducing costs and enhancing the system's performance, and effective IT resources management by using its computing resources through the internet. By realizing the potential benefits, the government of Myanmar is intensely interested in adopting cloud computing technology to effectively implement Ministries' specific systems and/or common public service delivery. Therefore, the government of Myanmar focused on the expansion of the Government's Fiber Network and Telecommunication Infrastructure Network. However, the implementation of cloud shared infrastructure and adoption rate of cloud-based services at all ministries level are still behind compared to the regional countries. This study, therefore, identifies the critical success factors to promote the adoption of cloud across the government of Myanmar based on a literature review and case study on the Republic of Korea and Vietnam. TOE framework and the Open Data Center Alliance (ODCA) cloud maturity model (CMM) was conducted as of the analysis framework to know each country's current cloud maturity level and suggest the recommendations as of the holistic view. The research identified a comprehensive deployment model and strategic guidance to encourage and transform government ICT through rapid adoption of cloud services at all ministries level by setting the required policies, and guidelines to achieve the national and regional ICT master plan.

Keywords: Public Sector; Cloud Computing; Deployment-Models; Technology Promotion; CMM

1. INTRODUCTION

Governments worldwide seek ways to enhance service delivery to citizens through the use of creative information and communication technologies (ICTs) rather than traditional online web services [6] due to rising consumer demands for government services. Cloud Computing technology, one of the innovative ICTs, can address these challenges with the successful development of the next-generation digital government services from the cost-saving perspective and increase productivity by sharing IT resources and providing dynamically extendable infrastructure on different devices [3, 6]. Therefore, it has been recognized as a strategic approach to the government's IT infrastructure and services [3].

Understanding the potential benefits of Cloud Computing, Myanmar's e-Governance Master Plan (2016-2020) aims to enhance Governance Services through the Cloud-based shared infrastructure by aligning with the Fourth

Strategic Initiative of ASEAN ICT Masterplan (2016~2020): "Strategic 4.3 Support Cloud Computing Development". The performance of fixed broadband infrastructure is a key driver to use cloud computing services [3,5,7,12,14,15]. Meanwhile, Myanmar's fixed-broadband speed, mínimum acceptable speed defined for cloud service provisions [5], can support all types of cloud applications as speed test global index result. However, the coverage of high-speed fixed-broadband network penetration is weak less than 1%[9]. At present, the investment and usage of the government's ICT are mainly relying on Ministries' own datacenter and server rooms. Among them, the majority of the government agencies (80%) are running their core systems as of the legacy system [11]. All ministries initiated cloud as the basic services: email, Office 365, etc. through the public cloud, and can't use widely for core business functions except Central Bank of Myanmar and Ministry of Education. Therefore, it is needed to analyze the current maturity level to be realized government intention in cloud technology based on the national master plan. Currently, no studies are exploring the Government's readiness to migrate and accelerate cloud computing in Myanmar. There are relatively few studies to research cloud computing in the public sector context[7]. This study addresses the following questions:

- What is the current situation of the cloud maturity level of Myanmar?
- Which cloud deployment model is suitable to enhance cloud technology adoption in the public sector of Myanmar to provide better online services, from a government IT management perspective?

The main objective of this study is to propose a suitable cloud deployment model and recommendations to enhance the adoption of cloud in the public sector by raising the awareness of cloud technology among government organizations.

2. LITERATURE REVIEW

A review of the literature was conducted to understand the background knowledge of cloud computing that involves the technology adoption model, identify the critical success factors for government to enhance the delivery of cloud services in the cloud computing strategy of the public sector aspects.

1. Cloud Computing

Many researchers mentioned the definition of cloud computing based on the National Institute of Standards and Technology (NIST) [1, 4, 5, 6, 8, 10, 14]. According to the NIST, *"cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."*

Under this definition, there are five essential characteristics, three types of cloud services, and four deployment models for all standard cloud services. There are four deployment models to choose from if an organization considers migration to the cloud.

- Public Cloud Model: Public cloud services are available to any organization, and the cloud infrastructure exists under the cloud service provider rather than the users.

- Private Cloud Model: The private cloud model is targeted for specific use by a single organization, operated by a particular organization, a third party, or a combination of them.
- Community Cloud Model: Community Cloud deployment model is provided for exclusive use by a specific community of cloud service customers who need to share requirements (i.e., mission, security requirements, policy, and regulation), and all computing resources are operated and controlled by at least one or more of the organizations in the community.
- Hybrid Cloud Model: The hybrid cloud deployment model consists of at least two different cloud models (private, community, or public) by bounding together using standardized technology to ensure interoperability, data, and application portability.

Many studies used the Technological, Organizational, and Environmental (TOE) framework as the research model to analyze the adoption and implementation of enterprise-level technological innovation including cloud computing technology [1,2,3,7,8,10]. In addition, the case study analysis methodology was also conducted widely to define lesson learn, and best practices based on developed countries [3,4,5,8,15]. The ODCA CMM offers in evaluating the enterprise's cloud maturity and support to develop a comprehensive cloud strategy and accelerate the adoption of cloud from existing level to next higher level [11,12].

According to the method of these previous studies, case study analysis methodology, TOE framework, and the ODCA CMM are suitable to be adapted for this research. By conducting a case study analysis, the differences between the current state and the desired future state can be defined as recommendations and suggestions. TOE framework is widely used to analyze the adoption and implementation of enterprise-level technological innovation, and ODCA CMM is suitable for the assessment of cloud maturity in both public and private sector organizations.

2.4. Cloud Computing Trends in Public Sector

Governments around the world vigorously encouraged the use of cloud computing aims to reduce information system development and operational costs and to manage efficient IT resources [2, 3, 4, 6, 13]. International Data Corporation reported that the global public cloud services market expanded 26.0% year-on-year in 2019 with total revenues of $233.4 billion [16]. A two-fold rise in the government sector's adoption rate in the public cloud, with an average growth rate of 17.7% annually through 2021, according to the Gartner Report. The following Table 1 describes the cloud initiatives in the public sector of developed countries by developing central cloud policy/strategy [3,4,5,7,10].

Table 1. Cloud Initiatives in Developed Countries

Country	Nature of Cloud Initiatives
U.S	Started with National Level "Cloud First Strategy" in 2012 Cloud Governance: composed of 7 organizations, leading by the Federal CIO Council. Cloud-based e-government project plan: migrate more than three services into the cloud The General Accounting Office: to monitor the progress status of the transition to cloud
Japan	Used the "Kasumigaseki Cloud Strategy" Private G-Cloud: a single cloud platform that can consolidate all government ICT systems

	The Ministry of Internal Affairs and Communications: Leading Ministry regarding cloud
Singapore	Initiated "G-Cloud Policy" Private G-Cloud: G-Cloud platform for systems related to sensitive data of public agencies. Local Cloud Service Providers: for non-critical applications as cost-saving aspects Info-communications Development Authority: Main Ministry regarding cloud

2.3. Key Cloud Computing Success Factors

As of the summary of the selected literature review shown in Table 2, three main components and eight sub-components of cloud adoption factors were defined as crucial success factors regarding technology, organizational, and environmental perspectives.

Table 2. Key Cloud Computing Success Factors

Main Components	Sub-Components	Descriptions	Resources
Technology-IT Infrastructure	Broadband Quality	Fixed Network Performance	[3,5,7,10,12,14,15]
		Mobile Network Performance	
		(upload speed kbps, download speed kbps, latency in milliseconds)	
	Data Center	Data Center Service Providers inside of the country	
	Government ICT services	Online Service Index	
		E-Participation Index	
	Cloud Readiness Index	To know cloud service provision by measuring Broadband quality, data center readiness, Gov't online services.	[1,5,12,15]
Organization-Governance	Top Management Support	Interest-leadership-engagement- commitment	[2,3,7,10,15]
		Government ICT vision	
	Employees' Knowledge	Knowledge of Cloud Computing and Awareness	
		Trained workforce	
Environment-Policy and Regulation	IT Policies	Privacy Policy	[2,3,7,10,13,14,15]
		Data Protection Policy	
		Cyber Security Policy	
	Cloud Related Policies	Open standards policies for the cloud	
		The Strong rule of law adoption of new technology	

3. METHODS

To accomplish this research objective, the conceptual research framework of this study focuses on the combination of the TOE framework, to analyze the key factors that influence the technological innovation decisions in the public sector, ODCA CMM, which guides the country's cloud maturity level in the development of the strategic recommendations and benchmarking analysis, that helps to identify the best practices. The key factors for the TOE framework were derived based on the insights from previous literature reviews, mainly the context of cloud technology adoption in government entities. TOE framework has been structured to analyze the case studies: the Republic of Korea and Vietnam. South Korea ranks fifth and Vietnam ranks 14th in the 2020 Cloud Readiness Index as of the Asia Cloud Computing Association. Both countries were selected as the case studies to do benchmark analysis. Data gathering in this study were collected from academic research papers that are relevant to the research objective, reports published by WorldBank, ITU-D, and United Nations, and government reports from Myanmar, and Benchmarking countries.

4. RESULTS

Based on the collected data regarding key critical factors that were examined by literature review, and the case study of the Republic of Korea and Vietnam, the TOE framework and ODCA's CMM were used to analyze the gap, define the key findings, and the implications for Myanmar.

1. Summary of Gap Analysis Based on CMM and TOE framework

According to the gap analysis between Myanmar and benchmarking countries based on the TOE framework, Myanmar is still behind in all successful factors (8 factors), under three domains: IT Infrastructure, Governance, and Policy and Regulation. The government of Myanmar started the cloud initiative as part of the e-Governance Master Plan. At present, the availability of IT skilled full person within government organizations is very limited in both technology and policy aspects. Knowledge exchange between government and ICT experts from research institutions, academia, and the ICT industry is weak. There is a lack of government guidelines/ standardization for cloud adoption and still weakness in data security and protection. The data collection from key factors of the TOE framework is measured by the criteria from five progressive levels of ODCA's CMM shown in Table 1. Meanwhile, the cloud maturity level of Myanmar is at CMM2 according to the current situation of Myanmar.

Table 1. Analysis of Cloud assessment between Myanmar and Benchmark Countries

Maturity Level	ODCA Cloud Criteria	South Korea	Vietnam	Myanmar
CMM1 (Initial Ad Hoc)	The current ICT environment is figured out and reported to be early cloud potential.	O	O	O
	A few ICT systems are running on virtualized systems, and most are under the traditional IT environment.	O	O	O
	The Private Cloud is used as the priority.	O	O	O
CMM2 (Repeatable Opportunistic)	Processes of IT, procurement, and controls are explicitly considered to use in the cloud environment.	O	O	Partial
	Private cloud is fully used to be the emergence of cloud-aware apps.	O	O	X
CMM3 (Defined Systematic)	Cloud policy and other ICT-related regulations start to be defined to manage and reduce the risk of cloud services.	O	O	X
	Employee's skill in cloud technology starts building up	O	O	X
	The more complex use of SaaS is evident and emerges private PaaS.	O	X	X
CMM4 (Measured Measurable)	Cloud-aware applications can be deployed in all types of cloud deployment models according to the needs of the business.	O	X	X
	Governance infrastructure is in place to measure and manage cloud capability in terms of quantitatively.	O	X	X
CMM5 (Optimize)	All applications' data are located in the appropriate cloud location and migrate according to business requirements.	O	X	X
	The organization has implemented market mechanisms to enhance inter-cloud activities.	X	X	X

Korean government continuously supports financial support and technical support in developing cloud technology & policy, amendments in various ICT-related policies, knowledge awareness programs, pilot projects, and R&D areas in both private and public sectors since 2009. Defining a specific Cloud Committee and main Ministry is also one of the best practices to define each participant's role and responsibilities among stakeholders clearly. Therefore, by leading them, the specific guideline and continuous monitors can be successfully supported to solve the issues and monitor each implementing agency's progress regarding cloud pilot projects implementation. Therefore, South Korea reaches the position of CMM4, and all types of cloud models can be adopted based on business requirements.

Vietnamese government started cloud adoption through the private cloud deployment model at all ministry levels in 2010, continuously improve the progress of cloud policy development, and amended the security guidelines/laws to comply with the modern ICT environment that is strongly influenced for the country smoothly transit to cloud environment. In addition, the government has a systematic approach for government staff via international cooperation agreement channel with other developed countries to improve in the knowledge of ICT awareness as well as encourage R&D in both private and public sectors. Based on these key criteria, therefore, Vietnam keeps going on the level of CMM 3.

4.2 Key Findings, Implications, and Recommendations

Meanwhile, Myanmar is still early-stage adopting of cloud in the public sector in terms of TOE aspects. This section describes the key findings, implications, and recommendations for Myanmar.

Technological Context

Weakness in broadband Infra and government online services: Robust IT infrastructure is a crucial enabler to adopt cloud computing for the country. Mobile broadband network (3G, 4G) penetration positively impacts the country with a penetration rate of 82% and 2Mbps. At present, despite being convenient for all essential cloud computing services, including email, video conferencing, and web services, there is still a limitation to access the medium and advanced cloud-based services. It is recommended that the government needs a strong commitment to follow up National Broadband Plan- (2019-2023) to leverage accessibility and affordability.

Weakness of government online services: The government's cloud services are considered based on the readiness of online service provision. The maturity level of online public services and utilization of government services in benchmark countries are higher. It's recommended that Myanmar E-Government Steering Committee needs to review the quality of online services and monitor the implementation process of each Ministry. Additionally, need to define clear roles and the responsibility of CIOs to accelerate the adoption of ICT services within an organization.

Organizational Context

Need strong commitment from the executive level: According to Korea's government, it is vital to have strong leadership and a specific council, which will perform as the focal point to resolve all issues related to the cloud for all Ministries. It is recommended that government need to take a leading role in CC adoption, in terms of technical and financial support as well as should establish a specific cloud committee to monitor and measure service.

Less awareness and imperfect understanding in the knowledge of cloud technology at all government levels: Availability of skilled people within the organization is also critical to cloud adoption, as the results from the benchmarking countries. The lack of qualified people in government ministries specializing in cloud computing is also a significant challenge for Myanmar. The study recommends that the government focus on upgrading ICT skills in cloud capacities by arranging ongoing cloud computing training programs within the government and also use international collaboration agreements to raise awareness of cloud technology at all government levels, including the executive level. Improving cloud technology knowledge awareness at the top management level plays the main role to get strong leadership commitment in Myanmar.

Inadequacy of training and knowledge transfer, government funding support, and human resources: There is no clear define human resource development policy regarding capacity building in the public sector, and the link between government, academia and research institutes, and the private sector is still weak. The government of Myanmar should establish a network to do information exchange between the government sector and cloud experts from academia and the private sector. Funding support for government cloud pilot projects should be initiated central government budget and then the PPP and ODA channel can be considered as a future expansion to continuously upgrade the existing government ICT infrastructure and services through the cloud including training support.

Environmental Context

Absence of Cloud-related Policy and not strengthened in legal frameworks for privacy, security, and data protection: The readiness of cloud policy and strengthened in the legal framework for data security and privacy concern is critical to mitigating the security risks in the cloud computing environment because of the national security concerns according to the benchmark countries. Hence, it is needed to develop a cloud-related policy that can remove the cultural change resistance within government ministries and provide the guideline for ICT leaders as a strategic approach for future ICT development. Cloud computing act/law can be considered as a long-term perspective that can give the roadmap to all Ministries regarding the development of cloud-related projects in terms of technical support as well as including budget allocation policy. In addition, cloud guidelines can support a short terms perspective with the support of technical criteria for cloud technology and information security. Furthermore, it is necessary to implement the legal and regulatory framework by aligning existing ICT-related policies especially to publish national cybersecurity law, revise e-transition law to be compatible with modern technology and develop data protection law that protects users' privacy and data online.

4.3 To-Be Model

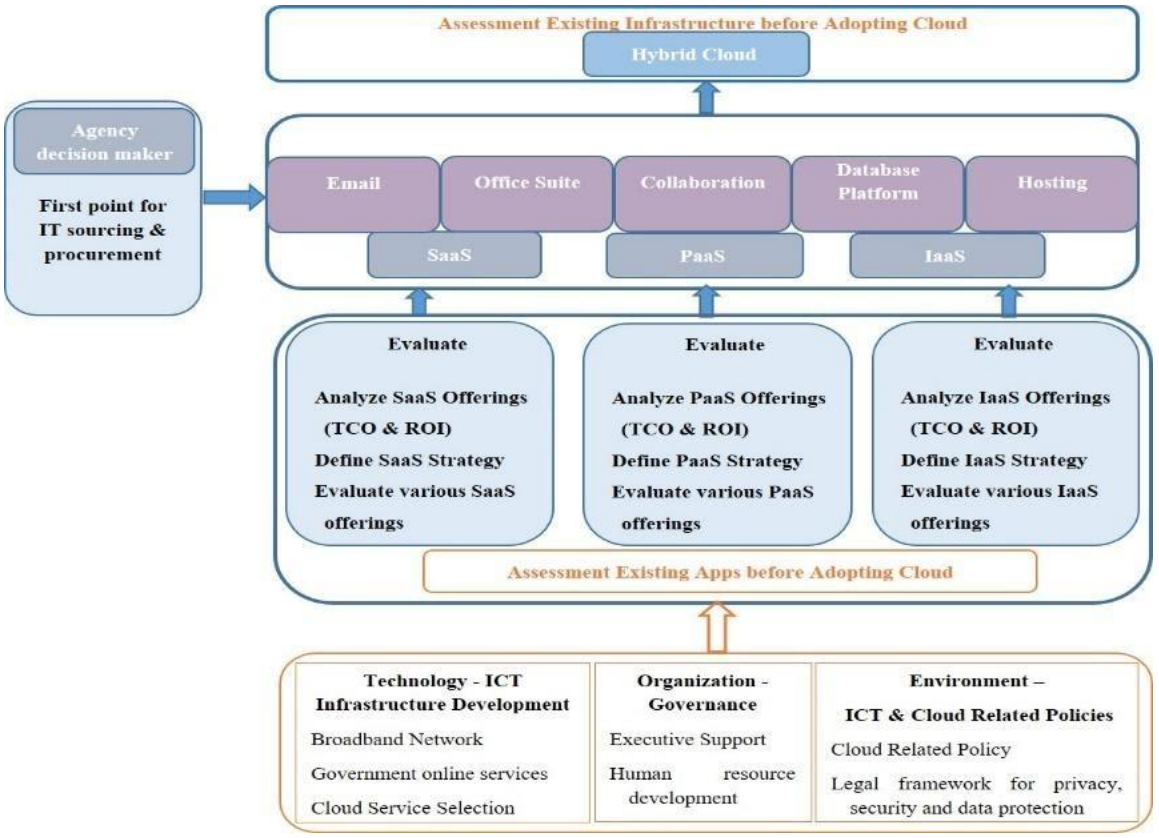


Figure 1. To-be Model for Cloud Service Provisions in Public Sector

As shown in Figure 1, there are two main components regarding the proposed to-be model for cloud promotion in this study: the Hybrid cloud deployment model and the essential requirements that are needed to identify before adopting cloud in the organization's working environment with the aim of-

- To ensure the current ICT infrastructure and applications readiness
- To define the willingness of executive-level support and the degree of human resource capacity
- To support policy enforcement and safety of the data in the cloud environment

The technology dimension considers three factors: Broadband Network, Government Online services, and Cloud Service & deployment model selections that are needed to assess before the adoption of cloud computing. The organization attribute considers two factors: Executive Support and Human resource development, as the requirements that affect an organization's decision how the executive level identifies the functions of cloud computing technology and how technology can affect the whole organization as well as know the degree of human resource capability. The environment dimension considers two factors: Cloud Related Policy and Legal framework to be strengthened in the security aspect. These two factors are important to give the roadmap for CIO as the direction during the implementation of cloud-related projects, and to ensure the safety of data located in the cloud environment. By ODCA's guideline and current situation of infrastructure and policy readiness, the Hybrid cloud deployment model is suggested as of strategic approach.

5. DISCUSSION

The main objective of this research study is to enhance the adoption of cloud in the public sector of Myanmar from the current cloud maturity level to the next higher level by finding out the key promoting factors, suitable deployment models, and strategic recommendations.

Overall, the results of this research showed that factors related to the organizational context and environmental context are a strongly negative impact on Myanmar. These findings show that less awareness and imperfect understanding of cloud technology at all government levels, followed by an absence of cloud policy, weakness in the legal and regulatory framework regarding security issues as well as weakness in the knowledge exchange network between government, academia, and industry.

In terms of limitations regarding the proposed model, it is identified for the Government of Myanmar according to the result of the currently existing infrastructure, and regulatory environment, especially cost-effective and ensure security and privacy concerns. However, Implementation Agencies' existing IT infrastructure is not compatible to integrate with the cloud environment, the upfront cost might be expensive. In addition, the data used in the research relied on only secondary data and the research analysis framework that is applied to TOE and ODCA's CMM. Hence, the proposed models, results, and recommendations can support the future forward for researchers by conducting different benchmark countries, methodology frameworks, and cloud assessment tools to be more understanding of the influence factors and give more strategic guidelines as different dimensions to enhance cloud adoption in the public sector, especially for developing countries.

6. CONCLUSION

As theoretical contributions, this study highlighted critical factors from organizational context and environmental context are strongly influence the promotion of cloud services in the Myanmar public sector. In other words, Top management support, cloud knowledge, cloud-related policy, and data security and privacy policy are the main key drivers to enhance cloud adoption, especially in the public sector with the evidence of past literature, and results of data analysis. In terms of practical contributions, it can help the public sector decision-makers to enhance the existing ICT infrastructure and applications through cloud technology. The results of case studies demonstrated that strong leadership and a cloud-first strategy are critical for all agencies to address the technical and cultural changes required to shift Myanmar's government from a typically segmented ICT service delivery method to a strategic ICT service approach. Furthermore, active policy intervention for capacity building is another key driver to improve absorptive and creative capacity within the organization's functional and technical perspectives.

AUTHOR CONTRIBUTIONS

The author has contributed the whole paper including the development of research design, data collection process, and set up the case study, followed by review the whole paper and provided the proposed model and recommendations.

ACKNOWLEDGEMENT

First of all, I would like to express my sincere gratitude to the Government of Korea for studying the Master program in Global Information and Telecommunication Technology Program (ITTP) for two years. My sincere gratitude also goes to Professor Seung Hun Han, Director of ITTP, for his guidance, and sincerely thank Professor Suk Kyoung Kim for her detailed guidance, throughout my research.

REFERENCES

1. Ali, K. E., Mazen, S. A., & Hassanein, E. E. (2018). A proposed hybrid model for adopting cloud computing in e-government. Future Computing and Informatics Journal, 3(2), 286–295. https://doi.org/10.1016/j.fcij.2018.09.001
2. Ali, O., & Osmanaj, V. (2020). The role of government regulations in the adoption of cloud computing: A case study of local government. Computer Law & Security Review, 36, 105396. https://doi.org/10.1016/j.clsr.2020.105396
3. Alkhwaldi, A., Kamala, M., & Qahwaji, R. (2018). Analysis of CLOUD-BASED E-government SERVICES acceptance In jordan: Challenges and barriers. Journal of Internet Technology and Secured Transactions, 6(2), 556–568. https://doi.org/10.20533/jitst.2046.3723.2018.0069
4. David C, W. (2010, January). The cloudy future of government IT: Cloud computing and the public sector around the world. AIRCC Publishing Corporation.
5. ITU-D, S. G. 1. (2017). Access to Cloud Computing: Challenges and Opportunities for Developing Countries. https://www.itu.int/net4/ITU-D/CDS/sg/doc/rgq/2014/D14-SG01-RGQ03.1-en.pdf.
6. Mohammed, F., & Ibrahim, O. B. (2019). Drivers of cloud computing adoption for e-government services implementation. Web Services, 1444–1459. https://doi.org/10.4018/978-1-5225-7501-6.ch075
7. Mohammed, F., Ibrahim, O., Nilashi, M., & Alzurqa, E. (2016). Cloud computing adoption model for e-government implementation. Information Development, 33(3), 303–323. https://doi.org/10.1177/0266666916656033
8. Moonasar, V., & Naicker, V. (2020). Cloud capability MATURITY model: A study of South African large enterprises. South African Journal of Information Managment, 22(1). https://doi.org/10.4102/sajim.v22i1.1242
9. MOTC. FACILITATING Faster Broadband and 5G Adoption in MYANMAR. Ministry of Transport and Communications, 2020.
10. M'rhaouarh, I., Okar, C., Namir, A., & Chafiq, N. (2018). Cloud computing adoption in developing countries: A systematic literature review. 2018 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD). https://doi.org/10.1109/itmc.2018.8691295
11. Myanmars.NET. (n.d.). Myanmar unicode. Analysis on e-Government Survey Data 2018 by Daw New Ni Soe Yin. https://mcf.org.mm/myanmar-unicode/71-right-competiton/ 493-analysis-on-e-government-survey-data-2018-by-daw-new-ni-soe-yin.html.
12. Open Data Center Alliance. (2016, February 1). Open data center Alliance publishes new CLOUD Maturity Model 3.0.

13. Shin, D.-H. (2013). User centric cloud service model in public sectors: Policy implications of cloud services. Government Information Quarterly, 30(2), 194–203. https://doi.org/ 10.1016/j.giq.2012.06.012
14. Vu, K., Hartley, K., & Kankanhalli, A. (2020). Predictors of cloud computing adoption: A cross-country study. Telematics and Informatics, 52, 101426. https://doi.org/10.1016/ j.tele.2020.101426
15. World Bank Group. (2017). Cloud Readiness Pilot Assessment Report (Vol. 1). Washington, D.C.
16. Worldwide public cloud services Market TOTALED $233.4 billion in 2019 with the top 5 Providers capturing more than one third of the Total, according to IDC. IDC. (n.d.). http://www.idc.com/getdoc.jsp?containerId=prUS46780320.

CRITICAL FACTORS AND BARRIERS TO THE ADOPTION AND USE OF TECHNOLOGY FOR AN EARLY WARNING SYSTEM: THE CASE OF NICARAGUA

Alina Rivas[1], Ronny Estrella[2]

[1] *ITTP, KAIST, arivas@kaist.ac.kr* [2] *ITTP, KAIST, restrella@kaist.ac.kr*

ABSTRACT

In the last years, Nicaragua, located in a high seismic activity area, has experienced catastrophic events related to earthquakes. Several studies have shown the value in the implementation of earthquake early warning systems (EEWS). The correct implementation of EEWSs can represent a minimization in loss of human lives, reduction of economic and social impact during natural disasters. In the last few years, EEWS technologies have improved significantly, incorporating new technologies like Big Data, the Internet of Things (IoT), or Artificial Intelligence (AI). However, studies show that implementing technology as-is without the correct understanding of its components could fail. Therefore, a correct understanding of the technology and its components is needed. This paper reviews several case studies relative to early warning systems for disaster management in the Republic of Korea and Mexico to present critical factors that improve the implementation of EEWS in Nicaragua. This study's results can help improve the understanding of success factors to adopting EEWS technology locally, developing policies and strategies to improve the implementation of EEWS in Nicaragua.

Keywords: Early Warning System, Earthquake, Emergency Response, Nicaragua, critical factors.

1. INTRODUCTION

Natural disasters represent one of the biggest problems in the world. Globally natural disasters cause severe impacts on the socio-economic system of the countries. However, prediction, warning, and mitigation improvements help to decrease natural disaster impact (Alexander, 2018). Natural disasters can be defined as some spontaneous, fast, or deep impact of the natural environment on the socio-economic system of a country. Earthquakes rank first as the most lethal among natural disasters. A study conducted by Santos and Reyes found that in the past 20 years, earthquakes had caused 56% of the deaths by natural disasters (Santos-Reyes, 2019). This is a sign that the world is in a race against time to find ways to prevent, mitigate the damage, and reduce the loss of human life caused by natural disasters. The geographic distribution of the countries also influences the type of Natural disaster that they need to afront. In the world, the zone with the highest seismic activity is known as the Pacific Ring of Fire. A zone in the shape of a horseshoe-shaped belt of 40,000 km (25,000 miles) long and up to 500 km (310 miles) wide. In this zone, 90% of the world's earthquakes (NOAA, 2021).Among these vulnerable countries to earthquakes is Nicaragua. In previous years, Nicaragua had encountered massive destructive earthquakes. The strongest event was registered in 1972 in the capital city "Managua". Around 80% of the city was destroyed. This event also generated a collapse of the economy. All public services were interrupted by two weeks. Most of the hospitals in the city disappeared as a consequence of this event. Around 10,000 human

lives were lost, and 21,000 were reported injured (Jr & Muñoz, 2016). Based on the examination of the successful cases, the second purpose of this article is to provide critical success factors and examine the possible barriers in the case of Nicaragua regarding the implementation of an EEWS. In section 2, we conduct a literature review regarding the technological advance in EEWS. In section 3, we provide a case study of the Republic of Korea and Mexico relative to EEWS. To them compare it with Nicaragua's current situation in EEWS. Section 4 provides the findings of this study. In section 5, a brief discussion with recommendations, limitations, and future work for implementing EEWS are provided, and in section 6 conclusion of the study. In the last section, the references used by this article can be found.

2. LITERATURE REVIEW

2.1. Earthquake Early Warning System

A critical component of the Earthquake early warning systems (EEWS) is early warning systems (EWS). EWS is vital to reduce disaster losses, alert disaster management departments, decision-making officials, and the general population affected by a natural disaster. It provides information and helps to ensure that people are aware and prepared for evacuation, hiding, or self-protecting themselves (Zschau & Küppers, 2013). EWS is mainly composed of four components: a network of sensors for observation of natural disasters, telecommunication systems for real-time data collection and transmission, a system for the data processing, analysis, diagnostics, and forecasting or warnings, and a system to transmit and disseminate warnings (Zschau & Küppers, 2013).In earthquakes, EWS allows the detection of events in real-time; sensors detect the primary waves (P waves) and secondary waves (S Waves). P waves are transmitted using radiofrequency waves that travel faster than S waves(Gemma & Carmine, 2020). This allows EWS to generate emergency alerts. The idea of implementing earthquake EWS is not new; for the first time in November 1868, JD Cooper proposed installing sensors in the area of Hollister, California, to detect earthquakes and suggested the delivery of alert notices through telegraphic signals (Gemma & Carmine, 2020)**.** Another important part of the EEWS is the Public Warning Systems (PWS). It provides information to people that can be at risk because of the Natural Disaster. However, it is important to consider that these advances have not been fully integrated into public warning systems. In earthquakes, there are no advanced methods that allow us to predict or anticipate it. Therefore, public warning systems allow us to send instant notifications at the moment of the earthquake (Sorensen, 2000). In the past 20 years, the most popular technology used in PWS has been outdoor sirens, digital mediums, and people walking through the streets with loudspeakers (known as route alerts). However, these technologies present several limitations depending on the case, for example, the area covered by route alert or attention that people have for outdoor sirens. (Sorensen, 2000). As a result, PWS has integrated cell phone message alerts as one of the options to deliver alerts. The current PWS uses a high level of mobile phone penetration to distribute alerts in emergency cases.

3. CASE RESEARCH METHODOLOGY

To explore the critical success factors and barriers. In this study, we propose to explore the current situation of the Republic of Korea and Mexico regarding EEWS.

3.1. EEWS in The Republic of Korea

The Korean Earthquake Early Warning System (KEEWS) began operations in 2015, with the main objective of detecting earthquakes of magnitude 5.0 or greater. The country presents a very robust seismic network based on the ElarmS-2 developed at the University of California, Berkeley, United States. In its first two years of implementation, the system efficiently detected earthquakes with magnitude 3.0. It detected 2016's earthquakes with a magnitude of 5.1 and 5.8. The system's goal is to send alerts within the 50s of detecting an earthquake over 5.0 (Dong-Hoon, 2017). The Korean Meteorological Administration (KMA) currently has 95 broadband seismometers, 27 short-period seismometers, and 142 accelerometers in its seismic observation network. This network was created to provide a fully automated seismic event response in the event of tsunamis or earthquakes. The network records seismic wave velocities and accelerations. It runs on its own and provides real-time data. With the help of a program called ANTELOPE, seismic waveforms are analyzed, and a report is generated automatically (Korea Meteorological Administration, n.d.). When a P wave is detected by six or more of the 150 seismometers installed in Korea, the EEWS device automatically analyzes and forecasts the estimated area of the earthquake epicenter and the magnitude of the occurrence. If strong shocks are predicted, KMA uses these projected forecasts to alert people in affected areas through television and radio. If a magnitude is greater than 5.0, an EEWS warning is given to the general public. Currently, the National Disaster Warning System in Korea is composed of 6 different modules and can alert 37.5 million users. The Government of Korea, through the Ministry of Public Safety and Security, is in charge of requesting the transmission of CBS messages in the disaster area (Jeong, 2009).

3.2. Critical success factors (CSFs)

John F. Rockart developed the concept of critical success factors in 1979. The main objective was to help area managers find key information needed for decision-makers (Rockart, 1979). Critical success factors are used to develop strategic plans, monitor activities, implement certain technology, and help to achieve high performance. In the case of Nicaragua, to determine the critical success factors needed for implementing an EEWS, and following the approach proposed by a PEST analysis, we propose critical success factors taken from successful cases of implementation of EEWS.

Table 1. Critical Success Factors for Nicaragua EEWS

DIMENSION	CRITICAL FACTOR	SOURCE
Politics	1. New policy and strategies.	(Westhead, 2012)
	2. Articulation of the legal framework.	(Westhead, 2012)
Environmental	3. Identification of the areas with the highest seismic activity.	(Santos-Reyes, 2019)
	4. Study of the soil and use of natural resources.	(Fancy et al., 2009)
	5. Geographic location and its implications	(Strauch et al., 2018)
Social	6. Training of the people who will benefit from the project.	(Santos-Reyes, 2019)
	7. Identify the cultural, educational, and characteristics of the population involved.	(Sutton et al., 2020)

Technologies	8. Identify the technology and its flaws or limitations.	(Cremen & Galasso, 2020)
	9. Accurate selection of the technology to implement	(Cuéllar et al., 2017)
	10. Adequate seismic network	(Santos-Reyes, 2019)

4. EXPECTED RESULTS

As mention in the critical success factors of section 3. It is important to consider several processes and components to develop a correct EEWS. As a result of our analysis, this study will proposed a model for Nicaragua EEWS. This system will take into consideration the critical factors and good practices from Mexico and the Republic of Korea.

5. DISCUSSION

The correct implementation of earthquake early warning systems represents an important difference between life and death. In Nicaragua, the country only possesses a system that can monitor and store seismic activity data. As a result of this study, after seeing the benefits, barriers, limitations, and critical success factors provided by EEWS systems implemented by the Republic of Korea and Mexico, we will like to discuss the key findings that can help Nicaragua in the successful implementation of an EEWS. For a successful implementation, the country needs to have national policies that coordinate the different institutions involved in the emergency alert and response process. An Earthquake classification criteria must be established to identify which events represent a risk to the population and must be communicated to the public. It is also crucial for the permanent emergency response training of the population to determine the factor of the effectiveness of the EEWS.

6. CONCLUSION

EEWS can help reduce the number of fatalities from high-magnitude earthquakes. It has been possible to identify the ability of countries to reuse existing technology to develop systems with a high degree of efficiency. In the case of Nicaragua, the earthquake detection system is in an elementary stage. It is essential that the country focus efforts on developing an EEWS that considers the use of CBS. This needs to be considered a priority considering that the country is located in high seismic activity. In conclusion, Nicaragua presents the optimal conditions for implementing an earthquake early warning and public emergency alert system, which could positively impact the way the population responds to these emergencies.

AUTHOR CONTRIBUTIONS

This section presents the contributions made by the authors: Ms. Alina Rivas and Mr. Ronny Estrella conceived and designed the analysis utilized in this paper. Ms. Alina Rivas performed the data collection. Mr. Ronny Estrella performed the analysis of the results. Both authors work to write the paper.

ACKNOWLEDGEMENT

The paper's authors would like to thank the Global Information and telecommunication technology program (ITTP) of the Korean Advanced Institute of Science and Technology (KAIST) for their support during this Research. We would also like to thank the organizing committee of the DIGG conference for the opportunity to present our work.

REFERENCES

1. Alexander, D. (2018). *Natural Disasters*. Routledge. https://doi.org/10.4324/9781315859149
2. Ali, M., Al-shamaileh, O., Aloudat, A., & Obeidat, B. (2018). The Viability of Mobile Services (SMS and Cell Broadcast) in Emergency Management Solutions: An Exploratory Study. *International Journal of Interactive Mobile Technologies (IJIM)*, *12*, 95. https://doi.org/10.3991/ijim.v12i1.7677
3. Cuéllar, A., Suaréz, G., & Espinosa-Aranda, J. (2017). *Perfomance Evaluation of the Eartquake Detection and Classification Algorithm 2 of the Seismic Alerta System of Mexico (SASMEX). Bulletin of the Seismological Society of America*.
4. Dong-Hoon, S. (2017). The First Stage of an Earthquake Early Warning System in South Korea. *Seismological Research Letters*.
5. Gemma, C., & Carmine, G. (2020). *Earthquake early warning: Recent advances and perspectives*. https://www.sciencedirect.com/science/article/pii/S0012825220302300?via%3Dihub.
6. Given, D. D., Allen, R. M., Baltay, A. S., Bodin, P., Cochran, E. S., Creager, K., de Groot, R. M., Gee, L. S., Hauksson, E., Heaton, T. H., Hellweg, M., Murray, J. R., Thomas, V. I., Toomey, D., & Yelin, T. S. (2018). Revised technical implementation plan for the ShakeAlert system—An earthquake early warning system for the West Coast of the United States. In *Revised technical implementation plan for the ShakeAlert system—An earthquake early warning system for the West Coast of the United States* (USGS Numbered Series No. 2018–1155; Open-File Report, Vols. 2018–1155). U.S. Geological Survey. https://doi.org/10.3133/ofr20181155
7. Hsiao, N.-C., Wu, Y.-M., Shin, T.-C., Zhao, L., & Teng, T.-L. (2009). Development of earthquake early warning system in Taiwan. *Geophysical Research Letters*, *36*(5). https://doi.org/10.1029/2008GL036596
8. INETER. (2002). *Actualizacion de Mapa de Fallas Geológicas de Managua*. The World Bank Group.
9. InfoSismos MX. (2020). *SASMEX*. InfoSismosMx. https://www.infosismosmx.com/sasmex
10. Jeong, D. H. (2009). *National Disaster Warning System in Korea*. Sep.
11. Jr, I., & Muñoz, J. M. (2016). Análisis de la amenaza sísmica en Nicaragua: El caso de la ciudad de Managua. *Investigaciones Geográficas*. https://doi.org/10.5354/0719-5370.2016.44732
12. Kang, H. (2016). *Disaster Early Warning Services in the Republic of Korea*. The First Pacific Regional Workshop on Multi-Hazard Risk Assessment and Early Warning Systems by Using Space and GIS Applications, Fiji.
13. Korea Meteorological Administration. (n.d.). *KMA Services*. Retrieved July 22, 2021, from https://web.kma.go.kr/eng/weather/kma_service/introduction.jsp
14. Mazurkiewicz, A., & Poteralska, B. (2017). Technology Transfer Barriers and Challenges Faced by R&D Organisations. *Procedia Engineering*, *182*, 457–465. https://doi.org/10.1016/j.proeng.2017.03.134

15. NOAA. (2021, July 22). *What is the Ring of Fire? : Ocean Exploration Facts: NOAA Office of Ocean Exploration and Research*. Ocean Explorer. https://oceanexplorer.noaa.gov/facts/rof.html
16. Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review*, *57*(2), 81–93.
17. Santos-Reyes, J. (2019a). *Earthquakes—Impact, Community Vulnerability and Resilience*. https://doi.org/10.5772/intechopen.77465
18. Santos-Reyes, J. (2019b). How useful are earthquake early warnings? The case of the 2017 earthquakes in Mexico city. *International Journal of Disaster Risk Reduction*, *40*, 101148. https://doi.org/10.1016/j.ijdrr.2019.101148
19. Satriano, C., Wu, Y.-M., Zollo, A., & Kanamori, H. (2011). Earthquake early warning: Concepts, methods and physical grounds. *Soil Dynamics and Earthquake Engineering*, *31*(2), 106–118. https://doi.org/10.1016/j.soildyn.2010.07.007
20. Sorensen, J. H. (2000). Hazard Warning Systems: Review of 20 Years of Progress. *Natural Hazards Review*, *1*(2), 119–125. https://doi.org/10.1061/(ASCE)1527-6988(2000)1:2(119)
21. Strauch, W., Talavera, E., Tenorio, V., Ramirez, J., Arguello, G., Herrera, M., Acosta, A., & Morales, A. (2018). Toward an Earthquake and Tsunami Monitoring and Early Warning System for Nicaragua and Central America. *Seismological Research Letters*, *89*. https://doi.org/10.1785/0220170193
22. Sutton, J., Fischer, L., James, L. E., & Sheff, S. E. (2020). Earthquake early warning message testing: Visual attention, behavioral responses, and message perceptions. *International Journal of Disaster Risk Reduction*, *49*, 101664. https://doi.org/10.1016/j.ijdrr.2020.101664
23. Unapcict. (2019, June 29). *Briefing note on an Overview of ICTs and Sustainable Development*. APCICT/ESCAP. https://www.unapcict.org/resources/publications/briefing-note-overview-icts-and-sustainable-development
24. Zschau, J., & Küppers, A. N. (2013). *Early Warning Systems for Natural Disaster Reduction*. Springer Science & Business Media.

PROPOSING A LINKED OPEN DATA SOLUTION TO ENABLE INNOVATIVE DATA SERVICES: A CASE OF BPS-STATISTICS INDONESIA

Eko Teguh Widodo[1, 2]

[1] *Global Information and Telecommunication Technology Program, KAIST, Republic of Korea*

[2] *Information System Analyst, BPS-Statistics Agency, Indonesia*

ABSTRACT

Government data in worldwide increases significantly. To generate new values, the government publishes a web portal as Open Government Data (OGD) implementation, presenting various data fields and formats. The Government of Indonesia establishes the OGD initiative through One Data Indonesia and entrusts BPS-Statistics Indonesia as a mentor for all government agencies in Indonesia. BPS has more than 500 web portals diverged from central, provincial, and municipal representatives. In addition, data integration solutions, such as a static and dynamic table, search engine, and web API, are provided to deliver data and information for the users. However, those solutions could not respond to users' needs instead of producing various data formats (i.e., HTML, PDF, XLS, CSV, XML, and JSON), taking much time and effort to transform into information or knowledge. Linked Open Data (LOD) offers a new publishing way to reform reusability, interlinking, and sharing data on the Web. Many countries have practiced it in government sectors. Under the umbrella of the Semantic Web, those data formats and their metadata can be represented as semantic information, and LOD integrates the information, making it easily readable and consumable by humans and machines. This research aims to propose a solution using LOD for BPS to enable innovative data services. It was conducted by analyzing the as-is of data integration solutions implemented by BPS compared to government agencies in the benchmarking countries Republic of Korea and Brazil. The to-be model is also designed based on findings from the gap analysis and is expected to be executed as a pilot project in BPS. Moreover, future work should cover technology adoption in all government agencies to enable more innovative data services in Indonesia.

Keywords: BPS-Statistics Indonesia; Open Government Data (OGD); data integration; Linked Open Data (LOD); Linked Open Government Data; Semantic Web.

1. INTRODUCTION

Data integration is defined as the process of combining data from heterogeneous sources, and it can be distinguished into manual integration, common user interface, integration by applications, integration by middleware, uniform data access, and common data storage [1]. As the Non-Ministry Government Agency directly responsible to the President, BPS-Statistics Indonesia currently implements some of the approaches into concrete data integration solutions, such as a static and dynamic table, Allstats search engine, and web API, to help users quickly get the desired information and knowledge. However, these solutions could not

perform as users expected in immediately receiving the desired information and knowledge. It takes a lot of time and effort before and after gathering data. As a result, the users will get data in various formats. Moreover, they should extract a subset of interest and manually match the data from different datasets before further processing to get insights.

Linked Open Data (LOD) is introduced as one of the solutions, described as a method to publish Open Data using Linked Data principles developed by the World Wide Web Consortium (W3C) [2]. The document-based produced from the existing solutions, including its metadata, can be represented into semantic information. Other data sources that have similar meanings; can then be interlinked and possible for reusability and sharing. Thus, new innovative data services may be generated, facilitating users to get information and knowledge quickly without spending much time and effort. Many countries have adopted LOD in the government [3-12], and BPS needs to adopt appropriate solutions.

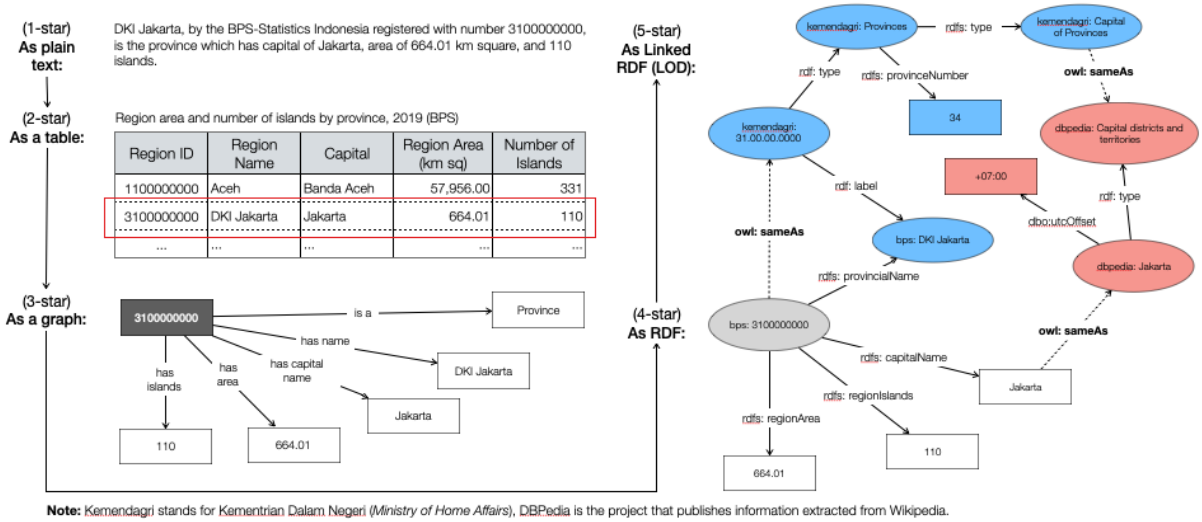
In this research, we contribute to (i) identify critical success factors (CSFs) that will be used for analyzing the situation of government agencies, (ii) analyze and compare the government agencies in Indonesia and the benchmarking countries to get findings for BPS-Statistics Indonesia, and (iii) propose a best-fit solution for BPS to adopt a LOD technology.

2. LITERATURE REVIEW

Linked Data is one of the Semantic Web technologies –*a collection of technologies and standards that allow machines to understand the meaning (semantics) of information on the Web* [13]. Publishing LOD on the Web should follow the Linked Data principles:

a. Use URIs (Unique Resource Identifiers) to name THINGS
b. Use URIs for those THINGS if possible
c. Provide helpful information at that URL
d. Include links to other THINGS

Sir Tim Berners-Lee, the inventor of the Web, suggested the 5-star level of Open Data. The higher the level of Open Data, the more data consumers and data producers benefit from it. **Figure 1** presents Open Data gathered from BPS and could be linked with other sources, such as the Ministry of Home Affairs and DBPedia.



Note: Kemendagri stands for Kementrian Dalam Negeri (*Ministry of Home Affairs*), DBPedia is the project that publishes information extracted from Wikipedia.

Figure 1. Representation of Open Data from each level

Critical Success Factors (CSFs) Identification

The concept of success in technology-driven project implementations might be diverse among the project stakeholders, where they have different expectations and evaluations [14]. Hence, the interpretations of the success will be various. We extract the CSFs from the various sources [3-12], categorized into the pioneer countries (the United States and the United Kingdom), the European, Latin American, and Asian countries. The extraction improves the data quality in technical and managerial aspects and lessons learned for government, community, and citizens/users. **Table 1** presents the CSFs identified from the findings.

Table 1. The CSFs identified from the LOD adoption in the government sectors

Government(s)	Findings	CSFs	Sources
The United States	The government/organization intention; research collaboration with the community (academia and researchers); available strategy/policy/regulation (NAP); IT infrastructure support	(1) organization intention (2) academia and research community support (3) strategy/policy, regulations, and legislation (4) IT infrastructure support (5) data integration solutions (6) prioritization (7) data and metadata	[3], [4], [5]
The United Kingdom	The collaboration of AKT research institute (University of Southhampton) with the UK government; prioritization of data and the actor (the AKT) who run the project; some datasets (10,000) that have data and metadata; financial resources (external); technical framework; IT infrastructure; data integration solutions		[6], [7]
European countries	Collaboration, legislation, policy or strategy, and regulation; technical framework (data, metadata, standards, URIs); public body support (leadership, policy, financial, and capacity building); user participation/engagement; IT infrastructure		[8], [9], [10]
Latin American countries	Academia and research support, mainly from W3C Brazil; skills and competencies of the ICT professional officers after giving training from		[11]

	the W3C; improved level of open data; creating data integration solution by mashup linked-RDF	(8) financial resources (9) technical framework (10) data integration solutions (11) technical framework (data, metadata, standards, URIs) (12) skills and competencies (13) level of open data (14) industrial support (15) types of interoperability (static, dynamic, syntactic, semantic)	
Asian countries	Top-management support; policy and regulation, academia and research support, industrial support, financial resources; organization intention; various types of interoperability (static, dynamic, syntactic, semantic)		[12], [13]

3. METHODS

After identifying the CSFs, we classify those factors using the TOE framework to explain the influence in adopting a technological innovation by an organization based on the technological, organizational, and environmental context [15]. This framework is used to analyze the as-is analysis of Indonesia by taking a case of BPS and the government agencies from the Republic of Korea and Brazil in the benchmarking analysis. The as-is analysis produces enablers (strengths) and barriers (weaknesses). The benchmarking analysis produces lessons learned. As a result, both as-is and benchmarking results are compared in the gap analysis to discover findings for BPS. In conclusion, as shown in **Figure 2**, all the results become references to construct recommendations and the to-be model.

In selecting benchmarking countries, we select a country with a top-level and another country with a middle level that Indonesia could catch up. Based on some recent vital indicators we gathered, such as ICT Development Index, E-Government Index, Open Data Barometer Index, OURdata Index, R&D Investment, and LOD adoption, we choose South Korea as the top one and Brazil as the middle one.

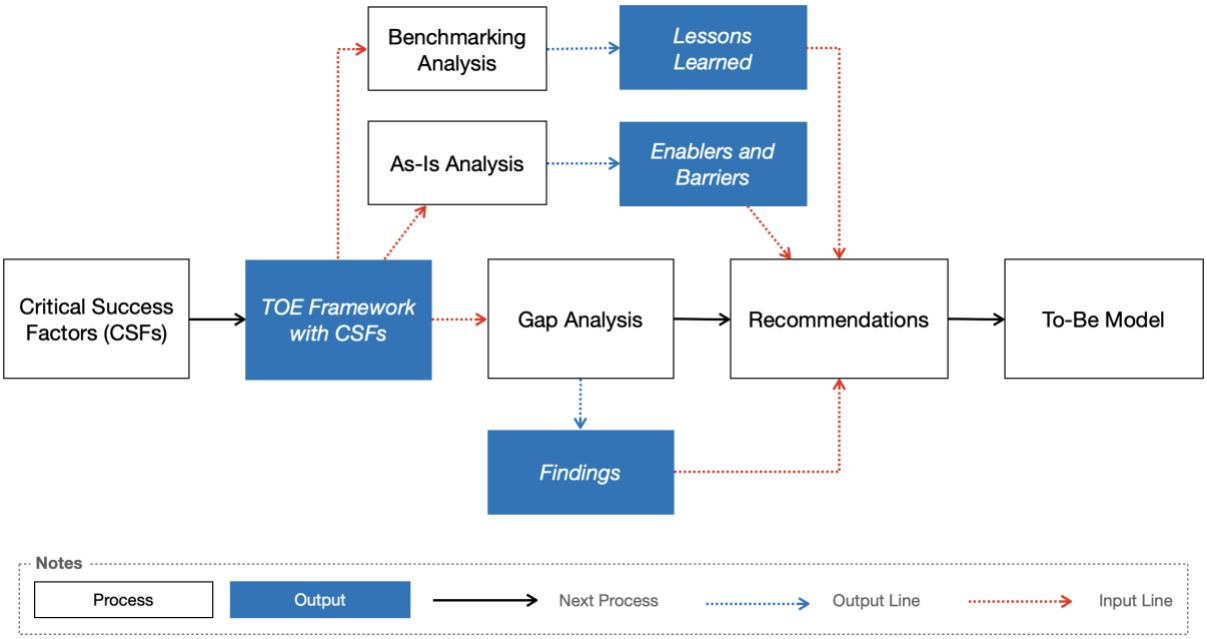


Figure 2. Research framework methodology

4. EXPECTED RESULTS

1. As-Is Analysis: The Case of Indonesia

As one of the founding countries that launched the Open Government Partnership (OGP) in 2011, Indonesia has committed to strengthening government data. Some strategies, policies, and regulations have been made, such as the Open Government Indonesia (OGI), One Data Indonesia (ODI), and recently Satu Data Indonesia (SDI). As one of the coaches/mentors, BPS has been selected for this research because the agency becomes a role model and data reference for all government agencies. However, although the agency has integrated data from various sources and built data services for users, there are still some lacks. The agency only provides data services that produce various data formats, which take much time and effort to obtain the information and knowledge. The data could reach 3-star of 5-star of Open Data level, where some data has been converted into CSV/JSON format, but most of them are still in the XLS format. A reported study informed that the agency has no standardized framework in improving skills and competencies of the workers and level of Open Data to use LOD technology [16]. Moreover, the agency also collaborates less with academia and the research community for research and development and promotion of data utilization. In 2020, BPS initiated the Indonesia Data Hub (INDAH) to overcome the lack and started gathering information to adopt LOD.

2. Benchmarking Analysis: The Case of South Korea

In South Korea, after joining the OGP in 2011, the government enacted the Public Data Act in 2013 as a foundation for managing and strengthening data quality. Moreover, other strategies and policies were established, such as creating Public Data Strategy Committee, The 1st, 2nd, and 3rd Basic Master Data Plan,

Public Data Innovation Policy, and Data/AI Economic Activation Plan. Technology transfer was also made with the first movers of LOD, the United States and the United Kingdom. As a result, with the government's support, priority, and intention to quickly adopt the technology, it made some changes. Under the Ministry of Interior and Safety (MOIS) and National Information Society Agency (NIA), a collaboration with many stakeholders (i.e., research institutes, universities, private companies) was made to provide a roadmap for service platforms, data representation technology, and data provision technology. LOD is one of the roadmaps, and it has been implemented in 14 public/private organizations. At least three private local companies (e.g., LiST, Saltlux, Frotoma) installed their innovation to those representatives to support the technological parts, like conversion data into RDF, storing to triplestores, and accessing the data using SPARQL. We study several government agencies, such as Seoul Open Data Plaza LOD using LiST technology, the Korean Intellectual Property Office (KIPO) using Saltlux technology, and the Ministry of Foreign Affairs (MOFA) using Frotoma technology. The agencies have successfully adopted and exploited it into innovative data services, like data visualization and semantic search. In addition, some events, such as the LOD conference (LODAC), are conducted to facilitate more discussion and collaboration in improving data quality and hackathon to gain data utilization and innovation.

3. Benchmarking Analysis: The Case of Brazil

In Brazil, we found that the intention, support, and priority from the top level of the government agency gave more impact to immediately adopt the LOD, particularly after the United States implemented it. The government enacted the regulation the Law on Access of Information (LAI) to regulate the constitutional rights of citizens to access government information and established the Information Organizing Committee of the Presidency (COI) to gather large amounts of aggregated data for digital publication. Additionally, the collaboration with the external entities, such as the W3C of Brazil and research communities, had been made, dramatically affecting the ICT professionals in the public sector to improve their skills and competencies. Furthermore, a technical framework (e.g., ePing, INE, INDA) is already provided as a guideline to enhance data quality. As a result, the Federal Budget Secretariat (SOF), as our study case, already adopted the technology regarding Open Fiscal Data and performed data visualization of budget and expenditure data and social security budget from 2000 onwards with limited IT infrastructure and developing the existing system (SIOP) into semantic information that anyone could use. To boost the utilization, the government held a contest or hackathon.

4. Gap Analysis

Table 2 presents the comparison of LOD implementations in the selected government agencies based on the defined CSFs. The findings of this analysis will be discussed in **Section 5**.

Table 2. Comparison by CSFs of Indonesia, South Korea, and Brazil

Context	CSFs	Indonesia	South Korea	Brazil	Findings for BPS
Technology (T)	Level of open data (maximum of 5-star)	3-star	5-star	4-star	*Low level of open data*

	Type of interoperability (static, dynamic, syntactic, semantic)	reach syntactic	reach semantic	reach semantic	*Only publishing data on the Web without adding semantic (meaning)*
	IT Infrastructure	○	✓	○	*No available IT infrastructure for LOD*
	Data integration solutions	×	✓	✓	*Existing solutions did not provide a LOD solution*
	Data and metadata	✓	✓	✓	*Well managed data and metadata using information systems*
	Technical framework (i.e., standards, license, URIs)	×	✓	✓	*No specific guideline in adopting LOD*
Organization (O)	Top-management support	✓	✓	✓	*More support, such as establish a committee or team focused on improving data quality*
	Organization's intention	✓	✓	✓	*INDAH platform as a future vision using LOD*
	Prioritization	○	✓	✓	*Less prioritization with other activities (survey, census.)*
	Skills and competencies	×	✓	✓	*Low skills and competencies in LOD*
	Financial resources	internal	internal & external	internal	*BPS only relies on internal budget*
Environment (E)	Legislation, strategy/policy, and regulations	○	✓	✓	Unclear strategy and should be synchronized
	Academia and research support	○	✓	✓	*Less collaboration with academia and research community*
	User participatory	○	✓	✓	*Less promotion on data utilization*
	Industrial support	×	✓	×	*BPS may use technology from industry or develop from scratch*

Note: ✓ (has already applied) ○ (still developing) × (has not applied yet)

5. Recommendation and To-Be Model

Based on the enablers and barriers from the as-is analysis, lessons learned from benchmarking analysis, and findings in the gap analysis, we construct the recommendations for BPS. There are five significant recommendations: (i) create a LOD strategy, (ii) collaborate with stakeholders, (iii) provide capacity building/training, (iv) transfer the technology, and (v) build a LOD system. In this research, we focus on proposing a technical solution regarding adopting the LOD in BPS. Therefore, as shown in **Figure 3**, we build a LOD system.

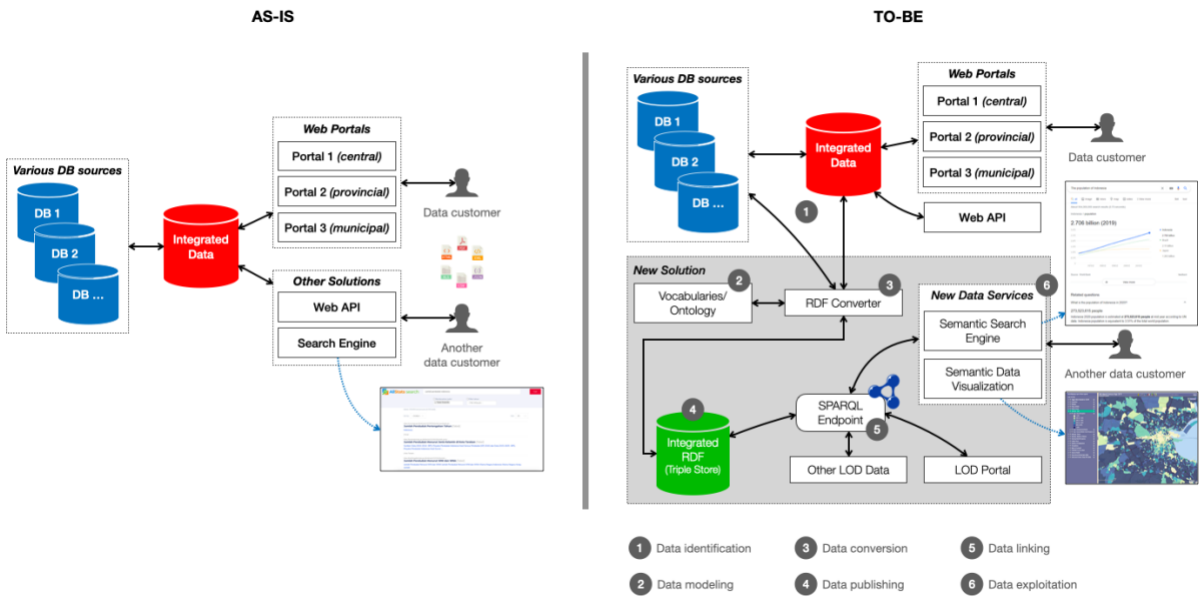


Figure 3. Proposed a LOD solution compared between the as-is and to-be

As shown in **Figure 3**, we categorized the solution into six stages. The data identification stage selects and analyzes the existing BPS data sources. We can prioritize the datasets that have reached 3-star, essential domain knowledge (i.e., population, poverty, SDGs), and completed metadata. In addition, we could also define the URIs and set the license. In the data modeling stage, we use some tools to design data models using ontology engineering. The data conversion stage will convert the results from the first two stages into an RDF data format. In the data publishing stage, those RDF will be stored in a data storage system called triplestores. Then, we also provide a system to link with other RDF sources in the data linking stage. Finally, in data exploitation, we could perform data utilization from Linked-RDF (LOD) to build an innovative data service that helps the users get the information or knowledge fast, such as Semantic Search Engine and Semantic Data Visualization.

5. DISCUSSION

This research aims to identify the CSFs to adopt the LOD in the government agency. We have already found the factors. However, some drawbacks need to improve. The first is to determine which factors influence the adoption by conducting quantitative research through a survey of stakeholders. Additionally, some sources seem not quite up-to-date. It is around 2011-2014, after the OGP was launched. Thus, strengthen the influence factors and collect more recent data would be our future work to provide a best-fit solution for BPS in adopting the technology.

Another goal of this research is to get findings for BPS after analyzing and comparing the government agencies in Indonesia, the Republic of Korea, and Brazil according to the defined CSFs. We have found that BPS has some lacks comparing to benchmarking countries. The agency mainly lacks establishing an IT infrastructure and technical framework to adopt LOD in a technological context. In the organizational context, BPS has less support from top-level management, intention, and priority to seriously adopt this technology through actions, such as establishing organizational structure (team or committee), improving skills and

competencies. BPS also lacks collaboration or partnership with academia, the research community, and industry to enhance innovations and data utilization for environmental context.

Lastly, we also construct the recommendations and propose a new solution for data integration in BPS. We have defined the recommendations in **Sub Section 4.5** and focused on the solution by building a LOD system. Thus, there are six stages to develop. In the data identification stage, we identify and analyze existing data and metadata. We strongly recommend using 3-star datasets to be processed. For the data modeling stage, we can model the schema from existing metadata. Then, the following stage is data conversion, where data and its schema are converted into RDF data. In the data publishing, those RDF data is stored in the data storage called "triplestores." The data linking stage will link the RDF within the storage or external storage to become Linked-RDF or LOD data. Finally, we can exploit those LOD to create innovative data services, such as semantic search engines or data visualization.

To sum up, we have discussed that this research has reached its goals. However, there are still some limitations that need to be improved in enhancing research quality. Even though the research concentrates more on building a LOD system that describes a technical thing, it should discuss other recommendations to get comprehensive information to build the system. Furthermore, it can be implemented as a project for BPS and adopted by other government agencies.

6. CONCLUSION

This paper successfully presents the CSFs identified from the LOD projects of government agencies worldwide. In addition, it also found the findings for BPS after comparing those factors to the Republic of Korea and Brazil. Besides, as part of recommendations, we focus on the technical solution by establishing a LOD system consisting of six stages, starting from data identification, data modeling, conversion, publishing, and exploitation. Each stage may use technologies that best-fit for BPS. Despite those, continuous research is required to overcome the pitfalls, such as quantitative research to evaluate the CSFs and non-technical research for other defined recommendations.

AUTHOR CONTRIBUTIONS

The author conceived and designed the analysis, collected the data, contributed data or analysis tools, performed the analysis, and wrote the paper.

REFERENCES

1. Ziegler, P., and Dittrich, K.R. (2007). Data Integration - Problems, Approaches, and Perspectives. In: Krogstie J., Opdahl A.L., Brinkkemper S. (eds) Conceptual Modelling in Information Systems Engineering. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-72677-7_3
2. Sakr, S., Wylot, M., Mutharaju, R., Phuoc, D.L., and Fundulaki, I. (2018). Linked Data: Storing, Querying, and Reasoning. Springer. ISBN: 978-3-319-73514-6. https://doi.org/10.1007/978-3-319-73515-3
3. Hendler, J., Holm, J., Musialek, C., and Thomas, G. (2012). US Government Linked Open Data: Semantic.data.gov. IEEE Intelligent Systems, 27(3), pp. 25-31. https://doi.org/10.1109/MIS.2012.27

4. Ding, L. et al. (2011). TWC LOGD: A portal for linked open government data ecosystems. Journal of Web Semantics, 9(3), pp.325-333. https://doi.org/10.1016/j.websem.2011.06.002
5. Gramaglia, L., Kormann-Fromageau, C., Delcambre, D., Museux, J. M., and Nagy-Rothengass, M. (2018). A European strategy for linked open statistics. CEUR Workshop Proceedings (Vol. 2317). CEUR-WS. http://ceur-ws.org/Vol-2317/article-11.pdf
6. Lebo T. et al. (2011). Producing and Using Linked Open Government Data in the TWC LOGD Portal. In: Wood D. (Eds) Linking Government Data. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-1767-5_3
7. Shadbolt, N. et al. (2012). Linked Open Government Data: Lessons from Data.gov.uk. IEEE Intelligent Systems, 27(3), pp. 16-24. https://doi.org/10.1109/MIS.2012.23
8. Shadbolt, N., and O'Hara, K. (2013). Linked Data in Government. IEEE Internet Computing, 17(4), pp.72-77. https://doi.org/10.1109/MIC.2013.72
9. Deirdre, L. (2014). Building an open data ecosystem: an Irish experience. Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance (ICEGOV '14). Association for Computing Machinery, New York, NY, USA, pp.351-360. https://doi.org/10.1145/2691195.2691258
10. Breitman, K. et al. (2012). Open government data in Brazil. IEEE Intelligent Systems, 27(3), pp.45-49. https://doi.org/10.1109/MIS.2012.25.
11. Kim, H. (2018). Interlinking Open Government Data in Korea using Administrative District Knowledge Graph. Journal of Information Science Theory and Practice, 6(1), 18–30. https://doi.org/10.1633/JISTAP.2018.6.1.2
12. National Information Society Agency (NIA). (2014). 링크드 오픈 데이터 국내 구축 사례집. Retrieved from http://lod.seoul.go.kr/home/guide/2014_Linked_Open_Data_internal_build_case.pdf [Online; accessed: 21-April-2021].
13. Allemang, D. and Hendler, J. (2011). Semantic Web for the Working Ontologist 2nd Edition: Effective Modeling in RDFS and OWL. Morgan Kaufmann. ISBN: 978-0-123-85966-2
14. Zuiderwijk, A., Susha, I., Charalabidis, Y., Parycek, P.,a nd Janssen, M. (2015). Open data disclosure and use : critical factors from a case study. CeDEM 2015 : Proceedings of the International Conference for E-Democracy and Open Government, p197-208. http://urn.kb.se/resolve?urn=urn:nbn:se:oru:diva-50203
15. Baker J. (2012). The Technology–Organization–Environment Framework. In: Dwivedi Y., Wade M., Schneberger S. (Eds.), Information Systems Theory. Integrated Series in Information Systems, vol 28. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-6108-2_12
16. Rahmatika, M., Krismawati, D., Rahmawati, S.D.,, Arief, A., Sensuse, D.I., and Fadhil Dzulfikar, M. (2019). An Open Government Data Maturity Model: A Case Study in BPS-Statistics Indonesia. The 7th International Conference on Information and Communication Technology (ICoICT), 2019, pp.1-7. https://doi.org/10.1109/ICoICT.2019.8835352
17. Romzi, M. (2020). Orkrestasi Satu Data Indonesia dengan INDAH (Indonesia Data Hub). Presentation Material, Jakarta, June 18th, 2020.

18. BPS Ontology Team. (2020). Dukungan Ontologi terhadap Indonesia Data Hub versi 1.2. Presentation material. BPS-Statistics Indonesia
19. National Information Society Agency (NIA). (2014). Public Database Service Technology Trend, 데이터베이스 활용기술 전망. Retrieved from https://www.slideshare.net/jino/ss-63404561 [Online; access: 21-April-2021].
20. Federal Budget Secretariat (SOF). SIOP - Dados Abertos. Retrieved from https://www1.siop.planejamento.gov.br/siopdoc/doku.php/acesso_publico:dados_abertos [Online; accessed: 10-April-2021]

SESSION 3: INDUSTRY TRANSFORMATION: SMART AGRICULTURE & FINTECH

PROPOSING IOT AND CLOUD-BASED ARCHITECTURE FOR SMART IRRIGATION – A CASE FOR TANZANIA

Emmanuel Fredy Mwakasege[1]

[1] *KAIST University – Department of Global Information and Telecommunication Technology Program,*

emanuel9281@gmail.com, e.mwakasege@kaist.ac.kr

ABSTRACT

Agriculture has been the main backbone of Tanzania's economy. Every year, it contributes between 25 and 30% of the GDP and employs over 60% of the country's total workforce. However, despite the abundance of water resources, farming in Tanzania has been seasonally restricted to rainy seasons only. Several irrigation methods such as flooding, water cane, drip irrigation, etc. have been employed by farmers, with the support of the government to ensure all-year-round farming, while these methods might be temporarily successful for subsistence farming, they are expensive, and have several drawbacks which result in inefficient outputs in commercial agriculture as well as other environmental degradation issues. The most paramount of these challenges is over-irrigation or under-irrigation.

As Information Technology continues to disrupt several socio-economic activities, this report discussed the adoption of emerging technologies; Climate-Smart Agriculture to resolve the over-irrigation and under-irrigation challenges. It proposed the adoption of IoT Sensors, IoT Actuators, and Cloud technologies after studying irrigation systems of Korea and Rwanda with information sourced from secondary data.

Due to the political, economic, social, technology, and environmental variations in these countries, the report recommended a best-fit IoT & Cloud-based irrigation systems architecture for Tanzania. A cost-benefit of the proposed solutions revealed that adopting an IoT & Cloud-based irrigation system in Tanzania will eradicate the challenge of over and under-irrigation, increase yield by a minimum of 30%, and reduces the cost of irrigation systems management by 52.3%.

Keywords: Climate-Smart Agriculture; Agriculture; IoT; Cloud Computing; Smart Irrigation; Architecture.

1. INTRODUCTION

The global population has been growing at a rate of over 1% adding approximately 81 million people every year since 1951. In Africa, the growth rate has been consistently over 2% since 1960 and the region has been the worst hit by rising global hunger and food security challenges with 20% (worldometer, 2021) of the population facing chronic hunger. Tanzania is 94th of 113 in Global Food Security Index and one-quarter of its 55.9 million people face chronic hunger (Global Hunger Index, 2021). A global situation that informed the 2015 UN Agenda to end global hunger by 2030.

Although statistics show that the world is producing enough to feed its growing population, Agriculture in Tanzania, even though employs more than 60% of her population, has experienced a stagnant growth of 4.4% over the past years. In seasons when there is adequate rainfall, Tanzania produces enough food to feed its growing population and export to neighboring countries. However, during drought seasons, the country experiences serious

food shortages largely due to seasonal dependencies, dwindling food production, lack of storage facilities, and often have to depend on food importation and receiving food aid (Amani, 2006).

Considering the abundance of water resources around the country, the Tanzanian Government, through the National Irrigation Commission had employed several irrigation schemes; sprinklers, flooding irrigation, plastic cane watering, treadle pumps, etc. to address challenges of seasonal dependent agriculture.

These irrigation schemes and techniques are not without their own challenges, most pressing of which is over, and under-irrigation stemming from the absence of modern irrigation systems due to high management cost and the initial cost of adoption (World Bank, 2019). Therefore, this study proposed a low-cost smart irrigation system easily adoptable by amongst subsistence Tanzanian farmers towards reduction of water loss, and improving agricultural productivity in the country with minimal management cost incurred.

2. LITERATURE REVIEW

The main challenges of conventional irrigation techniques are under and over-irrigation with the efficiency of water application in the field, *Field application efficiency (ea)*, at 60%, 75%, and, 90% for Surface, Sprinkler, and Drip irrigation methods respectively (C Brouwer et al., n.d.). While the drip irrigation systems have higher water-use efficiency, in East Africa, conventional irrigation systems are characterized with water use efficiency below 50% (Kimaro, 2019), the initial cost of adoption of modern systems are unaffordable to small-scale farmers with capital cost ranging from $1500 to $2500 per acre, and are knowledge-intensive (García et al., 2020).
As technology advanced, new low-cost drip irrigation (LCDI) systems with better field application efficiency than conventional drip systems have emerged. Practical deployments of LCDI in Nepal, India, USA proved that LCDI is more advantageous than conventional drip irrigation means in terms of long-term productivity and management cost savings(Von Westarp et al., 2004).
Further advances in sensors and the evolution of IoT and cloud computing technologies are heralding smarter LCDIs by adopting sensors in monitoring environmental parameters resulting in the reduction of water wastage by up to 95% (Pernapati, 2018), offering cheaper management costs by providing remote management of deployed LCDI systems, and precision agriculture.

1. Macro-Economic Factors affecting Irrigation Agriculture in Tanzania

Tanzania has abundant water resources, it is home to the greatest lakes in Africa; Lake Victoria, Lake Tanganyika, and Lake Nyasa. With relatively high, but seasonal rainfall. As an alternative solution for the seasonal rainfall and semi-desert vegetation, farmers turn to irrigation farming with water sourced from the Lakes, and as of 2017, 461,326 acres of land is irrigated.

The 2010 National Irrigation Policy (NIP) and National Irrigation Strategy (NIS) of 2015 of Tanzania hope to ensure sustainable irrigation for enhanced food production towards food security and poverty eradication. One of its specific objectives is to ensure irrigation development is technically feasible, economically viable, socially desirable, and environmentally friendly. The Ministry of Water and Irrigation expects that through the policy, schemes, and public-private partnership, the creation of the National Irrigation Commission (NIRC), and the

constitution of the National Irrigation Fund (NIF), the area of irrigated land in Tanzania would have increased to 1 million irrigated acres of land by 2020.

Tanzania's digital transformation is facilitated by Mobile technology. 82% of the population subscribes to a mobile service as per June 2020 report and mobile internet penetration has reached 49% of the total population. Presently, 3G coverage stands at 68%, 4G stands at 28%, while fibre 10,500KMs (August & Kowero, 2012).

2. IoT in Irrigation Agriculture?

The Internet of Things (IoT), Is a group of different forms of sensors interconnected together to allow their management, as well as the access to the data being generated by them. It employs to collect and send data over the internet. In agriculture, it has found uses in monitoring environmental parameters such as humidity, soil moisture, wind speed, precipitation, soil pH, temperature and others, providing farmers with the opportunity to observe, measure, and respond to inter and intra-field variability in crops.
In irrigation farming, the most relevant environmental parameters are soil moisture, the water level in reservoirs, temperature, and humidity. A low-priced, two-forked YL-69/38 sensor that provides soil moisture readings based on the conductivity between two electrodes placed in the soil is mostly used for measuring soil moisture. FC-28, S-XNQ-04, 200SS, SEN0114, all are all based on a similar principle with the YL-69/38. With different working principles, SM300 and VH400 are capable of measuring soil moisture and temperature. However, with YL-69/38 (García et al., 2020).

DHT11 and DHT12 are the most used humidity and temperature sensors while LM35 sensors (-40 to +125ºC) and THERM200 sensors (-40 to +85ºC) with an accuracy of +or-0.5 °C are commonly used to measure soil temperature. Irrigation systems that source water from rivers use solid-state relays to check water availability while the water level in reservoirs is measured by Ultrasonic based HC-SR04 sensors. Commonly deployed cloud services are AWS-IoT, Blink Cloud or Remote XY for remote operation of deployed IoTs such as actuators in the pumps, valves, and sprinklers of the irrigation. 3G communication technology is recommended in developing countries because of its wide deployment (García et al., 2020).

3. IoT-Based irrigation Agriculture Architecture.

System architectures are abstract system specifications consisting primarily of functional components described in terms of their behaviors and interfaces and component-component interconnections. Integration of different heterogeneous technologies; IoT, Data Analytics, Cloud Computing, and Fog Computing requires system architectures. The choice of architecture depends on the available technology, environment setting, budget, as well as expertise.

A PIC16F877A microcontroller was combined with a YL-69 soil moisture sensor and DS18B20 temperature sensor that all communicates via an RTC DS1307 sensor module was combined by (Gavali et al., 2018) and monitored via an android mobile application to monitor soil moisture and temperature, and control the water pump valves.

Price and power requirements were considered by (Gupta et al., 2017) in adopting Arduino UNO attached with soil pH and YL-69 moisture sensors and controlled by a python based analytics engine and messaging module to design an irrigation system that notifies farmers by message and automatically starts and stops the pump motors based on these readings.

In a rather knowledge-intensive architecture that requires LAN or WiFi to operate, (Kuruva & Sravani, 2016) deployed sensors (YL-69 soil moisture sensor, water level sensor, and DHT11 temperature and humidity sensor) connected through Arduino UNO for remote plant watering and monitoring system. Sensor data collected through the Arduino UNO is forwarded to a Raspberry Pi running Johnny-Fibre library and an AWS-IoT SDK and analyzed data is visualized from a Dynamo database presented to users from a Web application that also allows them to control the water pump.

(Zamora-Izquierdo et al., 2019) adopted a smart-farming architecture based on low-cost hardware and supported by three-tier open-source software platforms. At the local tier, Cyber-physical Systems also known as IoT are deployed to gather data and for actuators. The edge tier of the architecture is in charge of monitoring and managing the irrigation system, while the third tier, the cloud platform, adopts a FIWARE deployment to analyse past and current records. This architecture however requires an access network through microwave radio links, fibre optic, or DSL for interconnections.

3.0 METHODS

We reviewed works of literature on the subject matter and sourced information from secondary data; government white papers, acts, policies, publications, reports and compared the macro-economic conditions in Tanzania with that of two other countries. The Republic of Korea, a country that has implemented over 800,000 acres of smart irrigation in rice farms which in turn contributes to over 80% of the total rice production in the peninsula (*Statistics Korea*, n.d.), and Rwanda, an East African country who through the Smart Rwanda Strategy have implemented various smart irrigation systems (Bamurigire et al., n.d.). Figure 1 and 2 below presents smart architectures deployed in Korea and Rwanda respectively.

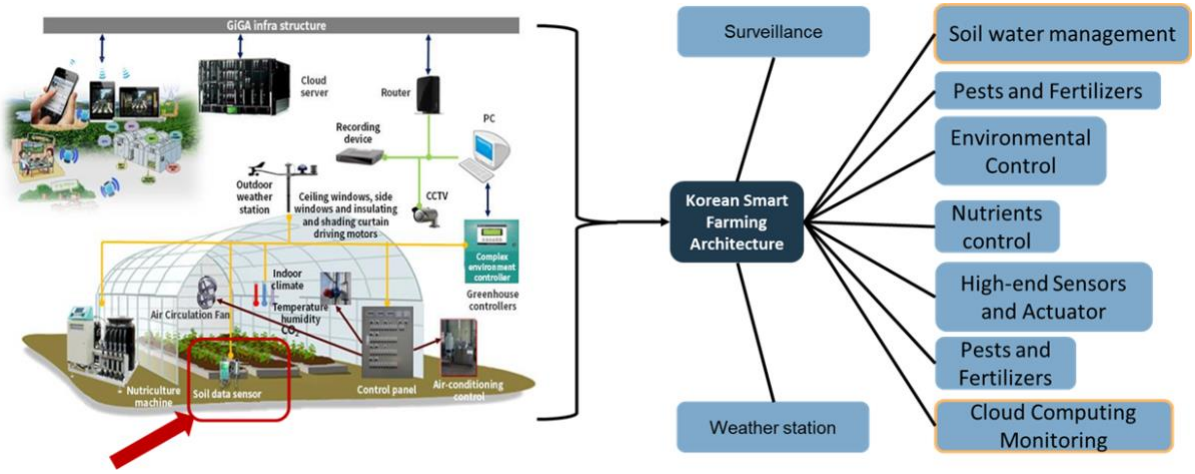


Figure 1: Popular smart farming/irrigation architecture in Korea. Source (*Smart Farm Dispersion Method*, n.d.)

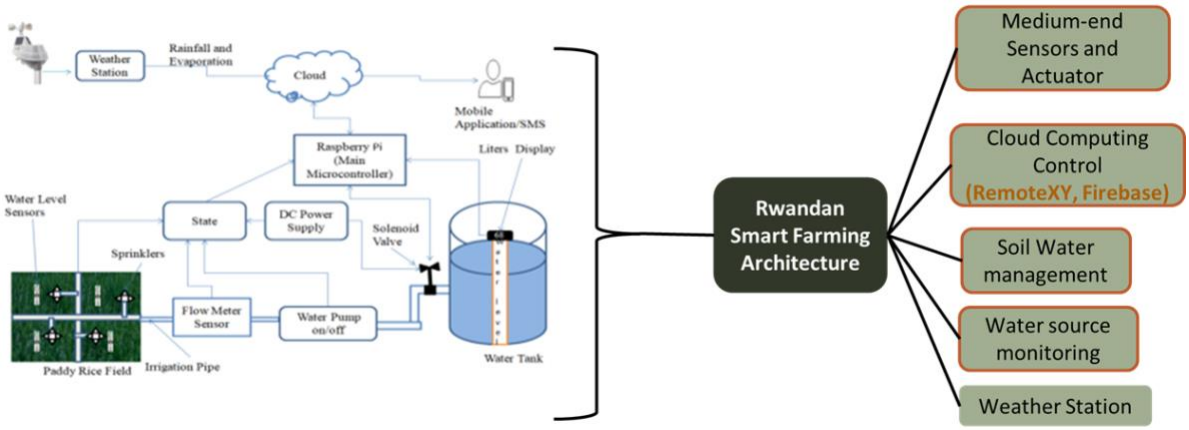


Figure 2: Smart Irrigation architecture deployed for a rice farm in Rwanda. Source (Bamurigire et al., n.d.)

Lessons learnt from the works of literature, secondary sources reviewed and the Gaps identified between Tanzania and the two countries benchmarked; Republic of Korea and Rwanda formed the pillar of our recommended architecture.

3. RESULTS

Comparative analysis of the situations in Tanzania, Rwanda, and the Republic of South Korea revealed the absence of Technology-based irrigation architecture that can be adopted easily by farmers in Tanzania. Therefore, to simplify and reduce the cost of smart irrigation adoption by farmers in Tanzania, the study proposed the following IoT sensors and Architecture

1. Proposed IoT Sensors and other Technologies

Table 1: proposed IoT Sensors for smart irrigation farming in Tanzania

SN	Sensor	Unit	Specification
1	Arduino Uno/Mega – IoT Agent	1 per farm	Tmega2560 Microcontroller, operating voltage of 5V and flash memory of 256KB. Its approximate cost is 35USD
2	DHT22 Sensor - Temp & Humidity Sensor	8 per acre	Operating voltage is between 3.3 – 6v, temperatures between -40 to 80ºC, and humidity 0 – 100% Relative Humidity. It costs about 10 USD for each DHT22 sensor
3	YL-38 Soil Moisture Sensor	40 per acre	Operating voltage is between 3.3 to 5 Volts. Each YL-38 sensor might cost around 12 USD
4	Ultrasonic sensor (Water level in a tank)	1 per water tank?	Operating voltage 5V, operating current 15mA, 2cm – 4m measuring range
5	SSR-40 DA Solid State Relay Actuator (remote water pump control)	4 per acre	24 – 380V operating voltage,
6	Raspberry Pi	1 per farm	8GB SDRAM, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz, 5V DC, PoE.

7	Cloud Database (Firebase)	Free	Open Source
8	RemoteXY – Remote Access Controller	(Free)	Open Source
9	Adapter (Node-red) - integration platform		development fragment framework

Source: compiled by author

2. Proposed Architecture

The conceptual framework assumes the farmer owns two farms with different water requirements and water sources/supply. Therefore, for each farm, as indicated in figure 1 below, individual IoT Agent (Arduino Uno) is required. This IoT agent will be responsible for monitoring and controlling all sensors connected to it.

YL-38 Soil moisture, Ultrasonic sensor, actuators, and DHT22 temperature and humidity sensors are connected to the Arduino Uno as indicated in the proposed architecture in figure 1, below. This IoT agent, which is also connected to the edge/fog, will be responsible for monitoring and controlling all sensors via internet.

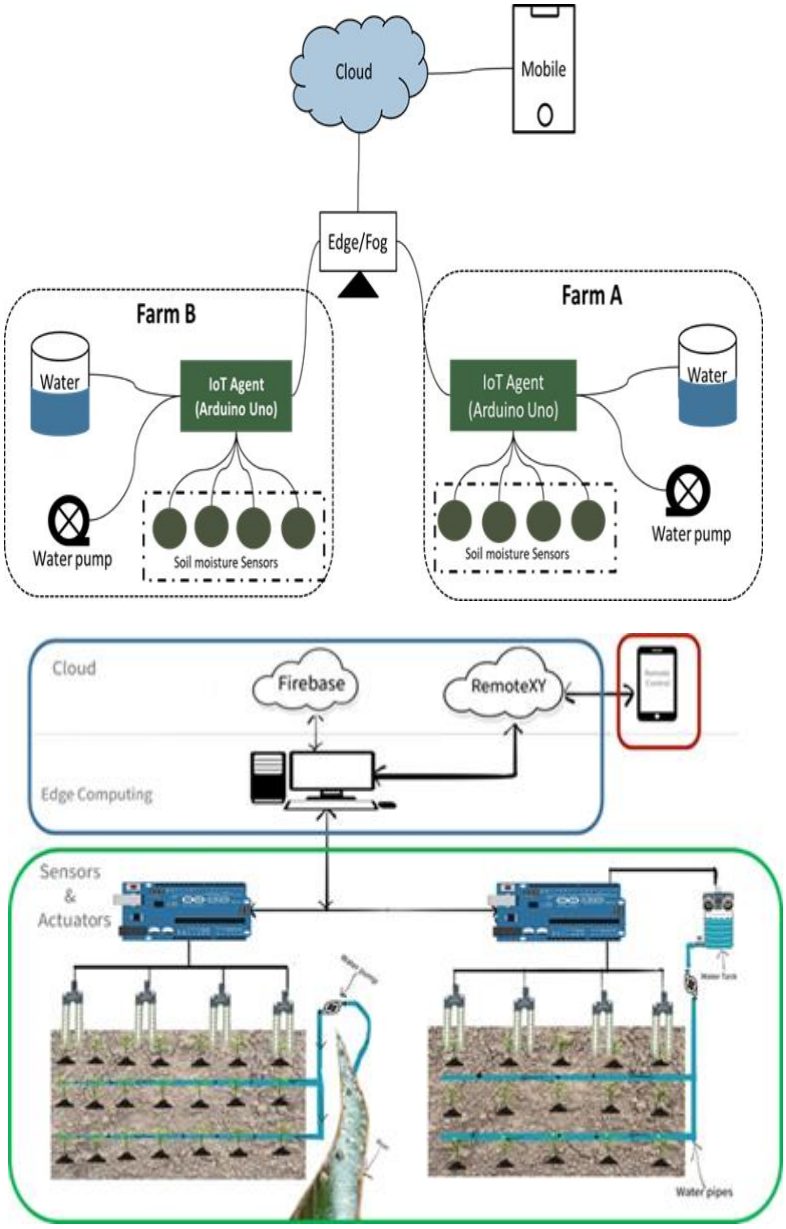


Figure 1. Proposed Conceptual Architecture for smart irrigation in Tanzania

Expected outcome/Benefit Analysis

Table 1. Estimated smart irrigation initial adoption cost per farm based on proposed architecture

SN	Item	Quantity	Unit Price (USD)	Total Price (USD)
1	Arduino Uno	1 per farm	35.00	35.00
2	SIM900 (GSM MODULE)	1 per acre	25.00	25.00
3	DHT22 SENSOR	8 per acre	10.00	80.00
4	YL-38 SENSOR	40 per acre	12.00	480.00
5	Ultrasonic Sensor	1 per water Tank	10.00	10.00
6	DA Solid State Relay	4 per acre	15.00	60.00
7	Water Valve	4 per acre	40.00	160.00

8	Raspberry Pi 4 B	1 per farm	250.00	250.00
9	Drip Pipes	per acre	1,009.67	1,009.67
10	Water Pump	1 per farm	300.00	300.00
11	Water Tank – 200liters	1 per farm	300.00	300.00
	Total (Smart Irrigation cost per farm)			**2,709.67**

Source: compiled by author based on market survey

Table 2. Estimated yearly management cost comparison between traditional and proposed irrigation system

		Traditional Drip Systems	Proposed Smart irrigation System
SN	Item	Price (USD)	Price (USD)
1	Labor Cost	5,400.00	0.00
2	Power Cost	900.00	300.00
3	Internet (20GB)	0.00	290.20
Total		**6,300.00**	**590.20**

Source: compiled by author based on market survey

3. Quantitative analysis of proposed Architecture.

On IoT-based smart irrigation projects with farm size ranging from one to 20 acres, (Nawandar & Satpute, 2019; Sales et al., 2015; Tiusanen, n.d.) achieved water savings varying between 20% and 70%. On similar projects between 0.5 to 15 Acres, (González Perea et al., 2018; Newman, 2012; USBR, 2008) achieved management cost savings of between 25% and 80%. The proposed architecture, with adoption cost of USD2,709.67 offers a 90.63% reduction in management cost when compared to traditional irrigation methods, and an estimated 30 – 50% water loss savings.

4. DISCUSSION

This study is proposing the adoption of IoT in improving irrigation systems in Tanzania. The study proposed an IoT-based irrigation architecture that considerably reduces the initial cost of adoption and management cost for traditional drip irrigation methods will promote personal and national socioeconomic development. A smarter and more efficient use of available water resources will ensure universal and equitable access to safe and affordable drinking water and food security by increasing yield and making all-year-round farming a possibility for Tanzanian farmers.

Although quantitative analysis of the proposed architecture estimates 30-50% water loss savings and, 90.63% management cost savings, A field evaluation of the proposed architecture has not been executed.

5. CONCLUSION

Agriculture plays a major role in the socioeconomic status of Tanzania. It employs 60% of its total workforce and contributes between 25 to 30% to the National GDP every year. However, farmers in Tanzania face several challenges, one of which is the seasonal dependence agriculture, stemming from unstable rainfalls, making it difficult to obtain water for crops. Due to abundant water bodies around the country, farmers are adopting

alternatives such as irrigation farming. However, Adoption and Management cost of such systems are high. In addition, human errors and drawbacks of some irrigation systems can lead to over-irrigation or under irrigation and possibly water loss.

This study proposed an IoT and Cloud based smart irrigation architecture that adopts various low-cost IoT sensors and cloud technology to provide a need-based automated irrigation of farm that is low-cost, and significantly reduces management cost when compared to the traditional irrigation systems.

The limitations of this study includes, most of the data gathered and used in this report are secondary data. The report lacks primary data in making recommendations, which makes a little bit gap between the situation presented and the reality. Furthermore, the cost suggested is based on online marks, which may be slightly higher or lower than the actual cost. The cost analysis should be done in detail by the suppliers of the technologies to determine the actual cost before committing the implementation budget.

AUTHOR CONTRIBUTIONS

Emmanuel Fredy Mwakasege sourced all secondary data that was used in the paper, designed, and carried out the quantitative assessment of the proposed architecture.

ACKNOWLEDGEMENT

This study was supported by the Information and Telecommunication Technology Program at the Korea Advanced Institute of Science and Technology through scholarships made available by the Korean Government and the African Development Bank.

REFERENCES

1. Amani, P. H. K. R. (2006). *AGRICULTURAL DEVELOPMENT AND FOOD SECURITY IN SUB-SAHARAN AFRICA (SSA) Building a Case for more Public Support The Case of Tanzania A Paper Prepared for the Policy Assistance Unit of the FAO Subregional Office for East and Southern Africa*.
2. August, E., & Kowero, B. (2012). *Tanzania Country Level Knowledge Network Exploiting the Potentials of the National Information and Communication Technology Broadband Backbone (NICTBB) in Tanzania. A Study Report*. www.clknet.or.tz
3. Bamurigire, P., Vodacek, A., Valko, A., Said, S. B., Ngoga, R., & Ngoga, S. R. (n.d.). *Simulation of Internet of Things Water Management for Efficient Simulation of Internet of Things Water Management for Efficient Rice Irrigation in Rwanda Rice Irrigation in Rwanda Simulation of Internet of Things Water Management for Efficient Rice Irrigation in Rwanda*. https://doi.org/10.3390/agriculture10100431
4. C Brouwer, K Prins, & M Heibloem. (n.d.). Annex I: Irrigation efficiencies. In *Irrigation Water Management: Irrigation Scheduling: Vol. Training Manual* (4th ed.). Food and Agriculture Organisation of the United Nations. Retrieved July 10, 2021, from http://www.fao.org/3/t7202e/t7202e08.htm#TopOfPage
5. García, L., Parra, L., Jimenez, J. M., Lloret, J., & Lorenz, P. (2020). IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture. *Sensors 2020, Vol. 20, Page 1042*, *20*(4), 1042. https://doi.org/10.3390/S20041042

6. Gavali, M. ., Dhus, B. J., & Vitekar, A. . (2018). A Smart Irrigation System for Agriculture Base on Wireless Sensors. International Journal of Innovative Research in Science, Engineering and Technology, 5, Issue 5. - References - Scientific Research Publishing. *Open Access Library Journal*, *5*(4). https://www.scirp.org/(S(czeh2tfqyw2orz553k1w0r45))/reference/ReferencesPapers.aspx?ReferenceID=2250608
7. Global Hunger Index. (2021). *Global Hunger Index Scores by 2020 GHI Rank - Global Hunger Index (GHI) - peer-reviewed annual publication designed to comprehensively measure and track hunger at the global, regional, and country levels*. Https://Www.Globalhungerindex.Org/. https://www.globalhungerindex.org/ranking.html
8. González Perea, R., Camacho Poyato, E., Montesinos, P., & Rodríguez Díaz, J. A. (2018). Prediction of applied irrigation depths at farm level using artificial intelligence techniques. *Agricultural Water Management*, *206*, 229–240. https://doi.org/10.1016/J.AGWAT.2018.05.019
9. Gupta, H., Pareek, V., & Mishra, R. (2017). Automated Precision Farming using Internet of Things. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, *6*(5), 2278–1323. www.ijarcet.org
10. Kimaro, J. (2019). A Review on Managing Agroecosystems for Improved Water Use Efficiency in the Face of Changing Climate in Tanzania. *Advances in Meteorology*, *2019*. https://doi.org/10.1155/2019/9178136
11. Kuruva, H., & Sravani, B. (2016). REMOTE PLANT WATERING AND MONITORING SYSTEM BASED ON IoT. *International Journal For Technological Research In Engineering*, *4*(4). www.ijtre.com
12. Nawandar, N. K., & Satpute, V. R. (2019). IoT based low cost and intelligent module for smart irrigation system. *Computers and Electronics in Agriculture*, *162*, 979–990. https://doi.org/10.1016/J.COMPAG.2019.05.027
13. Newman, J. (2012). *Smart Irrigation Systems, Rainwater Collection Are Cost-Effective - Facilities Management Insights*. Facilitiesnet.Com. https://www.facilitiesnet.com/green/article/Smart-Irrigation-Systems-Rainwater-Collection-Are-Cost-Effective--13436
14. Pernapati, K. (2018). IoT Based Low Cost Smart Irrigation System. *Proceedings of the International Conference on Inventive Communication and Computational Technologies, ICICCT 2018*, 1312–1315. https://doi.org/10.1109/ICICCT.2018.8473292
15. Sales, N., Remedios, O., & Arsenio, A. (2015). Wireless sensor and actuator system for smart irrigation on the cloud. *IEEE World Forum on Internet of Things, WF-IoT 2015 - Proceedings*, 693–698. https://doi.org/10.1109/WF-IOT.2015.7389138
16. *Smart Farm Dispersion Method*. (n.d.). Retrieved July 27, 2021, from https://www.mafra.go.kr/english/1406/subview.do
17. *Statistics Korea*. (n.d.). Retrieved July 14, 2021, from http://kostat.go.kr/portal/eng/index.action
18. Tiusanen, J. (n.d.). *How Can Farmers Reduce Center Pivot Irrigation Costs by 50%*. Www.Soilscout.Com. Retrieved July 27, 2021, from https://soilscout.com/blog/how-can-farmers-reduce-center-pivot-irrigation-costs
19. USBR. (2008). *Summary of Smart Controller Water Savings Studies: Literature Review of Water Savings for Weather and Soil Moisture Based Landscape Irrigation Control Devices. Final Technical Memorandum No 86-68210-SCAO-01*. *86*. http://www.usbr.gov/waterconservation/docs/WaterSavingsRpt.pdf

20. Von Westarp, S., Chieng, S., & Schreier, H. (2004). A comparison between low-cost drip irrigation, conventional drip irrigation, and hand watering in Nepal. *Agricultural Water Management*, *64*(2), 143–160. https://doi.org/10.1016/S0378-3774(03)00206-3
21. World Bank. (2019). Climate-smart agriculture (CSA) in Tanzania. *Climate Knowledge Portal*.
22. worldometer. (2021). *Population of Africa (2021) - Worldometer*. Worldometer.Com. https://www.worldometers.info/world-population/africa-population/
23. Zamora-Izquierdo, M. A., Santa, J., Martínez, J. A., Martínez, V., & Skarmeta, A. F. (2019). Smart farming IoT platform based on edge and cloud computing. *Biosystems Engineering*, *177*, 4–17. https://doi.org/10.1016/J.BIOSYSTEMSENG.2018.10.014

DIGITAL TRANSFORMATION OF FINANCIAL INSTITUTIONS AND ITS IMPACT ON THEIR PROFITABILITY

Ranjan Kumar[1], Maheshwor Shrestha[1], Yuosre F. Badir[1*]

[1] School of Management, Asian Institute of Technology, Pathum Thani, Thailand

ABSTRACT

Digital transformation is helping financial institutions, like banks, reduce their operating cost, increase profit by targeting prospective customers, and make better business decisions. Digitization can be a significant long-term cost-cutting strategy for banks, especially in the field of financial industry digitalization. Nowadays, there is more digital literacy among the customers, which sets the right pitch for the banking sector to go ahead and embrace digital transformation. During the COVID-19 pandemic, there was a sense of urgency to accomplish digital transformation goals, which prompted many banks to accelerate their transformation efforts. While banks are adopting digital solutions rapidly, the profitability of such endeavors has been questioned. Despite its importance, to date, very limited studies have explored this issue. This study focuses on analyzing the last decade's data provided by the Bank of Thailand (BOT) and examines how the banks' adoption of digital technologies help them to achieve operating cost optimization and financial profitability. In addition, going digital has added new revenue streams for the banks in terms of integrating the utility services. Firms can capitalize on massive consumer behavior data collected through digital touchpoints. Having those data analyzed gives greater insights that are useful for future business decisions and may lead to sustainability and resilience.

Keywords: Digital transformation; profitability; operating cost; resilience; banking industry

1. INTRODUCTION

Digital Transformation (DT) is the process of integrating various technologies into all aspects of a business, significantly transforming how organizations function and deliver value to customers [1,8,11]. The traditional consumer-business relationship is being reshaped by digitalization [34]. It's also a cultural shift [10] that entails firms challenging the existing status quo, innovating, and becoming comfortable with uncertainties. From small enterprises to large corporations, DT is essential in this digital era [21]. DT is enriching the end-user experience, transforming business processes and better-utilizing data [16]. Furthermore, the digital revolution is dramatically transforming business circumstances, and the financial services industry is no exception. With the increasing percentage of digital and financial literacy among the people in countries like Thailand [28], DT has broadened the business horizons for the banks and other firms to reach more customers easily and effectively with almost little or no marginal cost [23].

During the COVID-19 pandemic, there was a sense of urgency to accomplish DT goals, which prompted many firms to accelerate their transformation efforts [16,17]. The banking industry, like other businesses, attempts to

embrace new processes and integrate digital technologies into its daily operations [8]. Digital transformation in this sense refers to a series of changes made in the banking industry to integrate various fintech technologies in order to optimize, automate and digitize processes while also increasing data security. Digital banking development will lead to greater economic openness, a reduction in the shadow economy, and an increase in tax collections, job creation, and GDP [1].

The majority of the existing literature has focused on the implementation of digital technology in large organizations [9], especially high-tech giants, as well as in digital startups [12], whereas research concentrating on DT and financial profitability in banks, or the financial sector are relatively scarce. Nonetheless, the banks and financial firms are regarded as innovative and serve as the foundation for economic growth in all countries world-wide. In the recent years, banks have paid attention to their DT drive and continuously invested in achieving digital capabilities to deliver seamless services to their customers while optimizing their operating costs. Thus, this study establishes a relationship between DT and financial profitability in the banking industry. Specifically, relying on evidence from financial data made available by the Bank of Thailand (BOT), the objective of this article is to explore the relation between DT and financial profitability in banks, especially in developing countries like Thailand.

We provide a conceptual model that demonstrates why DT favorably affects operating costs, revenues, and banks' profitability. Then, to evaluate this conceptual model, we employ longitudinal archival data from a large sample of more than 20 Thai banks. Our findings indicate that DT has a major impact on banks' financial profitability. Specifically, we discovered that DT has a stronger influence on business profitability due to increased revenue and lower operational costs [23].

The rest of this article is structured as follows. Next, to explain our hypotheses, we present a theoretical foundation. Then we will go into our research methodology followed by the findings of our study. Finally, the discussion section is followed by the conclusion.

2. Hypotheses Development

As stated earlier, the goal of this study is to examine the relationship between digital transformation and financial profitability in banking industry. We argue that the effect of DT on FP is mediated by the both the bank's revenue and operating expenses. The article' conceptual model is shown in Figure 1.

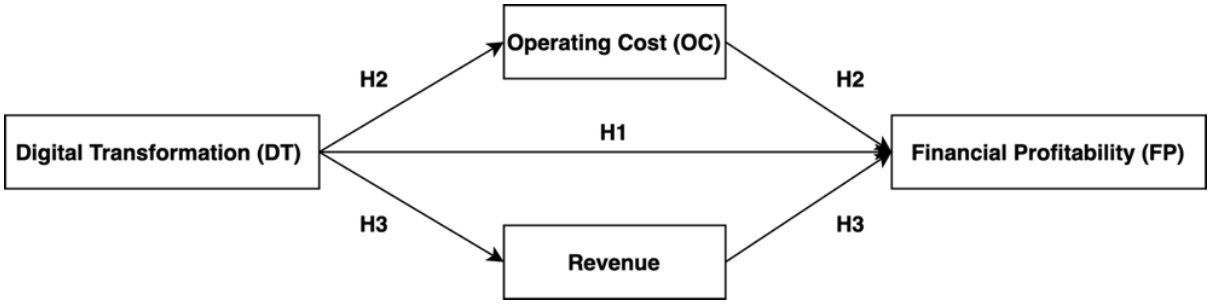


Figure 1. Conceptual Model

2.1. Digital Transformation

Digital Transformation (DT) is all about becoming a digital enterprise, a firm that leverages technology to improve all parts of its business models such as what it offers, how it operates and how it interacts with customers on a constant basis [10,11]. Digital transformation does not happen by chance. Instead, it demands a significant investment across the board because the disruptive potential of change, particularly at later phases of digital transformation, extends beyond technologies. It refers to a paradigm shift in how technologies are adopted and used, both at an individual and organizational level [14]. It is about value, people, optimization, and the ability to quickly react, when necessary, through the intelligent application of technology and data. According to [27] large institutions may use digital technology to fulfill a variety of goals, including meeting stakeholder expectations, simplifying procedures, innovating, reaping benefits, preparing for risks and threats, and improving business models.

Digitalization is fast transforming people's day-to-day living styles, due to the advancement of technology. Organizational design, employment processes, and personnel management have all been changed as a result of adopting DT. The digital revolution is transforming the business landscape, and the banking industry is no exception [8]. Transformation is likely to be variable for organizations and depends partly on the maturity level in technology adoption [27]. Due to progressive economic reforms and quick technological advancements, the banking sector has been undergoing rapid transition in this digital era. Banks offer end-to-end services efficiently to their customers via digital platforms such as mobile phones, tablets, and the internet. Banks offer contactless, branchless, signature-free services, as well as 24-hour banking, allowing consumers to access their accounts and make financial transactions even on holidays [22]. New job opportunities have been created in the banks' workforce due to the digital transformation.

2.2. Bank's Financial Profitability

Profitability is the ultimate bottom-line of the business which determines if business can continue to exist or cease. Measuring and projecting it is of paramount importance. Almost any internal or external change to the business is checked against profitability [31] to ensure that business can continue as it is, or adjustments are necessary. While measuring the profitability, which metric is the most suitable is another area of concern. Scholars [24] suggested that the "gross profit" to be better than various other measures like - dividends, net income, and cash flows. "Operating Profitability" has been claimed to display an even stronger link with expected return which is nearer to the concept of profitability [5]. Studies have used various other financial metrics as profitability measures like - total assets, total sales, pre-tax profits, operating expenses, profit margin, return on assets, return on equity, cost to income etc. Other Authors [26], used an advanced measure of profitability based on Data Envelopment Analysis (DEA) in their studies.

2.3. Financial Profitability of Digital Transformation

Digital Technologies hits five out of Forbes's top six industries to invest in 2021. Authors [13], claimed that globally the banking sector spent higher than many other businesses. While the spending on digital transformation is undisputed, their financial returns are not so clear. Information Technology (IT) productivity paradox has been long discussed in literature [2,7,18] several times from different angles. Though the consensus has been growing on Digital Transformation's positive performance effect [3,4] on business, very little studies have analyzed the

effect on a firm's financial profitability (FP). DT can influence the financial profitability because it allows businesses to create new marketing and sales channels to raise awareness of their product/service offerings among current customers and attract new ones [23].

Hence, it is assumed that:

H1. Digital Transformation has positive impact on Financial Profitability.

2.4. **Mediating** Role of the Bank's Operating Cost

Previous study [19] examined the revenue models that were employed by the online firms who traded in digital goods. While the firms fear IT as a cost center, digital goods almost have low cost of transactions, zero marginal expense of production and distribution, inexpensive marketing, and cheaper management. DT reduces cost with IoT, and automation supported by intelligent data analytics [6]. Cost of the service industry is also controlled as the single infrastructure can serve many clients and the labor force can be saved to utilize on other productive work. Transaction cost has gone down due to this; bringing the operation cost to negligible amounts which used to be expensive before [30]. Operating expenses include all the non-capital expenditures spent during the process of revenue generation.

Moreover, there are many reasons for operating costs to be decreased for the banks which adopted the DT. Most customers go to the bank's service branch to deposit the money, withdraw the money, pay the utility bills, and borrow the loans. Banks with the huge presence of digital channels observed that footfall for the customers decreased heavily in the service branches as most of the services could be delivered to the customers using Mobile Apps, Internet Banking, Cash Deposit Machines (CDS), Automated Teller Machine (ATM) and self-service Kiosks for paying the utility bills and as a result bank started closing their service branches in the area where their presence was very dense. There is a huge cost involved in making a branch operational such as the property rent, electricity bills, human resources, salary and other employee compensation and benefits. Therefore, the closing of the branches will decrease expenses.

Thus, the following is stated:

H2. The Operating Cost mediates the relationship between Digital Transformation and Financial Profitability;

i.e., DT lowers the operating cost and this, in turn, increases FP.

2.5. Mediating Role of the Bank's Revenues

The digital change has challenged the traditional sources of revenue but opened up avenues for different forms and channels of revenue [20]. The intention is to replace or enhance revenue streams for increased revenue [33]. There are other different examples of revenue enhancement brought by the digital transformation - marketing digitally to reach actual buyers and derive revenue from them [15], diversifying the business [29], value co-creating with partners [20] etc. These revenues can be measured from the income statement of the firms.

Moreover, we argue that DT facilitates revenue growth by introducing new value propositions, new marketing and sales channels, and improved customer life cycle management [23]. Without spending much, banks are providing numerous services through their digital channels like booking of movie tickets, selling insurance products, paying third party credit card bills or utility bills. In return, banks get hefty commissions from those third parties, which ultimately adds up to their revenue [1,25]. Having looked at the different new sources of the

revenue through the digital channels with lower operating cost, we may argue that it will increase the financial profitability.

Therefore, it is proposed that:

H3. The Revenue mediates the relationship between Digital Transformation and Financial Profitability; i.e., DT increases revenues, and this, in turn, increases the FP.

3. METHODS

Based on the hypotheses mentioned above, empirical research was conducted on the last ten years (2011-2020) of banking data available on the Bank of Thailand BOT website, such as the number of branches of all the banks, the total transactions made through the digital channels such as mobile and Internet banking, earning and expenses of the banks. In the last five years, most of the banks in Thailand embraced and implemented DT, in their internal process and customer-facing products. All the relevant financial data were analyzed to get insight into how DT influences the revenue, operating cost, and profitability in the banking industry.

In this study, DT has been operationalized as the degree of the services delivered through digital channels. In that respect, metrics like the value and volume of online transactions have been used to measure the DT. Gross profit has been used as a metric to approximate FP as suggested in different studies [5,32]. Total expenses are measured as operating costs (OC), whereas revenue is measured as total income.

4. RESULTS

While doing the data analysis, we observed a significant statistical relationship between banks' FP to their DT. Linear regression was conducted on the data to establish this relationship. In (Table 1), we observed that FP is related to Revenue, OC, and DT.

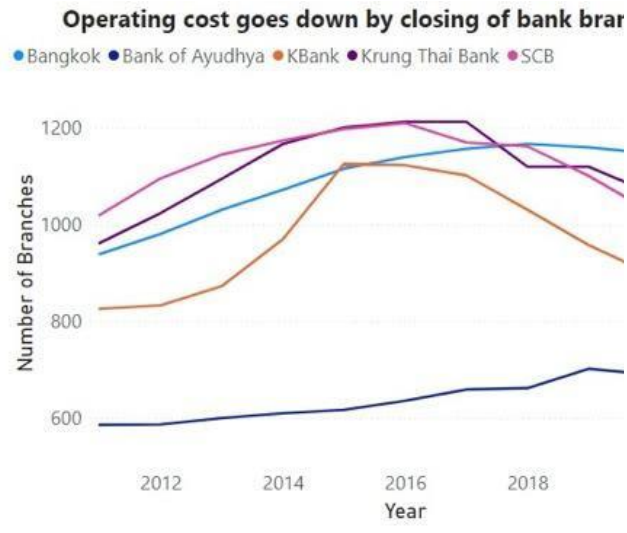


Figure 2. Operating costs goes down by closing of branches

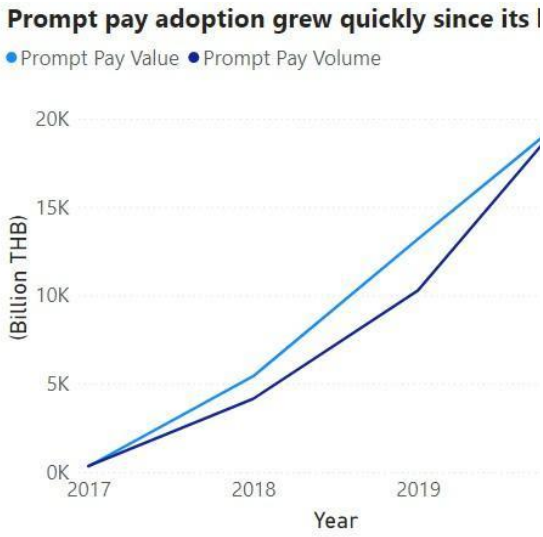


Figure 3. Prompt pay transactions (value & volume)

Table 1. Linear Regression Results (Financial Profitability)

	Coefficients	*Std. Error*	*P-value*
(Constant)	16,131.69334	2,915.569967	0.000003
Total Income	0.14302	0.025907	0.000003
Total Expenses	0.10407	0.039512	0.012487
e-Payments	0.00270	0.001032	0.013030

A similar statistical analysis was conducted to measure the impact of banks' DT on OC and Revenue. In (Table 2) and (Table 3), the results of the linear regression of banks' DT between OC and Revenue have been shown, respectively. Both financial entities are significantly dependent on banks' DT.

Table 2. Linear Regression Results (Operating Cost and Digital Transformation)

	Coefficients	*Std. Error*	*P-value*
(Constant)	141966.35419	3404.64447	0.00001
e-Payments	0.01499	0.00659	0.02865

Table 3. Linear Regression Results (Revenue and Digital Transformation)

	Coefficients	*Std. Error*	*P-value*
(Constant)	223671.39914	5653.92642	0.00001
e-Payments	0.03897	0.01095	0.00102

5. DISCUSSION

The study examined the impact of DT on FP and how that impact is mediated through revenue growth and lower operational costs in the banking sector in the emerging market, Thailand. We observed DT's influence on revenue growth is positive, whereas it lowers the operating expenses. Our empirical analysis shows that the top 5 banks have closed around 20% of their service branches, as shown in (Figure 2) over the last five years, although the customer base has increased manifolds in the last few years. Furthermore, the closing of the branches has helped banks reduce their operating cost and increase their revenue. With fewer branches, banks serve more customers than they had ten years before and deliver more quality services than ever. Our analysis also shows that people have availed banking services through digital channels for transferring and receiving money irrespective of the value of the transactions.

Next, prompt-pay was introduced in Thailand in 2017, which is another way to transfer money from one account to another account using mobile numbers. As shown in (Figure 3), data shows that there was a 6,000% of growth in its usage in the last three years. Hence, ease of use, improved accessibility are the biggest advantages of DT for the customers and banks [1]. Providing the services through the digital channel has almost no marginal cost [19]. However, serving an additional customer through a human resource need lots of extra costs, which is obvious.

Similar study done by scholars [23], suggests that DT is positively associated with profitability, and it creates further opportunities for value creation. Our study focused on the banking sector in Thailand validated the prior studies done in another context, which is in line with previous findings. We have the empirical evidence that DT has a positive impact on banks' FP in mediating the role of OC and revenue, which fills the research gap and answers whether DT leads to profitability [31].

Our study shows that DT helps banks lower their operating cost and expenses and provides more opportunities to earn more revenues than before from different new sources of income and, in return, increases the total revenue. Furthermore, lower operational costs and higher revenues lead to financial profitability, which is proved empirically in our study. The practical implication is that managers should consider DT initiatives to harvest better profitability as it contributes to revenue and slashes expenses.

In summary, DT has enabled banks to dispense 24X7 banking services to their customers conveniently and smoothly at minimum cost. On the other hand, DT empowered the customers to avail themselves the banking services in their comfort. Using more and more digital channels for banking services positively impacts the country's economy as these transactions are easily accountable and come under the tax system. However, some study limitations should be acknowledged. This current study is confined to the banking sector in Thailand to explore the DT and its influence on FP. Some more constructs could be added to the conceptual model, like the Environmental Turbulence, to measure its effect on DT and FP. In future, other researchers can take this study forward and validate the conceptual model presented in (Figure 1) in other industries or other countries.

6. CONCLUSION

In this study we explored the effect of DT on FP and found that it has a positive influence on it. Furthermore, this study confirms that DT helps firms reduce their operating cost and serving an extra customer has almost zero marginal cost which in turn increases the revenue. This has been empirically validated in the banking sector of Thailand using the statistical data provided by BOT. This study asserts the positive association of DT with a firm's productivity shown in the previous research. The theoretical contribution of this study is that it added empirical evidence by establishing the positive effect of DT on banks' profitability. Furthermore, the practical contribution of this study is that firms should speed up their DT drive if they want to be competitive and sustainable in the longer run.

AUTHOR CONTRIBUTIONS

Ranjan Kumar and Maheshwor Shrestha designed the conceptual model, performed the statistical analysis, and wrote the manuscript. Dr. Yuosre F. Badir conceived the study and was in charge of overall direction and planning.

ACKNOWLEDGEMENT

The authors would like to thank the BOT for making the extensive financial data available monthly, quarterly, semi-annual, and annual basis on their website. Financial data for all the banks for expenses, net profit, transactions via different channels helped to analyze and conclude the study. The authors would also like to thank the School of Management, Asian Institute of Technology, Thailand for providing the research environment, resources, and support to complete this study.

REFERENCES

1. Abbasov, A. M., Mamedov, Z. F., & Aliev, S. A. (2019). Digitalization of the banking sector: new challenges and prospects. *Economics and Management*, *6*, 81–89.
2. Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., & Price, B. (2014). Return of the solow paradox? It, productivity, and employment in US manufacturing. *American Economic Review*, *104*(5), 394–399. https://doi.org/10.1257/aer.104.5.394
3. Aral, S., Brynjolfsson, E., & Van Alstyne, M. (2007). *Information, Technology and Information Worker Productivity: Task Level Evidence*. https://doi.org/10.3386/w13172
4. Aral, S., Brynjolfsson, E., & Wu, L. (2012). Three-Way Complementarities: Performance Pay, Human Resource Analytics, and Information Technology. *Management Science*, *58*(5), 913–931. https://doi.org/10.1287/mnsc.1110.1460
5. Ball, R., Gerakos, J., Linnainmaa, J. T., & Nikolaev, V. V. (2015). Deflating profitability. *Journal of Financial Economics*, *117*(2), 225–248. https://doi.org/10.1016/j.jfineco.2015.02.004
6. Berge, J. (2018). Digital transformation and IIoT for Oil and gas production. *Proceedings of the Annual Offshore Technology Conference*, *2*(May), 1204–1213. https://doi.org/10.4043/28643-ms
7. Bloom, N., Sadun, R., & Reenen, J. Van. (2012). Americans Do IT Better: US Multinationals and the Productivity Miracle. *American Economic Review*, *102*(1), 167–201. https://doi.org/10.1257/aer.102.1.167
8. Carbó-Valverde, S. (2017). The impact on digitalization on banking and financial stability. *Journal of Financial Management, Markets and Institutions*, *1*, 133–140.
9. Cenamor, J., Parida, V., & Wincent, J. (2019). How entrepreneurial SMEs compete through digital platforms: The roles of digital platform capability, network capability and ambidexterity. *Journal of Business Research*, *100*, 196–206. https://doi.org/10.1016/j.jbusres.2019.03.035
10. Deja, M., Rak, D., & Bell, B. (2021). Digital transformation readiness: perspectives on academia and library outcomes in information literacy. *Journal of Academic Librarianship*, *47*(5). https://doi.org/10.1016/j.acalib.2021.102403
11. Ebert, C., & Duarte, C. H. C. (2018). Digital Transformation. *IEEE Softw.*, *35*(4), 16–21.
12. Ghezzi, A., & Cavallo, A. (2020). Agile Business Model Innovation in Digital Entrepreneurship: Lean Startup Approaches. *Journal of Business Research*, *110*, 519–537. https://doi.org/10.1016/j.jbusres.2018.06.013
13. Gopalan, S., Jain, G., Kalani, G., & Tan, J. (2012). Breakthrough IT banking. *McKinsey Quarterly*, *26*(2), 30–35. https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/breakthrough-it-banking
14. Halpern, N., Mwesiumo, D., Suau-Sanchez, P., Budd, T., & Bråthen, S. (2021). Ready for digital transformation? The effect of organisational readiness, innovation, airport size and ownership on digital change at airports. *Journal of Air Transport Management*, *90*. https://doi.org/10.1016/j.jairtraman.2020.101949
15. Hess, T., Benlian, A., Matt, C., & Wiesböck, F. (2016). Options for formulating a digital transformation strategy. *MIS Quarterly Executive*, *15*(2), 123–139. https://doi.org/10.4324/9780429286797-7

16. Hora V, Chutijirawong N, Bunsupaporn K, Satityathiwat S, & Bunyalug C. (2020). *The Thailand Digital Transformation Survey Report 2020*. https://www2.deloitte.com/content/dam/Deloitte/th/Documents/technology/th-tech-the-thailand-digital-transformation-report.pdf
17. Hussain, Z. (2021). Paradigm of technological convergence and digital transformation: The challenges of CH sectors in the global COVID-19 pandemic and commencing resilience-based structure for the post-COVID-19 era. *Digital Applications in Archaeology and Cultural Heritage*, *21*. https://doi.org/10.1016/j.daach.2021.e00182
18. Jones, S. S., Heaton, P. S., Rudin, R. S., & Schneider, E. C. (2012). Unraveling the IT Productivity Paradox — Lessons for Health Care. *New England Journal of Medicine*, *366*(24), 2243–2245. https://doi.org/10.1056/nejmp1204980
19. Lambrecht, A., Goldfarb, A., Bonatti, A., Ghose, A., Goldstein, D. G., Lewis, R., Rao, A., Sahni, N., & Yao, S. (2014). How do firms make money selling digital goods online? *Marketing Letters*, *25*(3), 331–341. https://doi.org/10.1007/s11002-014-9310-5
20. Malar, D. A., Arvidsson, V., & Holmstrom, J. (2019). Digital Transformation in Banking: Exploring Value Co-Creation in Online Banking Services in India. *Journal of Global Information Technology Management*, *22*(1), 7–24. https://doi.org/10.1080/1097198X.2019.1567216
21. Matarazzo, M., Penco, L., Profumo, G., & Quaglia, R. (2021). Digital transformation and customer value creation in Made in Italy SMEs: A dynamic capabilities perspective. *Journal of Business Research*, *123*, 642–656. https://doi.org/10.1016/j.jbusres.2020.10.033
22. Meena, M. M. R., & Parimalarani, G. (2020). Impact of Digital Transformation on Employment in Banking Sector. *International Journal of Scientific & Technology Research*, *9*, 4912–4916.
23. Mithas, S., Tafti, A., Bardhan, I., & Goh, J. M. (2012). Information technology and firm profitability:Mechanisms and empirical evidence. *MIS Quarterly: Management Information Systems*, *36*(1), 205–224. https://doi.org/10.2307/41410414
24. Novy-Marx, R. (2013). The other side of value: The gross profitability premium. In *Journal of Financial Economics* (Vol. 108, Issue 1, pp. 1–28). https://doi.org/10.1016/j.jfineco.2013.01.003
25. Olweny, T., & Mamba, T. (2011). Effects of Banking Sectoral Factors on the Profitability of Commercial Banks in Kenya. *Economics and Finance Review*, *1*(5), 1–30. http://wwww.businessjournalz.org/efr
26. Oral, M., & Yolalan, R. (1990). An empirical study on measuring operating efficiency and profitability of bank branches. *European Journal of Operational Research*, *46*(3), 282–294. https://doi.org/10.1016/0377-2217(90)90002-S
27. Pramanik, H. S., Kirtania, M., & Pani, A. K. (2019). Essence of digital transformation—Manifestations at large financial institutions from North America. *Future Generation Computer Systems*, *95*, 323–343. https://doi.org/10.1016/j.future.2018.12.003
28. Ratanabanchuen, R. (2021). *Understanding the dynamic of digital economy in the context of digital literacy of Thai households*. Puey Ungphakorn Institute for Economic Research.
29. Sayabek, Z., Oleg Litvishko, Dubrova, M., Smagulova, G., & Suyunchaliyeva, M. (2019). Diversification tourism in the conditions of the digitalization. *International Journal of Civil Engineering and Technology*, *10*(February), 1055–1070.

30. Schmidt, C. G., & Wagner, S. M. (2019). Blockchain and supply chain relations: A transaction cost theory perspective. In *Journal of Purchasing and Supply Management* (Vol. 25, Issue 4). https://doi.org/10.1016/j.pursup.2019.100552
31. Scott, S. V., Van Reenen, J., & Zachariadis, M. (2017). The long-term effect of digital innovation on bank performance: An empirical study of SWIFT adoption in financial services. *Research Policy*, *46*(5), 984–1004. https://doi.org/10.1016/j.respol.2017.03.010
32. Singh, A., & Harmon, G. (2003). Measuring profitability impacts of information technology: Use of risk adjusted measures. *Proceedings of the ASIST Annual Meeting*, *40*, 95–100. https://doi.org/10.1002/meet.1450400112
33. Sundaram, R., Sharma, R., & Shakya, A. (2020). Digital transformation of business models: A systematic review of impact on revenue and supply chain. *International Journal of Management*, *11*(5), 9–21. https://doi.org/10.34218/IJM.11.5.2020.002
34. Taiminen, H. M., & Karjaluoto, H. (2015). The usage of digital marketing channels in SMEs. *Journal of Small Business and Enterprise Development*.

PROPOSING A STRATEGY TO REDUCE THE NUMBER OF ILLEGAL FINTECH P2P LENDING PLATFORMS IN INDONESIA

Faradina Vidyani [1,2]

[1]*Global Information Telecommunication and Technology Program (GITTP), Korea Advanced Institute of Science and Technology (KAIST)*

[2] *Ministry of Communication and Informatics of the Republic of Indonesia*

ABSTRACT

Fintech Peer-to-Peer (P2P) Lending Platform is a fintech service that transforms traditional lending or credit application to digital and is distinguished by faster and easier loan disbursement than traditional ones. Since 2018, the emergence of this platform has increased significantly in Indonesia while also opening up opportunities for criminality practices, such as the rise of illegal Fintech P2P Lending platforms. The distribution of illegal fintech P2P Lending Platforms was approximately 200 percent greater than legal ones. They have been conducting unethical financial practices, which harmed the users, and some even led to suicide. This report aims to propose a strategy for the government of Indonesia to reduce the number of Illegal Fintech P2P Lending platforms in Indonesia. It was conducted by analyzing the as-is strategy implemented by the government of Indonesia compared to the benchmark countries Republic of Korea and People's Republic of China. The to-be model was also designed according to the potentials and weaknesses obtained from the gap analysis of Indonesia compared to the two countries. This is expected to achieve a sound fintech ecosystem in Indonesia. Moreover, the future study should cover technology adoption to enable proactive-oriented work for the government to reduce the number of Illegal Fintech P2P Lending platforms in Indonesia.

Keywords: Indonesia; fintech; Peer-to-peer Lending (P2P); fintech ecosystem; lending; legal strategy; illegal fintech P2P Lending platform.

1. INTRODUCTION

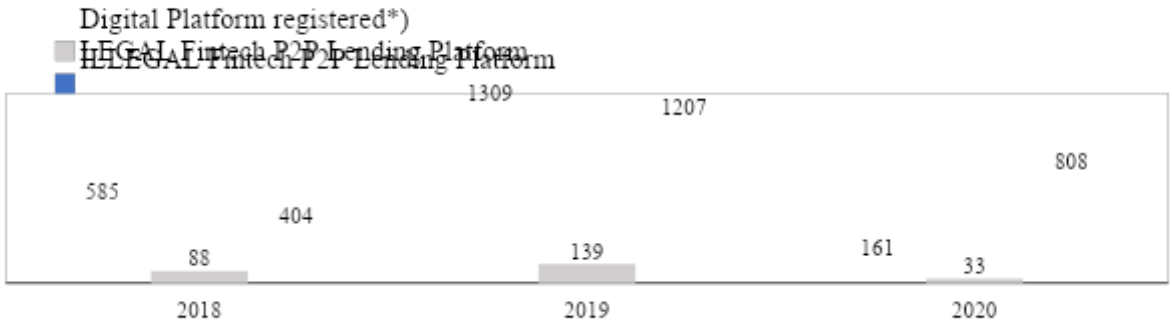
Approximately 1.7 billion adults worldwide are unbanked. There are four countries in the world with the greatest percentage of unbanked citizens. Indonesia ranked number fourth with 95 million unbanked population (Loh, 2018). There is 36% of the total population to fall under the category of financially excluded. One of the main causes is a dispersed geographical location. The issue of financial exclusion also indicates that there is limited access to the credit system is high. Some implications emerge due to the credit access limitation in Indonesia such as, lowering the level of financial inclusion, creating a sizeable MSMEs financing gap by 19% in 2018, and reducing the national gross domestic product (GDP) significantly by nearly $130 billion or approximately 14% of the total GDP (Batunanggar, 2017).

Following the current ICT trend, those challenges have turned into opportunities for some people by allowing high credit demand populations with minor to no credit history records, also known as the credit invisible, to access an ICT-enabled platform that can connect them with yield-hungry investors. This innovation leads to the idea of enabling the credit Invisibles to enter the credit market, resulting in a proliferation of financial technology (fintech) in Peer-to-Peer (P2P) lending platforms (Loh, 2018). It began to emerge in Indonesia in 2018. Its

popularity comes from its ability to provide a simple process and quick loan disbursement. In 2018, it contributed $25.97 trillion to Indonesia's GDP (PwC-Indonesia, 2019).

Between 2018 and 2020, the number of them registered with the government through the Financial Services Authority (OJK) out of the total number of digital platforms registered with the Ministry of Communication and Informatics (MCI) in Indonesia has been around 15%, or around 200 fintech P2P Lending platforms. This is shown in Graph **1**.

However, in the same period, the number of unregistered fintech P2P lending platforms distribution in Indonesia has increased significantly. It was almost 200 percent higher than the total number of digital platforms registered in Indonesia. In other words, there were over 2,000 unregistered fintech peer-to-peer lending platforms circulating freely in society. These platforms are also classified as *illegal Fintech Peer-to-Peer Lending platforms*.



Graph 1 Legal Fintech P2P Lending and Illegal Fintech P2P Lending Platforms in Indonesia (2018 -2020)

Some illegal Fintech P2P Lending platforms have engaged in unethical loan practices, some of which have resulted in suicide risk. This is due to improper loan repayment practices such as humiliation, cursing, abusive and sexual harassment, and collecting money before the due date (Hidajat, 2019). The most common problem has been the operators of Fintech P2P Lending platforms' lack of understanding of running the platforms appropriately. They also function as lenders and operators, pursuing big profits without sufficient due diligence (Loh, 2018). The government has been attempting to reduce the number of victims, including deploying techniques to shut down illegal Fintech P2P Lending Platforms based on user reports. However, this platform continues to emerge and grow, making it difficult for the government to respond (Hidajat, 2019).

Therefore, this study aims to generate and suggest a new strategy to reduce the growth of illegal fintech P2P lending in Indonesia by conducting a literature review to analyze what are the critical success factors of the fintech P2P lending ecosystem managed by the regulators, Indonesia's fintech P2P lending as-is analysis, benchmarking analysis with the Republic of Korea and the People's Republic of China, and Gap analysis. Then, it is expected to realize a more reliable and secured fintech P2P lending ecosystem through the suggestion of recommendation and a proposal of a to-be model.

2. LITERATURE REVIEW

To support the growth of fintech innovation in the country, particularly Fintech P2P Lending, the government must consider the Critical Success Factors (CSFs) to build a robust Fintech P2P Lending ecosystem. Identifying

and comprehending these CSFs will allow the government to concentrate its efforts on the most important resources rather than wasting time on less important matters. This is identified under **Table 1**.

Table 1 Identified Critical Success Factors

No.	Critical Factors	Details	Source(s)
1	Telecommunication infrastructure	The availability of telecommunication infrastructure in supporting the fintech P2P Lending platform establishment.	(Gomber et al., 2018); (Zavolokina et al., 2016)
2	Internet penetration	The coverage of internet service in the country presents the ability of its citizens to adapt to the service offered by the fintech P2P Lending platform.	(Chen, 2016); (Huang, 2018)
3	Smartphone User Penetration	The number of smartphone users in the country is related to the number of customers who would be impacted by the service offered by the P2P Lending platform.	(Chen, 2016)
4	Fintech Technology Infrastructure	The availability of the established ICT infrastructure for financial purposes to support the fintech industry.	(IMF and World Bank, 2018)
5	Scalability	The government's strategy is to support the growth and promote the fintech P2P Lending platforms to drive the national innovation system.	(Au et al. 2020); (Hommel and Bican, 2020)
6	Regulatory Knowledge	The government institutional task and responsibilities over fintech P2P lending ecosystem in the country.	(Werth et al., 2019)
7	Customer Adoption / Financial Literacy	The capability of the society adoption to the fintech P2P Lending platform and financial literacy in general.	(Gomber et al., 2018); Ryu et.al, 2020
8	Unmet Financial Needs	The number of unbanked population in the country represents the potential of fintech P2P Lending platforms to emerge.	(Au et al. 2020); (Huang, 2018); (Zavolokina et al., 2016); (Chen, 2016);
9	Collaboration / Partnership	The stakeholders and actors involved in the fintech P2P Lending ecosystem represent the opportunity to create a firm and healthy network.	(Chen, 2016); (Hommel and Bican, 2020); (Werth et al., 2019)
10	Regulatory Framework	The government's availability of regulations/policies to support the growth of the fintech P2P Lending platform.	(Chen, 2016); (Jinasena et al., 2020)
11	Consumer Protection	The government's availability of regulations/policies to protect the customer of the fintech P2P Lending platform.	(Chen, 2016)
12	Safety Aspect	The government's availability of regulations/policies to ensure transaction safety through the fintech P2P Lending platform.	(Chen, 2016)
13	Risk Management	The government's availability of regulations/policies prevents the risk of criminality through the fintech P2P Lending platform.	(Chen, 2016); (Ryu and Ko, 2020)
14	Cybersecurity	The availability of regulations/policies by the government to prevent the risk of privacy or internet security breach through fintech P2P Lending platform	(Gomber et al., 2018); (Chen, 2016)

3. METHODS

The methodology used in this paper was developed by combining the critical factors listed in **Table 1** with the Analytical Framework Model, which is the TOE Framework, to examine the current state of the Fintech P2P Lending ecosystem in Indonesia and the Benchmarking countries' strategies for fintech P2P Lending platforms in particular. The analysis was also combined with the model from the World Bank – Guidelines for Policy Makers and Regulators to Address Fintech. This was done so that the government's current plans in Indonesia and the

benchmarking countries could be measured in a structured way. The results of the analysis were then used to determine the gap in the Indonesian situation. And then, followed by defining recommendations by referring to the literature review and lessons learned from the benchmarked countries. Finally, the to-be model for Indonesia could be designed to assist the development of a strong and healthy fintech P2P lending ecosystem. The methodology is illustrated in **Figure 1**.

4. RESULTS

As-Is Analysis Indonesia

The ICT environment in Indonesia is currently centralized in Java island, resulting in a significantly low number of internet users outside this island (*Siaran Pers Pengguna Internet Indonesia @ Blog.Apjii.or.Id*, n.d.). It implies that the population in Java island is more in advantage in accessing government established ICT infrastructures. Moreover, this implies that financial education, commercial activities, and financial activities are more accessible on Java island in the financial domain. It corresponds to the inclusive financial condition of Indonesia, which is lower than the other two ASEAN countries due to the centralized financial activities in Java island (*Strategi OJK Untuk Kejar Target Inklusi Keuangan @ Money.Kompas.Com*, n.d.).

In increasing the accessibility of financial inclusiveness, Indonesia's government has taken action by supporting the fintech industry as the main actor to drive its growth within society through some programs and activities, such as financial literacy and in-depth development of financial education Sandbox regulatory (Nababan et al., 2019). However, there is still a long way to be able to increase the financial inclusiveness of Indonesia. As Indonesia's government has not been strict in controlling the industry, the illegal fintech P2P lending players are freely distributed. By collaborating under the SWI task force, the government blocked some illegal fintech P2P lending players on the internet (Terminanto, 2020).

Some conditions affecting the illegal fintech P2P lending in society are low financial literacy rate (Singapore, 2020), digital financial talent shortage, big MSMEs financing gap, and big unbanked population (Wahyuni & Turisno, 2019). In creating a safe ecosystem, the government established some regulations and the imposition of fines. Lastly, Indonesia does not have any regulations regarding international collaboration for the fintech P2P lending industry. In summary, the current strategy by the government of Indonesia is still performed in a reactive-oriented manner and not enough to create a deterrent effect for the illegal players.

Benchmarking Analysis

1. Republic of Korea (R.O.K)

The trend of fintech P2P lending in South Korea is being used as an investment media. It is mostly being utilized as an alternative platform for people to invest their money. This ICT environment also developed innovative government financial ICT environments through fintech infrastructures such as the regulatory sandbox system, the national financial information disclosure system, and the national regtech platform (Kingdom, 2020). In general, the South Korean government has always treat emerging industries by embracing them gradually.

It also applies to the fintech sector. The government covered the fintech sector in three periods gradually (*Financial Services Commission (FSC) of South Korea*, n.d.). By implementing this method, the government can monitor the needs of the player in the field. The government had included the fintech industry under the national

plan in 2015, the «24 key reform tasks in 2015», which include the deregulation, regulatory sandbox, and the establishment of the fintech support center (*AKR20151223092751001 @ Www.Yna.Co.Kr*, n.d.).
As the implementation of this plan, the government tried to lower the entry barriers for the new fintech businesses to allow new businesses to develop and encourage innovation. These approaches resulted in the firm and stable fintech ecosystem in South Korea. The important actor within the fintech ecosystem besides the fintech business players themselves is the people. South Korea is the most financially literate people amongst the APEC countries (*OECD/INFE Report on Financial Education in APEC Economies*, 2019).

2. People's Republic of China (P.R.C)

China is a big country, making it difficult to cover all areas of telecommunication infrastructure, especially an ICT infrastructure (Hootsuite, 2020). This resulted in the number of internet penetration is slightly more than half of the population. Along with the incentive scheme, the Chinese government also has enacted the sandbox regulatory for the fintech industry in general (*China @ Iclg.Com*, n.d.). As part of the fintech industry, fintech P2P lending in China has been distracting the ecosystem with its scandalous criminal activities. Since China has a potential in the second highest number of financial literacy rate amongst APEC countries (*OECD/INFE Report on Financial Education in APEC Economies*, 2019). In addition, the government has appealed to the fintech P2P lending firms to appoint an incumbent financial institution as their custodian (Huang, 2018). This approach is intended to re-build the credibility of fintech P2P lending to the people since the criminal cases have negatively affected their lives.

5. DISCUSSION

Gap Analysis

The Gap Analysis for Indonesia in comparison to the Benchmarking countries South Korea and China according to Technology Organization Environment Framework, *twelve* implications are necessary for the government of Indonesia, especially the regulator in the fintech P2P lending ecosystem, to take into consideration.
According to the findings of the TOE framework analysis conducted between Indonesia, South Korea, and China, there are *seven key findings* that the Indonesian government should consider. Under the Technology aspect, the factor of *Telecommunication Infrastructure* and *Fintech Infrastructure* are found lacking due to the inadequate coverage of telecommunication infrastructure that is not equal across all regions in Indonesia and the low technological adoption for financial infrastructure. Moreover, in the Organization aspect, the *Scalability* and *Regulatory Knowledge* show that the government still has weak supportive strategies and a lack of supervision and law enforcement. As for the Environment aspect, the *Financial Literacy*, *Collaboration/Partnership*, and *Regulatory Framework* are the identified factors that show that the Fintech P2P Lending environment is still poorly governed. This explained in **Table 2** in APPENDIX.

In addition, the analysis of the three countries using the World Bank Model yielded *five key* findings for Indonesia. Under Foster Enabling Environment to Harness Opportunities, it is identified that Indonesia *does not have a dedicated fintech national plan* to manage the fintech environment appropriately. According to Strengthen Financial Sector Policy Framework, Indonesia still *lacks information-sharing with incumbents*, and there is *no*

particular fintech P2P Lending regulation established. As for Address Potential Risks and Improve Resilience, Indonesia is currently *lagging in terms of financial infrastructure technology adoption*. Finally, for the aspect of Promote International Collaboration, it was discovered that Indonesia still *does not have a program for worldwide marketing and partnership* to support local fintech P2P Lending platforms. This explained in **Table 3** in APPENDIX.

Recommendation

According to the degree of similarity in the characteristics, all twelve essential elements were divided into four categories. After that, they were divided into two primary government functions of Policy and Service. This is shown in **Figure 2**.

In the Policy Recommendation, the government of Indonesia needs to focus on Fintech P2P Lending industry growth based on the factor of scalability and foster fintech to promote financial inclusion through the deregulation to provide clear guidelines and fintech national plan. Moreover, the law enforcement should also be considered by focusing on the factor of regulatory knowledge and regulatory framework through improving supervision by establishing a sub-unit dedicated for supervising fintech P2P Lending platforms distributed in Indonesia, also to improve enforcement through a reward and punishment law.

In the Government Service Recommendation, the government of Indonesia needs to focus on Financial & Data Infrastructure through the factors of Telecommunication Infrastructure, Financial Infrastructure, and the Robust Financial and Data Infrastructure to Sustain Fintech Benefits by establishing a strong broadband connection, developing a Financial Credit Data Center, and adopting financial infrastructure technology. Also, the government needs to focus on Financial Literature and Information-sharing through the factors of Financial Literacy, Collaboration/ Partnership, and the International Relationship by setting an attractive strategy and to enhance publication approach, also to collaborate with the digital startup to allow citizen engagement, and setting an information-sharing with the incumbents and develop an international collaboration.

To-be Model

The recommendation then designed into the to-be model by considering the existing environment that is comprises by the actors and their activities. This was conducted by connecting the actors with the recommendations mentioned in the previous section. It is depicted in **Figure 3**. This to-be model is expected to improve the government to address the illegal fintech P2P lending platform by changing the government orientation from reactive to proactive.

6. CONCLUSION

Their inability to obtain the lending application services becomes the target customer of Fintech P2P Lending platforms. Fintech P2P Lending platforms transform the traditional services into technology-based services, allowing users to apply easily without many requirements. Even though the government's illegal fintech P2P lending platforms have been closed down, the new platforms keep appearing and increasing. This report plays a vital role in addressing the problem as it is identified the gap the government of Indonesia needs to take care of in handling the illegal fintech P2P lending platforms.

According to the analysis conducted from the benchmark countries South Korea and China, the gap was identified, creating a sound fintech ecosystem through their legal aspects and strategies. According to the analysis performed, the study proposed a policy and government service recommendations for the government of Indonesia to be able to handle the illegal fintech P2P Lending platforms appropriately. Through the Policy recommendation, the government needs to provide clear guidance for Fintech P2P Lending platforms to enter the market, a fintech national plan, improve supervision and law enforcement, and enable proactive-oriented regulations.

AUTHOR CONTRIBUTIONS

Vidyani, Faradina conceived and designed the analysis; collected the data; performed the analysis' and wrote the paper.

REFERENCES

1. *AKR20151223092751001 @ www.yna.co.kr*. (n.d.). https://www.yna.co.kr/view/AKR20151223092751001
2. Au, C. H., Tan, B., & Sun, Y. (2020). Developing a P2P lending platform: stages, strategies and platform configurations. *Internet Research*, *30*(4), 1229–1249. https://doi.org/10.1108/INTR-03-2019-0099
3. Batunanggar, S. (2017). Fintech Development and Regulatory Frameworks in Indonesia. *Asian Development Bank Institute*, *1014*(1014), 1–12. www.adbi.org
4. Chen, L. (2016). From Fintech to Finlife: the case of Fintech Development in China. *China Economic Journal*, *9*(3), 225–239. https://doi.org/10.1080/17538963.2016.1215057
5. *china @ iclg.com*. (n.d.). https://iclg.com/practice-areas/fintech-laws-and-regulations/china#
6. *Financial Services Commission (FSC) of South Korea*. (n.d.). https://www.fsc.go.kr/eng/po020101
7. Gomber, P., Kauffman, R. J., Parker, C., & Weber, B. W. (2018). On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services. *Journal of Management Information Systems*, *35*(1), 220–265. https://doi.org/10.1080/07421222.2018.1440766
8. Hidajat, T. (2019). Unethical practices peer-to-peer lending in Indonesia. *Journal of Financial Crime*, *27*(1), 274–282. https://doi.org/10.1108/JFC-02-2019-0028
9. Hommel, K., & Bican, P. M. (2020). Digital entrepreneurship in finance: fintechs and funding decision criteria. *Sustainability (Switzerland)*, *12*(19), 1–18. https://doi.org/10.3390/su12198035
10. Hootsuite. (2020). Digital 2020. *July Global Statshot Report*, 247.
11. Huang, R. H. (2018). Online P2P Lending and Regulatory Responses in China: Opportunities and Challenges. *European Business Organization Law Review*, *19*(1), 63–92. https://doi.org/10.1007/s40804-018-0100-z
12. IMF and World Bank. (2018). The Bali Fintech Agenda - Chapeau Paper. *World Bank*, 1–36.
13. Jinasena, D. N., Spanaki, K., Papadopoulos, T., & Balta, M. E. (2020). Success and Failure Retrospectives of FinTech Projects: A Case Study Approach. *Information Systems Frontiers*. https://doi.org/10.1007/s10796-020-10079-4
14. Kingdom, D. for I. T. of U. (2020). *Fintech South Korea - Market Intelligence Report*.
15. Loh, J. (2018). The Fintech Edge. *KPMG Siddharta Advisory*, *November*.

16. Nababan, M. G., Maria, S. S. S., & Deristiandra, M. P. P. (2019). *Penguatan Regulatory Sandbox dan Scoring System Dalam Penerapan Prinsip Kehati-hatian Peer to Peer Lending*. 55–72.
17. *OECD/INFE Report on Financial Education in APEC Economies*. (2019).
18. PwC-Indonesia. (2019). Indonesia's Fintech Lending: Driving Economic Growth Through Financial Inclusion. *PwC Indonesia - Fintech Series*, *June*, 24. https://www.pwc.com/id/en/fintech/PwC_FintechLendingThoughtLeadership_ExecutiveSummary.pdf
19. Ryu, H. S., & Ko, K. S. (2020). Sustainable development of Fintech: Focused on uncertainty and perceived quality issues. *Sustainability (Switzerland)*, *12*(18). https://doi.org/10.3390/su12187669
20. *siaran pers pengguna internet indonesia @ blog.apjii.or.id*. (n.d.). https://blog.apjii.or.id/index.php/2020/11/09/siaran-pers-pengguna-internet-indonesia-hampir-tembus-200-juta-di-2019-q2-2020/
21. Singapore, F. (2020). *Indonesia Fintech Report 2020*. https://fintechnews.sg/wp-content/uploads/2020/12/Fintech-Indonesia-Report-2020.pdf
22. *Strategi OJK untuk Kejar Target Inklusi Keuangan @ money.kompas.com*. (n.d.). https://money.kompas.com/read/2020/10/15/183500126/kejar-target-inklusi-keuangan-90-persen-ini-strategi-ojk?page=all
23. Terminanto, A. A. (2020). ANALISA PENYELESAIAAN TRANSAKSI PENAGIHAN FINTEK TANPA ADANYA JAMINAN. *Journal of Islamic Economics, Finance, and Banking*, *53*(9), 1689–1699.
24. Wahyuni, R. A. E., & Turisno, B. E. (2019). Praktik Finansial Teknologi Ilegal Dalam Bentuk Pinjaman Online Ditinjau Dari Etika Bisnis. *Jurnal Pembangunan Hukum Indonesia*, *1*(3), 379–391. https://doi.org/10.14710/jphi.v1i3.379-391
25. Werth, O., Cardona, D. R., Nowatschin, J., Werner, M., Guhr, N., & Breitner, M. H. (2019). Challenges of the financial industry - An analysis of critical success factors for FinTechs. *25th Americas Conference on Information Systems, AMCIS 2019, May*.
26. Zavolokina, L., Dolata, M., & Schwabe, G. (2016). The FinTech phenomenon: antecedents of financial innovation perceived by the popular press. *Financial Innovation*, *2*(1). https://doi.org/10.1186/s40854-016-0036-7

APPENDIX

Proposing a Strategy to Reduce the Number of Illegal Fintech P2P Lending Platforms in Indonesia

Faradina Vidyani

1. Gap Analysis

Table 2 TOE Framework Gap Analysis Result

	Critical Factors	INDONESIA	R.O.K	P.R.C	Findings for Indonesia
Technology	Telecommunication Infrastructure	57.39 with speed of 13.83 Mbps	Broadband 100%; speed is 103.18Mbps	73.90%, internet speed is 67.71 mbps	• Low telco infra coverage. • Low speed of mobile internet
	Fintech Infrastructure	An offline system of Historical Debtor Individual Information in Indonesia (SLIK).	Regulatory sandbox online registration system An online financial information disclosure system (DART system) Regtech platform	Availability of The Credit Reference Center (CCRC) a system that provides a credit information that is beneficial to facilitate financial lending activities.	Unavailable technology adaptation for fintech players credit history data yet.
Organization	Scalability	• A strategy available to increase financial inclusive index in Indonesia: Fin. Literacy program; Digital education; Sandbox regulatory • Low fin. Inclusive level compare to ASEAN	• Deregulation of fintech to lower entry barrier • Sandbox regulatory • The establishment of fintech support center (FSC)	• Adoption of comprehensive incentive schemes system • A 2 year P2P lending transition plan	Available (Weak Supportive Strategies) the government of Indonesia needs to consider: • Deregulation for fintech to lower entry barrier • Establishment of Fintech support center • Adaptation of tax incentives • Transition plan for P2P lending
	gulatory Knowledge	• Formed a special task force named SWI • Fintech P2P Lending	• 3 period treatments. • 'P2P loan joint inspection meeting' to establish a	• Each state has different laws and regulations to control illegal p2p lending perpetrator	Available (Weak supervision) • Unavailable specific P2P lending supervision

		practices is the part of SWI supervision. • SWI works reactively. • Listing of legal & illegal fintech P2P Lending Platform.	cooperation system to cope with illegal activities related to P2P lending Platforms	• Introduced the internet finance 'guidance' policy framework in July	• Reactive supervision and law enforcement
Environment	Customer Adoption / Financial Literacy	• Financial literacy rate: 38% • Financial inclusion: 76%	69% (ranked as the top APEC performers in terms of financial knowledge)	67% (ranked 2nd for financial literacy amongst APEC countries)	Lowest financial literacy rate amongst the benchmarking countries
	Collaboration / Partnership	• Collaboration with fintech P2P Lending platform association (AFPI) • Collaboration with the experts through IFSoc	• Korea P2P finance association • World Bank Group Korea Office • Collaborated with start-up firm to allow citizens involvement in the criminal reporting method	Collaboration with a commercial bank to be ready as the custodian for P2P Lending Platforms	• Unavailable collaboration with digital startup for information-sharing between citizens and government through developed system. • Unavailable custodian scheme.
	Regulatory Framework	Separate regulations available for financial and technology	Availability of dedicated fintech P2P Lending act (P2P finance act)	A standard to set up fintech P2P Lending businesses	Inexistence of a specific regulation for fintech P2P Lending platforms.

Table 3 World Bank Model - Guidelines for Policy Makers and Regulators to Address Fintech Gap Analysis

Elements		**Indonesia**	**R.O.K**	**P.R.C**	**Key Findings for Indonesia**
Foster Enabling Environment to Harness Opportunities	Promote Financial Inclusion and Develop Financial Markets	Available (dispersed regulations)	Available	Available	Available (dispersed regulations) The government of Indonsia needs to consider providing a specific fintech national plan which could covers all relevant regulations.

Strengthen Financial Sector Policy Framework	Monitor Developments Closely to Deepen Understanding of Evolving Financial Systems	Partially Available	Partially Available	Available	Partially Available
	Adapt Regulatory Framework and Supervisory Practices for Orderly Development and Stability of the Financial System	N/A	Available	Available	N/A
Address Potential Risks and Improve Resilience	Develop Robust Financial and Data Infrastructure to Sustain Fintech Benefits	Partially Available	Available	N/A	Partially Available
Promote International Collaboration	Enhance Collective Surveillance and Assessment of Financial Sector Risks	N/A	N/A	N/A	N/A

SESSION 4: SMART DIGITAL TECHNOLOGIES & CAPABILITIES FOR GLOBAL GROWTH

THE IMPACT OF THE COVID-19 PANDEMIC ON THE BLOCKCHAIN IMPLEMENTATION PROJECT IN BRAZIL'S PUBLIC HEALTH SYSTEM

Izabella de Souza Lorenzon[1], Tumennast Erdenebold[2*]

[1] *Solbridge International School of Business, Woosong University, Daejeon, Korea.*

[2*] *Technology Studies Department, Woosong University, Daejeon, Korea.*

ABSTRACT

The world COVID-19 pandemic has caused significant changes in many aspects. Regarding technological projects, it evidenced the need to expand the applications of new technologies, such as blockchain, which has been receiving more and more investments. However, governments with a restricted budget and skilled labor had to face a higher priority: how to address to the COVID-19 crisis. In Brazil, one of the countries with the highest number of reported cases, the manpower available – already scarce – was forced to focus on simpler digitalization processes. If on the one hand it boosted and benefited technological advancements, on the other it required the government to abandon bolder projects to the detriment of more modest initiatives. This paper aims to analyze this impact on the evolution of Brazilian blockchain project called National Health Data Network (RNDS), by collecting its information before and after the pandemic outbreak. It was found that initially the program targeted blockchain usage on the public health system to promote the exchange of information between the nodes of the health care network, but it had to be redesigned to receive and share tests results related to COVID-19, while the original proposal was postponed.

Keywords: Blockchain; COVID-19; Brazil.

1. INTRODUCTION

Declared as a public health emergency by the World Health Organization (WHO) on January 30, 2020, the rapidly transmitted coronavirus disease 2019 (COVID-19) has reached all continents in a short period of time, becoming officially a worldwide pandemic on March 11, 2020 [1]. In order to contain the spread of the SARS-CoV-2, many countries have adopted lockdown measures, quarantine of the infected, and social distance protocols, following WHO's recommendation. Consequently, the responses to the crisis have rushed the implementation of digital technologies, which includes blockchain.

According to the International Data Corporation's (IDC) report, COVID-19 may encourage investments in blockchain and distributed ledger technologies, due to their characteristics of transparency, resiliency, and immutability [2]. In fact, the IDC forecasts that blockchain spending in Europe, for example, will triple in the next five years, specially driven by healthcare [3]. In Brazil, the third country with the most cases of COVID-19 registered, the Brasscom's pre-pandemic report showed a perspective of US$620 million in blockchain investments from 2020 to 2023 [4]. After the pandemic, the expectation increased to US$960 million from 2021 to 2024 [5].

In this context, governments have also been looking for possible blockchain applications in the public sphere. In 2020, the Brazilian federal government released the 11 major projects for blockchain application in the public administration, involving finance, aviation, and healthcare sectors [6]. Special attention is given to the blockchain project on the health care sector that was still under development at the time the state of public health emergency was declared in Brazil, on February 6, 2020. Hence, this paper aims to analyze the effect of the COVID-19 pandemic on the advancements of this program, contributing to the literature with a real-life case study on the blockchain application in the government healthcare system.

2. LITERATURE REVIEW

The literature review will briefly address blockchain concepts, possible blockchain applications in the government sphere, and the blockchain-based healthcare project in Brazil.

1. Blockchain Technology

In line with the Organisation for Economic Co-operation and Development (OECD), blockchain can be defined as "a shared ledger of transactions between parties in a network, not controlled by a single central authority" [7]. In essence, the blockchain operation consists of a set of transactions that are validated by the network participants and, if approved, it composes a block in the ledger, containing the hash – a cryptographic summary - of the previous block and the hash of its own block. Any change in the block modifies the hash, being easily detectable, as there would be an inconsistency in the chain. Therefore, the use of blockchain technology is indicated when the reliability of information and process must be improved in situations that include diverse and heterogeneous stakeholders [6].

Moreover, blockchains can be classified into two main categories: public/private and permissioned/permissionless. Public blockchains are open to the general public, while private blockchains are restricted. Likewise, permissioned blockchains require authorization to write and commit, unlike permissionless blockchains [7]. Government blockchain implementations, though, are mostly permissioned [8].

2. Potential Blockchain Application in Government Services

The application of blockchain technology in public administration is suggested in different ways and fields. Terzi *et al.* presents how blockchain could support energy and health-oriented e-government services [9]. Corten explored the dilemmas in the application of design principles for blockchain in government services, providing important perceptions into which design actions are recommended and which dilemmas possibly occur [10]. Going further, Clavin et al. summarized the blockchain use cases already being adopted by governments in different spheres, including healthcare, financial applications, critical infrastructures, blockchain city, asset and data management, and education, concluding that blockchain could be the best technology option to apply to guarantee data integrity and service availability [8].

3. The Blockchain Project in the Brazilian Public Health System

Of the 11 main government projects in Brazil involving blockchain listed by the study of the Union's Court of Accounts (Tribunal de Contas da União), 9 were related to the financial sector, 1 to the aviation sector, and 1 to

the healthcare [6]. As the interest in blockchain started with cryptocurrencies, it was expected that most applications would be financial [9]. Nevertheless, due to the public calamity of the pandemic, a greater focus will be given to the health system application, which was the most affected.

The Brazilian public health system is called Unified Health System (Sistema Único de Saúde, SUS), in which services are financed and provided by the government at the federal, state, and municipal levels [11]. The use of blockchain was proposed by the National Health Data Network (RNDS), which consists of a national platform intended to promote the integration and interoperability of health information between public and private health and the federal entity of health management, to ensure access to information necessary for the continuity of citizen care. The RNDS initiative belongs to the program Connect SUS (Conecte SUS), created to boost the Brazilian digital health strategy [12].

Initially, the RNDS' proposal was to facilitate interoperability of citizen records by making patient history items available in a blockchain structure shared across states. The permission blockchain was chosen, in which only the Ministry of Health, the secretariats of health that chose to be part of the network and, in the future, private participants, such as health plans or large hospital networks, would be allowed to participate, having their own nodes [6].

3. METHODS

The latest public information about the Brazilian government's blockchain project RNDS was collected and its progress during the COVID-19 pandemic was discussed.

4. RESULTS

The results section is split into three: the summary of changes to the RNDS project scope, the numerical results of adapting the project to meet the needs of the COVID-19 pandemic, and the RNDS' future steps.

1. RNDS Scope Changes

The RNDS development started in September 2019, expecting that by March 2020 a pilot project would be launched on the state of Alagoas with a duration of 4 months to allow the health professionals and citizens of the state to share and have access to health information for the transition and continuity of user care, as well as to analyze the lessons learned that should be applied in the future expansion of the project to the rest of the country, and to allow the health [13]. However, due to the outbreak of COVID-19 pandemic, the beginning of the pilot project was deprioritized, being replaced by the Crisis and Contingency Management Plan. In which, the RNDS project was modified to admit the results of COVID-19 tests upload on an integrated system (Portal Conecte-SUS) and communicate the test results to citizens and health professionals, being available to the population in August 2020 [14]. It should be noted that in May 2020 the government issued the ordinance GM/MS nº 1.046 to regulate the integration of tests results carried out for the detection of COVID-19 by any laboratory in the national territory, whether from the public or private sector, in the RNDS. The laboratories had 60 days from the date of its

publication to make the necessary adjustments regarding the submission of data to the RNDS in their systems information and internal procedures [15].

In February 2021, the RNDS was again adapted to allow the monitoring of the immunized population, guaranteeing the correct application of the immunization agents, and recording the adverse effects after receiving the vaccine, using a connected ecosystem [16].

2. RNDS and COVID-19

According to the bulletin published by SUS, from March 2020 to June 2021, 19 million COVID-19 test results have been submitted to RNDS [17]. As expected, this number is in line with the data collected by the Laboratory Environment Management System (GAL) of total molecular tests performed for COVID-19 in Brazil, arranged in Figure 1 per month [18]. This shows that the GAL data has been fully loaded into the RNDS.

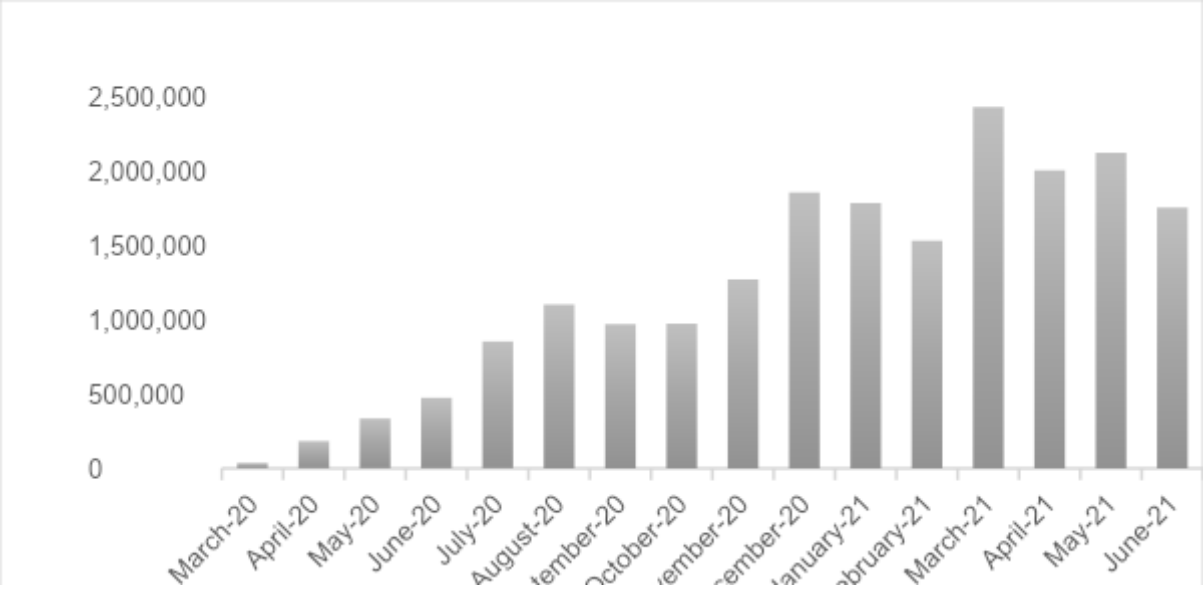


Figure 1. Number of molecular exams for COVID-19 per month in Brazil

Source: GAL, 2021 [20]

However, it is important to note that when adding other types of COVID-19 tests, such as the quick test, at the end of June 2021 the total number of tests performed was close to 54 million, as estimated by Giscard [19].

In relation to the number of COVID-19 vaccines applied, by June 2021 83 million doses had been registered in the RNDS [17]. Due to the obligation to report vaccination data to the RNDS and because the entire vaccination campaign is being carried out exclusively by the Brazilian public health system, it is considered that all data are already interconnected to the RNDS.

3. RNDS Future

According to the Ministry of Health in Brazil, “as soon as the emergency actions to combat COVID-19 are better structured, the Conecte SUS program [to which RNDS belongs] will resume its initial strategy, prioritizing computerization, and the exchange of information between Primary Healthcare facilities using the Electronic Health Record” [14]. Nevertheless, no other schedule-related information or more specific goals were found, since the COVID-19 pandemic is not yet under control.

5. DISCUSSION

First of all, despite the lack of qualified professionals for systems development in Brazil [20, 21], it surprised researchers about emerging technologies in the COVID-19 pandemic when appeared in the eighteenth position regarding papers production, being the only Latin American country in the ranking [22]. Still, it is one of the few nations to explore blockchain technology in government applications, following the market trend with higher investments planned for the evolution of this technology.

The Brazilian government's blockchain project in the healthcare sector – RNDS – was initially directed towards data sharing in a secure and reliable way, like most other similar projects from different countries [8], but its prime concern was changed to provide more immediate solutions to deal with COVID-19 pandemic, such as unifying data from tests performed and vaccines applied. Then, two considerations can already be made. First is that, undoubtedly, driven by COVID-19, interoperability with public and private laboratories was the first major achievement of the RNDS. However, the second is that since the project was remodeled without clear goals of when the expansion of the RNDS will be prioritized again, it is uncertain to estimate the time needed for the advancement of blockchain technology in the healthcare system, although it is expected that it will take years, considering all the challenges to be overcome, such as heterogeneity of data and the use of different management systems [23].

In search of other cases for comparison, we found Ontario, Canada, which also made available on its eHelth platform immediate access to COVID-19 lab test results stored in Ontario Laboratories Information System (OLIS), as well as to COVID-19 vaccination information from COVaxON (Ontario Ministry of Health's application for COVID-19 vaccination information), but there was no data about blockchain usage, and the eHealth program was already underway even before the outbreak of the pandemic, with 98% of Ontario's hospitals and 100% of Home and Community Care Organizations (LHINS) connected [24]. Also, there is the MyHealth-MyData (MHMD) blockchain project in Europe presented in 2017, whose main objective was to develop an open health information network connecting organizations and people [25], though no guidance regarding the COVID-19 pandemic was given, suggesting Brazil has a unique case of study.

The lack of sufficient data to assess the performance of RNDS in dealing with the pandemic, and the fact that it is still too early to consider its next steps are the limitations of this paper. As future directions, we suggested to continue monitoring the development of blockchain projects, so that this disruptive technology can be increasingly exploited.

6. CONCLUSION

Although timidly, the outbreak of COVID-19 pandemic contributed to the actual initiation of the RNDS project, allowing interoperability between the country's public and private laboratories in a short period of time to consolidate data related to the number of tests carried out and vaccines applied, in a way similar to the solution adopted by the eHealth system in Ontario, Canada. However, it was also responsible for the changes in the project scope, postponing without deadlines the boldest proposals of digitalization of Brazil' public health system using blockchain, even though it is still too early to evaluate effectiveness.

The theoretical contribution of this article was to add the case of blockchain application in public health system in Brazil to the literature, focusing on the effects of the COVID-19 pandemic on the project's progress. The practical contribution is to disseminate the Brazilian efforts about heath digitalization solutions.

AUTHOR CONTRIBUTIONS

Izabella de Souza Lorenzon

'All contributions' - First author. Email: izalorenzon@gmail.com

Dr. Tumennast Erdenebold

'Other contribution' - Corresponding author. Email: Tumennast@wsu.ac.kr

ACKNOWLEDGEMENT

"This research is was funded by Woosong University Academic Research in 2021."

REFERENCES

1. World Health Organization. (2021). Timeline: WHO's COVID-19 response. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline?gclid=CjwKCAjw87SHBhBiEiwAukSeUaDVwYqd0LRc_MFnJhsiglho4TDhwWHrb0-gLiu-4k3cwkB3U5PdhxoC5XIQAvD_BwE#event-115

2. Soohoo, S., Wester, J. (2020). COVID-19: Quantifying the Impact on Blockchain. IDC. https://www.idc.com/getdoc.jsp?containerId=US46299020

3. La Croce, C. (2021, April 13). A Year After COVID-19 Emerged, Blockchain Investments in Europe Remain Stable, Led by Banking and Manufacturing, with Opportunities in Healthcare and Utilities, According to New IDC Spending Guide. IDC. https://www.idc.com/getdoc.jsp?containerId=prEUR147607321

4. Brasscom. (2020). Relatório Setorial de TIC 2019 Macrossetor de TIC. https://brasscom.org.br/relatorio-setorial-de-tic-2019/

5. Brasscom. (2021). Relatório Setorial 2020 Macrossetor de TIC. https://brasscom.org.br/relatorio-setorial-2020-macrossetor-de-tic/

6. Brazil. (2020). Levantamento da Tecnologia Blockchain. Tribunal de Contas da União. https://portal.tcu.gov.br/levantamento-da-tecnologia-blockchain.htm

7. OECD. (2018). OECD Blockchain Primer. https://www.oecd.org/finance/OECD-Blockchain-Primer.pdf

8. Clavin, J., Duan, S., Zhang, H., Janeja, V.P., Joshi, K.P., Yeash, Y. (2020). Blockchain for Government: Use Cases and Challenges. Digit. Gov.: Res. Pract. 1, 3, 21 pages. https://doi.org/10.1145/3427097

9. Corten, P. (2017). Blockchain Technology for Governmental Services: Dilemmas in the application of design principles. https://repository.tudelft.nl/islandora/object/uuid:87709465-b9a1-48da-9ba5eba98bc263d7/datastream/OBJ1/download

10. Terzi, S., Votis, K., Tzovaras, D., Stamelos, I., Cooper, K. (2019). Blockchain 3.0 Smart Contracts in E-Government 3.0 Applications. Cornell University. https://arxiv.org/abs/1910.06092

11. Paim, J., Travassos, C., Almeida, C., Bahia, L., Macinko, J. (2011). The Brazilian health system: history, advances, and challenges. Lancet, 377(9779):1778-1797. https://doi.org/10.1016/S0140-6736(11)60054-8

12. Brazil. (2020). Portaria Nº 1.434, de 28 de maio de 2020. Ministry of Health of Brazil. https://rnds.saude.gov.br/wp-content/uploads/2020/06/portaria-n%C2%BA-1.434-202.pdf

13. Brazil. (2020). Plano de ação, monitoramento e avaliação da estratégia de saúde digital para o Brasil 2019-2023. DATASUS. https://www.gov.br/saude/pt-br/assuntos/saude-digital/material-de-apoio/PAMA_V511112020.pdf

14. Brazil. (2021). Conecte SUS Pilot Project Final Report: analysis of progress made between October 2019 and June 2020 [electronic resource]. Ministry of Health of Brazil.

https://bvsms.saude.gov.br/bvs/publicacoes/conectesus_pilot_project_final_report.pdf

15. Boletim Conecte SUS. (2021). Retrospectiva de dois anos da nova gestão do DATASUS. Coordenação-Geral de Inovação em Sistema Digitais, maio de 2021. Vol 15. https://www.gov.br/saude/pt-br/assuntos/saude-digital/monitoramento-e-avaliacao-da-esd/OS_199_Boletim_ConecteSUS_15_v5.pdf

16. Boletim Conecte SUS. (2021). Aplicativo Conecte SUS aumenta eficiência e segurança do processo de vacinação. Coordenação-Geral de Inovação em Sistemas Digitais, janeiro de 2021. Vol 11. https://www.gov.br/saude/pt-br/assuntos/saude-digital/monitoramento-e-avaliacao-da-esd/BoletinsConecteSUSJaneirode2021Volume11.pdf

17. Boletim Conecte SUS. (2021). Minuta da nova PNIIS é pactuada na CIT. Coordenação-Geral de Inovação em Sistemas Digitais, junho de 2021. Vol 16. https://www.gov.br/saude/pt-br/assuntos/saude-digital/monitoramento-e-avaliacao-da-esd/Boletim_ConecteSUS_16_v2.pdf

18. Brazil. (2021). Boletim Epidemiológico Especial nº 72 – Doença pelo Novo Coronavírus COVID-19. Ministério da Saúde. https://www.gov.br/saude/pt-br/media/pdf/2021/julho/23/boletim_epidemiologico_covid_72_final23jul21-c-1.pdf

19. Stephanou, G. (2021). Painel COVID-19 – Estatísticas do Coronavírus em Tempo Real. http://www.giscard.com.br/coronavirus/sobre.php

20. Lobo, A.P., Costa, P. (2021). Software brasileiro tem futuro ameaçado por falta de pessoas qualificadas. Convergência Digital. https://www.convergenciadigital.com.br/Negocios/Software-brasileiro-tem-futuro-ameacado-por-falta-de-pessoas-qualificadas-56355.html?UserActiveTemplate=site&amp=

21. Bertão, N. (2021). Mercado de tecnologia tem aumento de 310% de vagas em 2020. Valor Investe. https://valorinveste.globo.com/objetivo/empreenda-se/noticia/2021/01/10/mercado-de-tecnologia-tem-aumento-de-310percent-de-vagas-em-2020.ghtml

22. Queizoz, M.M., Wamba, S.F. (2021). A structured literature review on the interplay between emerging technologies and COVID-19 – insights and directions to operations fields. Annals of Operations Research. DOI: 0.1007/s10479-021-04107-y.

23. Rabano, M. (2021). Sistemas integrados e análise de dados são o futuro do setor de saúde no Brasil. Saúde Business. https://www.saudebusiness.com/ti-e-inovao/sistemas-integrados-e-anlise-de-dados-so-o-futuro-do-setor-de-sade-no-brasil

24. eHealth Ontario. (2021). Canada. https://ehealthontario.on.ca/en

25. Rizzo, A. (2017). Project Presentation: My Health-My Data. Lynkeus. http://www.myhealthmydata.eu/dissemination-materials/

THE CUSTOMIZED GRIPPER DESIGN FOR EXPLORATORY-PURPOSE ROBOTS: A PROTOTYPE OF THE REMOTELY OPERATED UNDERWATER VEHICLE (ROV) FOR POLLUTION CANALS

Jirapipat Thanyaphongphat[1], Wantana Areeprayolkij[1], Khanita Tumphasuwan[1]

[1] *College of Arts, Media and Technology, Chiang Mai University, Chiang Mai, Thailand*

jirapipat.than@cmu.ac.th, wantana.a@cmu.ac.th, khanita.t@cmu.ac.th

ABSTRACT

Robotics has not only been recognized as one of the disruptive technology, but it is also one of the phenomena of convergence of digital technology. It is the most demanded technology, particularly in developing countries such as Thailand, which is in the stage of development through Industry 4.0. Mostly, development projects on robotics in Thailand are for working in the operation line in factories; whereas, a handful of studies regards to apply it for an environmental solution. This research's main objective is to propose a gripped robot design as an option for exploratory underwater objects. In this study, we utilized knowledge from the robotics field, the internet of things, and digital technology for building a unique prototype of an underwater exploration robot with a customized design of a gripper. The prototyping design was mainly developed operational tests for a physical location in the canal. In the design part, the core component is called Remotely Operated Vehicle (ROV), which was driven with a direct DC motor and controlled directions and movement with a controller board. The gripper had been navigated the direction in the vertical- and horizontal-axis, as well as the arm releasing and catching, which were set by an onboard switch. This customized gripper design prototype would be productive and reusable for exploratory-purpose robots that work well underwater within pollution constraints.

Keywords: Exploratory underwater robots; Gripper design; Robotics; IoT.

1. INTRODUCTION

Environments such as water, air, soil are essential for human life. Humans need to utilize many of these natural resources. But using it regardless of the impact it will cause pollution in the environment. Water pollution is one of the most critical environmental problems in Thailand. Compared to other pollution problems, water pollution is more common in big cities, making it impossible to take full advantage of various water sources. One of the causes of water pollution is plastic waste and waste in water resources. Plastic waste in the environment is not the only problem in the country, but also a global problem. There are many different types of plastics being used around the world. In 2014, there were about 322 million tons of marine waste. Now, that number is growing incredibly fast [1].

Many scientists are being used robotics as a tool to collect basic information. They allow for new perspectives and a better understanding of the world and its environmental processes. Now, robots have explored our oceans and the state of pollution [2,3]. Underwater exploration robots are essential nowadays. The need for robots to

work under the sea is increasing, especially in the petroleum industry. It is used to find petroleum in shallow waters or in areas where it is more difficult for people to manage but for rivers. The water source in the community has not received much attention due to the high cost of underwater robotics and the cost-effectiveness of the investment. Therefore, we have the initiative to create underwater robots to explore rivers and canals. The water resources in the community are regular cloudy and dirty. It is challenging to send humans down to investigate the cause of polluted water or garbage underwater, and the constant flow of ships makes diving difficult to explore. In addition, ROV must take the health and safety of the surveyors into account. In comparison, underwater exploration robots have much higher exploration capabilities and durability than humans. For example, humans need oxygen to breathe underwater, but underwater robots do not. It only uses energy to make the robot work.

The robot industry was originally developed to aid or replace humans for dirty or dangerous tasks used in various applications. Robot arms are used in automated assembly lines, observation, radiation zones, surgery, space exploration, and modern industry with an efficient load capacity of 1000 kg [4]. But there has not addressed much research into the testing of robot arms or grippers in water.

To design a robot that aims to solve a specific problem with limited materials and equipment conditions, the usage issues are different, including working on the varied landscape. Especially in the competitions, the well-working underwater and diving mode are core features for robots. Another critical component is the gripper, which holds things up underwater. Most underwater grippers do not have an electronic circuit board to control the motor. This project's objective is to study the initial experiment of the robot's grip pattern picking things up in everyday life Weight not more than 450 grams. The IoT controller is chosen Arduino to use in programming to control the robotic arm.

2. LITERATURE REVIEW

Gripper's world is as expansive as imaginable. And before starting the design, it is essential to know more about the types available and what they used to choose the right type for use with underwater garbage collection robots.

1. Robotic and environment

Research in India has built a pond cleaning robot, "Pond Cleaning Robot," to eliminate water pollution in the Godavari River at Nashik. Due to the increase in water pollution in the form of solid waste. Equipment related to removing debris from the water surface and safely disposing of it from the water source. The pool cleaning robot Works on Bluetooth to separate wastewater, plastic, and waste from the Godavari River at Nashik [2]. The researcher invented the tiny water boatman robot, "Row-bot," for eats waste and reducing pollution. It can be self-recharged without any helping human operator required [3]. The study related that IoT was developed as a garbage monitoring system with notice via a mobile application that helps pollution less environment in a smart city. In addition, it prevents the overflowing of garbage in dustbins, reduces cost, and saves time using an algorithm to find the best route in collecting [5,6].

2. ROV and Gripper Design

According to previous research, some researchers have proposed the functions of underwater robots should have as follows: (1) a camera and sensors for the acquisition of images and environmental data. (2) robotic hands for

collecting objects and other necessary things. The recommended idea was easily removable and separated mechanical and electrical systems [7].

When designing the gripper, a rotational part of the motor has been considered for symmetrical movement for the two fingers. The design will be made focusing on the simplicity of the mechanism to ensure that it can grasp any object. And torque is directly transmitted to the jaws. However, we should also take the material used to build the gripper into account.

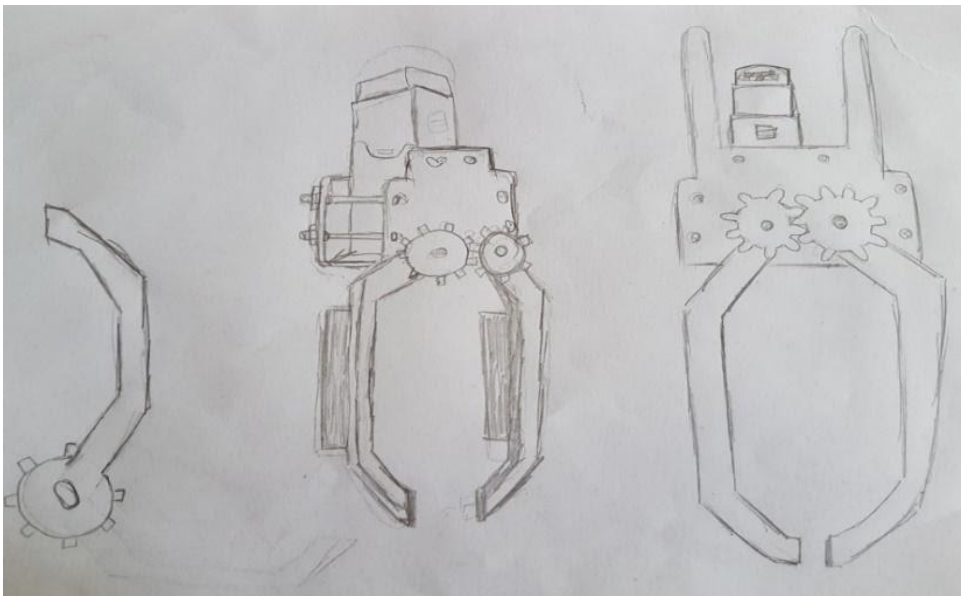


Figure 1. Gripper design

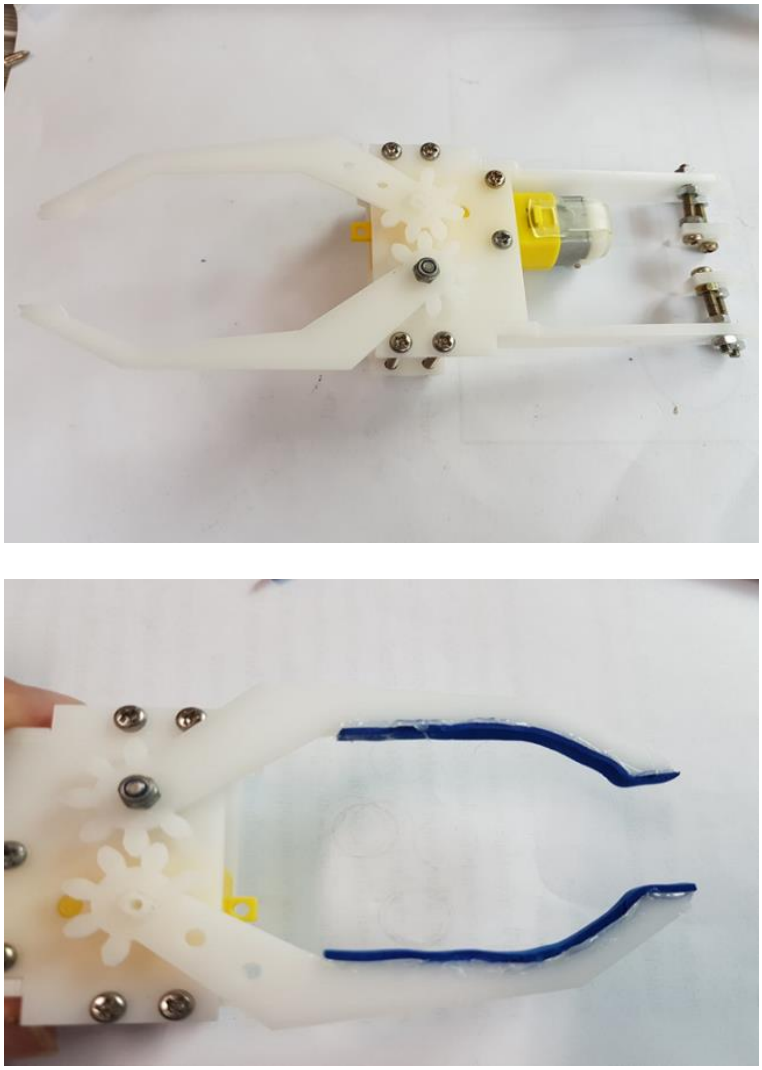


Figure 2. Gripper prototype (left) and gripper prototype adding texture (right)

For quantifying the construct difficulty, it is necessary to consider the number of pieces that are needed. On the one hand, the number of plastic pieces is laser-cut, and the number of screws and bolts used to fix it all together. And, the time required to assemble the prototype from all the separate pieces is also crucial when determining its building complexity.

3. Prototype Remotely Operated Vehicle Design

This project designs and constructs control systems for underwater exploration robots using a control-driven mechanism with wireless and manual joysticks. The operator can be visible via a video camera underwater environment from the monitor. This project has been designed and developed a gripper installed in underwater exploration robots (ROV). A DC motor had driven this ROV project; moreover, we controlled the gripper with a three-way toggle switch. The gripper could manipulate moving in the vertical and horizontal axes, grip objects, and release objects. The advantage of all equipment, it can proceed to install on the other robots. A prototype built based on the design specification in this section is introduced in the subsections as follows.

1. Motors and cameras are stored within a water-resistant vessel and prevent external torque are affects these electronic devices.

2. The underwater robot communicates semi-control with wire and wirelessly. Electricity is supplied through a cable.

3. A camera is attached to the manipulator. Images from the camera are able to be watched by the monitor on the control box.

The experiment is divided into two parts. The first part, an experiment, is the ability of grippers, which can able to grip some trash in day life (e.g., balls, cans, shoes, egg, and Marker). Second, testing operated in water; it can grasp objects in the water and moving up to the surface. From the result of grippers in each type, we found that different types of grippers had various forces to grab. The plastic gripper cannot hold any object, such as a bottle, because the shape and friction at the tip affected grasping the objects.

Figure 3. ROV prototype

3. METHODS

In order to measure up the goodness of each mode, some tests will be passed. We will evaluate the number of picking 8 objects in the types of grasping. Each test consists of four types of grasping: normal grasping, normal grasping with rotation, grasping in water, and grasping in water with rotation. In each test, the results will be accepted if the mission passes, and then it collects 1 point, whereas if it fails the task, it gets 0 points.

- Normal grasping (NG): Keeping the gripper installed on the front part of ROV and open. Each item approaches the gripper from the top with the axis (red line) placed vertically to the floor. Once the object has been grasped, it must be held for three seconds and then open and drop the object.
- Normal grasping with rotation (NR): It consists of the same procedure as the normal grasping. When object has succeeded the normal grasping then the gripper is rotated 90º to each side. It will check if it is stable enough to persist grasped and held object during three seconds
- Grasping in water (GW): The same procedure as normal grasping but the axis (red line) is placed vertical in the water. If it can hold three seconds will get a pass.
- Grasping in water with rotation (GWR): The procedure is similar to normal grasping with rotation, but the test occurred underwater.

This ensures that the gripper can grasp objects precisely in the same way. Before starting the experiment, we defined the centerline of the object by the red line in the vertical axis in Figure 4.

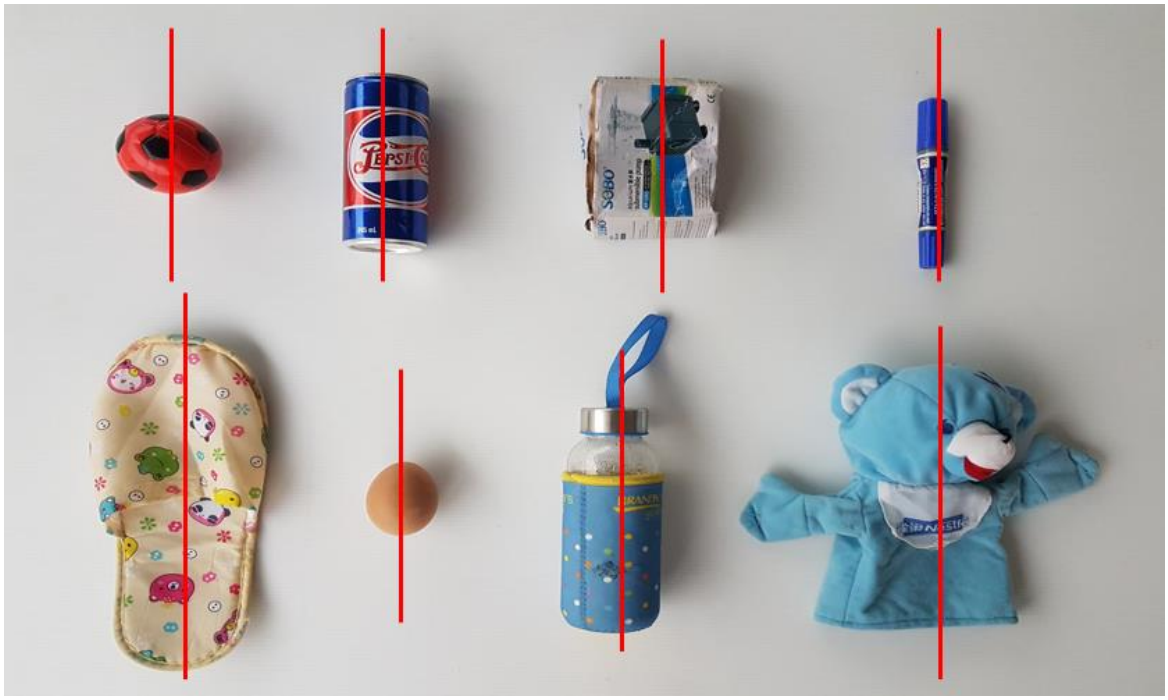


Figure 4. Objects with vertical axis in red

The objects used in the experiment differ in shape, material, and weight. The weight of the smallest object is 30 grams, and the greatest weight is 450 grams, as shown in the table below.

Table 1. Table of weights of objects used in the experiment

Objects	Weight (g)
1. Plastic ball	30
2. Beverage can	250
3. Egg	100
4. Shoe	140

5. Box	150
6. Glass bottle	450
7. Marker	90
8. Teddy	300

The experimentation will go through the four tests as follows. In the results table of each test, there are the four replicas' activities. We had calculated the total average of each object from the sum of them provides a grade from 0 to 4 of how successful the test was in the average of every grasping type.

This sequence is repeated with the eight objects. Then objects are grasped in their fixed order, and the results are written down in the table. Then the eight objects are grasped again in a normal grasping manner in the same order and then a third time. Finally, the average of the three tests is calculated.

4. RESULTS

In order to establish, explore the effect of the design of the gripper was conducted to compare the gripper types in four activities. We use the average success in each object to drawing a graph.

1. Results of the gripper prototype

From the experiment, it was found that the normal grasping cannot pick up a glass bottle. Whether it is a normal capture stationary, including clamping and turning, it was found that the glass bottle could not be clamped. Because the glass bottle is slippery and heavier than other objects, it cannot be lifted and rotate.

The results from the experiment of normal grasping in water with a normal gripper, it can be clamped to 7 different objects except for the glass bottle experiment (refers to Table 1.). Because the glass bottle is slippery and the clamping motor has not enough torque. It is unable to lift the glass bottle up to the surface of the water. Even the buoyant force of the water keeps the object floating but still unable to clamp the glass vial.

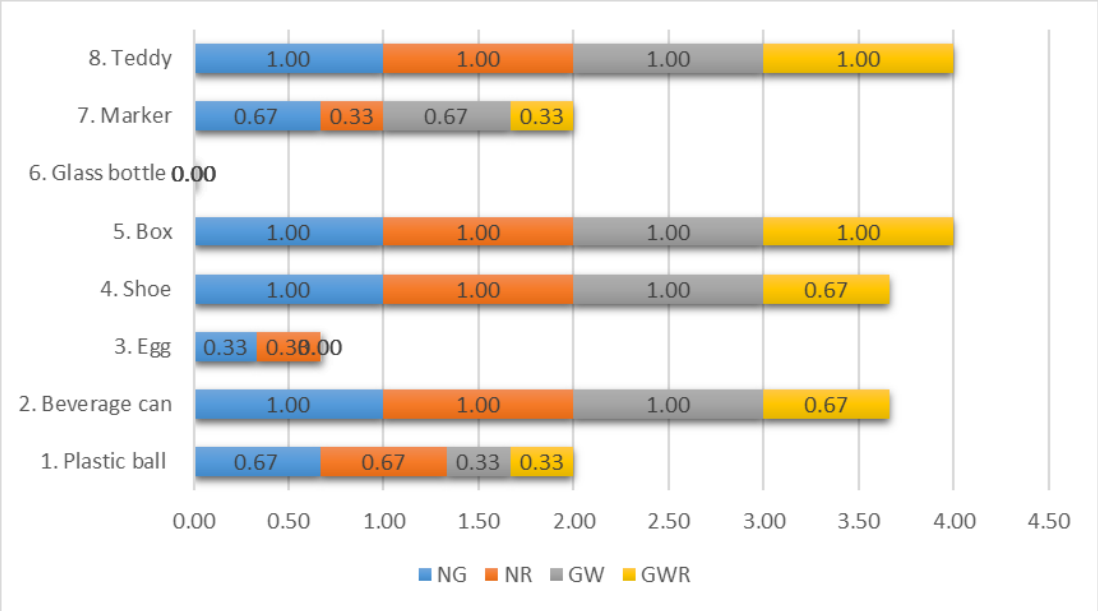


Figure 5. Average success of normal gripper.

2. Results of the gripper adding texture

The result of the gripper with added texture is the same as the normal grasping; that is the glass bottle cannot be clamped. However, it can clamp oval objects better than normal grasping. Although the gripper's touch surface is enlarged, it is still slippery when touching the bottle's surface. And the weight of the bottle is a cause of failure to incomplete the mission. Therefore, the glass bottle cannot be clamped. Another factor may be that because the motor used in the clamping test has relatively low torque, it is not sufficient for clamping the glass vial. The other object clamping can squeeze normally.

In testing the gripper with added texture in water, it can be clamped objects as if adding texture on land for both normal and rotary clamping because it contributes to increasing the contact surface, resulting in more firmly gripping objects. In addition, the buoyant force in the water makes the object lighter. But still cannot catch the glass bottle.

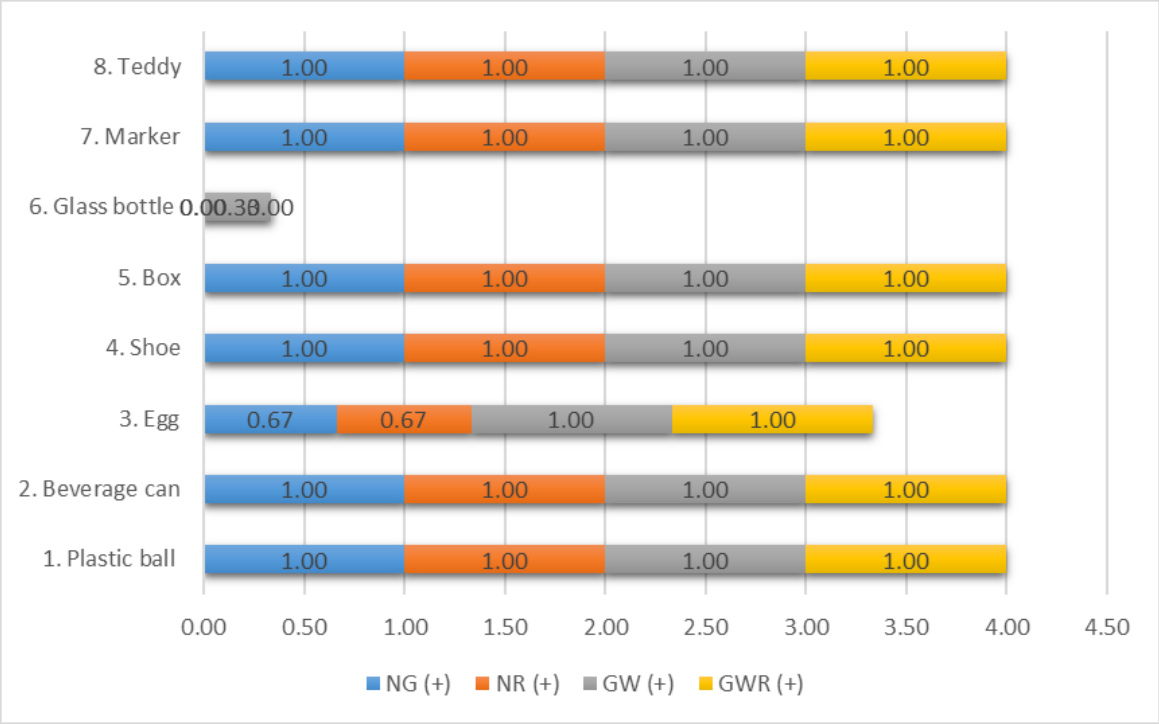


Figure 6. Average success of gripper adding texture.

3. Results of Comparison of the gripper in the water

Compared with the test results of both types in the water, we found that the gripper adding texture had a higher average number of times than the conventional gripper. The result of the gripper in the water when rotate is similar to a normal grip; the gripper adding texture can hold objects better than conventional ones.

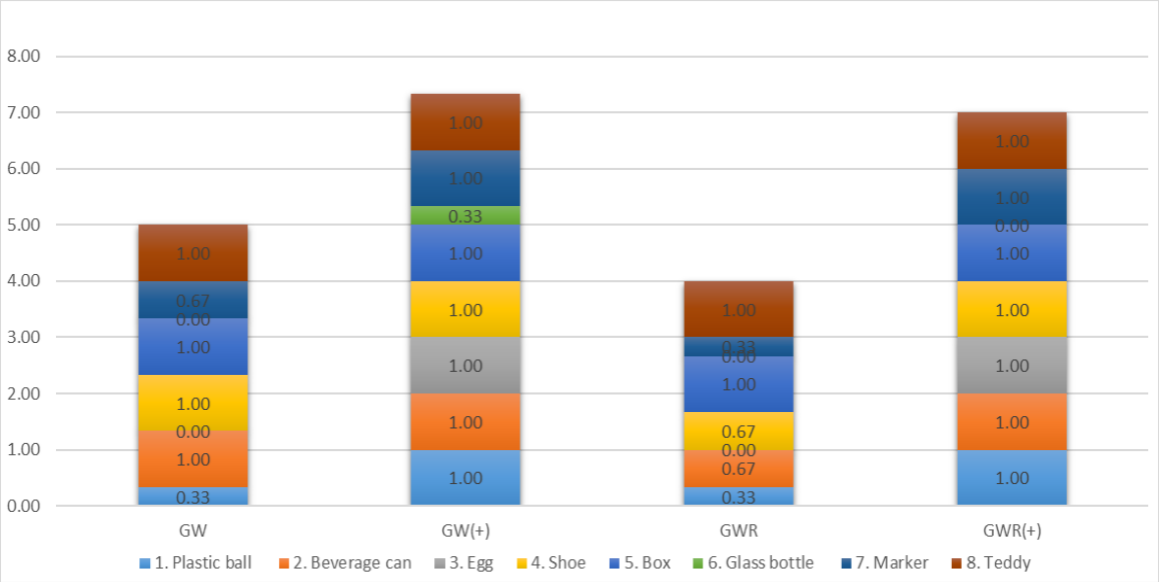


Figure 7. Comparison of gripper between types in the water.

5. DISCUSSION

The success of this study suggests that an experiment in this project has built a gripper to work with an underwater robot. In the investigation of the gripper, of robot have tried to pick up items that are found out in the canal. The prototype grippers made from acrylic are less robust, so they should improve the grippers joint. We should develop the width of the grippers to have a greater width than the old one.

For further study in terms of the design of the gripper and using a new material with different surface roughness for reducing the pressure between the contact surfaces and increase in friction may improve the adhesion of objects. Secondly, the subsequent study is the control of wireless robotic underwater how deep it can use. In the next version of the gripper prototype, AI technology will be implemented and replaced the manual control of the remote feature to grasp objects accurately.

Even if we build robots technology IoT to reduce pollution by collecting waste in the water, its structure consists of plastic structures, motors, and wires, which are not biodegradable. Therefore, it cannot be operating in the water all the time to prevent water pollution occurrence.

6. CONCLUSION

From the experiment and investigation, we obtained satisfactory results with some constraints. Firstly, two gripper types can clamp and lifting objects used in the experiment. Most of all types of the gripper are capable of clamping 7 items out of the 8 according to the weight of each object shown in Table 1, except for glass bottles. It cannot be grasped in the center of the bottle. Therefore, the clamping is incomplete. Additionally, with the glass bottle having a slippery surface and weight than 300g, the acrylic gripper cannot be incompletely clamped. Secondly, this prototype has an opportunity to develop product commercialization; therefore, the cost of the fabrication

process, the price of components, and complexity optimization should be firmly considered for success in the market, together with the ultimate features of usability.

The final point, one of the problems encountered when the gripper was attached to the robot caused the robot's balance when in the water to change. Therefore, we plan to improve the balancing adjustment for the weight control in the next upgraded robot.

AUTHOR CONTRIBUTIONS

T.J. designed and performed experiments. A.W. contributed to experiment preparation. Both A.W. and T.K. authors contributed to the interpretation of the results and discussion. T.J. wrote the manuscript in consultation with A.W. and T.K.

REFERENCES

1. Rojas, J. (2018). Plastic waste is Exponentially filling our oceans, but Where are the robots? 2018 *IEEE Region 10 Humanitarian Technology Conference (R10-HTC)*. https://doi.org/10.1109/r10-htc.2018.8629805
2. Gornicki, K., Groves, K., Carrasco, J., & Lennox, B. (2018). The pond cleaning system. *2018 UKACC 12th International Conference on Control (CONTROL).* https://doi.org/10.1109/control.2018.8516738
3. Pooja Niturkar. (2021). Row-Bot eating pollution for environment clean-up. *JournalNX - A Multidisciplinary Peer Reviewed Journal*, 331–334.
4. Siciliano, B., Khatib, O., & Kröger Torsten. (2016). *Springer Handbook of robotics*. Springer.
5. Khoa, T., Phuc, C. H., Lam, P. D., Nhu, L. M., Trong, N. M., Phuong, N. T., Dung, N. V., Tan-Y, N., Nguyen, H. N., & Duc, D. N. (2020). Waste management system using IoT-based machine learning in university. *Wireless Communications and Mobile Computing*, 2020, 1–13. https://doi.org/10.1155/2020/6138637
6. Hassan, H., Saad, F., Fazlin, N., & Aziz, A. (2018). Waste monitoring system based on Internet-of-Thing (IoT). *2018 IEEE Conference on Systems, Process and Control (ICSPC).* https://doi.org/10.1109/spc.2018.8704142
7. Takemura, F., Shiroku, R. T., Kawabata, K., & Sagara, S. (2013). Development of easy-removable Underwater Manipulator unit with Built-in Controller. *Journal of Robotics and Mechatronics*, 25(5), 778–784. https://doi.org/10.20965/jrm.2013.p0778

ORGANIZATIONS' READINESS FOR DIGITAL INNOVATIONS: EVIDENCE FROM ETHIOPIA

Shibiru Ayalew Melesse
Adama Science & Technology University, Ethiopia; email: shibekoo84@gmail.com

ABSTRACT

Organizational readiness theory asserts that "readiness for change" is a precursor to the effective implementation of complex changes. Scholars argue that innovation with digital technologies can be challenging and dynamic and innovation with digital technologies requires multiple and simultaneous adjustments in resources, staffing, culture, decision making, communication and reward systems. However, studies show that organizations are struggling to reap the full innovation potential, and the new ideas do not manifest into product or service deliveries because of the lack of organizational readiness particularly in developing countries. The objective of the current study was therefore to assess organizations' readiness for digital innovation in Ethiopia using a comprehensive approach; examine if digital innovation readiness differs across sectors in Ethiopia; investigate whether managers rating (perception) of organizational readiness is different from that of non-managerial employees, and identify key barriers and facilitators that provide the time and context of the development of an organizationally "ready" culture in Ethiopia. Organizational readiness for digital innovations was measured using eight dimensions namely resource readiness, IT readiness, cognitive readiness, partnership readiness, innovation valance, cultural readiness, and strategic readiness. Using sample of respondents from different firms in the financial, higher education, manufacturing, and public sectors in Ethiopia, the study found out that digital innovation readiness is far from being good across the sectors in Ethiopia in all standards and the private manufacturing sectors seems to be in a better position in terms of digital innovation readiness with respect to other sectors while the higher education sector appears to be the least. In addition, the results show that there exists disagreement between managers and employees in terms of organizations digital readiness for innovation and that managers are more likely than employees to positively perceive (rate) their organizations' digital innovation readiness. Finally, both practical and theoretical contributions of the study and policy directions are discussed.

Keywords: Digital innovation; Readiness; Ethiopia; Readiness theory; Readiness for change.

1. INTRODUCTION

Technological innovation demands coordination of substantial resources. Firms' readiness for digital innovation enables them to reap the benefits of adopting digital technologies. For instance, information systems scholars argue that readiness to innovate with technologies is positively associated with innovation outcomes and negatively related to innovation risks (Lokuge, 2019). Studies also show that about 90% of ideas failed to reach end-users as a result of firms' lack of readiness (Larsen & Roberts, 1971). In the same vein Pettey & Stevens (2009) noted that substantial opportunities have been lost due to organizations' lack of readiness for innovation. Emerging technologies such as cloud computing, artificial intelligence (AI), big data analytics, internet of things (IOT), business analytics, and block chain provide unprecedented opportunities to innovate, however they are not immune to failure.

In this proposed study "Digital technologies" refer to emerging technologies such as cloud computing, big data analytics, internet of things, artificial intelligence, block chain, social media, business analytics, wearable, and mobile. These emerging digital technologies are relatively inexpensive, or available on demand, functionally oriented, and flexible and have the potential to connect with both external stakeholders and customers. Such features of digital technologies minimize barriers for technology innovation.

Digital technologies will provide innovation opportunities at lower capital investment, challenging the traditional equation of innovation with IT sophistication and resource availability. However, organizations are struggling to reap the full innovation potential, and the new ideas do not manifest into product or service deliveries because of the lack of organizational readiness (Snyder-Halpern, 2001; Williams, 2011). Innovation with digital technologies presents new set of challenges. For organizations to succeed in digital innovation, it is required that they unfreeze, freeze, and refreeze their resources similar to three stage model of change management (Lewin, 1951). Hence, innovation with digital technologies can be challenging and dynamic. In addition, innovation with digital technologies requires multiple and simultaneous adjustments in resources, staffing, culture, decision making, communication and reward systems (Lokuge, Sedera, & Nanayakkara, 2018; Nambisan & Sawhney, 2011; Sirmon, Hitt, Ireland, & Gilbert, 2011). Furthermore, the non-exclusivity of digital technologies, where the competitors can easily emulate IT innovations (Nylén & Holmström, 2015) means that organizations must be able to adjust their resources and strategy configurations continuously to achieve competitive advantage (Avedillo, Begonha, & Peyracchia, 2015). It is also important to note that the digitization success stories have demonstrated that not only the modernity of technologies but also their IT decision makers, and organizational culture play a crucial role in implementing innovation (Nylén & Holmström, 2015; Swanson, 2012; Weill & Vitale, 2002).

Therefore, given a substantial potential to innovate using digital technologies, and the risks of not to innovate in today's competitive environment, the current study will scientifically assess organization's readiness of digital innovation within and between sectors and Ethiopia. The organizational readiness for digital innovation will be captured using the most recent instrument developed by Lokuge, Sedera, Grover, and Dongming (2019) for similar purpose.

2. LITERATURE REVIEW

Crossan and Apaydin (2010, p 1155) state that innovation is "a production or adoption, assimilation and exploitation of a value added novelty in economic and social spheres, renewal and enlargement of products, services and markets; development of new methods of production; and establishment of new management systems." Following the work of Lokuge et al. (2019), the current study defines digital innovation as innovation enabled through or triggered by digital technologies. The key terms in Crossan and Apaydin (2010) definition of innovation such as production, adoption, assimilation, exploitation, renewal, enlargement and development suggest that innovation can happen only when the organization is ready to change its innovation approach periodically.

Lokuge et al. (2019) suggested that the terms "readiness" and "innovation" have been examined under two main perspectives: i) the readiness of an organization to withstand an innovation and ii) the readiness of an organization to deliver or enable innovation. The focus of the current study is on the latter in that it evaluates an organization's level of readiness. Organizational readiness for digital innovation has received neglected attention in the literature

(Lokuge et al., 2019; Snyder-Halpern, 2001). Lokuge et al. (2019) defines readiness as a state that is attained prior to the commencement of a specific activity in relation to psychological, behavioral, and structural preparedness of organizations. They also suggested that readiness can be observed from multiple levels and then can be analyzed at the individual, team, department or organizational (Grover, Fiedler, & Teng, 1999; Molla et al., 2009). The current study attempts to examine readiness at organizational level though. In addition, scholars suggested that readiness is best conceptualized as a degree of readiness in a continuum rather than as a dichotomous variable of being "ready" or "not ready". Hence, according to these scholars organizational readiness for digital innovation is not a monologues construct (Klein & Kozlowski, 2000) rather it is a construct that has a different meaning, measurement, and relationship with other variables across different levels of analysis (Weiner, Amick, & Lee, 2008; Weiner, Lewis, & Linnan, 2009). Hence, in the context of the current study organizational readiness for digital innovation can be defined as "an organization's assessment of its state of being prepared for effective production or adoption, assimilation, and exploitation of digital technologies for innovation" (Lokuge et al., 2019, p. 446).

1. Readiness theory

Researchers argue that theory of organizational readiness for change can be used as theoretical lens to assess organizational readiness for digital innovation (Lokuge et al., 2019). Readiness theory asserts that "readiness for change" is a precursor to the effective implementation of complex changes. Specifically, organizational readiness for change refers to organizational members' change commitment and change efficacy to implement organizational change (Lokuge et al., 2019; Weiner, 2020; Weiner et al., 2008; Weiner et al., 2009). For instance, Weiner et al. (2009) contends that organizational readiness for change is a state of being both psychologically and behaviorally prepared to take action (i.e.; willing and able). Being prepared for innovations is nontrivial (Nelson & Winter, 1977). Drawing from organizational change literature, it is postulated that organizations produce or adopt, assimilate, and exploit innovation if the changes are i) perceived as necessary (willingness) and ii) the organization has the required capabilities (ability) (Armenakis, Harris, & Mossholder, 1993; Teng, Fiedler, & Grover, 1998).

The readiness theory has also been used by previous researchers (e.g.; Lokuge et al., 2019) to derive appropriate constructs for organizational readiness for digital innovation by conceiving through i) change valance , ii) change efficacy, and iii) contextual factors(for details see Lokuge et al., 2019, pp. 446-447). Based on these three theoretical paradigms, Lokuge et al. (2019) developed validated sub-constructs and measures for assessment of organization's readiness for digital innovation. They developed seven sub constructs with 21 measures to assess organization's readiness for digital innovation. The sub-constructs included resource readiness, IT readiness, cognitive readiness, partnership readiness, innovation valance, cultural readiness, and strategic readiness, each of which is discussed below.

Resource readiness: While the term "resource readiness" has been employed for brevity, it firmly emphasizes on the "flexibility" that the organization has to configure and reconfigure its resources in order to facilitate the needs of digital innovation. The construct is defined as the flexibility of a shared set of financial, technology, and human resources that provide the foundation on which digital innovation can be delivered upon. Here the emphasis is on

flexibility of financial, technology infrastructure, and human resources, this is also in line with notions on flexibility proposed in prior IS studies (e.g.; Kim, Shin, & Grover, 2010) .

IT readiness: IT readiness is defined as the strength of the IT portfolio to facilitate digital innovation. The stability of an enterprise system, which influences the innovation capacity of digital technologies, was discussed in recent studies by Sedera, Lokuge, Grover, Sarker, and Sarker (2016). In addition, Chen, Wang, Nevo, Benitez, and Kou (2017) noted that organizations that use IT to support core competencies will experience improved strategic flexibility, which may lead to innovation and increase performance.

Cognitive readiness: Cognitive readiness be can defined as the strength of the knowledge base in an organization in facilitating digital innovation. This refers to knowledge, skills, and adaptability of the staff as the core readiness facet of digital innovation. Previous studies (Rose, Jones, & Furneaux, 2016; Sedera & Gable, 2010) argued that knowledge, skills and abilities of employees can be of special relevance and significance for organizations that must adapt quickly or rapidly emerging, unforeseen challenges. Both individual and organizational units can be prepared to perform required tasks.

Partnership readiness: Partnership readiness is defined as the affiliation of external stakeholders to an organizations digital innovation. According to extant literature, organizations seek assistance from a wide spectrum of partners especially for digital innovation including software and hardware vendors, consultants, suppliers, and even customers (Abrell, Pihlajamaa, Kanto, Vom Brocke, & Uebernickel, 2016; Benitez, Ray, & Henseler, 2018; Gawer, 2014). For instance, Abrel et al (2016) highlight the distinct roles of customers and users in supporting digital innovation.

Innovation valance: The innovation valance is adapted from the change valance concept. Innovation valance measures the positivity the stakeholders have toward digital innovation. It refers to the i) attitude, ii) motivation, and iii) empowerment that employees have for digital innovation. Research notes that positive attitudes of employees foster open-ended creativity, which is a key driver for the digital innovation (Lokuge, Sedera, & Nanayakkara, 2018; Mueller, Rosenbusch, & Bausch, 2013). Likewise, motivation is one of the salient attributes that encourage open-ended value creation, especially in demanding circumstances (Berlyne, 1965). Motivational attitude is a psychological state that allows organizations to overcome deficiencies in resources such as finance and human capitals.

Cultural readiness: Cultural readiness is defined as the strength of the core values of an organization that facilitates digital innovation. Organizational culture is highlighted as a crucial factor for any innovation (Damanpour, 1991; Jansen, Van Den Bosch, & Volberda, 2006). The recent literature argues that the organizational culture is the most salient factors for innovation in organizations that thrive the digital economy (Lee, Raschke, & Louis, 2016). Companies such as Google, Apple, and Facebook, have strong organizational cultures that promote innovation (Boudreau & Lakhani, 2013; Jana, 2013). For instance, Lashisky (2011) in fortune Magazine describes Apple as the "world's biggest start-up," describing the conducive culture at Apple Inc. for innovation.

Strategic readiness: Strategic readiness is defined as a set of managerial activities that an organization engages in to facilitate digital innovation. Strategic readiness provides the knowledge that communicates a plan of actions

and forms the guidelines for compliance in digital innovation. A poor understanding of details of such changes and unawareness of what is expected have been found to be prominent but often unrecognized factors in unsuccessful innovation projects. Studies discuss the importance of clarity, continuous refinement, and communication of strategic goals (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Grover et al., 1999).

3. METHODS

1. ***Data collection methods:*** primary data was collected online using structured questionnaire via Google forms. A sample of 32 subjects from various sectors including higher education (n=9), industry (n=6), public service (n=10), and banks (n=7) responded to the survey questions and used in this preliminary analysis of organizations' readiness for innovation using digital technologies. 12 of the respondents were non managers, 10 of them were team leaders, 6 of them were middle level managers, and 4 of them were top managers. All of the respondents have attained masters or above education levels. In addition, out of the 32 respondents, 27 of them were male while the remaining (n=5) were female. The average age of the respondents is 33.125 years while their average work experience is 7.2 years.
2. **Measures of organizational readiness:** organizational readiness was measured using seven dimensions on a scale of 5 (5= strongly agree; 1=strongly disagree) each of which are discussed below.

1. ***Resource readiness***: resource readiness was measured by using three measures. These include i) flexible financial resources (Oke, Walumbwa, & Myers, 2012; Popadiuk & Choo, 2006), ii) human resources (Grover & Kohli, 2013), and flexible infrastructure resources (Chen, Wang, Nevo, Benitez-Amado, & Kou, 2015).
2. ***IT Readiness***: IT readiness was measured using three measures including i) stability of the enterprise system (Chen et al., 2017; Lokuge, Sedera, & Perera, 2018; Sedera et al., 2016), ii) availability of technological technologies (Nylén & Holmström, 2015; Sedera et al., 2016), and iii) stability of the IT infrastructure (Tilson, Lyytinen, & Sørensen, 2010; Tilson, Sorensen, & Lyytinen, 2012) that were used to collect information about IT readiness of an organization.
3. ***Cognitive Readiness:*** Cognitive readiness of an organization was measured using three measures including: i) knowledge, ii) skills, and iii) adaptability of the employees.
4. ***Partnership Readiness***: partnership readiness was suggested to be measured by three items: i) IT vendor relationship (Ceccagnoli, Forman, Huang, & Wu, 2012; Tate, Sedera, McLean, & Burton-Jones, 2014), ii) relationship readiness with management consultants (Bessant & Rush, 1995), and iii) readiness for establishing partnerships with customers or vendors (Lubatkin & O'Neill, 1987; Walther et al., 2018).
5. ***Innovation Valence***: Three measures were used to measure change valance using i) attitude of the employees (Ecker, van Triest, & Williams, 2013; Evanschitzky, Eisend, Calantone, & Jiang, 2012), ii) motivation (Antikainen, Mäkipää, & Ahonen, 2010; Damanpour, 1991), and iii) empowerment (Ecker et al., 2013; Mate-Sanchez-Val & Harris, 2014).
6. ***Cultural Readiness:*** Three measures were used to collect information cultural readiness: i) sharing of ideas in a connected workplace (Patanakul, Chen, & Lynn, 2012; Shane, Venkataraman, & MacMillan, 1995), ii) decentralization of decision making culture (Ford & Gioia, 2000; Lengnick-Hall, 1992), and iii) risk aversion.

7. ***Strategic Readiness:*** Strategic readiness was measured by three measures: i) the clarity of the goals (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004; Oke et al., 2012), relevance (Damanpour, 1991; Ecker et al., 2013), and iii) strategy communication (Backmann, 2013; Evanschitzky et al., 2012).
8. **Overall Readiness:** overall organizational readiness was measured using the mean of all the seven readiness dimensions discussed above.

4. PRELIMINARY RESULTS

The primary of objective of this paper is to assess organizations' readiness for digital innovations in Ethiopia to understand the extent of readiness and variations within and across different sectors in the country. This section presents the preliminary result of 32 samples taken from various sectors in Ethiopia. These sectors include higher education sector, private sector (industry), public service sector, and financial sector (Bank).

1. Readiness for digital innovations across sectors

The Figure 1 below shows organizations level of readiness for digital innovations by sector using the seven readiness dimensions resource readiness, strategic readiness, cultural readiness, IT readiness, innovation valence, cognitive readiness, and partnership readiness. As can be seen from the figure, level of readiness for digital innovations is far from excellent for all the sectors included in the study. In addition, in all sectors there is variation in readiness levels as measured by the seven dimensions of readiness for digital innovations. Furthermore, the overall readiness level varies across sectors. Relative to other sectors the industry sector (private) seems to be better in readiness level for digital innovations while the higher education sector seems to be the least (see Appendix I&III).

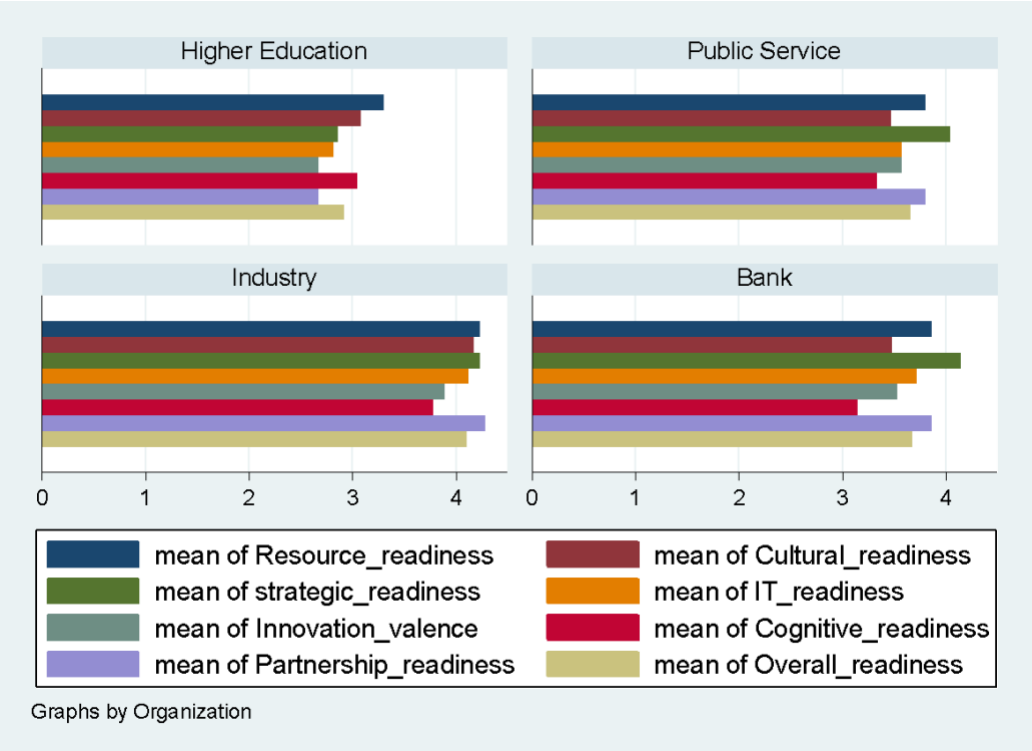


Figure 1 Organizations' readiness level for digital innovation by sector

Figure 2 shows the overall readiness levels of all sectors. There seems to be better readiness level with respect to readiness for resources and strategic readiness. However, there is considerable variation of readiness for digital innovations with respect to the seven dimensions of readiness. As can be seen from the table the overall readiness for digital innovations in Ethiopia is about average.

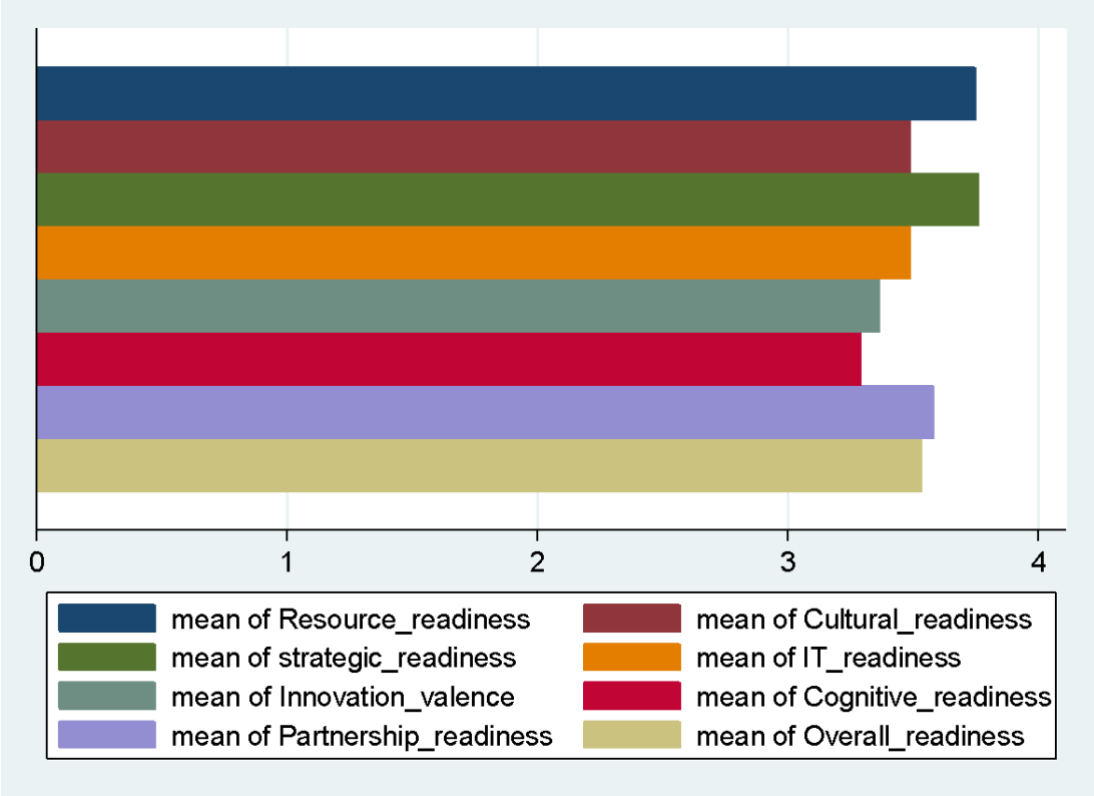


Figure 2 Overall readiness levels of organizations for digital innovations in Ethiopia

2. Readiness for digital innovations perceptions of managers and non-managers

Shared beliefs on digital readiness among management and employees are a precursor to successfully guide and implement organizational change. Another goal of the current paper is to examine of how readiness for digital innovations are distributed among managers and employees, or whether their perceptions of digital innovation readiness systematically differ. The preliminary findings reveal that perceptions of digital readiness for innovations differ considerably (see fig 3). In addition, the study shows that employees in managerial positions are more likely to perceive organizational readiness for digital innovation positively than non-managerial employees both within and across sectors (see Appendix II&III).

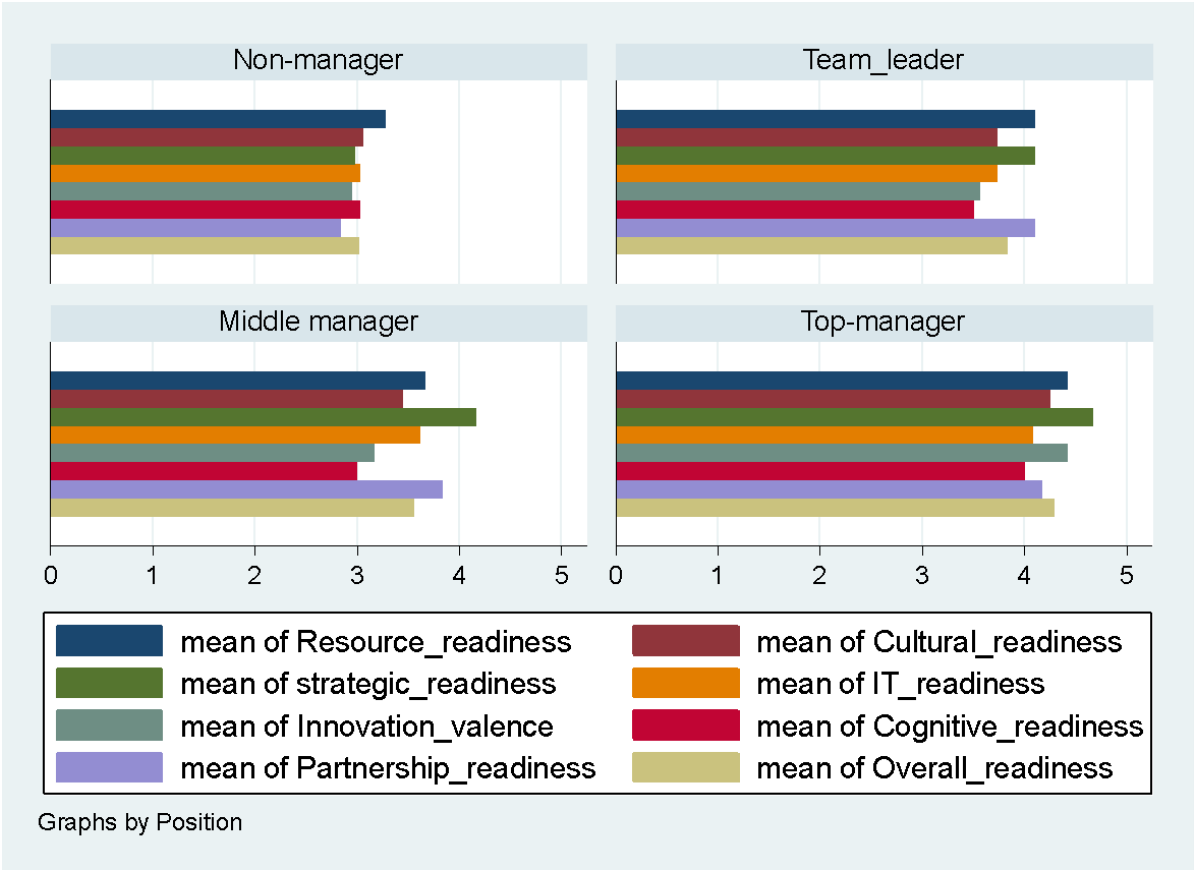


Figure 3 Organizations' readiness level for digital innovation by employee type

5. DISCUSSION

The current paper assesses organizations' readiness for digital innovations across several sectors in Ethiopia with the goal of understanding the extent of readiness level and agreement between managers and employees in terms of their readiness perceptions with reference to digital innovations. The preliminary findings of the study reveal an uneven readiness level of digital innovations across various sectors. In addition, the study shows that organizations' readiness for digital innovations remain far from being an excellent. Furthermore, managers and employees (non-managers) seem to differ in their perceptions of readiness levels where managers tend to perceive readiness for digital innovations more positively than non-managerial employees. In general, the higher education sector seems to be the least compared to other sectors in terms of its level of readiness for digital innovations while the private sector seems to have the highest level of readiness of digital innovations compared to the other sectors. According to Lokuge et al. (2019), highly consistent scores indicate some level of agreement about the constructs of organizational readiness for digital innovation (e.g., a cross a full sample, within stakeholder groups, within organizational entities). On the other hand, inconsistent scoring may point to areas if differences within these groupings, thus warranting attention. The current study has limitations. First, because of small sample size (n=32), the findings may suffer from internal and external validity problems. Hence, future research can benefit by replicating (extending) this study with an adequate sample size. Second, even though the population of the study is heterogeneous, the

current study used non probability sampling technique. The researcher believes that more reliable results can be attained if future studies use probability sampling methods and a large enough sample size.

6. CONCLUSION

In conclusion, organizations' readiness for digital innovations is vital for survival and growth in today's competitive environment especially in developing countries. However, organizations in the developing world such as Ethiopia seem to lack enough readiness for digital innovations. In addition, there seems to exits lack of agreement between managers and employees on how they perceive organizations' readiness for digital innovations. Furthermore, while the higher education sector is supposed to be innovation hub, its level of readiness for digital innovations is the lowest compared to other sectors. On the other hand, the private sector is found to be in a better readiness positions compared to other sectors such as higher education, banks, and public service sectors.

Organizations in the study area do not only reflect inadequate level of readiness for digital innovations but also demonstrate uneven (inconsistent) type of readiness for digital innovations as measured by digital innovation readiness measures. The current study has both practical and theoretical contributions.

The availability, accessibility, scalability, and easy-to-use and ease-of deployment of digital technologies have increased the temptation (and the necessity) for all organizations to innovate using such technologies (Lokuge et al., 2019). This readiness assessment allow organizations understand the capabilities available to them in order to effectively implement digital innovations which will lead to formulation of appropriate policies and strategies in a way they can reap the benefits of digital technologies. The current study also provides information for the organization under consideration how ready it is to innovate with emerging digital technologies. That is, the findings of this study help the case organizations to avoid "false-starts" which have been blamed for the notoriously high rate of innovation failures (Lokuge et al., 2019; Nylén & Holmström, 2015). The literature highlights the importance of the necessity of considering all factors before engaging in innovation (Lokuge et al., 2019; Swanson, 2012). The results of this study may also be used to establish bench marks for comparison against similar firms especially competitors.

Periodic benchmarks demonstrate the progress that an organization makes in relation to a particular sub-construct, allowing them to identify facets of improvements or facilitate organization wide knowledge on capabilities. Organizational readiness for digital innovation can be a tool to allocate and manage investments into digital innovation readiness factors. Having understood benchmarked, and identified possible areas of strength and weakness in relation to organizational readiness for digital innovation sub constructs, the organization can now allocate resources in the basis of evidence. The readiness assessment result will develop an evidence based practice to focus on resources and capabilities and pay attention to those aspects that are lacking in an organization. Such an approach will minimize the risks involved in digital technologies and innovation in general. Analysis of data samples based on various demographics or other distinctions can facilitate potentially useful comparisons for organizations.

In terms of its contribution to the literature, the current study provides consolidated information on organizational readiness for innovation unlike the previous studies that examined the antecedents of innovation bit by bit (e.g.; Roy & Sarkar, 2016; Saemundsson & Candi, 2014; Wan, Williamson, & Yin,

2015). In addition, it does so in a developing country context where a neglected attention has been given by previous study.

AUTHOR CONTRIBUTIONS

Shibiru Ayalew Melesse as a sole author of this paper conceived and designed the analysis, collected the data, performed the analysis, and wrote the paper.

ACKNOWLEDGEMENT

The author received no financial support for the research.

REFERENCES

1. Lashinsky, How Apple Works: Inside the World's Biggest Startup, Fortune, 2011, http://tech.fortune.cnn.com/2011/08/25/how-apple-works-inside-theworlds-biggest-startup.
2. Abrell, T., Pihlajamaa, M., Kanto, L., Vom Brocke, J., & Uebernickel, F. (2016). The role of users and customers in digital innovation: Insights from B2B manufacturing firms. *Information & Management, 53*(3), 324-335.
3. Antikainen, M., Mäkipää, M., & Ahonen, M. (2010). Motivating and supporting collaboration in open innovation. *European Journal of Innovation Management*.
4. Armenakis, A. A., Harris, S. G., & Mossholder, K. W. (1993). Creating readiness for organizational change. *Human relations, 46*(6), 681-703.
5. Avedillo, J. G., Begonha, D., & Peyracchia, A. (2015). Two ways to modernize IT systems for the digital era. *McKinsey & Company*.
6. Backmann, J. (2013). *Antecedents of Interorganizational New Product Development Project Performance: A Meta-Analysis.* Paper presented at the Academy of Management Proceedings.
7. Benitez, J., Ray, G., & Henseler, J. (2018). Impact of information technology infrastructure flexibility on mergers and acquisitions. *MIS quarterly, 42*(1).
8. Berlyne, D. E. (1965). Structure and direction in thinking.
9. Bessant, J., & Rush, H. (1995). Building bridges for innovation: the role of consultants in technology transfer. *Research Policy, 24*(1), 97-114.
10. Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: toward a next generation of insights. *MIS quarterly*, 471-482.
11. Boudreau, K. J., & Lakhani, K. R. (2013). Using the crowd as an innovation partner. *Harvard Business Review, 91*(4), 60-69, 140.
12. Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. (2012). Cocreation of value in a platform ecosystem! The case of enterprise software. *MIS quarterly*, 263-290.
13. Chen, Y., Wang, Y., Nevo, S., Benitez, J., & Kou, G. (2017). Improving strategic flexibility with information technologies: insights for firm performance in an emerging economy. *Journal of Information Technology, 32*(1), 10-25.

14. Chen, Y., Wang, Y., Nevo, S., Benitez-Amado, J., & Kou, G. (2015). IT capabilities and product innovation performance: The roles of corporate entrepreneurship and competitive intensity. *Information & Management, 52*(6), 643-657.
15. Crossan, M. M., & Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies, 47*(6), 1154-1191.
16. Damanpour, F. (1991). Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of management journal, 34*(3), 555-590.
17. Ecker, B., van Triest, S., & Williams, C. (2013). Management control and the decentralization of R&D. *Journal of Management, 39*(4), 906-927.
18. Evanschitzky, H., Eisend, M., Calantone, R. J., & Jiang, Y. (2012). Success factors of product innovation: An updated meta-analysis. *Journal of Product Innovation Management, 29*, 21-37.
19. Ford, C. M., & Gioia, D. A. (2000). Factors influencing creativity in the domain of managerial decision making. *Journal of Management, 26*(4), 705-732.
20. Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy, 43*(7), 1239-1249.
21. Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: systematic review and recommendations. *The Milbank Quarterly, 82*(4), 581-629.
22. Grover, V., & Kohli, R. (2013). Revealing your hand: caveats in implementing digital business strategy. *MIS quarterly*, 655-662.
23. Grover, V., Fiedler, K. D., & Teng, J. T. (1999). The role of organizational and information technology antecedents in reengineering initiation behavior. *Decision Sciences, 30*(3), 749-781.
24. Jana, R. (2013). Inside Facebook's internal innovation culture. *Harvard Business Review*.
25. Jansen, J. J., Van Den Bosch, F. A., & Volberda, H. W. (2006). Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. *Management Science, 52*(11), 1661-1674.
26. Kim, G., Shin, B., & Grover, V. (2010). Research note: Investigating two contradictory views of formative measurement in information systems research. *MIS quarterly*, 345-365.
27. Klein, K. J., & Kozlowski, S. W. (2000). From micro to meso: Critical steps in conceptualizing and conducting multilevel research. *Organizational research methods, 3*(3), 211-236.
28. Larsen, J., & Roberts, A. (1971). Effective Use of Mental Health Research Information, Final Report to the National Institute of Mental Health. *American Institutes for Research, Palo Alto, California*.
29. Lee, M. T., Raschke, R. L., & Louis, R. S. (2016). Exploiting organizational culture: Configurations for value through knowledge worker's motivation. *Journal of Business Research, 69*(11), 5442-5447.
30. Lengnick-Hall, C. A. (1992). Innovation and competitive advantage: What we know and what we need to learn. *Journal of Management, 18*(2), 399-429.
31. Lewin, K. (1951). Field theory in social science: selected theoretical papers (Edited by Dorwin Cartwright.).
32. Lokuge, S., Sedera, D., & Nanayakkara, K. S. (2018). Innovate or copy: a qualitative document analysis to entrepreneurship in developing countries.
33. Lokuge, S., Sedera, D., & Perera, M. (2018). *The Clash of the Leaders: The intermix of leadership styles for resource bundling.* Paper presented at the PACIS.

34. Lokuge, S., Sedera, D., Grover, V., & Dongming, X. (2019). Organizational readiness for digital innovation: Development and empirical calibration of a construct. *Information & Management, 56*(3), 445-461.
35. Lubatkin, M., & O'Neill, H. M. (1987). Merger strategies and capital market risk. *Academy of management journal, 30*(4), 665-684.
36. Mate-Sanchez-Val, M., & Harris, R. (2014). Differential empirical innovation factors for Spain and the UK. *Research Policy, 43*(2), 451-463.
37. Molla, A., Cooper, V. A., & Pittayachawan, S. (2009). IT and eco-sustainability: Developing and validating a green IT readiness model. *ICIS 2009 proceedings*, 141.
38. Mueller, V., Rosenbusch, N., & Bausch, A. (2013). Success patterns of exploratory and exploitative innovation: A meta-analysis of the influence of institutional factors. *Journal of Management, 39*(6), 1606-1636.
39. Nambisan, S., & Sawhney, M. (2011). Orchestration processes in network-centric innovation: Evidence from the field. *Academy of Management Perspectives, 25*(3), 40-57.
40. Nelson, R. R., & Winter, S. G. (1977). In search of a useful theory of innovation *Innovation, economic change and technology policies* (pp. 215-245): Springer.
41. Nylén, D., & Holmström, J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. *Business Horizons, 58*(1), 57-67.
42. Oke, A., Walumbwa, F. O., & Myers, A. (2012). Innovation strategy, human resource policy, and firms' revenue growth: The roles of environmental uncertainty and innovation performance. *Decision Sciences, 43*(2), 273-302.
43. Patanakul, P., Chen, J., & Lynn, G. S. (2012). Autonomous teams and new product development. *Journal of Product Innovation Management, 29*(5), 734-750.
44. Pettey, C., & Stevens, H. (2009). Gartner reveals five business intelligence predictions for 2009 and beyond. *Stamford, CT: Gartner Group*.
45. Popadiuk, S., & Choo, C. W. (2006). Innovation and knowledge creation: How are these concepts related? *International journal of information management, 26*(4), 302-312.
46. Rose, J., Jones, M., & Furneaux, B. (2016). An integrated model of innovation drivers for smaller software firms. *Information & Management, 53*(3), 307-323.
47. Roy, R., & Sarkar, M. (2016). Knowledge, firm boundaries, and innovation: Mitigating the incumbent's curse during radical technological change. *Strategic Management Journal, 37*(5), 835-854.
48. Saemundsson, R. J., & Candi, M. (2014). Antecedents of innovation strategies in new technology-based firms: interactions between the environment and founder team composition. *Journal of Product Innovation Management, 31*(5), 939-955.
49. Sedera, D., & Gable, G. G. (2010). Knowledge management competence for enterprise system success. *The Journal of Strategic Information Systems, 19*(4), 296-306.
50. Sedera, D., Lokuge, S., Grover, V., Sarker, S., & Sarker, S. (2016). Innovating with enterprise systems and digital platforms: A contingent resource-based theory view. *Information & Management, 53*(3), 366-379.
51. Shane, S., Venkataraman, S., & MacMillan, I. (1995). Cultural differences in innovation championing strategies. *Journal of Management, 21*(5), 931-952.

52. Sirmon, D. G., Hitt, M. A., Ireland, R. D., & Gilbert, B. A. (2011). Resource orchestration to create competitive advantage: Breadth, depth, and life cycle effects. *Journal of Management, 37*(5), 1390-1412.
53. Snyder-Halpern, R. (2001). Indicators of organizational readiness for clinical information technology/systems innovation: a Delphi study. *International journal of medical informatics, 63*(3), 179-204.
54. Swanson, E. B. (2012). The managers guide to IT innovation waves. *MIT Sloan Management Review, 53*(2), 75.
55. Tate, M., Sedera, D., McLean, E., & Burton-Jones, A. (2014). Information systems success research: The "20-Year update?" Panel Report from PACIS, 2011. *Communications of the Association for Information Systems, 34*(1), 63.
56. Teng, J. T., Fiedler, K. D., & Grover, V. (1998). An exploratory study of the influence of the IS function and organizational context on business process reengineering project initiatives. *Omega, 26*(6), 679-698.
57. Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Research commentary—Digital infrastructures: The missing IS research agenda. *Information systems research, 21*(4), 748-759.
58. Tilson, D., Sorensen, C., & Lyytinen, K. (2012). *Change and control paradoxes in mobile infrastructure innovation: the Android and iOS mobile operating systems cases.* Paper presented at the 2012 45th Hawaii International Conference on System Sciences.
59. Walther, S., Sedera, D., Urbach, N., Eymann, T., Otto, B., & Sarker, S. (2018). Should We Stay or Should We Go? Analyzing Continuance of Cloud Enterprise Systems. *J. Inf. Technol. Theory Appl., 19*(2), 4.
60. Wan, F., Williamson, P. J., & Yin, E. (2015). Antecedents and implications of disruptive innovation: Evidence from China. *Technovation, 39*, 94-104.
61. Weill, P., & Vitale, M. (2002). What IT infrastructure capabilities are needed to implement e-business models? *MIS quarterly, 1*(1), 17.
62. Weiner, B. J. (2020). A theory of organizational readiness for change *Handbook on Implementation Science*: Edward Elgar Publishing.
63. Weiner, B. J., Amick, H., & Lee, S.-Y. D. (2008). Conceptualization and measurement of organizational readiness for change: a review of the literature in health services research and other fields. *Medical care research and review, 65*(4), 379-436.
64. Weiner, B. J., Lewis, M. A., & Linnan, L. A. (2009). Using organization theory to understand the determinants of effective implementation of worksite health promotion programs. *Health education research, 24*(2), 292-305.
65. Williams, I. (2011). Organizational readiness for innovation in health care: some lessons from the recent literature. *Health Services Management Research, 24*(4), 213-218.

	Resource readiness	Cultural readiness	Strategic readiness	IT readiness	Innovation valence	Cognitive readiness	Partnership readiness
Higher Education	-0.926	-1.093*	-1.370**	-1.296*	-1.222*	-0.741	-1.611**
	(0.521)	(0.496)	(0.472)	(0.568)	(0.518)	(0.469)	(0.524)
Bank	-0.365	-0.690	-0.0794	-0.397	-0.365	-0.635	-0.421
	(0.550)	(0.524)	(0.498)	(0.599)	(0.546)	(0.496)	(0.553)
Public	-0.422	-0.700	-0.189	-0.544	-0.322	-0.444	-0.478
	(0.511)	(0.486)	(0.463)	(0.556)	(0.507)	(0.460)	(0.513)
Constants	4.222***	4.167***	4.222***	4.111***	3.889***	3.778***	4.278***
	(0.404)	(0.384)	(0.366)	(0.440)	(0.401)	(0.364)	(0.406)
N	32	32	32	32	32	32	32
R^2	0.107	0.148	0.318	0.174	0.197	0.089	0.293

APPENDIX

Appendix I

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1 Regression output for testing readiness for digital innovations differences by sector

Appendix II

	Resource readiness	Cultural readiness	Strategic readiness	IT readiness	Innovation valence	Cognitive readiness	Partnership readiness
Non-manager	-1.139*	-1.194*	-1.694**	-1.056	-1.472*	-0.972	-1.333*
	(0.545)	(0.534)	(0.489)	(0.643)	(0.561)	(0.495)	(0.577)
Team leader	-0.317	-0.517	-0.567	-0.350	-0.850	-0.500	-0.0667
	(0.558)	(0.547)	(0.501)	(0.658)	(0.575)	(0.507)	(0.591)

Middle manger	-0.750	-0.806	-0.500	-0.472	-1.250	-1.000	-0.333
	(0.609)	(0.597)	(0.546)	(0.718)	(0.627)	(0.554)	(0.645)
constants	4.417***	4.250***	4.667***	4.083***	4.417***	4***	4.167***
	(0.472)	(0.462)	(0.423)	(0.556)	(0.486)	(0.429)	(0.500)
N	32	32	32	32	32	32	32
R^2	0.187	0.178	0.391	0.118	0.214	0.155	0.285

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2 Regression output for testing readiness for digital innovations differences by employee type

Appendix III

	Overall readiness	Overall readiness
Non-manager	-1.266*	
	(0.473)	
Team-leader	-0.452	
	(0.485)	
Middle-manger	-0.730	
	(0.529)	
Higher education		-1.180*
		(0.440)
Bank		-0.422
		(0.465)
Public		-0.443
		(0.432)
Constant	4.286***	4.095***
	(0.410)	(0.341)
N	32	32
R^2	0.252	0.223

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Regression output for testing readiness for digital innovations differences

THE STUDY OF REQUIRED COMPETENCE FOR ICT WORKFORCE IN THE DIGITAL TRANSFORMATION: THE CASE OF NORTHERN INDUSTRY, THAILAND

Wantana Areeprayolkij[1], Jirapipat Thanyaphongphat[1], Khanita Tumphasuwan[1]
[1] *College of Arts, Media and Technology, Chiang Mai University, Chiang Mai, Thailand*
wantana.a@cmu.ac.th, jirapipat.than@cmu.ac.th, khanita.t@cmu.ac.th

ABSTRACT

Over the last decade, humanity has inevitably adopted Information and Communication Technology (ICT) and be transformed into digital and mobility life. ICT skill becomes to required competence for the new generation workforce. Moreover, it is a challenge for human resource development to motivate the current workers for learning digital and automation technology. To define the ICT skill qualification, the capability of personas should be analyzed circumspectly corresponding with the regions' industrial context. This paper proposes a factor structure model as an analysis methodology design for examining the ICT competence gap. Categories of skill-sets were formed to the assumption model. The structure model of required ICT competence was confirmed through the survey inquiring for the self-evaluation comparing to the result of an ICT proficiency test from the program participants. The study focuses on the case in the northern industry of Thailand, where is in the early stage of digital transformation; still, there is high demand for digital ICT competence improvement. The results reveal trends and required ICT competence that specifies the right workforce development points that align with industrial demands and expectations in the sample context.

Keywords: ICT competence; ICT workforce; Skill gap analysis; Competency trends

1. INTRODUCTION

In the transition period of industrial digitization, ICT competency constitutes an essential qualification of manpower. In the same way, digital technology has been realized as a common feature for businesses applying in several knowledge fields. Not only for organization evolution themselves, but it is also for coping with the technology disruption to the profession. This is an elaborate obligation to human resource development both in new recruitments and in-house training. The most complicated proposition is characterizing the precise and relevant skill-sets of capabilities in modern technology combined with existing organizational knowledge. Competence gap analysis and foreseeable technical trends are imperative actions.

ICT competency assessments seem to be simple under organizational control; because it is a part of education programs in academic institutions. Nevertheless, it is still an enormous variety of plenty curriculums. The efficient assessment should be designed underlying the particular expertise specification corresponding with the industry requirements. Many firms seek out a proper certificate to define the right skills qualification of employment. Recently, various ICT proficiency tests are emerging in academia and related ICT affairs. Most of them outline broad contents which cover the overview of ICT competence. Some assessments have been imposed on national

ICT examinations, which are used for required ICT competence determination and workforce qualifications in the ICT industry and business services. However, the affirmation of required skill-sets, which are best suited to a specific area of the business subject, is matter for well-fit evaluation that leads to setting up a productive training course for workforce development.

The subject of the ICT context in the region of northern industry, Thailand, where several ICT examinations are utilized for occupational standards, has been chosen as a case study. Regarding government support, Thailand has adopted the foreign test schemes as a global standard examination. These tests could be an excellent option for the Thai ICT workforce to evaluate their capability in the ICT career; however, it is always questionable of the contents, which one is the most suitable for Thai's industry. The distinctions of each exam are elaborately written according to the ICT technology and software market trends in the region of the source. Even the test was well-created and well-organized, though the variety of practical issues in the contents through the domestic examinee's perspective appears.

This study proposes the analysis model for the competence gap examination. The competence is compared well-matched contents between categories of skill-sets, which are framed from the assumption model, within the confirmation of skill-sets expectation survey from the sample group and the results of ICT competency assessment through the volunteers participating in an ICT proficiency test named the Test of Practical Competency in IT (TOPCIT). The sample has covered the people in the expert field of ICT, academic personnel, and university students.

This paper has organized the structure composing the study background, literature reviews, methodology, analysis and results, discussion, and conclusion, respectively. The methodology is classified into two parts: the design of the analysis model according to assumptions and data collections for pre-test and post-test.

2. LITERATURE REVIEW

1. ICT competence

Digital transformation is a part of a national plan for driving the Thailand 4.0 industry. It has been in national trends and ongoing forward. Since there is increasing investment in ICT development in the private sector continuously, it has indicated the growth of positive contribution in IT digital to national gross domestic production (GDP); yet, ICT capability significantly accelerates competitiveness and productivity to firms. Individual ability in ICT is critically required in the transitional concept of the knowledge-based economy [1]. Digital IT competency is a key for human resource development in this period. Organizations have to moderate themselves getting ready for changes. ICT and digital technology are core knowledge of young generation workers; however, the scope of ICT profession demands is vary depending on the areas of business and industry sector [2]. Additionally, ICT competence is discussed widely in several aspects, such as organizational policy and plans for manpower development. c

Competency is defined in several terms; nevertheless, competence has a compliable semantic in the same way, a skill-set of individual possession. Competence proficiency is an imperative criterion for maintaining individual performance [3]. In the competency framework [4], competence is determined as a combination of skills, knowledge, behaviors, and attitudes of individuals that empowers them to effectively take actions on a task within

a specific context [5]. ICT competency has an explicit explanation in academia. Teachers should fulfill with skills in both hardware and software, especially for communication, presentation, and class management [6]. Moreover, ICT competency means comprehensive skills to solve problems with a well-understanding ICT principle suitable with existing environments [7].

The assessment of skill readiness level is necessary for educational preparation [8]. Due to the diversity in educational institutions and ensuring the quality of employed workers, test-based competence proficiency measurements designed and applied as international standards are becoming pervasive as a trustable reference to a personal level of proficiency. For instance, ICTC-Test (Information Communication Technology Competency Test) is adopted to assess the ICT competency among postgraduate students in the Higher Learning Institutions (HLI). This test has been used to validate interactions between cognitive skills and technical skills in the ICT field [9]. Another well-known examination is named Information Technology Professionals Examination (ITPE). This examination originated in Japan; later, it widely applies in several ally countries under the Information Technology Professionals Examination Council (ITPEC), such as Bangladesh, Philippines, Vietnam, Myanmar, Mongolia, and Thailand. ITPE was framed to be the standard criteria of expertise level for IT engineers [10]. The late arrival ICT competence evaluation is the Test of Practical Competency in IT (TOPCIT) supported by the Korean government. TOPCIT was created for driving policy implications regards to ICT skill development on a global scale. Inside the examination contents, it specified for people in the software area coupled with the evaluation system of the ICT proficiency level [11]. Both ITPE and TOPCIT are recognized in the Thailand ICT workforce market.

Nevertheless, the contents of ITPE test figure more in-depth specificity, whereas TOPCIT illustrates more ICT skill combination within the business context. That makes TOPCIT seems to be more generalized in practices for industry sectors. Therefore, in this research, the description of categories and skill items from TOPCIT was implied and composed in the analysis model.

2. Competency gap analysis

1. ICT requisite competence

The competence of qualified Chief Information Officers (CIOs) was proposed by Shalamanov et al., (2020)[12]. Being ICT professional and abilities regarding to foresee and manage ICT infrastructures and resources are required. Also, they emphasized the competence in cybersecurity should be concerned in priority. Siddoo et al., (2019)[13] defined proficient skills for the digital workforce in Thailand's Industry 4.0 context. The associated categories between professional skills, IT technical, IT management, and support were principled clarified; however, the skill-sets for ICT specialists were slightly explanation. The requisite skills from the literature are listed in Table 1.

Table 1. The ICT requisite skills

Category	ICT Skills
IT technical	Computer Network
	Cybersecurity
	Database design and development

	Software convergence application
IT management and support	Business concept
	Project Management
Personal skill	English for technical communication

Note: ICT skills are taken from Siddoo et al., (2019)[13] and Lee and Seo, (2018)[14].

2. ICT Competency gap analysis methods

The competence gap analysis was initiated from a factor structure model. In two-factors construction, coefficients examination is a suitable analysis method [15]. This method was applied to measure preservice teachers' ICT competencies. The factor model investigated the correlation between ICT competencies in two aspects which are 1) competencies for supporting in-class pupils and 2) competencies for instructional design. The results could confirm the impact of the factors from a structure coefficients model, which were formed by the ICT competence items.

Alternatively, the ICT competency gap is able to examine by levels of proficiency. Gastelú et al. (2015)[16] reported the analysis in university students, Hungary and Mexico. ANOVA was operated mainly for the analysis methodology. In addition, they classified ICT competencies into three sections according to the sample study, which are the core competencies of 1) digital literacy, 2) implementation, and 3) ethics.

From the reviews, we found that each method was considered from the characteristics of the case study and proposition corresponding to demands in different aspects. In this study, we focus more on ICT technical profession skill-set items that have effects on ICT competency level for the future workforce corresponding with the relationship on the practical ICT competence proficiency test, TOPCIT. The investigation is conducted by PLS-SEM and basic statistical analysis.

3. METHODS

The methodology was structured into three major actions, which are:

1) ICT competence skill-sets Model Formation
2) Pre-test questionnaires
3) Post-test questionnaires

Initially, the ICT competence skill-sets model was created from the test categories of TOPCIT and literature reviews that define the explicit description of each illustrates in Figure 1. Then, the questionnaires surveying the confirmation skill-sets requirements were conducted for pre- and post- taking the test. PLS-SEM was used as an analysis tool. The ICT competence Model is composed ICT Competency as a latent variable that has indicators for skill-sets clarification such as Software Programming, Software Design and Analysis, Database Design and Programming, Network and Security, IT Business Concepts and Technology Trends, Software Project Management, Application Convergence, English for Technical Communication, Software Testing, UX CX and Service Design, and FinTech. The effect of ICT competency subjects on the perception of a well-fit competency test, TOPCIT, is ascribed in the model.

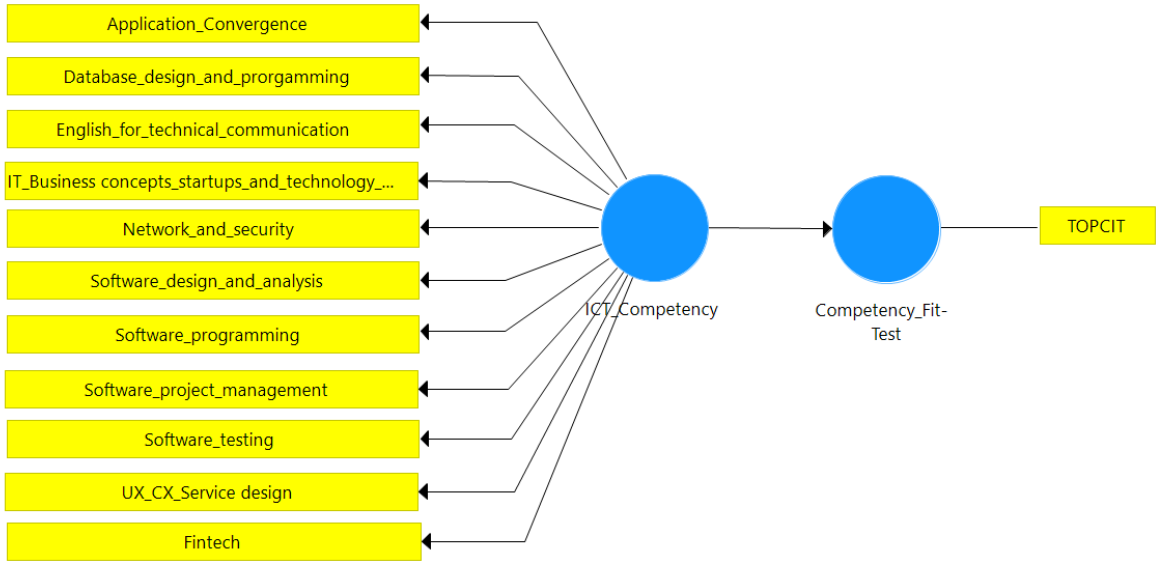


Figure 1. ICT competence skill-sets model

4. DATA

The data was collected from the workforce in ICT fields that have different levels of competence. Twenty-seven participants living in Northern Thailand were recruited to respond to the questionnaires before and after taking the ICT proficiency exam. About 30% of examinees represent workers currently working in the companies, and the rest is the sample of the future workforce.

Table 2. Data Profile

	Attributes	n=27
1	**Workforce type:**	
	Future workforce (Students and individuals without working experience)	62.96%
	Current workers	37.04%
2	**Age range (years old)**	
	< 20	43%
	20-29	39%
	30-39	9%
	40-49	9%
3	**Education level**	
	Bachelor	88%
	Master	9%
	Doctoral	3%
4	**Work experience (years)**	
	No experience	55%
	<1	12%
	1-5	18%

	6-10	6%
	>10	9%
4	**Major business operation**	
	Software development	46%
	ICT Services	6%
	Electronic parts manufacturer	3%
	Education	39%
	None	6%

5. RESULTS

From the results, as shown in Figure 2 of the competency survey, we evaluated before and after the test. 33 and 21 respondents gave us feedback; before and after the trial, respectively. Most participants interested in the project live in Chiang Mai (88%) and only a few in nearby provinces such as Tak, Lamphun, and Lampang. 55% of participants are studying in the university without work experience; whereas, 18% of people are working in a company with experience from 1-5 years, 12% with less than one-year experience, 9% and 6% for senior expertise over 10 years and 5-10 years respectively. All of them are personal in the ICT profession.

The subjects that respondents commented on the topics they want to develop their expertise in descending order: Software Programming, Software Design and Analysis, Database Design and Programming, Network and Security, IT Business Concepts and Technology Trends, Software Project Management, Application Convergence, English for Technical Communication, Software Testing, UX CX and Service Design, and FinTech. After test feedback, the sample group answered positively on the project being organized and corresponded to their intended purpose. More than half of them commented that the project's outcome met their expectations before joining the project. A significant critique indicates that the TOPCIT exam contents are consistent with the context of the ICT career of respondents highly to 74% of registrars. Specifically, the result from PLS-SEM analysis appeared highest factor-load on the subjects, English for Technical Communication (0.890) and IT Business Concepts and Technology Trends (0.820), which could reflect the perception of the well-fit competency test, TOPCIT, to the sample.

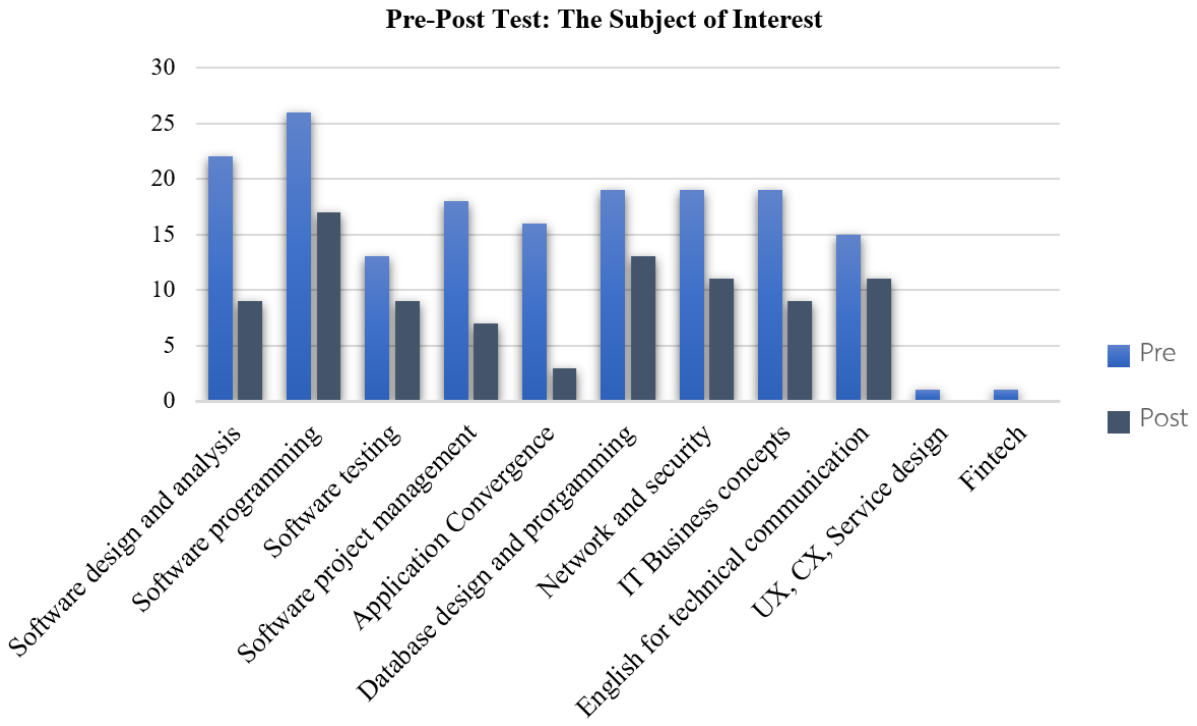


Figure 2. Feedback response to the subjects of interest

6. DISCUSSION AND CONCLUSION

The results projected the noticeable competency gap in skill-sets of participants' self-improvements. It implied that the approximate of the ICT skills requirements had been affected after the test taken. We received high positive responses consistently in the skill-sets of software programming, Database Design and Programming, and English for Technical Communication; whereas, the demand on Software Design and Analysis, Software Project Management, and Application Convergence have been declined significantly. The proficiency could consider being an advanced development skill such as Network and Security and Software Testing. Apparently, the Application Convergence is slightly at the edge of interest; likewise, the IT Business Concepts and Technology Trends knowledge should be maintained but not for intensive focus on the training aspect.

Explicitly, there are demands of skill upgrade in ICT competence towards more in the subject categories of the software developer than business and management [13]. The training program should mainly plan for software programming, Database Design and Programming, and Network and Security. Besides that, the capability in IT Business Concepts and Technology Trends is still needed for future employees; in the same way, English language skill is still a classic weakness for technical communication in the Thai ICT workforce.

In conclusion, this research proposed the method aiming for ICT competence gap analysis. The proposition in this study targets a sample group of the ICT workforce in Northern Thailand. The ICT competence skill-sets were defined and consequently confirmed with demands and requirements of the proficiency development. The research investigation illustrates technology trends that indicate the direction of Thai's ICT industry in the digital

transformation stage. This study's findings convey the practical implication for policymakers in education and human resource management to scheme the ICT skill-sets in training, individual competence development, proficiency measurement, and performance manipulation. Additionally, further study has been planned to augment the investigation scope by recruiting more participants in various industry sectors; as well as, the analysis model would be considered to reconstruct the attributes including attitude and necessary contexts such as problem-based constraints and ICT adoption issues.

AUTHOR CONTRIBUTIONS

A.W. conceived of the presented idea and designed the analysis method. A.W. and T.J. collected the data as well as contributed analysis tools and performed the analysis. T.K. contributed to the interpretation of the results. A.W. took the lead in writing the manuscript. All authors discussed the results, provide critical feedback, and contributed to the final manuscript.

REFERENCES

1. Jones, C., & Pimdee, P. (2017). Innovative ideas: Thailand 4.0 and the fourth industrial revolution. *Asian International Journal of Social Sciences, 17*(1), 4-35.
2. Müller, E., & Hopf, H. (2017). Competence center for the digital transformation in small and medium-sized enterprises. *Procedia Manufacturing, 11*, 1495-1500.
3. Sampson, D., & Fytros, D. (2008). Competence models in technology-enhanced competence-based learning. *In Handbook on information technologies for education and training* (pp. 155-177). Berlin, Heidelberg: Springer.
4. UNIDO. (2002). Human Resource Management Framework (HRMF) - Administrative Instruction. Retrieved August 22, 2021, from https://www.unido.org/overview/legal-resources/human-resources-documents
5. Zervas, P., Chatzistavrianos, K., & Sampson, D. G. (2014). Towards modelling teachers' ICT competence profile in Europe. *ICT in Education in Global Context* (pp. 163-181). Berlin, Heidelberg: Springer.
6. UNESCO. (2011). *ICT competency framework for teachers.* United Nations Educational, Scientific and Cultural Oraganization.
7. Cha, S. E., Jun, S. J., Kwon, D. Y., Kim, H. S., Kim, S. B., Kim, J. M., ... & Lee, W. G. (2011). Measuring achievement of ICT competency for students in Korea. *Computers & Education, 56*(4), 990-1002.
8. Puriwat, W., & Tripopsakul, S. (2020). Preparing for Industry 4.0--Will Youths Have Enough Essential Skills?: An Evidence from Thailand. *International Journal of Instruction, 13*(3), 89-104.
9. Ahmad, M., Karim, A. A., Din, R., & Albakri, I. S. M. A. (2013). Assessing ICT competencies among postgraduate students based on the 21st century ICT competency model. *Asian Social Science, 9*(16), 32.
10. *ITPEC*. (2021, July 30). Retrieved from Information Professionals Examination Coucil: https://itpec.org/
11. *TOPCIT*. (2021, July 30). Retrieved from Test of Practical Competency in IT: https://www.topcit.or.kr/
12. Shalamanov, V., Monov, V., Blagoev, I., Matern, S., Vassileva, G., & Blagoev, I. (2020). A Model of ICT Competence Development for Digital Transformation. *Information & Security: An International Journal, 46*, 269-284.

13. Siddoo, V., Sawattawee, J., Janchai, W., & Thinnukool, O. (2019). An exploratory study of digital workforce competency in Thailand. *Heliyon, 5*(5), e01723.
14. Lee, H. S., & Seo, Y. W. (2018). An Analysis of the proliferation Case of TOPCIT (Test of Practical Competency in ICT) and policy implications. *Journal of Digital Convergence, 16*(5), 1-12.
15. Tondeur, J., Aesaert, K., Pynoo, B., van Braak, J., Fraeyman, N., & Erstad, O. (2017). Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century. British Journal of Educational Technology. *48*(2), 462-472.
16. Gastelú, C. A. T., Kiss, G., & Domínguez, A. L. (2015). Level of ICT competencies at the university. *Procedia-Social and Behavioral Sciences, 174*, 137-142.

1st International Conference on Digital Innovation for Global Growth (DIGG) 2021

Telephone: +82-42-350-6845(6393) Fax. +82-42-350-6858

http://ittp.kaist.ac.kr