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MEASURING CORRUPTION IN INDONESIA USING FUZZY LOGIC

Joko Waluyo*[1]
Tri Haryanto[2]
Bambang Eko Afiatno[3]
Tri Achmadi[4]

[1,2,3] Department of Economics, Universitas Airlangga, Indonesia

[4] Department of Marine Transportation Engineering, Institut Teknologi Sepuluh November, Indonesia

ABSTRACT

Corruption is a phenomenon not easy to observe. Corruption theory and existing definitions are ambivalent, both in size and level. Mathematical models, and econometrics are prone to statistical errors. Fuzzy logic facilitates more humane modeling and analysis. Fuzzy logic is not bound by strong assumptions, as a solution to solve complex problems, and not precise, including corruption analysis. The main objective of this study is to measure corruption in Indonesia. The research method used fuzzy logic by specifying the Mamdani fuzzy inference system (FIS) model. FIS Mamdani was chosen because it is more human manner. Sources of secondary data used in this research from various institutions. The results show that corruption time series data can be produced. During the research year (1995-2020), corruption that occurred in Indonesia was 36.14 percent of real GDP per capita.

Keywords: *Corruption, Fuzzy logic, FIS Mamdani*

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*Correspondence:
Joko Wluyo
E-mail:
mrwaluyo@gmail.com

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Introduction

Discussions about corruption are very complicated and even tend to be vague. In recent decades research topics have revolved around the theory of corruption, a comprehensive definition of corruption, and the measurement of corruption (Moise, 2020). The phenomenon of corruption can be a serious problem in an economy. If the level of corruption that occurs is very high, it will affect the level of public welfare. Public corruption that occurs on the side of the government bureaucracy is directly related to the use of the state budget, so that the budget that is supposed to improve public welfare is diverted to the pockets of bureaucrats (Mauro, 1997). The impact that occurs can be very broad, including: the provision of public goods is reduced both in quality and quantity. On the other hand, corruption can also occur in the private sector, in the form of bribery and collusion by private companies to obtain projects (Klitgaard, 1988 and 2000; Shleifer & Vishny, 1993; Bliss & Di Tella, 1997; Lambsdorff, 1999; Ventelo, 2002).

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The current literature on corruption builds indicators of corruption from a one-sided perspective, which is narrowed down to a technical issue of how to measure actual or perceived corruption. According to Mailto (2014), methodologically the preparation of corruption indicators has several problems, namely: *First*, the data used is subjective, using opinion and perception data to build corruption indicators. *Second*, composite indicators that cause dependence on various data sources. Composite indicators provide power in summarizing data, but run the risk of losing conceptual clarity or using unclear methods. *Third*, data collection and missing data. Missing data causes researchers to use other data sources, without considering whether these data can be combined with other data. Recent research has shown that perceptions of corruption may not be a good indicator of actual corruption in a country (Bahoo et al., 2019).

Corruption cannot be measured directly, as there are complex governance issues related to corruption. The problem of corruption is complicated, complex, and tends to be vague, requiring an alternative approach to analysis, especially in measuring the level of corruption. Zadeh (1965, and 1987) introduced a fuzzy logic to facilitate modeling and analysis of humanism systems including economics. Economic models are used to predict changes in economic activity that are influenced by internal and external factors. This causes the prioritization of the use of linguistic concepts, fuzzy logic and fuzzy modeling. The advantages of using fuzzy logic are 2, namely (1) it can avoid complicated mathematical modeling and expressions, is not sensitive to data availability, is not sensitive to model specifications, and (2) fuzzy rules with linguistic terms are easy for humans to understand, simple, and flexible. (Abbneh, 2016; Tahmasebi, 2015; Pernica, 2018; Manga, 2019). The question in this research are how to measure corruption using fuzzy logic and how much corruption occurs in Indonesia ?

Literature Review

Definition of Corruption

According to the Kamus Besar Bahasa Indonesia (KBBI) corruption is described as an act of using power for one's own interests (such as embezzling money or accepting bribes). This means that corruption is the abuse of office authority for personal and group interests. According to the Oxford Learner's Dictionary, it is described as: (1) dishonest or illegal behavior, especially towards people in authority, (2) actions or consequences that make a person change from a standard of moral behavior to be immoral. This means that corruption includes 3 important elements, namely: morality, behavior, and authority. According to the Oxford Dictionary of Economics (2016), corruption is described as the use of bribes to influence public action. More generally, corruption refers to obtaining personal gain from public office through bribery, extortion, and embezzlement of public funds.

In general, corruption is defined as "the abuse of public power for private benefit", the abuse of public power for private gain (Shleifer & Vishny, 1993; Bardhan, 1997; Tanzi, 1998; Klitgaard, 2001, 2002; Transparency International, 2009, 2015). Corruption is an illegal activity carried out through abuse of authority or power in the government and private sectors as office holders for personal gain and financial or other benefits (Bahoo, 2019). The depiction has 3 characteristics, namely: illegal activities, abuse of power, and making personal gain. Included in this definition are bribery, fraud, financial crimes, abuse, counterfeiting, favoritism, nepotism, and manipulation.

Corruption is related to bureaucrats - economic agents, bureaucrats - bureaucrats, economic agents - economic agents. In general, the relationship that occurs involves consum-

er households, producer households and government households. Corruption can be denoted simply as C = M + D – A, where C: Corruption, M: Monopoly, D: Discretion, A: Accountability (Klitgaard, 2001 and 2002). Based on the model compiled by Klitgaard above, it shows that corruption will manifest itself if there is a monopoly on economic resources, deviations from public policies occur, and there is no accountability for every policy taken by the government. The agent's behavior in corruption is strongly influenced by the probability of being caught, the penalty received, and the outcome of corruption, compared to the salary and incentives obtained.

Indicators of Corruption

Corruption as a socio-economic and political phenomenon does not exist as a "product of production", but interferes with a production process. When an economy is running a production process, corruption manifests itself in the form of project mark-ups, bribery, collusion, and nepotism (Klitgaard, 1988). The impact can affect the structure of production costs, which in turn will increase the price that consumers have to pay for goods and services. This is due to the increasing deadweight loss in the economy.

The existing literature offers some guidance regarding appropriate indicators of corruption. In general, corruption causes poor countries to become poorer. Corruption undermines economic development and is considered a cause of perpetual poverty in Africa and stagnation in Latin America. Almost all evidence shows that corruption has a negative impact on economic development (Mauro, 1995; Adam et al., 2011). The right indicator to describe this condition is GDP per capita.

Corruption manifests itself as bribery or giving gratuities. In Indonesia, the euphoria of regional autonomy was followed by the decentralization of corruption to the regions. Kuncoro (2002, 2004) shows that the low salary of bureaucrats in the regions causes many civil servants to be willing to accept bribes. In the developed model, it can be seen that the relationship between bribery and the sacrifice of working time is positive and significant. This conclusion shows that the bribery phenomenon that is spreading at the government level causes the work ethic of civil servants to be reduced. Bureaucrats prefer to enjoy extra time to "increase" their income, rather than working in an office with a steady income.

A well-functioning justice system is essential for dealing with corruption effectively. This condition is important to maintain the certainty of the legal system in development (Gloppen, 2014). An independent judicial system is demonstrated by a judiciary that is impartial to political influence by members of the government, lobbyists or special interest groups.

Determinant of Corruption

Corruption cannot only be seen as a mere economic problem, in which the wealth of the country is reduced. The real problem is more than that, because corruption involves socio-cultural, political, and defense and security aspects. The socio-cultural aspect is related to the destruction of the nation's morale because state officials always want to get more income beyond their rights. Politically, it is related to the unfairness of determining public policies, where those who have money can regulate the results of public choices. The existence of corruption interferes with national defense, if the freedom of the state to regulate policies in accordance with national goals cannot be implemented. Theoretical and empirical literature is used to identify the causes and indicators of corruption. To facilitate the explanation, the causal variables have been categorized into 4 main factors, namely: political and legal factors,

bureaucratic and regulatory factors, socio-cultural factors, and economic factors.

The first factor is politics and law. Political and legal causes of corruption seek to explain the democracy and institutions of a country and the quality of the political system. Corruption is related to weaknesses in the political system and administrative system, both in the form of clear rules, and a long tradition of institutions in preventing corruption. Political competition, increased transparency, and increased accountability can reduce the scope of bribery. Political characteristics of a country's political system, such as electoral rules, and the degree of decentralization influence corruption (Shleifer & Vishny, 1993). A strong and efficient legal system protects property rights and provides a stable framework for conducting economic activity. On the other hand, a weak legal system will damage the market, reduce individual incentives to participate in productive economic activities, and even worse will encourage counter-productive activities such as corruption.

The second factor is bureaucracy and regulation. The judicial system and the quality of the bureaucracy play an important role in influencing corruption. Low salaries of state apparatus are associated with law enforcement and the quality of the bureaucracy and have an effect on corruption (Rijckeghem & Mauro, 1997). In developing countries, low salaries of state apparatus lead to corrupt behavior. Institutions in poor countries are unable to detect corrupt behavior because of the low salaries of state apparatus. Corruption is related to the quality of the bureaucracy. A merit system in employee recruitment and promotion, and professional training is the key to producing a quality bureaucracy.

The third factor is socio-cultural. Many individuals in poor countries with low literacy rates have a poor understanding of governance. This condition causes individuals to low expectations for the government. The culture of corruption stems from ignorance, thus making it a tradition that one should give a gift to show gratitude for decisions that favor Pasuk et al, (1994). According to Mauro (1994), countries with high levels of corruption often underinvest in the education system and human resources, thus perpetuating the tradition of giving gratuities.

The fourth factor, namely the economy. The government often interferes with the economy through regulations and tax burdens imposed on economic actors. This reduces economic freedom. Greater economic freedom can reduce corruption. This condition causes individuals to have many choices in doing business, and reduces the complexity of the bureaucracy. Tanzi (1998) & Dreher (2020) mention that the size of the public sector offers bureaucrats the freedom to allocate goods and services. The bigger the role of the public sector, the higher the level of corruption. Rijckeghem & Mauro (2001) found a relationship that the larger the size of the public sector with the lower salary levels of bureaucrats, the higher the level of corruption.

The granting of regional autonomy and fiscal decentralization gives the regions the authority to manage their own households, including regional financial independence. Fiscal decentralization follows the money follow function principle, so that regions manage finances that are increasing. This risks increasing corruption in policy making at the regional level. In developing countries, the richer an area is, the possibility of corruption also increasing (Suprayitno & Pradiptyo, 2017). The opposite result occurs in developed countries, the relationship between corruption and fiscal decentralization is negative (Fisman & Gatti, 1999).

Data and Research Methods

Fuzzy logic is logic based on fuzzy set theory and introduced by Lofti A Zadeh (1965). In fuzzy logic, there is a mapping process from an input space into an output space and has a continuous value. Fuzzy expressed in degree of membership and degree of truth. Therefore something can be said to be partly right and partly wrong at the same time. The fuzzy model generally consists of 3 general steps, namely: fuzzification, fuzzy inference, and defuzzification which can be illustrated in Figure 1.

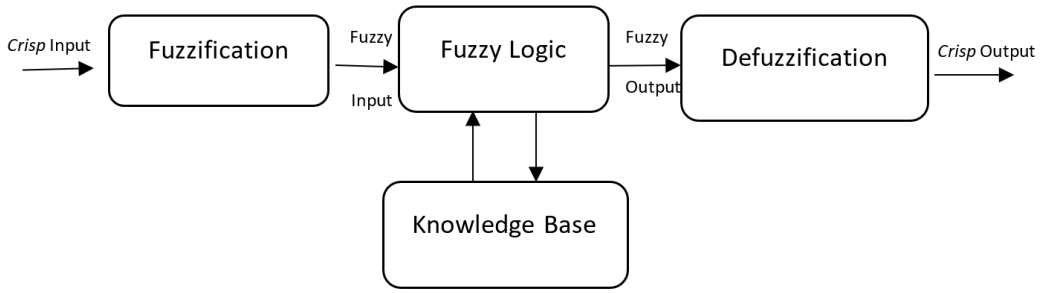


Figure 1: General Steps in Fuzzy Model

Fuzzyfication

The fuzzification process is a process to convert numeric values into fuzzy terms that have been quantified by the fuzzy membership function. This is done based on the fact that numerical and deterministic quantities are not always deterministic, but are subject to uncertainty to some extent. If the uncertainty is the result of imprecision, ambiguity or ambiguity, it can be concluded that the variable is most likely fuzzy.

Fuzzy Inference

Apply algebraic expressions by combining data to provide better visualization, understanding, and interpretation of data relationships. Data modeling is a good choice for combining data. This can be interpreted as an attempt to represent the information available from a set of data in a clear way. Data modeling is the first stage to generate fuzzy statements, especially in large databases, and helps in the decision-making process. A fuzzy statement can be defined as an attribute of a linguistic term, either a single term or a compound term (with two or more single terms joined by linguistic conjunctions) to a variable.

In general, fuzzy rules are expressed in the form of “IF ... AND ... THEN” which is the essence of the fuzzy relationship. A fuzzy relation, denoted by R, is also called a fuzzy implication. There are two main ways to get the “IF ... AND ... THEN” rule:

1. Asking human operators who have been able to control the system manually, are known as “human experts”.

2. Using training algorithms based on input and output data.

Defuzzification

There are situations that require the output of the fuzzy process to be a single scalar quantity. Thus, another step is needed to produce a specific response. Defuzzification is the

conversion of fuzzy output into crisp (firm/classical) precise output. The fuzzy output process can be a logical union of two or more fuzzy membership functions defined in the universe of output variables.

Decisions resulting from the reasoning process (logic) are still in fuzzy form, namely in the form of output membership degrees. This result must be converted back into a non-fuzzy numeric variable through a defuzzification process. In general, there are 7 defuzzification methods, namely: max membership principle, centroid method, Weigthed Average Method, mean max membership, center of sum, center of largest area, and first (or last) maxima.

The computational process to complete the calculation of the fuzzy model using empirical data will use the fuzzy toolbox in Matlab R2020a. Secondary data research used from various international institutions as shown in table 1.

Table 1: Name of Variable, Definition, and Sources of Data

Variable	Definition	Sources
Corruption	The abuse of public power for private benefit	Corruption Perception Index, Transparency International
Government Effectiveness	An effort to improve the quality of public services that are free from political pressure.	*World Development Indicators* (WDI), World Bank
Rule of Law	An effort to enforce and position the law at the highest level	*World Development Indicators* (WDI), World Bank
Bureaucratic Cost	Costs that arise in a government organization as a result of problems related to coordination and motivation.	*Economic Freedom of the world*, Fraser Institute
School Participation	Number of school-age children attending school	*World Development Indicators* (WDI), World Bank
Economic Freedom	The basic right of every human being to control his own work and property	*Index of Economic Freedom*, The Heritage Foundation
Fiscal Decentralization	Delegation of fiscal authority from the central government to local governments	*Government Finance Statistics* (IFS), IMF

Sources: Research data

Finding and Discussion

Finding

The convetional fuzzy model consists of 3 steps, that are fuzzification, fuzzy inference, dan defuzzification, which will be explained as follows

Fuzzification

This study will use a fuzzy membership function representation in the form of a shoulder (triangular in the middle and trapezoid on the left and right), both for input and output. Shoulder shape is a logical consequence of the use of 5 scales in determining membership functions. The fuzzy set linguistic terms used can be explained in table 2

Table 2: Membership Function and Linguistik Terms input

Variable		Linguistic Terms (LT) and Membership Function (MF)				
Government Effectiveness	LT	Very effective (VE)	effective (E)	Normal (N)	Not effective (NE)	Very in Effective (VE)
	MF	0,24	-0,04	-0,32	-0,60	-0,88
Rule of Law	LT	Very Free (VF)	Free (F)	Normal (N)	Limited (L)	Very Limited (VL)
	MF	66,59	62,10	57,60	53,10	48,61
Bureaucratic Cost	LT	Very Expensive (VE)	Expensive (E)	Normal (N)	Inexpensive (In)	Very Inexpensive (VIn)
	MF	7,67	7,15	6,63	6,10	5,58
School Participation	LT	Very Superior (VS)	Superior (S)	Normal (N)	Inferior (I)	Very Inferior (SI)
	MF	-0,23	-0,41	-0,60	-0,78	-0,96
Economic Freedom	LT	Huge (H)	Many (M)	Normal (N)	Little (Li)	Least (Le)
	MF	95,05	93,64	92,24	90,84	89,43
Fiscal Decentralization	LT	Huge (H)	Many (M)	Normal (N)	Little (Li)	Least (Le)
	MF	0,47	0,37	0,28	0,18	0,09

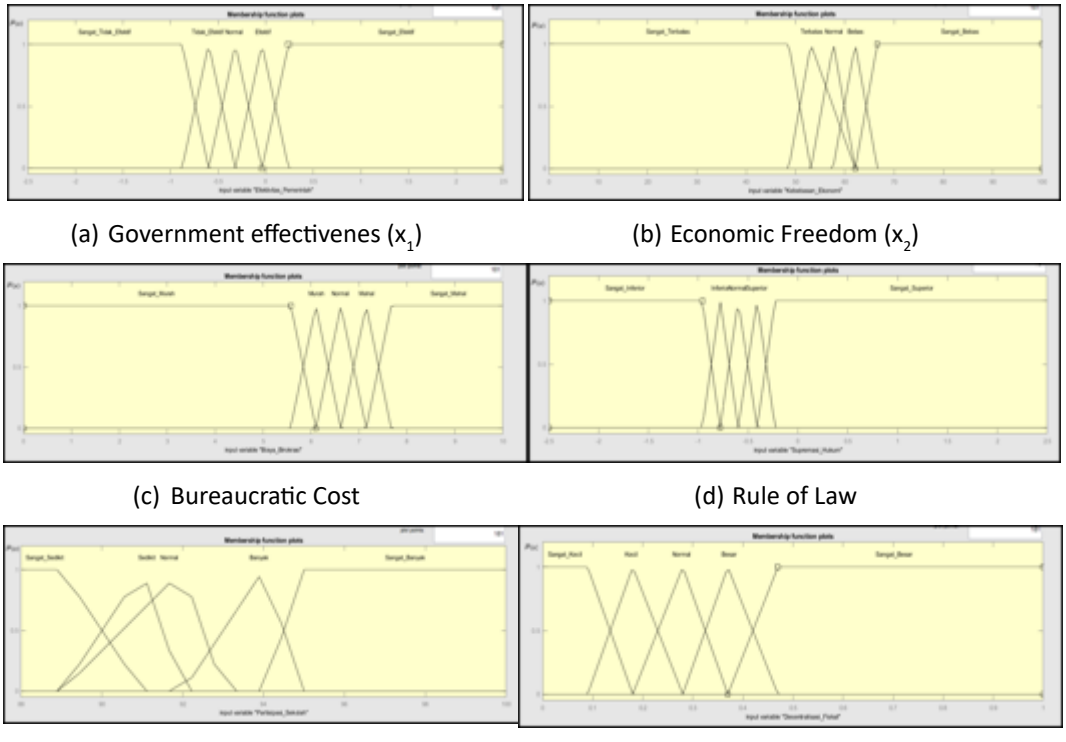
Source: Result Analysis

description:

LT = Linguistic Terms,

MF = Membership Function.

Graphically the membership function of the input and output can be illustrated in figure 2.



(a) Government effectivenes (x_1) (b) Economic Freedom (x_2)

(c) Bureaucratic Cost (d) Rule of Law

(e) School Participation (f) Fiscal Dicentralization

Figure 2: Membership Function of Input

Fuzzy Inference

Fuzzy rules and inferences are presented in Tables 3 (A), 3 (B), and 3 (C) to combine several fuzzy rules that have relevant membership degrees. The main diagonal shows the results directly and the other rules are arranged symmetrically according to the rules of Lindstorm (1998), and Tahmasebi (2015). The rules on the main diagonal are used as the benchmark rules, while the other rules are determined on an ad hoc basis. The degree of membership provided is used to correct for the membership function of the linguistic terms generated by each rule. For example at a degree of 0.80, the magnitude of the value of corruption in that year is not completely high and needs correction to be able to use the rules, IF the rule of law is very superior VS AND the effectiveness of the government is not effective (NE) THEN corruption is small (S).

Table 3 (A): Fuzzy rules and The Degree of Membership of The Government Effectiveness Variable Pair With The Rule of Law

VE		Government Effectiveness				
		E	N	NE	VE	
Rule of Law	VS	Le,1	Le,1	Li,1	Li, 0,80	Li, 0,50
	S	Le, 0,95	Li,1	Li, 0,8	N, 1	Li, 0,80
	N	Li, 0,95	Li, 0,75	N,1	Li, 0,80	Li, 1
	I	Li, 0,75	N, 0,75	M, 0,75	M, 1	Le, 1
	SI	N, 0,45	M, 0,75	M, 0,95	Le, 1	Le,1

Sources: Result and analysis

Table 3 (B): Fuzzy Rules and Membership Degrees Pair Bureaucratic Costs with Fiscal Decentralization

VE		Bureaucratic Cost				
		E	N	Li	Le	
Fiscal Decentralization	H	H,1	H, 1	M, 1	M, 0,80	N, 0,50
	M	H, 0,95	M, 1	M, 0,80	N, 1	M, 0,80
	N	Li, 0,95	M, 0,75	N, 1	M, 0,80	M, 1
	Li	M, 0,75	N, 0,75	Li, 0,75	Li, 1	Le, 1
	Le	N, 0,45	M, 0,75	Li, 0,95	Le, 1	Le, 1

Sources: Result and analysis

Table 3 (C): Fuzzy Rules and Degrees of Membership Of Pairs of Economic Freedom Variables (X1) with School Participation (X5)

VF		Economic Freedom				
		I	N	L	VE	
School Participation	H	Le, 1	Le, 1	Li, 1	Li, 0,80	N, 0,50
	M	Le, 0,95	Li, 1	Li, 0,80	N, 1	Li, 0,80
	N	Li, 0,95	Li, 0,75	N, 1	Li, 0,80	Li, 1
	Li	Li, 0,75	N, 0,75	M, 0,75	M, 1	H, 1
	Le	N, 0,45	M, 0,75	M, 0,95	H, 1	H, 1

Sources: Result and analysis

The following variables were determined: government effectiveness with the rule of

law, government costs with fiscal decentralization, and economic freedom with school participation. Fuzzy rules with relevant membership degrees can be described in table 3 above.

Defuzzification

In this study, the centroid or COA (centre of area) method is used, by taking the center point of the fuzzy area. Membership functions and linguistic output terms can be explained in table 4 and figure 3.

Table 4: Membership function and output linguistic terms

Variable		Linguistic Terms (LT) dan Membership Function (MF)				
Corruption	LT	Huge (H)	Many M)	Normal (N)	Little (Li)	Least (Le)
	MF	42,08	34,66	27,24	19,82	12,39

Source: Result Analysis

description:

LT = Linguistic Terms,

MF = Membership Function.

Table 4 and Figure 3 explain the value of the output variable domain (corruption), whether the corruption that occurred was Huge (H), Many (M), normal (N), Little (Li), or Least (Le).

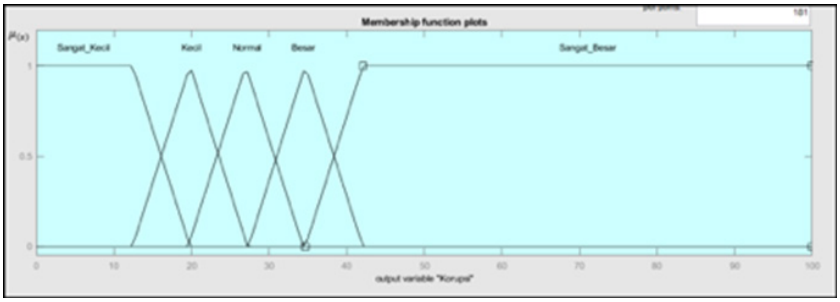


Figure 3: Membership Function Output

Source: Result Analysis

The surface of the function between the input and the output can be shown in Figure 4

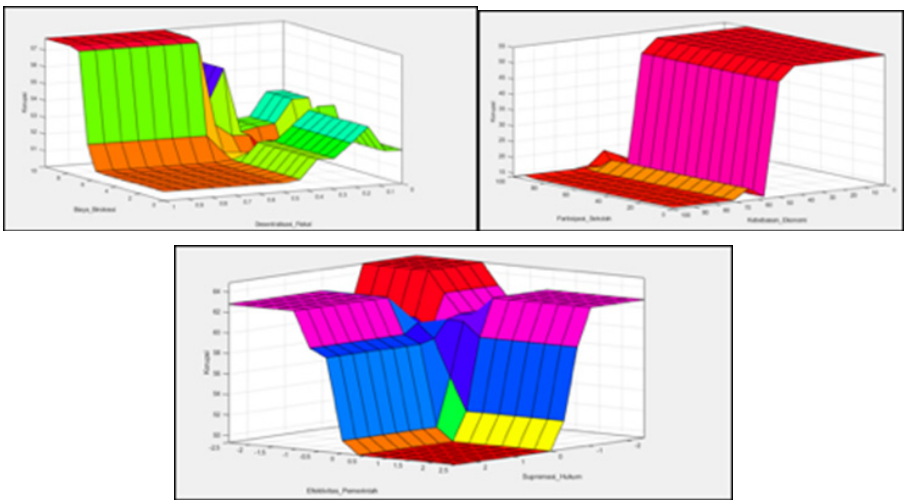


Figure 4: Surface Function Between Input and Output

Source: Result Analysis

Discussion

The relationship between inputs and outputs in the mamdani inference system is used to calculate the magnitude of corruption in Indonesia. The average level of corruption in Indonesia during 1995 – 2020 was 0.3613846 or 36.14 percent. This figure shows that corruption in Indonesia is "huge". This level of corruption can also be interpreted as national leakage or inefficiency of the national economy. The figure of 36.14 percent of real GDP per capita is a large number for an economy. This figure is not much different from the ICOR calculation figure proposed by the late Prof. Soemitro Djojohadikoesoema in the fifth lamp, which is 30 percent. For almost 3 decades the leakage of the national economy increased by 6 percent.

Figure 6 shows the time series of corruption in Indonesia. Time series shows that in 1997 there was an increase in the level of corruption, while the sharpest increase occurred in 1998-2000. This year, Indonesia is experiencing a monetary crisis and increasing demands for comprehensive reforms, as well as the enactment of Law no. 22 and 25 of 1999 concerning local government and fiscal decentralization. This package of laws was amended in 2004. A very significant pattern of decreasing corruption began in 2003. On December 29, 2003, the KPK was established based on Law no. 30 of 2002 concerning the establishment of Komisi Pemberantasan Korupsi (KPK).

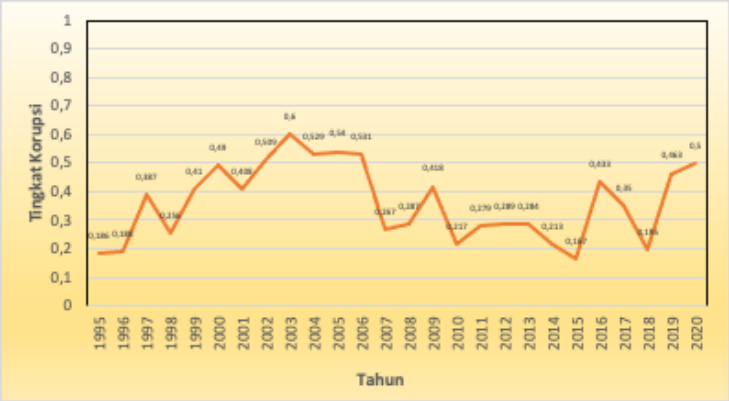


Figure 5: Corruption in Indonesia

Source: Result Analysis

Another interesting phenomenon shows that the political year (2004, 2009, 2014, and 2019) experienced a decline in corruption. This is probably due to the increased generosity of the "philanthropy" of election contestants. Even after the political years (2005, 2010, 2015, and 2020) corruption increased sharply. This is the possibility of "politics of reciprocation" among donors of political parties and other election contestants (governors, regents, mayors, and elected members of the legislature).

Funding for political parties in Indonesia comes from member fees, government subsidies/assistance, and private or business entity contributions which are not binding and the amount is limited by law. The source of funding for political parties is an important instrument, to always maintain the neutrality of political parties. Funding through membership dues has not been able to fund party financing. Sources of funds originating from private donations or business entities cause the influence of the party political elite (contributors) to the direction of party policy is very large. In this condition, the government's role is very important to provide subsidies for political party funding (Faisal et al, 2018). This is different from the implementation of democracy in developed countries. Donor based corruption does not occur

(Power, 2020). Political maturity, transparency, and accountability in managing party funds are the main keys in preventing corruption. Besides, political parties in developed countries are not willing to risk their political image by committing corruption.

Conclusion

Measuring corruption means documenting loss of resources, public budgets, bribery, and weak legal systems. Indonesia as a country with a high category of corruption requires a more accurate way of measuring corruption, so that policies to prevent and eradicate corruption can be more targeted. The study of corruption is confronted with ambivalent theories of corruption and very complex determinants of corruption. By using a fuzzy logic approach, it can be concluded that corruption in Indonesia is 36.14 percent of real GDP per capita. This value linguistically indicates a large number or above normal. This study has several limitations (1) The complexity of determining the rules and fuzzy membership functions, if there is no clear pattern available, (2) most of the data are perception data, so the possibility of research subjectivity is very large.

Based on the conclusions, the following points can be suggested: (1) For the government: (a) increase the role of supervisory agencies from the planning, implementation, and reporting in the process of fiscal decentralization. (b) create/optimize an "early warning system" to detect fraud in the economy. (c) enhance the rule of law. (2) For further researchers: (a) may consider using the adaptive neuro fuzzy inference system (ANFIS) technique, with more data so that the results obtained are more reliable and dynamic policy simulations. (b) using cross-country or micro-enterprise data to produce more reliable conclusions.

References

Abdullah, S., Gray, T., & Clough, E. (2018). Clientelism: factionalism in the allocation of public resources in Iraq after 2003. *Middle Eastern Studies*.

Adam, A., Delis, M. D., & Kammas, P. (2011). Are democratic governments more efficient? European Journal of Political Economy, 27(1). https://doi.org/10.1016/j.ejpoleco.2010.04.004

Al-Abbneh, H. A. (2016). Relevance of Fuzzy Logic in The Economy. *International Scientific Journal*, 4 (4).

Alatas, S. H. (1999). *Corruption and the Destiny of Asia*. Prentice Hall, Malaysia.

Bahoo, S., Alon, Ilan., & Paltrinier, A. (2019). Corruption in International Business: A Review and Research Agenda. *International Bussines Review.* 7 (8):50-61

Bliss, C. & Di Tella, R., (1997). Does competition kill corruption?. *Journal of Political Economy*, 105: 1001–1023.

Boumans, M (Eds). (2007). *Measurement In Economics: A Handbook*. Emerald Publishing

Buehn, A., & Schneider, F. (2009). Corruption and the Shadow Economy: A Structural Equation Model Approach. *IZA Discussion Paper No. 4182*, Institute of Labor Economy.

Burnett, S., Everett, S., Garcia, J., Kaiser, G. G., & Quine, T. I. Thomas. (2010). Transparency International 2009.

Dell'Anno, R. (2019). Corruption Around the World: An Analysis by Partial Least Squares-Structural Equation Modelling. *Public Choice*, 184: 327 – 350.

Draeseke, R., Giles, D. E. A. (1999). A Fuzzy Logic Approach to Modelling the Underground Economy. Makalah *Econometrics Colloquium* di the University of Victoria, Canada.

Dreher, A, Kotsogiannies, C., & McCorriston, S. (2007). Corruption Around the World: Evidence from a structural model. *Journal of Comparative Economics*, 35: 443-466.

Faisal, F., Barid, B., & Mulyanto, D. (2018). Political Party funding in Indonesia: Finding the Ideal Financing Pattern to Prevent Corruption. *INTEGRITAS: Jurnal Anti Korupsi*, 4(1), 265-287. https://doi.org/10.32697/integritas.v4i1.248

Fisman, R., & Gatti, R. (1999). Decentralization and Corruption:Evidence Across Countries. *Journal of Public Economics*, 8 (3):325-345.

Frisch, R. (1936). Annual Survey of General Economic Theory: The Problem of Index Number. *Econometrica*, 4 (1):1-38.

Gloppen, S. (2014). Court, Corruption and Judicial Independence. Tina Soriede dan Aled Williams (eds). *Corruption, Grabbing and Development: Real World Challenge*. Edward Elgar Publishing.

Gwartney, J., Lawson, R., Hall, J., & Murphy, R. (2018). *Economic Freedom of The World*. Fraser Institute. https://www.fraserinstitute.org

Hossein, S., Abbas, A., & Vahid, S.S. (2011). Measuring Corruption in Iran by Using Fuzzy Logic. *Economic Approach*, 10: 139-174.

Kaufman, D., Kraay, A., & Mastruzzi, M. (2010). The World Governance Indicators: Methodology and Analyctical Issues. *World Bank Policy Research Working Paper* No. 5430.

Klark, A. K. (2017). "Measuring Corruption: Transparency International's "Corruption Perceptions Index"" *In* Corruption, *Accountability and Discretion*. Published online: 12 Oct 2017; 3-22

Klir, G. J., & Yuan, B. (1995). *Fuzzy Set and Fuzzy Logic: Theory and Applications*. Prentice Hall, New Jersey.

Klitgaard, R. (1988). *Controlling Corruption*. Berkeley: University of California Press.

Klitgaard, R., Macean-Abaroa, R., & Parris, H. L. (2000). Corrupt cities: A practical guide to cure and prevention. Washington, D.C.: World Bank.

Klitgaard, R. (2001). *Membasmi Korupsi.* (Hermoyo., Trans). Yayasan Obor Indonesia. (Original work published 1988).

Klitgaard, R., Abaroa, M., Parris, R., & Lindsey, H. (2002). *Penuntun Pemberantasan Korupsi dalam Pemerintahan Daerah*. (Masri Maris, Trans). Yayasan Obor Indonesia. (Original work published 200).

Kuncoro, A. (2002). Corruption And Economic Growth In Indonesia. *Ekonomi Dan Keuangan Indonesia*, Vol. XLX, No. 1.

Lambsdorff, J. G. (1999). Corruption in Empirical Research - A Review. *Transparency International Working Paper*.

Lindstrom P. (1969).On extensions of elementary logic. *Teoria*, 35: 1–11.

Macias, J. B., & Cazzavilan, G. (2010). Modelling the Informal Economy : A Structural Equation Approach. *The Journal of Developing Areas*, 44 (1): 345-365.

Malito, D. V. (2014). *Measuring Corruption Indicators and Indices.* Robert Schuman Centre for Advanced Studies. European University Institute.

Manga. (2019). A Proposed Model for Determining a Level of Corruption Nigeria Using Mamdani Fuzzy Inference Framework. *American Journal of Engineering Research (AJER)*, 8 (12): 58-63.

Masoud, K. (2015). Estimating The Index of Corruption in Iran Using Fuzzy Logic and Investigation of its Relationship with underground Economy Using Hsiao Causality Test. *Journal of Quantitative Economics*, 12 (3):1-25.

Mauro, P. (1995). Corruption and Growth. *Quarterly Journal of Economics*, 110: 681-712.

Moise, G. M. (2020). Corruption in the Oil Sector: A Systematic Review and Critique of the literature. *The Extractive Industries and Society*, 7: 217-236.

Pasuk, Phongpaichit, Piriyarangsan, Sungsidh. (1997). *Corruption and democracy in Thailand.* Thailand: Silkworm Books.

Pernica, B., Tomaskova, H., & Slouf, V., (2018). Fighting Corruption: A Counter-Corruption Fuzzy Model. *Journal of Engineering and Applied Sciences*, 13 (2): 309-313.

Rahman, M. G., & Islam, M. Z. (2016). Missing value imputation using fuzzy clustering based EM approach. *Knowledge and Information system*, 46:389-422.

Rijckeghem, C. van, & Mauro, B. W. di. (1997). Corruption and the Rate of Temptation: Do Low Wages in the Civil Service Cause Corruption? (No. 97/73).

Seldadyo, H., & Haan, J. D. (2006). *The determinant of corruption: a literature survei and new evidence*. EPCS Conference.

Shleifer, A., dan Vishny, R. W. (19939), Corruption, *Quarterly Journal of Economics*. 108 (3).

Singpurwalla, N.D., Booker, J,M., Lindley, D.V., & Laviolette, M. (2004). Membership functions and probability measures of fuzzy sets**.** *Journal of the American Statistical Association, 99 (*467): 867 – 889.

Suprayitno, B., & Pradiptyo, R. (2017). Fiscal decentralization and corruption: the facts in regional autonomy in Indonesia. *Journal of Advanced Research in Law and Economy*, 5(27):1468-1484.

Tahmasebi, M. (2015). The estimate of underground economy: the contributions of the fuzzy modeling. *Dissertation in Economics and Finance*, University Grenoble Alpes.

Tahmasebi, M., & Rocca, M., (2015). A Fuzzy model to estimate the size of the underground economy applying structural equation modeling. *Journal of Applied Economics*. 18(2): 347-368.

Tanzi, V., (1998). Corruption around the world: causes, consequences, scope and rures. *IMF Staff Papers*, 45 (4).

Yu, T. H. K., Min. D. H., & Chen, W.S.J. (2006). A Fuzzy Logic Approach to Modeling the Underground Economy in Taiwan. *Physica A*, 362 (2): 471-479.

Zadeh, L.A. (1987). *Fuzzy Sets and Applications: Selected Papers*. Wiley, New York. 1987.

Zadeh, L.A. (1965). Fuzzy sets. *Information and Control*. 8 (3): 338-353.