



## On the Rank-Size Distribution of Local Government Debt

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### Abstract

Rank-size distributions of local government debt, regardless of the way in which data is categorized, whether by region, type, or all local governments, are found not to be normally distributed but rather consistent with a mathematical principle known as power law. This implies that local government borrowing resembles a complex adaptive system in the sense that it is self-organized with positive feedback among concerned parties. In such a system, a critical point could be reached wherein a local government debt crisis eventually disrupts a government's fiscal and financial status as well as that country's economic system. This kind of event is extremely difficult to predict in advance because it represents both an emergent phenomenon and scale-invariance. One cannot really tell beforehand what type or size of local government debt will transpire, or which local government would cause such a crisis. Therefore, rules and regulations designed to regulate and monitor local government borrowing, as well as manage the risk of local government debt, should emphasize mitigation measures in addition to disciplinary procedures. This study proposes a rule that requires each local government to maintain enough reserves to service its debts. The rationale is that, in the event of a local government debt crisis, the local government, indirectly affected by such a crisis, may encounter problems from liquidity shortage and therefore not be able to pay principals and/or interest to its creditors. Having such mitigation measures in place should not only lower the probability of local governments defaulting on debts, but also help build trust in the system.

**Keywords:** Local Government Debt, Power Law, Self-Organized Criticality, Complex Adaptive System, Risk and Uncertainty Management

**JEL Classifications:** D39, D81, H74

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## 1. Introduction

‘My personal concern is that the next crisis comes from nowhere, in other words, from the place where we have no idea that it will come from... from an area that we regard as safe and secure at the moment but which will suddenly... under the radar screen for a period of time... suddenly bloom and threaten the stability that we have and that is something which we care about...’

Christine Lagarde<sup>1</sup>  
Managing Director and Chairwoman  
of the International Monetary Fund

One objective of local government borrowing is to improve the standard of living of people in the community. In Thailand, local government can borrow in accordance with the Determining Plan and Procedures in Decentralizations to the Local Administrative Organization Act B.E. 2542 (1999) and the Establishment of the Local Administrative Organization Acts, namely, Provincial Administrative Organizations Act, B.E. 2540 (1997), Municipal Act, B.E. 2496 (1953), Pattaya City Administration Act B.E. 2542 (1999), and Bangkok Metropolitan Administration Act B.E. 2528 (1985). After reviewing the details of these Acts, the Ministry of Finance of Thailand found that they do not stipulate any rules or guidelines regarding monitoring local government borrowing and building a fiscal discipline framework on debt issuance. For this reason, the Public Debt Policy and Supervision Committee on behalf of the Ministry of Finance of Thailand issued the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018) . This Regulation has been effective since July 17, 2018<sup>2</sup>.

The process of drafting this regulation required interdisciplinary knowledge on such fields as political sciences, public administration, law, and fiscal and financial economics. However, this study views that it is necessary to incorporate knowledge from mathematics and statistics to analyze the data on local government debt. This is because knowing the true nature of the distribution of local government debt would affect the way in which policies with regard to local government debt monitoring, fiscal discipline framework building, local government debt risk and uncertainty management should be designed and formulated. After reviewing the existing literature about local government borrowing in Thailand, this study finds that very few studies concerning the probability of local government debt crises and their mitigation measures or focusing on guidelines for monitoring local government debt exist<sup>3</sup>. In addition, these studies do not analyze the true nature of the distribution of data on local government debt. Furthermore, studies about the probability of financial crises and state agency risk management normally focus on state agencies at individual levels by analyzing fiscal

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<sup>1</sup> BBC Radio 4 (2018).

<sup>2</sup> According to the Public Debt Management Act B.E. 2548 (2005) and the additional amendment Section 35 (3), the Public Debt Policy and Supervision Committee has the powers and duties to prescribe rules on loan raising, guaranteeing, debt repayment, public debt restructuring and the development of the domestic debt market, including rules related to expenses incurred in loan raising and the issuance and management of debt instruments, provided that where the rules have been approved by the Council of Ministers, state agencies, agencies under state supervision, local administrative organizations, state enterprises, and state financial institutions shall be bound to act in compliance therewith.

<sup>3</sup> An example is the Fiscal Policy Office (2016).

burdens that might occur in the future<sup>4</sup>. We have yet to find research that analyzes the risk of local government debt crises as a whole. More importantly, most studies about risk management use methods to calculate risk and probability concerning financial crises by either explicitly or implicitly assuming that the analyzed data follows normal distribution<sup>5</sup>. We argue that assuming economic and financial data is normally distributed is inconsistent with the true distribution of such data and would result in a substantial underestimation of the risk that occurs in the real world. We also note that misunderstanding of the true distribution of the data and a lack of realization concerning the limitations of knowledge employed in calculating risk could make analysts and/or policy makers unaware of risks that might occur and eventually cause harmful effects to the government's fiscal and financial status, as well as to the economic system as a whole.

For these reasons, this study aims to investigate Thai local government debt by analyzing their rank-size distributions. Our hypothesis is that data in a complex adaptive system with a property of self-organized criticality should obey power law distribution. Power law distribution has been proved using empirical evidence from a number of studies in the past to be suitable for studying the probability of crisis events<sup>6</sup>. If the distribution of local government debt is found to follow power law, the public authorities in charge of monitoring and formulating fiscal discipline frameworks on local government borrowing, as well as implementing risk management policy with regard to local government debt, must be aware that the relevant rules and regulations should be designed by not assuming that local government debt is normally distributed. It should be noted that normal distribution has long been the core foundation of the financial risk analysis appearing in most textbooks<sup>7</sup>. In addition, the findings from this study could be used by public authorities as empirical evidence for designing and/or revising fiscal and financial regulations in order to lower the probability of having financial and economic crises in the future.

This study is divided into five sections. Following the Introduction, Section 2 discusses our theoretical background. Section 3 explains the research methodology and data used. Empirical findings are presented in Section 4. Finally, Section 5 discusses policy recommendations.

## **2. Theoretical Background**

This study applies three principles and concepts, namely power law, complex adaptive systems, and self-organized criticality, to investigate and explain the relationship between the rank and size of local government debt. They could be described as follows:

### **2.1 Power Law**

Power law is a mathematical relationship between rank and size of quantity which can be presented in the following equation:

$$M(R) = (1 + a * e^{-\phi R^{\gamma}}) * (k * R^{-\alpha}) * \left(1 - \left(\frac{R}{(N+c)^{\beta}}\right)\right) \quad (1)$$

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<sup>4</sup> Examples are Kaeokla & Tanlamai (2010) and Sitthiyot (2013).

<sup>5</sup> Examples are Alphametrics (2011) and Foxley (2013).

<sup>6</sup> Details of applying power law to explain probability of crisis events are described in Section 2.1. For those interested in applying power law to study economic issues, please see Gabaix (2016).

<sup>7</sup> Examples are Chunchachinda (2010) and Eiteman et al. (2010).

where	M	=	Size of quantity of interest
	R	=	Rank of quantity of interest corresponding to its size
	a, $\phi$ , $\gamma$ , k, $\alpha$ , c, $\beta$	=	Parameters
	e	=	Natural number (2.71828...)
	N	=	Number of observations

This study has developed a power law relationship between rank and size as shown in equation (1). Given such a relationship, we can estimate parameters a,  $\phi$ ,  $\gamma$ , k,  $\alpha$ , c, and  $\beta$ . The main reason that we choose power law in order to test the relationship between rank and size of local government debt is because previous studies about natural, economic and social phenomena have empirically found that rank-size distributions of such phenomena can be explained by power law. Examples of such natural, economic, and social phenomena are income distribution, growth of gross domestic product, returns on the Dow Jones Industrial Average Index, cotton price volatility, credit growth, energy released in earthquakes, rainfall, population size in cities, death counts in a terrorist attack or war, and traffic jams<sup>8</sup>. We view that local government borrowing is an economic and social phenomenon and therefore the distribution of local government debt should follow power law. If our hypothesis is not rejected, having local government debt distributed power law implies that such data has the property of self-organized criticality, as described in Section 2.2. Briefly speaking, any systems possessing self-organized criticality are complex and extremely difficult or impossible to predict in advance. This is because the relationship between cause and effect in such systems is highly nonlinear. Public authorities responsible for formulating policies at organizational and national levels must design and/or revise the rules and regulations related to local government debt monitoring and risk management in such a way that helps mitigate the negative effects that might occur from local government debt crises.

## **2.2 Self-Organized Criticality**

Bak (1999) studies natural phenomena such as earthquakes, sand pile avalanches, and mass extinction, as well as economic and social phenomena such as economic crises and traffic jams and finds that natural, economic, and social phenomena share common characteristics that Bak (1999) names it self-organized criticality. Self-organized criticality is an important property of complex adaptive systems. If the system has self-organized criticality, it implies that, regardless of the size of an event either small or large, the process that causes an event is the same. Moreover, the impact that occurs in the system does not necessarily result from external factors, but internal factors could also be the causes of such an event. In complex adaptive systems, we cannot analyze each individual part of a system in isolation, but need to analyze the system as a whole using a bottom-up approach. This is because the event self-organizes and emerges from the interaction among the individual parts which comprise the system in such a way that the whole is not equal to the sum of its parts<sup>9</sup>.

<sup>8</sup> Examples are Nagel & Paczuski (1995), Bak (1999), Buchanan (2001), Ball (2004; 2005), Ormerod (2006), Mandelbrot & Hudson (2008), Sornette (2009), Taleb (2010), Ball (2012), and Haldane & Nelson (2012).

<sup>9</sup> According to the concept of self-organized criticality, a process that causes earthquakes with a magnitude of 1 richter and 9 richter is the same. A process that causes large earthquakes is no different

Therefore, public authorities should be aware that it is extremely difficult or almost impossible to predict systems that have the property of self-organized criticality since the relationship between cause and effect is highly nonlinear. This concept has been employed by Ball (2012), Haldane & Nelson (2012), and Sitthiyot (2015) to analyze the risks faced by financial institutions and the probability of having economic and financial crises. In addition, Sitthiyot (2013) uses this concept to explain the effects of the risks of state agency debts on fiscal sustainability in Thailand.

Given the previous empirical studies mentioned above, this study chooses to employ the concept of self-organized criticality to explain the probability of local government debt crises. This is because we view that local government borrowing is complex and adaptive involving more than 2,500 local governments<sup>10</sup>. If a system is complex and adaptive, it will possess the property of self-organized criticality. Testing whether or not local government debt has a property consistent with the concept of self-organized criticality could be technically achieved by investigating the relationship between the rank and size of local government debt to see if it is distributed power law or not. If local government debt is found to have the property of self-organized criticality, committees and/or state agencies should be aware that rules and regulations about borrowing and risk management should be designed accordingly in order to lower the chance of facing a local government debt crisis. In addition, mitigation measures should be designed differently from studies where the property of self-organized criticality is not present.

### **2.3 Complex Adaptive Systems**

Holland (1996) describes complex adaptive systems as systems composed of interacting agents described in terms of rules. These agents adapt by changing the rules as their experiences are accumulated. In complex adaptive systems, the major part of the environment of any given adaptive agent consists of other adaptive agents, so that a portion of an agent's efforts at adaptation is spent adapting to other adaptive agents. Complex adaptive systems exhibit coherence under change via conditional action and anticipation and do so without any central command. In addition, interaction among less complex agents in complex adaptive systems could lead to the emergence of a state wherein each agent cannot do it alone<sup>11</sup>. The idea of complex adaptive systems has so far been adopted across various fields. For example, Ostrom (1999) and Ostrom & Janssen (2004) use this concept to analyze issues concerning rural development and public goods management. Haldane & May (2011) use it to study systemic risk among financial institutions. Furthermore, Ormerod (1999), Kirman (2010), Helbing (2013),

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from the one that causes small earthquakes. This property is called scale-invariance. Applying this idea to study economic crisis implies that a process that causes small and large economic crises is the same. A process causing large economic crises has no special characteristics relative to the one causing small economic crises. Furthermore, these natural and economic events are not necessarily caused by external factors. Rather, internal factors could cause earthquakes and economic crises as well. The concept of self-organized criticality is different from those that view that events that have large effects either in a good or bad way are caused by factors that are different from events that have small effects. For further reading on the concept of self-organized criticality, please see Bak (1999), Ball (2005), and Haldane & Nelson (2012).

<sup>10</sup> According to information from the Department of Local Administration (2018), there are 2,519 local governments that can issue debt, comprising 76 provincial administration organizations, 2,441 municipalities, and 2 special local administrative organizations, namely, Bangkok Metropolitan Administration and Pattaya City.

<sup>11</sup> Holland (1996) uses an ant colony as an example of a complex adaptive system that has an emergence property in which one ant cannot do everything by itself.

Sitthiyot (2013), and Sitthiyot (2015) suggest that complex adaptive systems should be employed to study and explain the workings of economic systems, the eruption of financial and economic crises, and the effects of fiscal and financial policy on the economy.

This study views local governments as complex adaptive systems comprising agents that interact under rules and regulations imposed at local and national levels. The interactions within a local government, among local governments, and between local governments and other state agencies, private sector organizations, and people could create emergent phenomena within which each individual local government cannot do it alone. In addition, previous studies have applied the concept of complex adaptive systems to analyze risk within financial systems, as well as to study the workings of economic systems, and economic and financial crises. This study, therefore, applies the concept of complex adaptive systems to explain the probability of local government debt crises. This is because local government borrowing involves multiple interacting agents in economic and social systems operating under rules and regulations. These multiple interacting agents can evolve and adapt to the changing rules and environment which could lead to positive or negative outcomes for the local government and/or for the Thai economy as a whole.

### 3. Research Method and Data Analysis

To test the hypothesis whether or not the relationship between rank and size of local government debt follows power law distribution, this study employs equation (1) in order to test such a hypothesis as follows:

$$M(R) = (1 + a * e^{-\phi R^\gamma}) * (k * R^{-\alpha}) * (1 - (\frac{R}{(N+c)^\beta}))$$

where	M	=	Size of local government debt
	R	=	Rank of local government debt corresponding to its size from the highest to the lowest
	a, $\phi$ , $\gamma$ , k, $\alpha$ , c, $\beta$	=	Parameters
	e	=	Natural Number (2.71828...)
	N	=	Number of observations

This study uses Microsoft Excel Solver to estimate parameters a,  $\phi$ ,  $\gamma$ , k,  $\alpha$ , c, and  $\beta$  by minimizing the error sum of squares. The emphasis is on the values of  $\alpha$ s, which represent the relationship between rank and size of local government debt in the form of  $M(R) = k * R^{-\alpha}$ <sup>12</sup>. The data used in this study is from the Public Debt Management Office, Ministry of Finance, Thailand which collected information on outstanding debts of 853 local government bodies in 2011<sup>13</sup>

<sup>12</sup> The main reason this study puts emphasis on the relationship between rank and size in the form of  $M(R) = k * R^{-\alpha}$  because the majority of samples falls in the  $(k * R^{-\alpha})$  range, while a relatively small proportion of samples falls in the  $(1 + a * e^{-\phi R^\gamma})$  and  $(1 - (\frac{R}{(N+c)^\beta}))$  ranges.

<sup>13</sup> it should be noted that even though the local government debt outstanding data was collected in 2011, we view that data can still be used to test our hypothesis since there have not been any significant changes in the amount of local government debt. In addition, as of this writing, the Public Debt Management Office just started to systematically collect debt outstanding data from each local government on March 19, 2018 by informing each local government to report its debt outstanding to the Public Debt Management Office.

### 4. Empirical Findings

This study begins by testing whether or not the distributions of local government debt are normal using the Shapiro-Wilk test. The test results shown in Table 1 indicate that the distributions of local government debt classified by region, type, and all 853 local governments are statistically found to be not normally distributed with  $p$ -value = 0.01 in all cases.

Table 1: Normal distribution test results for local government debt categorized by region, type, and all local governments using the Shapiro-Wilk test.

Local Government Categorization	W-Statistic	Degree of Freedom	p-value
<b>Regions</b>			
- Central	0.485	244	0.000
- Northeast	0.369	281	0.000
- North	0.334	195	0.000
- South	0.500	133	0.000
<b>Types</b>			
- City Municipal	0.852	25	0.002
- Municipality	0.829	129	0.000
- Municipal District	0.743	648	0.000
- Provincial Administration	0.634	51	0.000
Organization			
<b>All</b>	0.415	853	0.000

Source: Author’s calculations.

Since rank-size distributions of local government debt categorized by region, type, and all local governments are not normally distributed, this study, therefore, proceeds to estimate the values of  $\alpha$ s which are the exponents of the relationship between rank and size of local government debt. The values of  $\alpha$ s as well as other parameters, namely  $a$ ,  $\phi$ ,  $\gamma$ ,  $k$ ,  $c$ , and  $\beta$ , are estimated separately for different data categorizations, that is region, type and all local governments. The estimated results are reported in Table 2.

Table 2: Parameter estimation results based on rank-size equations of local government debt categorized by region, types and all local governments

Local Government Categorization	a	$\phi$	$\gamma$	k	$\alpha$	c	$\beta$	N	$\Sigma$ error <sup>2</sup>
<b>Regions</b>									
- Central	0.17	0.00	4.11	1.35	<b>-0.39</b>	2.14	0.18	244	0.02
- Northeast	2.61	-0.54	0.61	0.47	<b>-0.38</b>	0.69	0.33	281	0.01
- North	2.90	-0.40	0.84	0.39	<b>-0.41</b>	1.85	0.37	195	0.01
- South	4.31	-4.28	5.00	10.82	<b>-0.37</b>	3.63	0.02	133	0.04
<b>Types</b>									
- City Municipal	0.85	0.00	4.35	0.81	<b>-0.19</b>	0.25	0.35	25	0.01
- Municipality	0.23	0.00	0.00	0.95	<b>-0.17</b>	0.76	0.39	129	0.03
- Municipal District	0.86	-0.98	0.30	0.83	<b>-0.18</b>	1.85	0.37	648	0.02
- Provincial Administration	0.00	-1.53	0.14	1.18	<b>-0.41</b>	0.69	0.47	51	0.21
Organization									
<b>All</b>	0.00	-1.65	6.09	1.28	<b>-0.38</b>	2.14	0.22	853	0.18

Source: Author’s calculations.

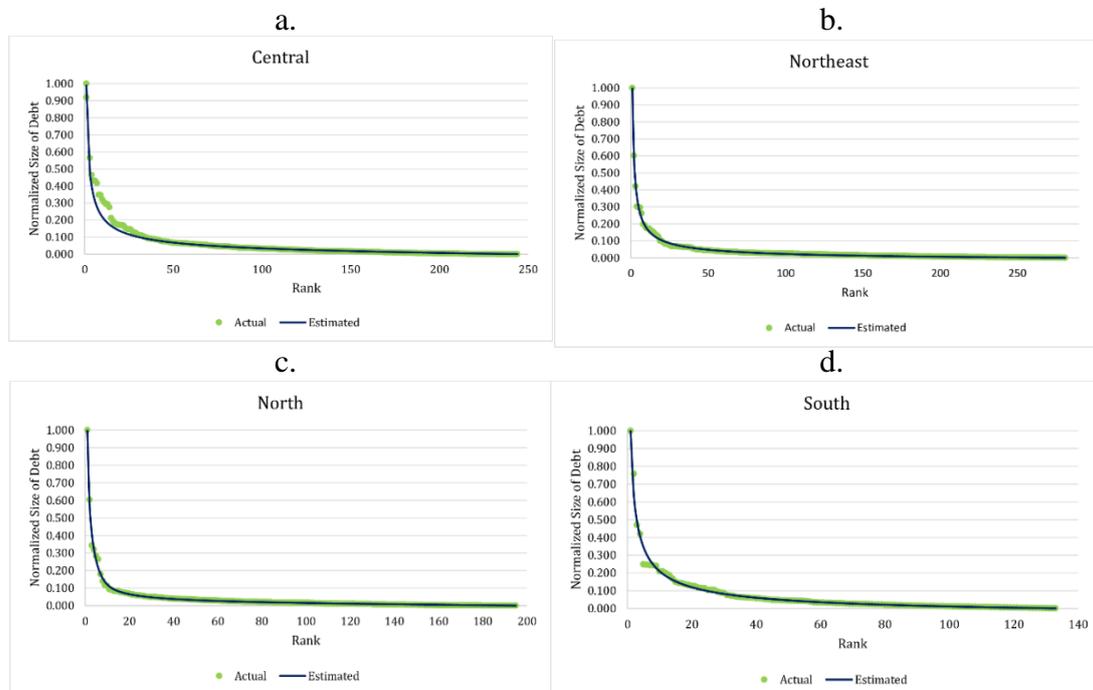
The estimated results for the values of  $\alpha$ s which indicate the exponents of the nonlinear relationship between rank and size of local government debt confirm our hypothesis that such rank-size distributions follow power law in all cases. Through

analyzing local government by region, this study finds that the northern region has  $\alpha = -0.41$  followed by the central, northeastern, and southern regions whose  $\alpha$ s =  $-0.39$ ,  $-0.38$ , and  $-0.37$ , respectively. The results from this study show that if analyzing local government debt separately by region, for every change in the rank of local government debt, the size of local government debt in the northern region would change the most. This is followed by the change in size of local government debt in the central, northeastern, and southern regions, respectively. With respect to the rank-size relationship of all 853 local governments, the value of  $\alpha = -0.38$ , which is not markedly different from the figures for central, northeastern, and southern regions.

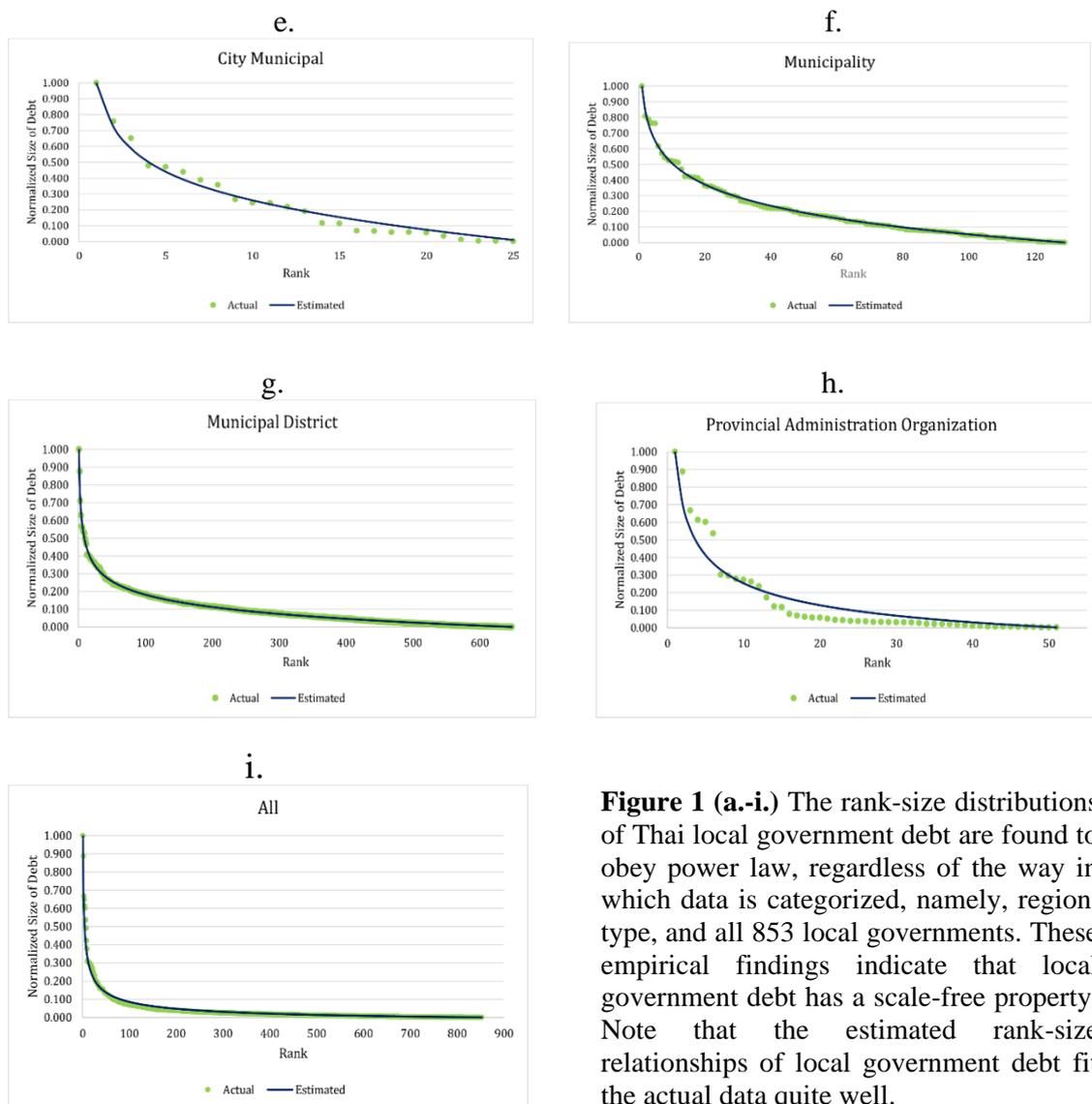
When analyzing local government debt by type, this study finds that the rank-size relationships of local government debt are also nonlinear. However, the magnitudes of  $\alpha$ s are two times smaller than those estimated in the case of regional classification. For every change in the rank of local government debt categorized by city municipal, municipality, and municipal district, the changes in size of local government debt are  $-0.19$ ,  $-0.17$  and  $-0.18$ , amounts which differ only slightly from each other. However, for every change in the rank of a provincial administration organization's debt, its magnitude changes by  $-0.41$ , which is two times larger than those of city municipal, municipality, and municipal district.

Furthermore, when comparing the estimated relationships between rank and size of local government debt with the actual data classified by region, type, and all local governments as shown in Figure 1 (a-i), this study finds that the estimated rank-size relationships of local government debt calculated using equation (1) fit the actual data quite well with values of sum squares of errors ranging between 0.01-0.04, except for the sum squares of errors of all local government debt and provincial administration organization which are equal to 0.18 and 0.21, respectively.

Figure 1: Rank-size relationships of local government debt categorized by region, type and, all local governments following power law distribution.



(continued).



**Figure 1 (a-i.)** The rank-size distributions of Thai local government debt are found to obey power law, regardless of the way in which data is categorized, namely, region, type, and all 853 local governments. These empirical findings indicate that local government debt has a scale-free property. Note that the estimated rank-size relationships of local government debt fit the actual data quite well.

Source: Author’s calculations.

The empirical findings on the rank-size distributions of local government debt indicate that it is necessary to separately analyze local government debt by region and type since the change in the magnitude of local government debt varies differently. More importantly, the changes in the magnitude of local government debt as rank changes are nonlinear in the form of exponents. If analyzing the size of local government debt from the largest (rank no. 1) to the lowest (rank no. N), the size of local government debt would decrease exponentially at the beginning and then gradually decline as the rank becomes higher, but at a lesser rate than the size of local government debt decrease at the beginning. In contrast, if analyzing the size of local government debt from the smallest (rank no. N) to the largest (rank no. 1), the size of local government debt would gradually increase as the rank decreases and would exponentially increase as the rank approaches rank no. 1. Based on the estimated values of  $\alpha_s$ , the changes in the size of local government debt in the central, northeastern, southern regions, and all local governments are not markedly different from each other ( $\alpha_s = -0.39, -0.38, -0.37$  and  $-0.38$ , respectively) while the change in size of local government debt in the northern region is similar to that in provincial administration organization ( $\alpha_s = -0.4075$  and  $-0.4090$ , respectively)

As outlined in Section 2, any systems in which their rank-size distribution follows power law are considered as complex adaptive systems with the property of self-organized criticality. The nonlinear relationships between rank and size of the Thai local government debt which follows power law distribution found in this study suggests that local government borrowing resembles a complex adaptive system with the property of self-organized criticality. Our explanation is that each local government has the authority to issue debt under both certain rules and state agency monitoring. If there are changes in the rules and regulations concerning local government borrowing, each local government would adjust its borrowing accordingly. Local governments may seek and share knowledge among each other regarding new borrowing rules and regulations, or they may ask relevant state agencies to enable them to correctly comply with particular rules. Despite the fact that borrowing rules and regulations are designed and enforced by the central government, local government borrowing is self-organized from the bottom-up since each local government independently makes its own decisions on how much it borrows without any top-down order from central government. During the process of local government borrowing, there are interactions among agents within the local government itself, between local government and its people, between local government and funding sources and private sector parties involved in the procurement process, as well as interaction between local governments and state agencies at the regional and national levels. These interactions along with positive feedback, resulting from each local government trying to improve the standard of living of its people, would require local governments to issue debt in order to spend on development projects. This process eventually leads to an increase in the amount of local government debt as a whole.

If an increase in local government debt leads to positive developments and an improvement in the quality of life of people, it benefits communities. However, if a local government were to have a problem in managing and/or servicing its debts which may be caused by factors within the particular local government or by external factors beyond their control, it should be aware that, in a complex adaptive system, there is usually a delay in recognizing the problem. The problem would gradually self-organize until it reaches its critical state and then spreads. Such a process makes it very difficult for the problem to be corrected in time. This issue along with positive feedback in the system could accelerate a cumulative cycle having negative effects on other local governments that are not directly related to the initial problem, as well as the economic system as a whole.

More importantly, the size of the problem does not matter in this context. In a complex system such as local government borrowing, a problem that seems trivial considered in terms of the size of local government debt relative to the size of gross domestic product or the size of bond market capitalization could possibly ignite a crisis that spreads widely through other local governments and the economic system at the national level<sup>14</sup>. This process is known as the butterfly effect. By analyzing through the lens of a complex adaptive system, the spread of the problem is not different from the problem of a local government having a large amount of debt since local government debt possesses the property of scale-invariance, which is a property of a rank-size

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<sup>14</sup> According to information from the Public Debt Management Office (2018) and the Thai Bond Market Association (2018), as of December 2017, local government debts outstanding approximately equals 30,000 million baht or 0.20% of gross domestic product and 0.27% of debt market capitalization.

relationship that obeys power law<sup>15</sup>. Given the property of scale-invariance, it is very difficult or almost impossible to predict in advance which type and/or size of debt or what type of local government would cause a local government debt crisis. If a local government debt crisis were to happen, it would represent an emergent phenomena which cannot be analyzed by studying each local government in isolation, but the entire network of local governments, financial institutions, and state agencies, as well as related stake holders, which could directly and/or indirectly affect local governments. This is simply because the whole is not equal to the sum of its parts. Moreover, because of the property of emergence, local government debt crises cannot be prevented in advance since it is very difficult to know the true cause of a particular crisis<sup>16</sup>. All that can be done is to mitigate the problem once it occurs. It is sensible that the Public Debt Policy and Supervision Committee issued the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018). However, we confidently believe that the empirical evidence on the rank-size distribution of local government debt that obeys power law found in this study, along with the knowledge about complex adaptive systems and the concept of self-organized criticality, can be used to redesign and/or revise the rules and regulations relating to local government borrowing so that such rules and regulations would be more complete and prudent than existing measures.

## **5. Policy Recommendations<sup>17</sup>**

Based on the empirical results about the relationships between rank and size of local government debt that follows power law distribution found in this study, we suggest that in the process of designing and drafting rules and regulations related to monitoring and building the fiscal discipline framework for local government borrowing, public authorities should analyze the distribution of data on local government debt. The results concerning data distribution can then be used as supporting information for designing and formulating rules and regulations that reflect the true nature of the distribution of data regarding local government debt. Local government debt obeying power law distribution indicates that local government borrowing should be viewed as a complex adaptive system with the property of self-organized criticality. Given the existence of positive feedback in the system and the property of scale-invariance of local government debt, it is very difficult or almost impossible to predict which type of local government or what size of debt would cause a local government debt crisis that could harmfully affect their fiscal and financial status, as well as the economic system as a whole. This is simply because local

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<sup>15</sup> It should be noted that if the rank-size relationship of data follows power law distribution, the data would have the property of scale-invariance, but not vice versa.

<sup>16</sup> Hillis (2015) notes that, in complex systems, the notion of cause and effect is not entirely clear and cannot be separated.

<sup>17</sup> All recommendations are based on a critical assumption that any local governments that wish to take on debt and public authorities that have powers to approve such borrowing, as well as monitor and formulate policy regarding risk management are benevolent and have good intentions for the well-being of the community and the country as a whole. Both local government and public authorities have no deliberate intention whatsoever to engage in corruption in order to reap benefit for themselves.

government debt crises represent emergent phenomena that cannot be prevented beforehand.

By analyzing the details of the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018) which emphasizes borrowing, debt management, debt repayment, monitoring and local government debt reporting, we agree that this regulation can be used to monitor and build a fiscal discipline framework for local government borrowing to a certain extent. However, given the fact that local government debt crisis is an event that cannot be prevented in advance, we suggest that the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018) should be revised by adding a clause that requires each local government to have measures to mitigate problems that might arise as a result of local government debt crises which could indirectly affect other local governments that do not have financial problems. One example of such a mitigation measure is requiring local governments to maintain reserves to ensure enough liquidity to be able to service its debt in the event of a crisis. It should be noted that there is no such clause stipulated in the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018) which has been effective since July 17, 2018.

This study is well aware that according to the Official Letter (Most Urgent) No. Mor Tor 0808.2/Vor.7272 dated 26 December 2017 regarding the guidelines on the spending of collected money of the Local Administrative Organization for supporting state policies in strengthening its operations, the Ministry of Interior of Thailand requires all local governments to have accumulated money in order to strengthen their fiscal position and be ready to solve problems that might occur in their community in the unforeseeable future. However, in reviewing the details of the Ministry of Interior Regulation on the Reception, Disbursement, Deposition, Retention and Inspection of the Money of the Local Administrative Organization B.E. 2547 (2004) and the additional amendment in Chapter 8: Accumulated Money, local governments can use their accumulated money in case of emergencies resulting from public disasters only<sup>18</sup>, excluding a local government debt crisis. This could make local governments that do not have financial problems lack enough liquidity to repay debts.

This study views that this issue is very important and should not be overlooked. The rank-size distribution of local government debt that follows power law implies that it is possible that a small problem occurring to any local governments could spread through the system and become a large problem at the national level. An example is the financial crisis in the United States of America in 2007 which was partly caused by public authorities overlooking the comparatively small problem of subprime mortgages which, according to most analysts at that time, should not have caused any large impact on financial markets and the U.S. economy as a whole. As we all know by now, in the end, it affected the U.S. financial markets and economic system profoundly and the total cost of damages still cannot be fully assessed. Therefore, this study suggests that local governments should have enough reserves to be able to face a local government debt crisis so that any local governments that do not have default problems but lack liquidity can service their debts on time. This is a mitigation measure that could lower

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<sup>18</sup> Public Disaster Prevention and Mitigation Act, B.E. 2550 (2007), Section 4 dictates that the phrase “public disaster” denotes fire, windstorm, flooding, drought, epidemics in humans, in animals or in marine animals, or invasion of plant pests, including other disasters which affect the public, whether caused by nature, persons, accidents or any other causes, and thereby causes harm to the lives or bodies of the people, or damages properties of the people or of the state, and shall also include air disasters and terrorism.

defaults on debt repayments. If we look at both sides of the system, namely local governments and creditors, this study views that trust could be built in the system if local governments that do not have problems, but are indirectly affected by local government debt crises, can service their debts. In times of crisis, trust is the most important currency in the system. Having local governments be able to service their debts should mitigate problems during a crisis. For this reason, this study would like to suggest amending the rules and regulations related to local government borrowing in such a way that local governments either maintain enough reserves or be able to use their accumulated money to service their debts. This could be done in three possible ways which are 1) amending the Public Debt Policy and Supervision Committee Regulation Concerning Borrowing Rules of Local Administrative Organization B.E. 2561 (2018) by adding a clause that provides guidelines for local governments to maintain reserves in order to be able to service their debts 2) adjusting the Ministry of Interior Regulation on the Reception, Disbursement, Deposition, Retention and Inspection of the Money of the Local Administrative Organization B.E. 2547 (2004) such that local governments can use their accumulated money in order to service their debts during a crisis or 3) the State Financial and Fiscal Policy Committee should impose an additional guideline with regard to reserve maintenance in the form of financial and fiscal discipline for local governments to comply with<sup>19</sup>. This study views that these mitigation measures are far superior than trying to solve immediate problems by issuing special decrees or ministerial regulations after a local government debt crisis has already erupted.

In addition to measures for mitigating problems arising from the local government debt crises suggested above, committees and/or state agencies, involved in monitoring, analyzing, and recommending risk and uncertainty management policies arising from local government debt crises, should study and thoroughly understand the concept of power law so that they can propose policy recommendations that take into account the true distribution of the data involved<sup>20</sup>. The empirical results found in this study suggest that, if possible, committees and/or state agencies should avoid analyzing data using mean and variance calculated from the samples. This is because data that is distributed power law, in principle, has no true population mean and has infinite

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<sup>19</sup> The State Financial and Fiscal Discipline Act B.E. 2561 (2018) Section 11 (1) grants power upon the State Financial and Fiscal Policy Committee to lay down financial and fiscal disciplines in addition to those provided in this Act or in other laws, for observance by state agencies without prejudice to the independence in the performance of duties of state agencies.

<sup>20</sup> According to the Public Debt Management Act B.E. 2548 (2005) and the additional amendment Section 36 (1) and (3), the Public Debt Management Office has a duty to study and analyze the debt of local administrative organizations and to provide consultations and recommendations to and enhance the capabilities of local administrative organizations for the purpose of debt management.

In addition, the State Financial and Fiscal Discipline Act B.E. 2561 (2018) states that in considering the matter on debt issuance, the Council of Ministers must meticulously take into account the risks and losses that may likely be caused to state financial and fiscal affairs (Section 9, para 2) and provides that the State Financial and Fiscal Policy Committee (Section 10) shall have the duties and power to lay down policies on, and supervise, financial risk management (Section 11 (5)). Furthermore, the Act also provides that the Ministry of Finance and agencies concerned shall conduct financial risk management in accordance with the financial risk management policy prescribed by the Committee (Section 30). The Ministry of Finance shall prepare a report on financial risks at the end of the financial year for submission to the Council of Ministers and the Committee for Information within sixty days from the end of the financial year (Section 76). Within the month of March each year, the Ministry of Finance shall prepare an annual report on financial risk indicating the results of assessment of the risks expected to be caused by effects on the macro-economy, fiscal systems, government policies and operations of state agencies likely to cause financial burdens on the government and directions for the management of such risks (Section 78).

variance<sup>21</sup>. As a result, using sample mean does not offer a satisfactory representation of true population mean and variance is not a useful method to analyze risk.

It is critical to note that data distributed power law has totally different properties from that distributed normal. In a normal distribution world, a sample mean can be used as a representative of true population mean if the sample size is large enough. This is because the sample mean would approach the population mean and variance can be used to analyze risk since its value is finite.

Last but not least, this study would like to suggest that when analyzing the risk and uncertainty that might occur from local government debt, analysts should not exclude data that represent outliers since the rank-size distribution that follows power law has the property of scale-invariance. It is possible that outliers, either extremely small or large, could be a cause of a local government debt crisis that adversely affects the financial and fiscal status of government, as well as the economic system as a whole. Excluding those outliers leads to significantly underestimating the risk that might actually manifest itself in the real world.

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<sup>21</sup> For further reading on this issue, please see Barabási (2016).

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