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Applying Decision Tree and Bibliometric Analysis: The Analysis of Digital Governance Determinants

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Abstract

Digital governance plays a crucial role in leading organizations in their digital transformation process. This paper aims to explore the analysis of digital governance determinants through the application of decision tree and bibliometric analysis techniques. Understanding these factors can help organizations in developing effective digital governance initiatives and strategies. Bibliometric analysis is utilized to identify new trends and overall research landscape of digital governance. K-means clustering and decision tree are then used to identify key determinants of effective digital governance. Our results show that leadership is the most initial important factor. In addition, to enhance digital governance to the highest level, organizational culture that is driven from the leader is also another important factor. The findings of this study yield insights for practitioners and managers who seek to improve their digital governance practices.

Keywords**:** *Bibliometric analysis; decision tree modeling; determinants; digital governance; digital transformation.*

1. Introduction

International Institute for Management Development (IMD) has been developed "World Digital Competitiveness Ranking" that measures the countries capacity and readiness to adopt digital technology for exploring business and nation competitive (International Institute for Management Development, 2023). In 2022, Denmark came to the first rank while Thailand accounted for the 40th from 63 economies. Denmark excels in ranking that measures how well economies are exploring new technologies. IMD found that the high rank country of world digital competitiveness indicates not only about to embrace digital to cultivate business growth but they also focus on cybersecurity.

Thailand as a developing country in ASEAN, intends to the fourth industrial revolution (Thailand 4.0) as a solution for stimulated growth by investing in innovative and digital solutions (Sae-Lim, & Jermsittiparsert, 2019). Thailand's 13th National Economic and Social Development plan has included digital as one of the important goals. The plan indicates that in order to achieve the digital national goal, 30% of Thailand's gross domestic product (GDP) should derive from digital portion. In this case, the government then arranges some spending to enhance digital ecosystem as well as to support business sector where business values are created through digital platform.

For this reason, government agencies align their strategies with Thailand's 13th National plan to become digital government agencies. On the contrary, private sectors also often utilize digital platform as a competitive tool. Moreover, digital platform adds business value, reduces operating

cost and maintains the organization's existence (Guo et al., 2020). According to Velmurugan et al. (2022), digital transformation is a systematic initiative in several industries. However, digital aspect is not a panacea.

Welchman (2015) stated that even CISCO, a globally prominent digital network company that was highly mature in the digital domain, encountered the challenge that "more than half of the time was spent not exactly determining what type of functionality needed to be implemented in the intranet, yet on who got to decide what functionality would be implemented". In this situation, it is not a problem of digital literacy or maturity, but it is a starting point of the materialized digital governance risk.

Lacking of digital governance materializes several organizational risks. One of the most important risk is cybersecurity. As mentioned, IMD measures nation digital competitiveness from digital governance and cybersecurity. According to National Cyber Security Agency (NCSA), the number of cybersecurity threats in Thailand experienced inclined from 135 cases in 2021 to more than 772 cases in 2022. Most of the cases are from data breaches occurring through educational and public sector websites (Bangkok Post, 2023). Moreover, according to the global security index (GCI), Thailand was ranked 44 out of 194 ITU Member States with the score of 86.50/100 in 2020 (The International Telecommunication Union, 2023). The index is derived from five pillars: (i) legal measures, (ii) technical measures, (iii) organizational measures, (iv) capacity development, and (v) cooperation – and then aggregated into an overall score. Yet, the third pillar: organizational measures focus on policy, governance structure that Thailand has an urgent improvement. As a result, this paper focused on the studying of "digital governance" determinants as a foundation of organizational digital transformation.

1.1 Exploring Research Landscape with Bibliometric Analysis on Digital Governance

1.1.1 Digital Governance Trend Analysis

In this section, we applied bibliometric analysis to research articles related to digital governance to highlight some conceptual topics hidden in the body of literature. Initially, bibliometric analysis uses counts of publications, patents, and citations to measure research outputs (Narin et al., 1994). Then since the year 2000, bibliometric analysis has expanded into text mining where bibliographic data or full text are analyzed to extract useful information and detect hidden patterns (Porter, & Cunningham, 2004).

We retrieved 474 articles published between 2001 to 2023 from Scopus database with the following search query: (TITLE–ABS–KEY "digital governance") where "TITLE" is the article title; "ABS" is the article abstract, and "KEY" denotes the keywords (Figure 1). We then used VantagePoint software to perform bibliometric analysis on the retrieved data (Figure 2).

Figure 2 illustrates that trend of research in digital governance is increasing over time. Especially the number of the publications in 2017 was more than double the number in the previous year. Then after the year 2017, the number of publications started to rise exponentially. After investigating the list of keywords, we found that in digital governance context, prior to the year 2017, no publication has mentioned the term "digital transformation", "artificial intelligence", "blockchain", "machine learning", "cybersecurity", "digital literacy", "digital leadership" and "transformational leadership". These emerging terms suggest that for the last 5 years, applying new technologies such as AI, blockchain, and cybersecurity for their digital transformation has become the new research trends for organizations. In addition to the focus on applying new technologies, organizations also pay attention to other organizational factors such as digital literacy and digital leadership that could influence effective transition to the new digital organizations.

1.1.2 Digital Governance Research Landscape

To look at the research landscape of digital governance, a map of keywords can be created. We construct a research landscape map to represent relationships graphically. The map is generated by applying Principal Components Analysis (PCA) of keywords under the assumption that keywords that co-occur frequently have strong correlations.

A research landscape map (Figure 3) generated by clustering the top 217 keywords (those appearing 3 or more times in the full 474 abstract records) reveals conceptual topics related to digital governance research. To investigate cluster of interest, a "pull-down" box that contains the leading keywords used to construct that particular cluster can be displayed (Figure 4). From the map, some socio-technical research topics include:

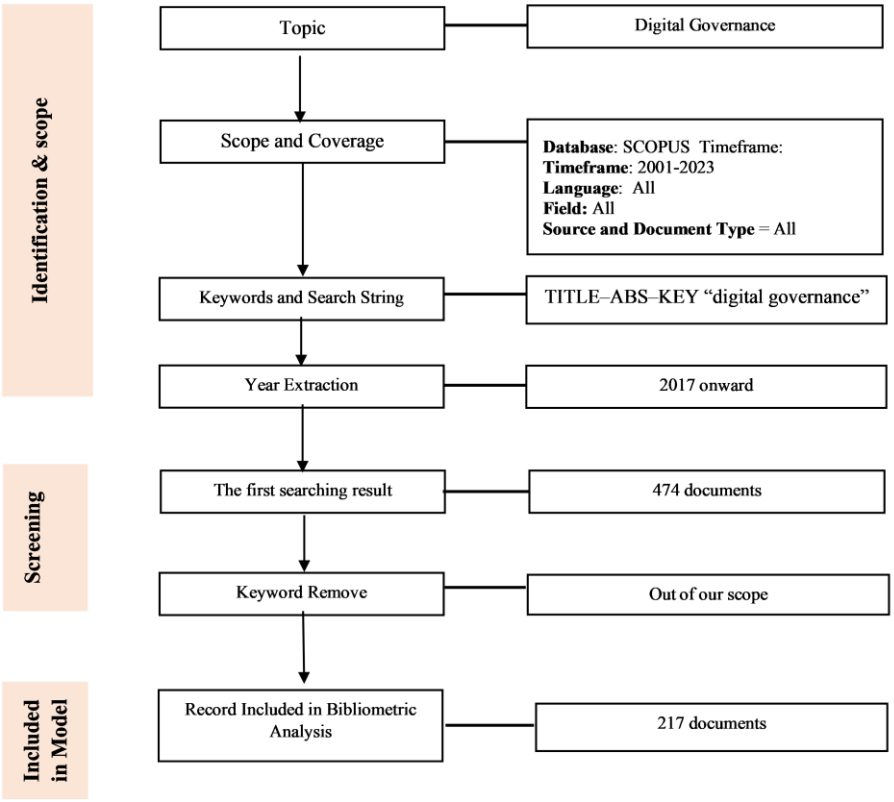

Figure 1 Bibliometric Analysis of Digital Governance

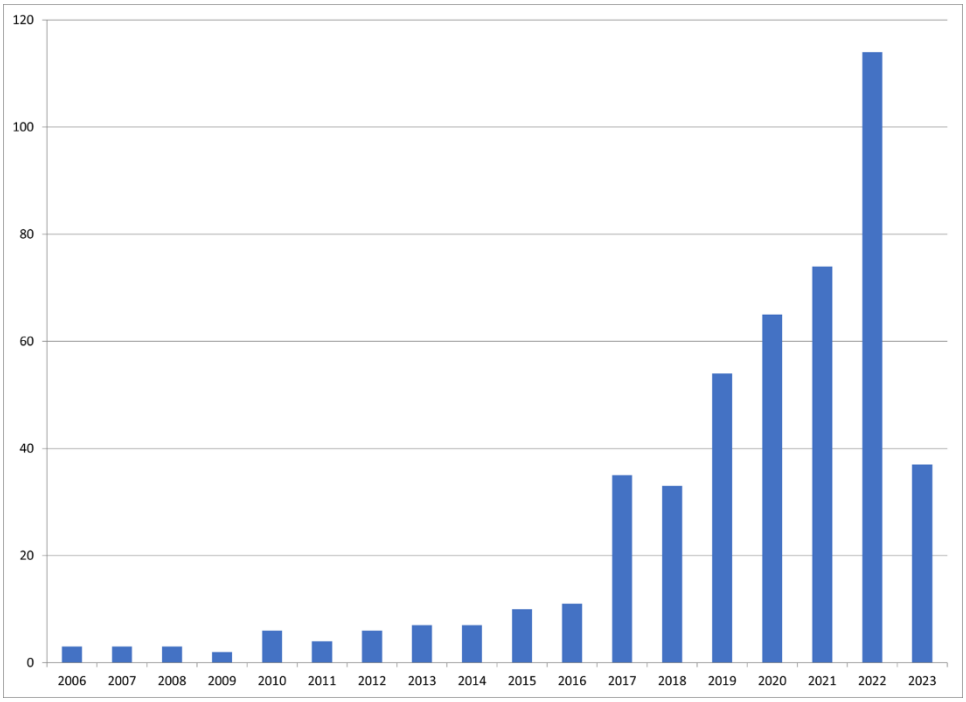

Figure 2 Bibliometric analysis of query "digital Governance" articles published between 2001 to 2023

I. Citizen Engagement and Participation

This area of research focuses on how digital technologies impact democratic processes, citizen engagement, and participatory governance (Panagiotopoulos et al., 2012). Digital governance intends to assure that government and citizens have greater access and control over the governance mechanism which leads to more transparency, accessibility, and citizen participation. Social media platforms can be used to facilitate interaction between citizens and government. Text mining and opinion mining have become effective tools to extract and analyze views of citizens towards government practices and policies (Misra et al., 2018).

II. Open Data and Transparency

Research on open data and transparency in digital governance investigates the potential benefits and challenges associated with opening government data and enhancing transparency in decision-making processes. It explores issues related to data sharing, data governance, data quality, data standards, and the impact of open data on accountability, public participation, and service delivery (Jetzek et al., 2019; Zine et al., 2022).

III. Cybersecurity

Research in this area investigates the challenges of cybersecurity and the protection of critical digital infrastructure. Extant research on cybersecurity governance has focused on the NIST cybersecurity framework to address governance and processes internal to an organization (National Institute of Standards and Technology, 2018). Additional research examines the security challenges posed by emerging technologies such as artificial intelligence, Internet of things and blockchain. This research investigates policy frameworks to address the risks and vulnerabilities associated with these technologies (Weber, 2010; Sharma et al., 2020).

IV. Digital Inclusion

Inclusion which is one of key principles of digital governance aims to ensure that everyone has fair access to digital resources and opportunities. By promoting inclusive digital governance, governments and organizations can address barriers to access, bridge the digital divide, and empower marginalized communities (Chen et al., 2020). Electronic document identification systems can contribute to digital inclusion efforts by providing individuals with secure and convenient digital identities. By facilitating digital identification, barriers related to identify verification and authentication can be reduced.

V. Digital Ethics and Digital Regulation

Digital governance, digital ethics, and digital regulation are interconnected concepts that shape the way digital technology is governed, used, and regulated. Currently with the advancement of emerging technologies such as artificial intelligence, blockchain and biometrics, organizations pay close attention to these three concepts. Digital governance and digital regulation should incorporate ethical considerations and principles to guide decision-making and ensure responsible and accountable use of digital technology. Digital ethics can shape digital governance and digital regulation through the relation of moral evaluation of what is socially acceptable or preferable. This helps organizations align their actions with societal values and ethical norms, promoting responsible digital practices (Floridi, 2018).

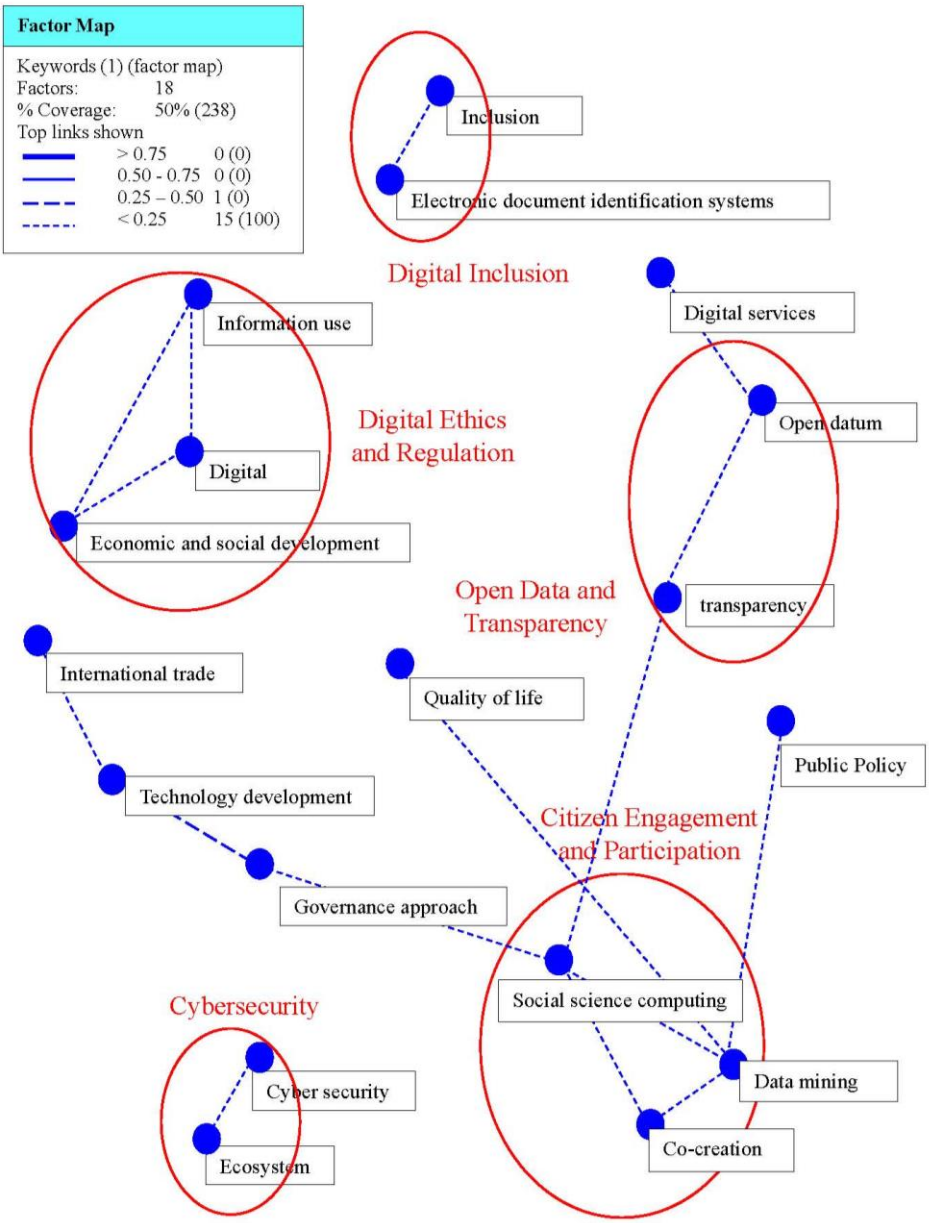

Figure 3 Digital Governance Research Landscape

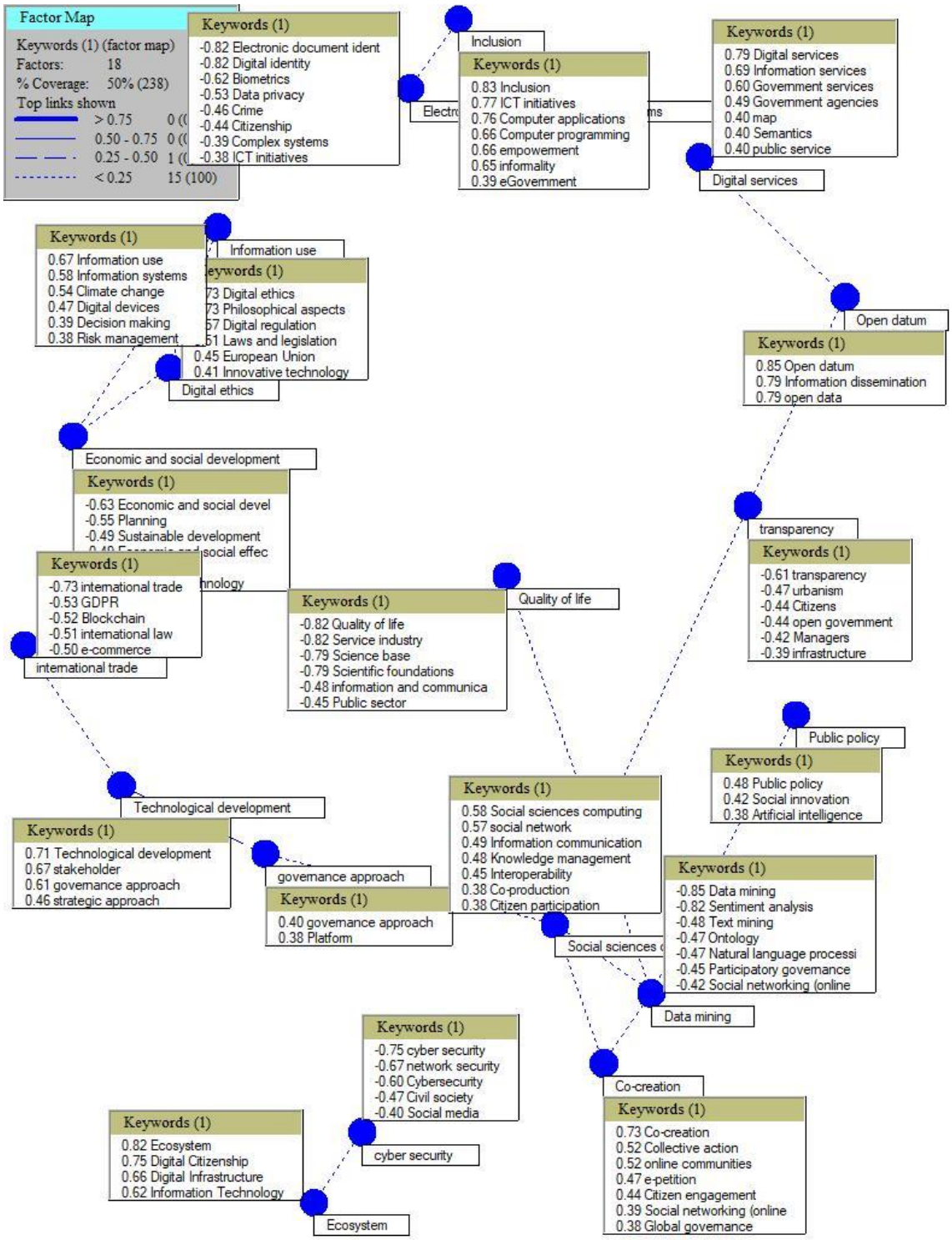

Figure 4 Digital Governance Research Landscape with the "pull-down" boxes enabled

1.2 Related Work

Digital transformation is a part of the roadmap toward organization sustainability despite some risks on the cyber-attack. Digital conduct is a key to control, manage and digital usage in a country. Moreover, the conduct supports confidence and development on economy of private and public sectors. The digital transformation is a significant challenge that has garnered the interest of every country around the world (Jia, & Chen, 2022) by using the digital conduct to balance the integration of data between organization in-country and foreign countries (Kurbalija, 2023). For example, Denmark focuses on the cybersecurity topic while China focuses on the digital conduct to create transparency and fairness on digital accessibility, standardize policies and procedure to compatible with other countries, resist monopoly business and unfair trade (Interesse, 2023).

The results of bibliometric analysis of literature in digital governance show the majority of research focuses on applying emerging technologies to help organizations or governments digitally transformed. However, only small number of research explores the effects of organizational factors that could influence the transformation effectively. Yet, according to the introduction, we perceive that successful path of organizational digital transformation requires organizational factors as well as people motive.

Our team initially studied organizational factors relating to digital governance from the determinants. Previous articles defined "digital governance" in several ways. While some academia provided the meaning of digital governance as a clear role and responsibility (Welchman, 2015), the rests defined it as a process of facilitating coordination, creating the transactional transparency and ultimately for trust (Hanisch et al., 2021). Even the articles defined digital governance in the distinctive way, our common ground accounts for "how to design effectively digital governance as the same time of creating business competitiveness".

The role of digital governance is similar to corporate governance when organizations include several involved stakeholders. One of the most important factors relating to effectively implement digital governance is "leadership". Chung et al. (2022) concluded that president's leadership has effect to the success or failure of digital government innovation. In addition, top management drives change and the awareness of digital governance (Pongsiri, 2017). This study thus quantified appropriate leaders from vision, understanding, clarifying and agility" (Bawany, 2018). Ultimately, leaders determine digital governance maturity toward the creating suitable organizational culture.

Another digital governance determinant used in this empirical study is "digital literacy". There were six reliable articles in SCOPUS (Scopus) adopted Technology Acceptance Model (TAM) to frame the conceptual model of firm digital transformation. To illustrate, Balaskas et al. (2022) conducted the confirmative model using TAM while Greece government adopted E-Government during the COVID-19. Despite being a traditional model, the TAM - rationale encompasses two aspects - the perceived ease of use and usefulness - is still applicable in explaining digital governance within firms.

The prior research gap is "how could an organization measure the achievement of digital governance?". We propose to close the gap by clustering digital governance from the below factors to quantify digital governance maturity level. Firstly, according to IMD and ITU mentioned in the first part, digital governance maturity should be determined from the robust of cyber-attack and privacy (International Institute for Management Development, 2023; The International Telecommunication Union, 2023). High maturity of digital governance means lower vulnerable cybersecurity risk.

Moreover, digital governance should include digital functionality. Marc, and Seang-Tae (2005, 2007) analyzed the determinant of digital governance with longitudinal assessment of municipal websites throughout the world. The finding showed that "New York, Shanghai, Seoul, Sydney and Riga are top ranked cities in the category of usability". In addition, New York, Sydney and Riga also identified content as a top priority in digital governance maturity. To this study, digital governance should incorporate usability and content.

2. Objectives

The research objective is:

1) to explore the digital governance research landscape using bibliometric analysis.

2) to analyze the determinants of digital governance by decision tree analysis.

After we adopted bibliometric analysis to explore research landscape and literature search of organizational factors relating to digital governance, the goal of this research was to empirically analyzed factors relating to the enhancing of organizational digital governance using quantitative decision tree modelling.

The key contribution of the paper is twofold. Theoretically, even though our main goal is about social science research relating to digital governance, our team develops dynamic research design using both manual literature review and text analytics to explore digital governance research landscape. In terms of practical contributions, the research results will foster awareness of digital governance and provide insights on how to enhance it. Hopefully, this research will be a starting point to improve Thailand Digital Competitiveness Ranking and global security index, respectively.

3. Methodology

3.1 Research Design

Step 1: Identify research questions, objectives as well as research landscape using bibliometric analysis on digital government research articles to highlight pertinent themes by applying Principal Components Analysis (PCA) of keywords. PCA is adopted to reduce a large amount of text/data into significant groups and remove insignificant factors out of model. PCA was created by Pearson in 1901 (Jolliffe, 2002; Rancher, 2003).

Step 2: Extracting the lists of determinants of digital governance and its maturity to proposed empirical model in figure 5.

Step 3: Collecting 400 sets of questionnaire data by distributing them to employees in digital organizations, which used the interval Likert scale measurement and determined digital governance factor scores using cluster analysis. We reduced the biased by selecting the purposive sampling based on 1) the one who responds directly to the process of digital transformation 2) he or she appoints as digital governance committee.

Step 4: Conducting quantitative modelling using the K-Means cluster technique to group the digital governance maturity and then quantified associated factors using decision tree modelling relating to the enhancing of digital governance.

Cluster analysis accounts for a data analysis technique that explores the scatter data occurring groups within a data set known as clusters (Hair et al., 2010). This paper clustered our dependent variables from 13 measurement items into 5 maturity levels.

After conducting cluster with K-Mean, a decision tree, which is a classification model, was used to analyze the determinants. The decision tree model is suitable for category of data in dependent variables (Breiman et al., 1984; Rokach, & Maimon, 2005).

Step 5: Writing research results, conclusions and policy recommendations.

3.2 Proposed Empirical Model

According to the above literature review, we proposed empirical model as the following figure 5.

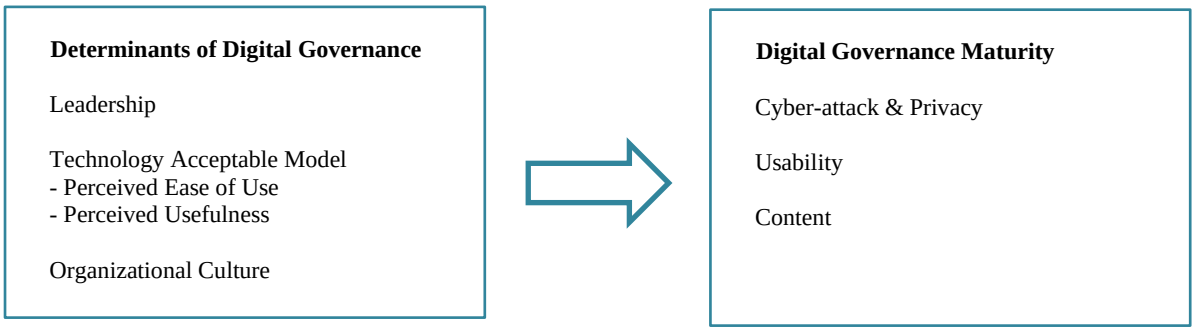

Figure 5 Proposed Empirical Model Framework

Table 1 Digital Governance Clustering with K-Means Cluster Analysis Techniques

Group	Maturity Definitions	Number of respondents
1	Ad hoc Level: Digital Governance maturity key concepts are not yet defined.	8
2	Low Level: Digital governance maturity key concepts are initially implemented.	10
3	Middle Level: Some digital governance maturity factors: such as cyber-attack, privacy, usability and contents are implemented.	146
4	High Level: Digital governance maturity concepts are well implemented.	28
5	Very High: Digital governance maturity concepts are well implemented and integrated.	208
	Total	400

Table 2 Factors effect on digital governance

Factors	Decision Tree				
	Df1	Df2	F	Sig.	Interpretation
Leadership	2	1	119.819	0.000	Significance
Organizational Culture	397	160	27.167	0.000	Significance

***** Statistical significance at 0.05

4. Results and discussion

Digital governance maturity factors were framed using the mentioned theories. After conducting K-mean clustering, we found 5 digital governance subgroups. The characteristics and numbers of the respondents were displayed below (Table 1).

According to clustering, it could ensure that our team collected data where the majority of high digital governance maturity is covered (208/400). Our next research question relating to the associated factors enhancing digital governance maturity was fixed using decision tree technique which is a good method to classify and select the best solution for complexity reduction and match factors that have impact to digital governance (Han et al., 2012; Hunt et al., 1966). Decision tree classification use Gini Index measurement which is represented by the following formula (Breiman et al., 1984):

$$\text{Gini}=1-\sum_{i=1}^{n}(p_i)^2$$

where P_i = probability of the classification class

After conducting decision tree (Table 2), the output displayed two associated factors: leadership and organizational culture. Both factors affect digital governance with a statistical significance level of 0.05 (Sig. = 0.0000).

We could also analyze the sequential of correlated factors relating to digital governance maturity given decision tree model. From figure 6, in order to start implementing digital governance, the leader is the most significant factor. Leadership is perceived as a starting factor that could enhance digital governance maturity among low, middle until high level. Moreover, decision tree model provides more insight. To improve digital governance maturity to high and very high level (more than 4), another important factor should be cultivated is "organizational culture". However, organizational culture is not solely created, but also driven by suitable leader who pays attention to digital governance.

Leadership is the most crucial element for the success of organizational digital governance. Their role and responsibility drive organizations to cultivate a good governance culture. Leaders should have vision, market forecast and digital trend analytic mindset and ability to drive strategies both in short-term and long-term situations toward digital organization which can quickly adapt to rapid changes such as VUCA situation.

The digital culture organization is the creation of the digital mindset by using technology to improve organization's activities which includes processes optimization and digital skill development, resulting in integration and flexibility coordination works. This also includes awareness creation on digital ethic regulations, and knowledge transfer in the right manner (Araujo et al., 2020; Saputra, & Saputra, 2020; Trushkina et al., 2020).

It ensures that to enhance digital governance maturity level, organizations should establish leaders who prioritize digital governance as well as cultivating a good digital governance culture. They need to include digital governance into corporate strategy.

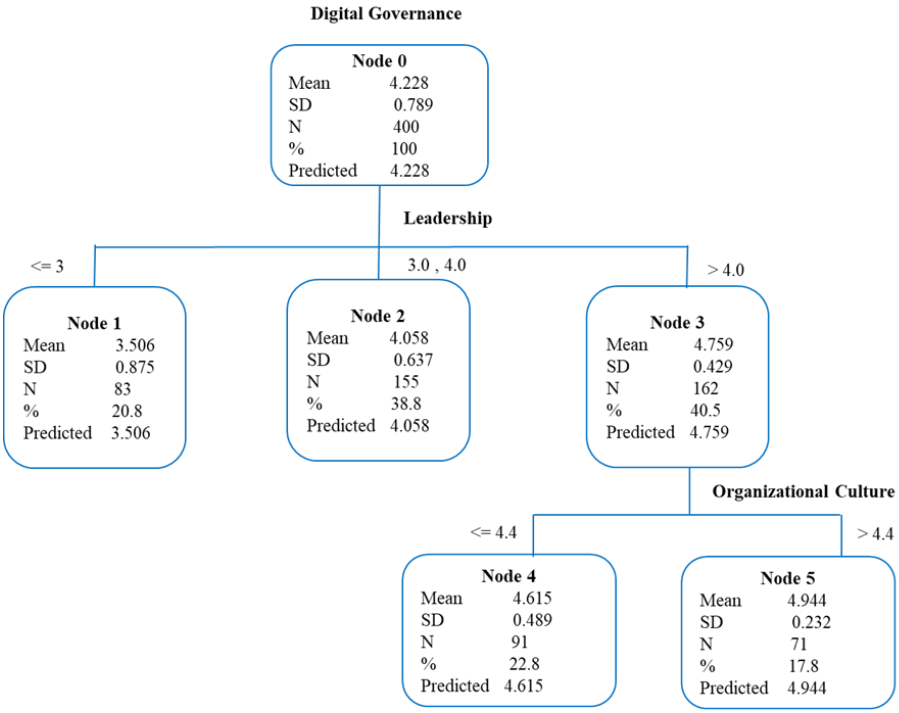

Figure 6 Decision Tree Result

Nevertheless, one important research contribution argues to the previous study that Technology Acceptance Model (TAM) were out of the decision model. It was insignificantly correlated with digital governance maturity. Even though TAM is a traditional framework cited in several articles, it was not correlated with digital governance in organizations.

5. Conclusions and Future Works

This paper adopted bibliometric analysis to explore research landscape on "digital governance". Also, we found the five co-occurrence concepts derived from bibliometric analysis that leave the gap according to implement a high maturity of digital governance in organizational level. To close this gap, this paper analyzed the factors influencing digital governance maturity to support the process of organizational digital transformation.

Clustering and decision tree model were both employed. K-mean analysis proposed five digital maturity levels. Our sampling indicated the most respondents located in "very high maturity". It ensures that we collected the data from the very high digital governance organizations. After conducting a decision tree model, the most significant factor accounts for "leadership". Leadership posits as an initial factor; nevertheless, to enhance digital governance at the highest level, organizational culture that is driven from leader is also cultivated. Our research output challenges the previous study. We found that TAM is not associated with enhancing digital governance.

This research concluded that leadership is a critical factor to improve digital governance maturity. Yet, what types and what characteristics of leadership are the suitable form to create an appropriation of high digital governance firm. Moreover, future research should compare between low and high digital governance maturity organizations, and why they do better. With this type of research questions, in-depth interview will be appropriate to fix with "why questions". Ultimately, future researchers should include what types of organizational culture is suitable to enhance a robust digital governance system and why they pay attention on it. However, studying about motives, people's attitude, qualitative research can convey important information.

Last but not least, according to our bibliometric analysis, we found that the research landscape of "digital governance" should be driven

from the robust of government policy. To force organizations to be better performed in digital governance, government should put-in-place a suitable digital policy, Therefore, digital governance should align between macro and micro policy.

The government has an important role to drive the digital economy since the government is the entity who regulates and controls overall systems of a country. One of the government's duties includes transparency and trustworthiness escalations which lead to sustainable development of a country (Barbosa, 2017; Kumar et al., 2023). For example, the Chinese government launched the digital economy regulation by providing the Internet access to all Chinese population, supporting digital transformation for internal organizations, standardize processes which compatible with international integrations, regulate personal data privacy and protection. This also includes introducing new government management policies to create positive digital mindset, Artificial Intelligence (AI) startup program and initiation of digital services and products to support digital transparencies and fairness trading (Interesse, 2023). For Thailand, the government also have a roadmap to support the digital economy such as "The National Digital Economy and Society Development Plan and Policy" which create trust on digital usage (Office of the National Digital Economy and Society Commission, 2023) and lead toward the Thailand 4.0 plan.

Digital conduct has a very important role because it controls, protects, response and reduces digital crime. A government should study and adapt phototype from digital law of other countries to be used for Thailand. In the meantime, the government should conduct a public hearing before launching any policy so the government can obtain feedback from the citizens which reflect their real need. The government should promote digital regulation when it is ready so the citizens can acknowledge and act correctly. The regulations/programs which should be created are PDPA, digital support program, cyber security program (cybercrime act, cyber war and cyber program committees) to create country's cyber safeguard and confident for the in-country citizen**.**

5.1 Limitation

1) We don't have secondary data about digital governance.

2) The bibliometric analysis contains some limitation (Holden et al., 2005) such as

2.1) Well-known published articles are likely to be more referred than articles from other sources even the quality of the articles are the same.

2.2) Reference patterns are differentiated by published time, faculties and countries.

3) We have selected and validated purposive sampling from the digital transformation organization, however the processes might not fully comply with the External validity regulation (Calder et al., 1982).

4) Decision Tree Analysis has some limitations due to the complexity and variation of the algorithm. Overfitting can occur if limited sampling data is used as input which results in less accuracy and hardly predicting long term result. However, we have already clustered the data, determining factors and optimized data set before using decision tree process in this research so that is why we do not face the mentioned limitation in this study (Song, & Lu, 2015; Gupta et al., 2017).

6. Acknowledgements

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7. References

Araujo, L. M., Priadana, S., Paramarta, V., & Sunarsi, D. (2020). Digital leadership in business organizations: an overview. *International Journal of Educational Administration Management, and Leadership*, *2*(1), 45-46. https://doi.org/10.51629/ijeamal.v2i1.18

Balaskas, S., Panagiotarou, A., & Rigou, M. (2022). The Influence of Trustworthiness and Technology Acceptance Factors on the Usage of e-Government Services during COVID-19: A Case Study of Post COVID-19 Greece. *Administrative Sciences*, *12*(129), 1-25. https://doi.org/10.3390/admsci12040129

Bangkok Post. (2023). *Facing the Future of Cyber Security*. Retrieved April 12, 2023, https://www.bangkokpost.com/thailand/pr/2513529/facing-the-future-of-cyber-security

Bawany, S. (2018). *The VUCA Prime Model. Leading in a Disruptive VUCA World*. Retrieved January 29, 2023,

https://www.slideshare.net/cee-global/leading-in-a-disruptive-vuca-world-2018

Barbosa, L. S. (2017, November 21–23). *Digital governance for sustainable development* [Conference presentation]. Digital Nations–Smart Cities, Innovation, and Sustainability: 16th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2017, Delhi, India, Proceedings 16. Springer International Publishing. https://doi.org/10.1007/978-3-319-68557-1_9

Breiman, L., Friedman, J. H., Olshen, R. & Stone, C. J. (1984). *Classification and Regression Tree* (1st ed). Chapman and Hall Publications.

Calder. J. B., Philips, L. W., & Tybout, A. M. (1982). The Concept of External Validity. *Journal of Consumer Research, 9*(3), 240-244. https://doi.org/10.1086/208920

Chen, Y.-C., Lee, J., Ganapati, S., Ahn, M., & Huang, C. (2020, June 15-19). *DG.O 2021: Digital innovations for public values: Inclusive collaboration and community* [Conference presentation]. The 21st Annual International Conference on Digital Government Research. https://doi.org/10.1145/3396956.3396991

Chung, C.-S., Choi, H., & Cho, Y. (2022). Analysis of Digital Governance Transition in South Korea: Focusing on the Leadership of the President for Government Innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(1), 1-28. https://doi.org/10.3390/joitmc8010002

Floridi, L. (2018). Soft ethics, the governance of the digital and the General Data Protection Regulation. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2133), Article 20180081. https://doi.org/10.1098/rsta.2018.0081

Gupta, B., Rawat, A., Jian, A., Arora, A., & Dhami, N. (2017). Analysis of Various Decision Tree Algorithms for Classification in Data Mining. *International Journal of Computer Applications*, *163*(8), 15-19. https://doi.org/10.5120/ijca2017913660

Guo, H., Yang, Z., Huang, R., & Guo, A. (2020). The digitalization and public crisis responses of small and medium enterprises: Implications from a COVID-19 survey. *Frontiers of Business Research in China*, *14*(1), 1-25. https://doi.org/10.1186/s11782-020-00087-1

Hair, J. F., Black, W.C., Babin, B. J., & Anderson, R. E. (2010) *Multivariate Data Analysis* (7th ed.). New Jersey: Pearson Prentice Hall.

Han, J., Kamber, M., & Pei, J. (2012). *Data Mining Concept and Techniques* (3rd ed.). Morgan Kaufmann Publishers.

Hanisch, M., Theodosiadis, V., & Teixeira, F. (2021). *Digital Governance: How Blockchain Technologies Revolutionize the Governance of Interorganizational Relationships.* Groningen Digital Business Centre (GDBC).

Holden, G., Rosenberg, G., & Barker, K. (2005). Tracing thought through time and space: A selective review of bibliometrics in social work. *Social Work in Health Care*, *41*(3-4), 1-34. https://doi.org/10.1300/J010v41n03_01

Hunt, E. B., Marin, J., & Stone, P. J. (1966). *Experiments in induction*. Cambridge: Academic Press.

Interesse, G. (2023). *China's Position on Global Digital Governance*. Retrieved September 1, 2023, https://www.china-briefing.com/news/chinas-position-on-global-digital-governance/

International Institute for Management Development. (2023). *World Digital Competitiveness Ranking* 2022. Retrieved March 1, 2023, https://www.imd.org/centers/wcc/world-competitiveness-center/rankings/world-digital-competitiveness-ranking/

Jia, K., & Chen, S. (2022). Global digital governance: paradigm shift and an analytical framework. *Global Public Policy and Governance*, *2*(3), 283-305. https://doi.org/10.1007/s43508-022-00047-w

Jetzek, T., Avital, M., & Bjorn-Andersen, N. (2019). The Sustainable Value of Open Government Data. *Journal of the Association for Information Systems*, *20*(6), 702-734. https://doi.org/10.17705/1jais.00549

Jolliffe, I. T. (2002). *Principal Component Analysis* (2nd ed.). New York: Springer-Verlag

Kumar, K. R., Pravee, C., Rahma, A. (2023, August 26). *Digital Governance and Its Impact on Society* [Conference presentation]. Proceedings of the International Conference on Education,

Humanities, Social Science (ICEHoS 2022). https://doi.org/10.2991/978-2-38476-088-6_24

Kurbalija, J. (2023). *Tracking the pulse of digital governance and diplomacy in 2023: A quarterly process report*. Retrieved September 1, 2023, https://www.diplomacy.edu/blog/2023-digital-governance-predictions/

Misra, A., Misra, D. P., Mahapatra, S. S., & Biswas, S. (2018, May 30 – June 1). *Digital transformation model: Analytic approach on participatory governance & community engagement in India* [Conference presentation]. Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age. https://doi.org/10.1145/3209281.3209359

Narin, F., Olivastro, D., & Stevens, K. A. (1994). Bibliometrics/Theory, Practice and Problems. *Evaluation Review*, *18*(1), 65-77. https://doi.org/10.1177/0193841X9401800

National Institute of Standards and Technology. (2018). *Cybersecurity Framework V1.1*. Retrieved March 20, 2023, https://www.nist.gov/cyberframework/framework

Office of the National Digital Economy and Society Commission. (2023). *National Digital Economy and Society Development Plan and Policy*. Retrieved September 3, 2023, https://onde.go.th/assets/portals/1/files/DE-EN%20BOOK%20FINAL.pdf

Panagiotopoulos, P., Al-Debei, M.M., Fitzgerald, G., & Elliman, T. (2012). A business model perspective for ICTs in public engagement. *Government Information Quarterly*, *29* (2), 192-202. https://doi.org/10.1016/j.giq.2011.09.011

Pearson, K. (1901). On lines and planes of closest fit to systems of points in space. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, *2*(11), 559-572. https://doi.org/10.1080/14786440109462720.

Pongsiri, N. (2017). Leader in Digital Economy Age. *HR Society Magazine Journal*, *15*(172), 20-23.

Porter, A. L., & Cunningham, S. W. (2004). *Tech mining: exploiting new technologies for competitive advantage*. New Jersey: John Wiley & Sons. https://perpus.univpancasila.ac.id/repository/EBUPT181426.pdf

Rancher, A. C. (2003). *Methods of Multivariate Analysis* (2nd ed.). John Wiley & Sons.

Rokach, L., & Maimon, O. (2005). *The Data Mining and Knowledge Discovery Handbook*. New York: Springer. https://doi.org/10.1007/978-0-387-09823-4

Sae-Lim, P., & Jermsittiparsert, K. (2019). Is the fourth industrial revolution a panacea? Risks toward the fourth industrial revolution: Evidence in the thai economy. *International Journal of Innovation, Creativity and Change*, *5*(2), 732-752.

Saputra, N., & Saputra, A. M. (2020). Transforming into Digital Organization by Orchestrating Culture, Leadership and Competence in Digital Context. *GATR Global Journal of Business and Social Science Review*, *8*(4), 208-216. https://doi.org/10.35609/gjbssr.2020.8.4(2)

Sharma, G. D., Yadav, A., & Chopra, R. (2020). Artificial intelligence and effective governance: A review, critique and research agenda. *Sustainable Futures*, *2*. Article 100004 https://doi.org/10.1016/j.sftr.2019.100004

Song, Y. & Lu, Y. (2015). Decision tree methods: applications for classification and prediction. *Shanghai Archives of Psychiatry*, *27*(2), 130-135. https://doi.org/10.11919/j.issn.1002-0829.215044

The International Telecommunication Union (ITU). (2023). *Global Cybersecurity Index*. Retrieved May 9, 2023, https://www.itu.int/en/ITU-D/Cybersecurity/Pages/global-cybersecurity-index.aspx

Trushkina, N., Abazov, R., Rynkevych, N., & Bakhautdinova, G. (2020). Digital Transformation of Organization Culture under Conditions of the Information Economy. *Virtual Economics*, *3*(1), 7-38. https://doi.org/10.34021/ve.2020.03.01(1)

Velmurugan, K., Saravanasankar, S., Venkumar, P., & Pandian, R.S. (2022). Digital Transformation in the context of maintenance management systems in SMEs: critical factors and empirical effects. *Journal of Current Science and Technology*,

12(3), 428-438. https://ph04.tci-thaijo.org/index.php/JCST/article/view/256

Weber, R. H. (2010). Internet of Things–New Security and Privacy Challenges. *Computer Law & Security Review*, *26*(1), 23-30. https://doi.org/10.1016/j.clsr.2009.11.008

Welchman, L. (2015). *Managing Chao: Digital Governance by Design*. New York, US: Rosenfeld Media.

Zine, H., Medkour, K.E., Zemmouchi-Ghomari, L., & Ghomari, A.R. (2022). Open Data Influence on Digital Governance. *International Journal of Innovation in the Digital Economy*, *13*(1), 1-11. https://doi.org/10.4018/IJIDE.292491