INTEGRATED DOUBLE LOOP DATA DRIVEN MODEL FOR PUBLIC POLICYMAKING

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DEDICATION

To my lovely father and mother, Bakri Nasution (Alm.) and Akmal Adham who give me endless love, trust, constant encouragement over the years, and for his and her prayers.

To my uncle, Asrul Adham who support me financially.

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ABSTRACT

Public policy is the critical key of the welfare programs. An Integrated Double Loop Data Driven Model is proposed to assist in Public Policymaking in solving public problems in a holistic and complete way. The Integrated Model consists of two components: Data Driven Model and Double Loop Model. The first model utilizes Big Data in E-Government Maturity (EM) for Public Policymaking (PP), in which a new E-Government Maturity Model is proposed to support data driven public policymaking based on Big Data. Subsequently, the second model adopts the double loop learning in System Dynamics (SD) whereby, a case study is discussed to show on how to utilize Big Data and System Dynamics for Public Policymaking. The interaction between Big Data, System Dynamics and Public Policymaking are captured in one conceptual model. A new method, System Breakdown Structure (SBS), to bridge between the two models is introduced in the case study. PLS-SEM test on the relationship between EM, SD and PP supports the positive correlation between EM to SD, SD to PP and EM to PP. The R square of PP is 0.48 indicating a high confidence level of the contribution of EM and SD in PP. The R square of SD is 0.45. Both results are also emphasized by the path coefficient result, whereby the path coefficient between EM to SD and SD to PP is higher than 50%. By comparing the path coefficient of EM to PP with and without the SD, the strong influence of SD puts it as full mediation effect. This result would also be similar if the multi-group analysis were conducted. Only for certain paths, there are significant statistical differences between each group; however they still produce positive correlations. The paths are EM to SD path in multigroup analysis of PNS (civil servant) and non-PNS (non-civil servant) and EM to PP path in multigroup analysis of Java and Sumatera islands (more developed region) and Other islands (less developed region). Based on the case study and PLS-SEM test, the Integrated Double Loop Data Driven Model is recommended to be implemented to assist in solving public problem.

ABSTRAK

Dasar awam adalah kunci penting kepada program kebajikan. Satu Model Bersepadu Gelung Ganda Berpacu Data dicadangkan untuk membantu dalam pembuatan dasar awam untuk menyelesaikan masalah awam secara holistik dan lengkap. Model Bersepadu terdiri daripada dua komponen, yakni Model Berpacu Data dan Model Gelung Ganda. Model pertama menggunakan Data Raya dalam Kematangan E-Kerajaan (EM) untuk Pembuatan Dasar Awam (PP) di mana Model Kematangan E-Kerajaan baharu dicadangkan untuk menyokong Pembuatan Dasar Awam berdasarkan Data Raya. Sementara itu, model kedua mengamalkan pembelajaran gelung berganda dalam Sistem Dinamik (SD) di mana kajian kes dibincangkan untuk menunjukkan cara menggunakan Data Raya dan Sistem Dinamik untuk Pembuatan Dasar Awam. Interaksi antara Data Raya, Sistem Dinamik dan Pembuatan Dasar Awam dimuatkan dalam satu model konseptual. Kaedah baru, Struktur Pembahagian Sistem (SBS), untuk menjambatani antara dua model diperkenalkan dalam kajian kes. Ujian PLS-SEM terhadap hubungan antara EM, SD dan PP, menyokong korelasi positif antara EM ke SD, SD ke PP dan EM ke PP. R persegi PP ialah 0.48 yang memberikan tahap keyakinan tinggi kepada sumbangan EM dan SD dalam PP. R persegi SD ialah 0.45. Kedua-dua keputusan juga ditekankan oleh hasil pekali jalan, di mana pekali jalan antara EM ke SD dan SD ke PP lebih tinggi daripada 50%. Dengan membandingkan pekali jalan EM ke PP dengan dan tanpa SD, pengaruh kuat SD meletakkannya sebagai kesan pengantaraan penuh. Keputusan ini juga memberikan dapatan yang sama jika analisis multi kumpulan dikendalikan. Hanya untuk laluan-laluan tertentu, terdapat perbezaan statistik signifikan antara setiap kumpulan, walau bagaimanapun ia masih memberikan korelasi yang positif. Laluan-laluan itu ialah laluan EM ke SD dalam analisis pelbagai kumpulan PNS (penjawat awam) dan bukan PNS (bukan penjawat awam) dan laluan EM ke PP dalam analisis pelbagai kumpulan Pulau Jawa dan Pulau Sumatera (kawasan yang lebih maju) dan Pulau-pulau lain (kawasan yang kurang maju). Berdasarkan kajian kes dan ujian PLS-SEM, Model Bersepadu Gelung Ganda Berpacu Data disarankan untuk dilaksanakan dalam membantu menyelesaikan masalah awam.

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LIST OF ABBREVIATIONS

AMOS	-	Analysis of a Moment Structures
API	-	Application Programming Interface
AVE	-	Average Variance Extracted
DOE	-	Design of Experiment
CMB	-	Common Method Bias
CMV	-	Common Method Variance
CRM	-	Customer Relationship Management
ETL	-	Extract, Transform and Load
EM	-	E-Government Maturity
EMM	-	E-Government Maturity Model
HDFS	-	Hadoop Distributed File System
ICT	-	Information and Communication Technology
IDM	-	Identity (ID) Management
ISO	-	International Organization for Standardization
ITIL	-	Information Technology Infrastructure Library
JSON	-	JavaScript Object Notation
KMO	-	Kaiser-Meyer-Olkin
LDAP	-	Lightweight Directory Access Protocol
MB	-	Macroblocks
NFS	-	Network File System
NMS	-	Network Management Station
NoSQL	-	Not only Structured Query Language
OS	-	Operating System
OSM	-	Online Social Media
PCI DSS	-	Payment Card Industry Data Security Standard
PEGI	-	Pemeringkatan e-Goverenment Indonesia (E-Government Indonesia Rating)
PLS-SEM	-	Partial Least Squares Structural Equation Modeling
PNS	-	Pegawai Negeri Sipil (civil servant)
PP	-	Public Policymaking

PSO	-	Particle Swarm Optimization
SBS	-	System Breakdown Structure
SD	-	System Dynamics
SEM	-	Structural Equation Modeling
SPSS	-	Statistical Package for the Social Sciences
SQL	-	Structured Query Language
UNDP	-	United Nations Development Program
VIF	-	Variance Inflation Factor
VPF	-	Variation of Prediction Footprint
XMILE	-	XML Interchange Language
XML	-	Extensible Markup Language

LIST OF SYMBOLS

$a \in b$	-	set membership symbol means "*a* is an element of *b*"
A	-	amplitude
f_2	-	effect size
$f_G(x)$	-	function *f* of *x* in a set of a system ***G***
$f(x)$	-	function *f* of *x*
g_n	-	member of a set ***G*** or component of system ***G***
G, ***X***	-	a set or a system
n, m	-	symbol of positive integer number
N	-	total sample or population
$r_{a\text{-}b}$	-	function *r* (relation) between component *a* to component *b*
r_{xy}	-	correlation coefficient between *x* and *y*
R	-	function relation for a set or a system
R^2	-	coefficient of determination
S_{xy}	-	standard error between *x* and *y*
t	-	time
T	-	period
$x_i \cap x_j$	-	intersection of two sets x_i and x_j
x_n	-	member of a set ***X*** or subset of a set ***X***
$x(t)$	-	function *x* of *t*
β	-	path coefficient
Θ	-	phase
π	-	the ratio of a circle's circumference to its diameter. It is approximately equal to 3.14159
$\sum_{l=1}^{m}(x_l)$	-	summation of all object x_l, where *l* is from 1 to *m*.
~***G***	-	negation of ***G*** means "it is not ***G***"
$\|a\|$	-	absolute value of *a*
$\forall i$	-	universal quantifier means "for all *i*"
$\exists i$	-	existential quantifier means "there exists *i*"

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CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, the huge growth of information technology (IT) usage has led to the new era, Big Data (Hong, Zhang and Lu, 2018). It started with the internet revolution in 1970s and continued with invention of World Wide Web (WWW) browser in 1990s. Since then, traffic on the internet continues to increase exponentially. After the emergence of social media websites such as Facebook and Twitter in the 2000s, everybody can contribute simply to the traffic and volume of data in the internet. It is expected that the volume of digital data reachs Zeta bytes by 2020 and most of the data (about 90%) is generated by humankind. In addition of that, another big contribution is coming from the usage of RFIDs tags. It is estimated to be 209 billion units using RFIDs tags implemented by 2021 (Arunachalam, Kumar and Kawalek, 2018). Some usage examples of RFIDs tags are in parking availability system, personal identification data and packaging delivery system. IoT (Internet of Things) is another technology which is popular recently which contributes to the volume of digital data (Vassakis, Petrakis and Kopanakis, 2018) such as sensor for flood, street light energy usage efficiency and air pollution detection.

Big Data has been used in many areas. In marketing, Big Data is utilized in market analysis to get more information about customer behavior whereas in supply chain, supply and demand analytics are performed. Government bodies analyze Big Data of tax income and government spending; and ease the process of analyzing and detection of fraud. Nowadays, web and social media analytics using Big Data as input become a less costly technique to get feedback from the customer directly (Vassakis et al, 2018). On the positive note, Big Data supports better data driven decision making in achieving organization goal, increased productivity, reduced costs, improved customer services, fraud detection, increased revenue, increased agility, greater innovation and faster speed to market (Harvey, 2018). However, these benefits do not make Big Data implementation in some sectors run smoothly. Some issues still exist such as those related to organization leadership, human skill who runs the system, complicated business process and unsupported organization culture. In technical aspect, the implementation of Big Data also faces certain issues, such as: worse data quality, higher privacy breach, easier to do fake identity, more difficult to meet compliance to regulation and other cybersecurity risks (Vassakis et al, 2018; Sarker and Wu, 2018; Harvey, 2018). Regardless of these advantages and disadvantages, many governments have agreed to accelerate Big Data implementation (Hong et al, 2018).

The implementation of Big Data has many challenges such as technology, budget, and human resources (Joshi and Islam, 2018). In the effort or intensity of utilizing Big Data in government operation, it should relate to the existing E-Government Maturity or Readiness. Principally, E-Government is the use of information technology (such as Wide Area Networks, Internet, Big Data system and other advanced technology) by governments that are able to transform government services to the public, business or fellow governments in effectively, efficiently and transparently (Alahmed, 2018; Qureshi, Salman and Irfan, 2017; Misra, 2007; Yildiz, 2007). E-Government Maturity or Readiness consists of several stages from initiation stage until matured or final stage. Each stage should be monitored by indicators to measure the status or level of existing E-Government in the government organization.

Big Data is one of the components in the E-Government. It should be aligned with other components of E-Government such as: IT Infrastructure and Application as Technology Perspective; Human Resource and Organization Culture as People Perspective; Leadership or Policy as Business Perspective (Al-Sai and Abualigah, 2018; Hidayanto, Ningsih and Sandhyaduhita, 2014; Das, Singh and Joseph, 2017). Jadhav, Patankar and Jadhav (2018) give a good viewpoint in collaborating Big Data analytics and IT Infrastructure based on Apache Hadoop in their E-Government. The readiness of all components of E-Government contributes to E-Government Maturity. The success of Big Data utilization in government is related to the level of E-Government Maturity (Al-Sai et al, 2018; Tripathi, 2017; Romijn, 2014). The higher the E-Government Maturity level, the more intensive the utilization of Big Data is in the government. At the highest level of E-Government Maturity (EM), the data and information are utilized optimally to feed into the Public Policymaking (Joshi et al, 2018; Bashir.Lusta and Aktas, 2017; Krishnan, Teo and Lim, 2013; Giest, 2017; Bri, 2009).

The challenge in utilizing Big Data in assisting the Public Policymaking is due to the nature of Big Data itself, which has four characteristics of data: volume, variety, velocity and veracity of data (Giest, 2017; Saabith, Sundararajan and Bakar, 2016). It creates its own complexity in storing, operating, managing and analyzing (Wadhwani and Wang, 2017). If it is used in understanding the problems in the public which is also complex (Strehlenert, 2017; Mamouney, 2018), it becomes worse because of double complexity. A public policy expert and academician, Dunn (2018) suggests using problem structuring in public policymaking. The systematic procedure is suggested by him in handling ill-defined, ill-structured, or wicked problem. In the system expert's perspective, the problem in society is related to the existing system in the society. For this reason, a system study is required to understand the underlying causes of the problem, such as System Dynamics.

A System Dynamics approach in solving public problem has been recommended by several experts (Eker, Zimmermann and Carnohan, 2017; Madachy, 2017; Schoenenberger and Tanase, 2017). The key factor in utilizing System Dynamics is its model. Madachy (2017) mentions that even small System Dynamics model is useful for assisting in understanding of complex public policy issue. Another paper points out that the System Dynamics model is able to capture the complexity in the housing, energy and well-being issues (Eker et al, 2017). To reduce complexity in the model, Tulinayo, Weidem and Bomme (2018) suggests using a decomposition mechanism.

System Dynamics modelling can benefit from Big Data analytics (Kianmehr, Sabounchi and Begdache, 2018). According to Atyeh, Jaradat and Arabeyyat (2017), Big Data has ability to provide advanced analytics. This analytics capability is correlated to more application development conducted by some parties to integrate Big Data to existing technology, such as Phyton and XMILE (Houghton, 2018). In System

Dynamics, stakeholders run analysis and simulation on the temporary agreed policy to confirm the consensus between them (Thomopoulos, Moulin, and Bedoussac, 2017). Ding, Gong and Li (2018) suggests using System Dynamics (SD) to solve problems or issues in complete and holistic way and avoid the restrictions of one perspective thinking. Application of Big Data and System Dynamics for Public Policymaking in government environment requires the E-Government Maturity (EM) as a foundation to make the collaboration successful. Theoretically, the higher the stage of EM, the higher the Big Data readiness, the higher SD modelling validity, and the higher possiblity of public policy is able to solve the problem.

In this chapter, the background of the study, the problem statement, research questions and objectives, the scope of the research, and the significance of the study which are related to Big Data in E-Government Maturity, System Dynamics and Public Policymaking are elaborated. The next section discusses background of the research.

1.2 Background of the Research

Data driven public policymaking is needed to provide more objective solution to solve issues or problems in the society (Gover, 2018; Hauser, 2017; OECD, 2017). Most of the public issues or problems are considered as the gaps exist in the society which is defined as difference between the problematic (existing) situation and the expected situation. The intervention, called as public policy is needed to move condition from the problematic situation into the expected situation. Usually, the problematic situation in society is also called as the ill-defined, ill-structured, or wicked problem (Dunn, 2018), observed in the complex system (EU, 2017; Strehlenert, 2017; Walsh, 2017).

In the current practice, the data driven public policymaking is based on the Big Data (Sarker et al, 2018; Klievink, Romijn and Cunningham, 2017; Joshi et al, 2018; Jadhav et al, 2018; Hochtl, Parycek, and Schollhammer, 2016). Sarker et al (2018) suggest that Big Data is used to enhance the E-Government Maturity and proposed to support public agency to transform from traditional public administration to modern and smart public administration. It solves social issues, such as transport congestion, healthcare provision and sustainable energy production (Klievink et al, 2017). The public agency is expected to be efficient, responsive, transparent, and hassle-free (Sarker et al, 2018).

Based on some studies, some governments with their own initiative and collaboration between governments, such as US, Australia, Abu Dhabi, China, Iraq, Uganda, Ukraine, Colombia and Mexico have made use of Big Data in their statistical products in health, agriculture and economic (Mohd-Din, Ya'akub and Chellamuthu, 2017). However, many governments in developing country still have not taken advantage of the availability of this Big Data due to the limited access to skilled manpower, good infrastructure, supported finance and advance technology (Kalema and Mokgadi, 2017). It is very regrettable, bearing in mind Big Data can be used to understand better the existing conditions in the public. It could assist government in Public Policymaking (Giest, 2017). A successful Public Policymaking based on Big Data is beneficial to all stakeholders such as governments, parliaments and public. Utilization of Big Data will solve problem in Public Policymaking which previously is not based on data in many cases. Big Data will eliminate unfair Public Policymaking which bias towards personal or group interest instead of public interest. An appropriate public policy is a strong factor of any welfare programs. It becomes an important tool for a feasible national competitiveness (Urbanov, 2018).

Big Data is not able to standalone to support Public Policymaking. It is related to many other factors, such as IT Infrastructure and Application as Technology Perspective; Human Resource and Organization Culture as People Perspective; Leadership/Policy as Business Perspective (Al-Sai et al, 2018; Hidayanto et al, 2014; Das et al, 2017). All these factors are part of E-Government. Since Big Data is part of the E-Government (Al-Sai et al, 2018), the success of E-Government deployment is aligned with accomplishment of Big Data implementation. By putting Big Data as a part of the E-Government, Big Data readiness and E-Government Maturity are correlated positively. In a simple way, Big Data readiness is a subset of E-Government Maturity. The Big Data readiness is only one of many factors to achive a high stage of E-Government Maturity.

Some cases of E-Government Maturity that adopt Big Data are discussed in literatures (El-Omari and Alzaghal, 2017; Ng, 2018; Hong et al, 2018; Sixin, Yayuan and Jiang, 2017). Based on the evaluation of El-Omari et al (2017), the maturity level of Jordan E-Government is getting better in serving the citizen over the past of few years. The program is diversified. The total users keep increasing. The technology is matured. The quality is improved. The stage grows from the focus on websites only, and now about integrated infrastructure and open data. It is in line with the data usage. In 2006, the Jordanian E-Government program was launched with minimum data utilization. In 2015, the Jordanian Department of Statistics held the first ever digital census in the country. Today, Jordan E-Government is the driver behind collecting Big Data from many sources such as: census, geospatial data, health data, financial indicators, and energy readings. It makes Big Data available for its citizens. It is collaboration of people, technology, processes, data and things in collecting data from many sources (El-Omari et al, 2017).

Singapore topped the ranks for E-Government implementation in 2013. Even Finland, USA, Korea, Japan and Sweden were behind Singapore. This achievement was happening because Singapore E-Government has been supported by several factors. First, the technology provides services on demand, the resources are scalable over multiple data centers, the services are easily accessible and location independent, and the service quality is guaranteed for bandwidth and memory. Second, the society is preventive to negative outcomes or mistakes and supportive to positive outcomes or promotions. Indirectly, these factors show the maturity level of Singapore E-Government. Even though, Singapore E-Government is considered already mature enough, it is still recommended to consider running some initiatives on skill-gap due to the new technology related to Big Data analytics (Ng, 2018).

The growth of data in Chinese E-Government has put the urgency to implement Big Data. Because of Big Data, the adjustment is made in Chinese E-Government Maturity for better level or stage, such as: the change of communication mode from one-way to two-way model and the better services or application (Hong et al, 2018). Sixin et al (2017) mentioned that Chinese government realizes the needs for more E-Government involvement in the age of Big Data. More E-Government involvement means more E-Government readiness or higher maturity or better preparation to accommodate all factors to support the Big Data era. More intensive utilization of Big Data needs a higher level of E-Government Maturity which is to support Public Policymaking (Joshi et al, 2018; Bashir.Lusta et al, 2017; Krishnan et al, 2013; Giest, 2017; Bri, 2009). Many governments have agreed to accelerate Big Data implementation (Hong et al, 2018). Although, many governments realize the potential of Big Data, but still some of them do not convince about their readiness to utilize it in their environment (Klievink et al, 2017). It is due to the existing E-Government Maturity Model not able to clearly explain the method to understanding their readiness. Joshi et al (2018) have highlighted some limitation on existing E-Government Maturity Model (EMM) such as total stages, sequence of process between stages and adoption of new technology. An evaluation on existing EMM should be able to give a better perspective how to enhance the Big Data adoption for Public Policymaking. Additionally, indicators on each stage and a method to guide E-Government development are other issues in EMM at this moment.

Public policymaking is supported better if it is also utilized the double loop learning capability (Jarvie and Stewart, 2018; Brinkerhoff, Frazer and McGregor-Mirghani, 2018; Moyson, Scholten and Weible, 2017). This double loop learning is embedded in System Dynamics model which also adopted the concept of feedback loop (Brzezina, Biely and Helfgott, 2017; Lumowa and Kurniawati, 2017). The gap which is present in the problematic and expected situation is iteratively minimized by the learning process. The double loop public policymaking using System Dynamics is designed to minimize the gap efficiently and effectively by adopting concept of continual improvement (Scherling, 2017). Increase of complexity in social, economic and political interactions makes identification of all stakeholders and their interests become strategic initiation step in double loop public policymaking. Especially, if there are intensive conflicts of interests between various stakeholders. The goal is to find a solution that can provide the best exchange and development consensus on their adoption (Thomopoulos et al, 2017). Problematic situations like this usually result from extraordinary interactions between stakeholders in complex systems which exist in any public policymaking. Sometimes, this condition of complex system is in continuous evolution and poorly understood, even by the stakeholders themselves. In such context, System Dynamics approaches are increasingly recognized as valuable tools to better understand these complex systems and to build models that are useful for public policymaking (Eker et al, 2017; Madachy, 2017; Schoenenberger et al, 2017). Eker et al (2017) describes complex interactions between stakeholders in the case of housing performance, energy, communal spaces and wellbeing in UK. Using the help of participatory modelling settings, and with a diverse group of stakeholders, it is found that monitoring and energy efficiency were the solutions for the housing stock. In other cases, System Dynamics is used by Madachy (2017) to assist in improving lawmaking processes in USA. In Madachy's paper, levels are created as the state variables representing accumulations, such as any things related to laws or rights, violation and people. In more practical, the level can represent cost expenditures, fines levied or paid, case schedule dates and personnel attribute. All these variables are put together in a model. The example is in modelling illicit drug laws before formally publishing the policy. The model is to simulate drug demand levels, the number of cartels, or agricultural resource levels of cartel. Schoenenberger et al (2017) emphasize how System Dynamics has frequently demonstrated its importance in solving complex policy problem. He explains the complex model as vertices connected by edges. It becomes a big network with components of the system as vertex and the interrelation between components is connected by edges. This idea creates a new approach in developing a model, called network controllability. It is an iterative process, until at the final state where no significant changes on the model which is called as model stability. Model creation using network controllability needs a balancing feedback loop (Brzezina et al, 2017) to guide into stability.

By understanding the benefits between data driven and double loop public policmaking, combination between data driven and double loop public policymaking is a perfect way to take two advantages of data driven and double loop learning into public policymaking (Jarvie et al, 2018; Brinkerhoff et al, 2018; Moyson et al, 2017). But unfortunately, data driven and double loop public policymaking are standing respectively and not integrated at this moment. Some experts focus on the data driven public policymaking based on Big Data (Joshi et al, 2018; Bashir, 2017; Krishnan et. al, 2013; Giest, 2017; Bri, 2009) and others focus to the double loop public policymaking based on System Dynamics (Eker et al, 2017; Madachy, 2017; Schoenenberger et al, 2017). And few other experts discuss how to use data driven based on Big Data in double loop based on System Dynamics modelling (Kianmehr et al, 2018; Pruyt, 2016), but they do not elaborate more the continuation in public policymaking. Kianmehr et al (2018) explain how to use Big Data approach to assist System Dynamics modelling to investigate the causal relationships between brain structures, nutrients and mental health. Pruyt (2016) discussed more cases such as infectious diseases, crime fighting, integrated risk-capability analysis, stress testing banks, traffic and congestion management. Some data analytics techniques are briefly discussed to assist System Dynamics modelling, but unfortunately, none of them discuss about how to use Big Data analytics and System Dynamics in Public Policymaking. The discussion stops at the simulation outcome of System Dynamics hence the overall integration between Big Data, System Dynamics and Public Policymaking are not captured completely.

Collaborating Big Data Analytics in System Dynamics modelling is not easy task and event more complicated if it is used to solve public problems or issues. It is due to the charectistic of public problem which is ill-defined, ill-structured, or wicked problem. In simple way, it is called as complex problem. Therefore, in this opportunity, a modification method (System Breakdown Structure) is suggested to associate Big Data analytics into System Dynamics modelling with minimal efforts for Public Policymaking. The participatory modelling settings suggested by Eker et al (2017), decomposition idea from Tulinayo et al (2018) and breakdown structure in project management practice could creates systematic, hierarchical process of decomposition of the system model. A complex explanation based on Graph Theory from Schoenenberger et al (2017) could be substituted with simple illustration using Set Theory in a new method, System Breakdown Structure (SBS), which is decomposing method to adopt the Big Data Analytics in System Dynamics modelling which is not discussed by Tulinayo et al (2018).

To make a clear understanding on the process of collaboration between Big Data and System Dynamics in Public Policymaking, three models are created. First model is Data Driven Model based on Big Data. Second model is Double Loop Model based on System Dynamics. Third is the integration between the first and second model which is called as Integrated Double Loop Data Driven Model for Public Policymaking. In Data Driven model, utilization of Big Data in public policymaking is related closely to E-Government Maturity. An adjusted supportive E-Government Maturity Model (EMM) to accomodate Big Data should be recommended to make the successful adoption of Big Data for Public Policymaking. Data driven public policymaking builds a holistic and complete public policy. Data mining is used to gather data which is analysed to obtain knowledge of system. This knowledge is useful in creating a model in System Dynamics, as in the Double Loop Model.

The Double Loop model is expected to utilize System Dynamics in doing simulation for trial and error test of some scenarios to solve problem before implementing it in Public Policymaking. Simulation with several scenarios is run on the model. The scenario, which produces the best outcome, is chosen as an input for Public Policymaking. The model is a replication of the real system. It is dynamically adjustable as the time runs. Each of the approaches is independently and collaboratively exercised for developing a better Public Policymaking.

Positively, Integrated Double Loop Data Driven Model creates holistic and complete System Dynamics model for Public Policymaking. Data Driven Model based on Big Data contributes more data and information for modelling. The predictive modelling with large and transactional data can be made substantially by increasing the data size to a massive scale (Fortuny, Martens and Provost, 2013). Double Loop Model based on System Dynamics maintains the dynamics of its model. Indirectly, Big Data which assist in System Dynamics modelling also contributes to the dynamics of the model. Any update on the data, Big Data Analytics will update the model automatically or regularly depending the policy maker’s requirement how uptodate process of the model is needed. The Integrated Double Loop Data Driven Model for Public Policymaking is also tested by Partial Least Squares Structural Equation Modelling (PLS-SEM) (Khan, Sarstedt and Shiau, 2018; Akter, Wamba and Dewan, 2017). The result of test can explain how strong the relationship or correlation between Big Data in E-Government Maturity, System Dynamics and Public Policymaking. It also becomes a feedback for government in developing Big Data in E-Government Maturity, System Dynamics and Public Policymaking. The next section discusses about problem statement of Big Data in E-Government Maturity, System Dynamics and Public Policymaking.

1.3 Problem Statement

E-Government Maturity Model (EMM) becomes a critical success factor in data driven public policymaking. In current study, some limitations on existing E-Government Maturity Model are spotted (Joshi et al, 2018). They identify that all stages of existing E-Government Maturity Model (EMM) are in the linear manner. For certain cases, the condition from previous stage may jump to next stage not in sequential manner. It is also important to keep the EMM updated with an advanced and modern technology, such as Big Data. Each stage of EMM must have indicators to assist the government official to create strategy and process to improve the existing condition of E-Government Maturity. The indicators are recommended to accommodate non technical perspective as well (Al-Sai et al, 2018; Hidayanto et al, 2014; Das et al, 2017). A method to guide the development of E-Government is not discussed in existing EMM.

Big Data in E-Government Maturity (EM) should assist System Dynamics (SD) modelling for a holistic and complete Public Policymaking (PP). At this moment, almost all existing EMM have proposed to use Big Data in public policymaking without utilizing the capability of System Dynamics to provide double loop learning process (Joshi et al, 2018; Bashir.Lusta et al, 2017; Krishnan et al, 2013; Giest, 2017; Fath-Allah, Cheikhi and Al-Qutaish, 2014). As far, the research is concerned, only Bri (2009) introduces System Dynamics in his last stage of EMM, but there were no clear indicators on how to identify the stage are reached. Big Data in E-Government Maturity should offer their analytics capability for System Dynamics modelling. Exploration of several existing data analytic techniques and methods are very crucial.

System Dynamics should come with a method to support Big Data analytics, especially in identification component of the system and its interrelation. To handle a big and complex system, especially in Public Policymaking, the decomposition mechanism (Tulinayo et al, 2018) and the assumption of a system as collection of vertices connected by edges (Schoenenberger et al, 2017) are considered. Unfortunately, Tulinayo et al (2018) and Schoenenberger et al (2017) do not discuss how Big Data Analytics can be designed as per components and subsystems of the complex system in continual improvement manner to support double loop learning public policy.

System Dynamics is adopted to take the advantage of double loop learning process and the complete and holistic approach in solving problem is utilized for Public Policymaking (PP). Similar as EM to support PP, the System Dynamics (SD) is also able to support PP. The interaction between the Big Data in EM (Al-Sai et al, 2018; Sarker et al, 2018) and the SD modelling process (Eker et al, 2017) need to be explained clearly in one conceptual model. Without one conceptual model to show integration between Big Data in EM, SD and PP, the understanding concept and implementation in real situation is more difficult and complicated. The case study based on SD approach for Public Policy should also be conducted to show the learning process clearly. It is not easy to show the case study which is involving real public policy. The support from different expertise is needed. In this case study, it is shown that without integrating Big Data in E-Government Maturity and System Dynamics, the objective of holistic and complete public policy will be difficult to achieve. Next section accommodates Big Data in EM and SD for PP into research questions.

1.4 Research Questions

Basically, there are three view points for the research questions. First research question is on the E-Government Maturity (EM) in Data Driven Model. Second research question is related to Conceptual Model of Big Data in EM and SD for PP in Double Loop Model. Third research question is related to Integrated Model which is the final objective of our research.

1. How does the E-Government Maturity Model in Data Driven Model support Big Data analytics capability and public policy data preparation for Public Policymaking?
2. How does the Conceptual Model of Big Data in EM and SD for PP accommodate Double Loop Model in assisting their interaction?

3. How can the Integrated Double Loop Data Driven Model be developed to integrate between EM, SD and PP?

1.5 Objectives of the Research

Aligned with the research questions, three research objectives are created as below:

1. To create the E-Government Maturity Model to support Big Data analytics capability and Public Policy data preparation in Data Driven Model for Public Policymaking.
2. To develop the Conceptual Model to accommodate Double Loop Model in assisting the interaction between Big Data in EM and SD for PP.
3. To integrate between EM, SD and PP in the Integrated Double Loop Data Driven Model and this is tested with PLS-SEM.

1.6 Scope of the Research

The scope of this research consists of:

1. The generic Public Policymaking process is used.
2. The software application is used: Vensim, Hadoop, HBase, Nutch, Solr, WarpPLS and SPSS.
3. Implementation of the Public Policymaking based on the proposed model is not conducted in this research.

1.7 Significance of Research

By understanding the capability to utilize Big Data in E-Government Maturity for developing a model of System Dynamics, it will help a public policymaker to analyze a system holistically and completely. The creation of E-Government Maturity Model; Conceptual Model of Big Data, System Dynamics and Public Policymaking; and Integrated Double Loop Data Driven Model provides the urgency on each government to continuously develop their E-Government based on Big Data to support System Dynamics modelling for Public Policymaking.

This study will provide statistical analysis based on survey related to the model of EM, SD and PP relationship. The result of this study gives advice of future strategy to get a better public policy. By following this model, Public Policymaking will be more effective and efficient to solve problem in society.

1.8 Structure of Thesis

Chapter 1 presents a brief introduction of the subject. The context of the study and the research problem are discussed. The objectives of this study, the significance, scope, and structure of the study are provided.

Chapter 2 reviews the literature on Big Data, System Dynamics, E-Government Maturity Model, Public Policymaking, Partial Least Squares Structural Equation Modelling (PLS-SEM) and related theories. The chapter identifies theories and strong evidence guiding the formation of the research framework.

Chapter 3 presents methodology as well as the justification of choices and uses. The chapter discusses research framework and approaches that are particularly relevant to this study.

Chapter 4 presents the process of the Data Driven E-Government Maturity Model to meet the first research objective. It is started from the proposed E-Government Maturity Model (EMM) which is to support Big Data analytics capability and Public Policy data preparation in Data Driven Model for Public Policymaking. The relation between Big Data in E-Government Maturity (EM) and Public Policymaking (PP) is tested by using Partial Least Squares (PLS) Structural Equation Model (SEM).

Chapter 5 presents the process of the Double Loop Model. The conceptual model is created to show the interaction between Big Data in E-Government Maturity and System Dynamics for Public Policymaking. The conceptual model that accommodates Double Loop Model is used in the one of the case studies. The simulation result of the case study of System Dynamics for Public Policymaking is analyzed and discussed as well.

Chapter 6 presents the test of the Integration Double Loop Data Driven Model for Public Policymaking by using Partial Least Squares (PLS) Structural Equation Model (SEM).

Chapter 7 highlights the key findings that have emerged from this study and concludes with a discussion of the contributions of the research outcomes, the limitations of the study, and the suggestions for future research.

1.9 Summary

This chapter presents an overview of the thesis. It begins by introducing the background and research problems of this study. The development of research questions and research objectives are discussed. Subsequently, the scope and significance of the study are discussed as well.

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