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A Frame of Thinking to Evaluate Anti-Corruption Programs

Neuro-Fuzzy Model

Rio Sahala Siagian
(rio_siagian@yahoo.com)
Bandung Fe Institute

Abstract

Because corruption is very damaging for a country, then numbers of countries reform themselves by developing strategies and apply them to combat corruption. This programs eventually used linguistic parameters, which usually embedded fuzziness (vagueness, unclearly, uncertainty, imprecisely). Since that, it is important to build an approach based on fuzziness. Fuzzy Logic as alternative way of thinking, which allows modeling systems using a higher level of abstracting originating from our knowledge and experience, provable can used to explain the thing that embedded fuzziness. This paper aims to introduce neuro-fuzzy model as a frame of thinking to evaluate anti corruption program. The neuro-fuzzy approach is based on the integration of neural networks and fuzzy inference systems. This fuzzy model can be used as a means of capturing human's expert knowledge about the process, in terms of fuzzy (*if-then* rules like. The neuro-fuzzy technique provides an ability to handle imprecision and uncertainty from data, and can be applied in the system simulation which not required high precision and parameters can be easily estimated for measurement. Applied in evaluate anti corruption program the neuro-fuzzy models creates fuzzy rules, which are easy to comprehend because of its linguistic terms and the structure of *if-then* rules.

Key words: anti-corruption program, fuzzy logic, neuro-fuzzy

1. Introduction

To day, corruption is a worldwide problem and not unique in countries of developing world. Corruption is not a new, nor is it confined to any particular part of the world. On the contrary, corruption is a global phenomenon, although its severity varies from country to country.

Corruption, which we can be defined as "the misuse of public office for private gain"[1], has various forms. From the bribing of public officials, to the abuse of tenders, in faulty privatization, in the rewarding of public contracts, in formation of monopolies on basic goods, in discriminatory application of laws and taxes against competitors, in illegal funding of political parties and electoral competition and in the outright theft of state property and revenues.

In most developing countries, corruption has become a quest that urgently needs to be solved in order to maintain their nation livelihood. Corruption often presents as a problem that causing a country's economical hope descending since it fails to allocate its resources and decreasing its social and political capability to become developed. In further, corruption behavior in

[1] Definition of corruption used by The World Bank.

developing countries has turned to become an endemic and systematic thing (see Kaufmann, D, 1997).

The consequence of corruption, which we commonly find in a country, is how foul public services are (see e.g. Tomaszewska and Shah, 2000 for empirical evidence), the rise of poverty, the downing of foreign investment causing the decline of economic growth. Corruption may be regard as weakness symptom in political, economic, social and law system of those countries.
If we look at the reality, we may find that corruption is very damaging for a country and then numbers of countries reform themselves by developing strategies and apply them to combat corruption. In most countries, the demand for reform and combating corruption is being led by organization of civil society (like NGO's in Indonesia) and the international donor community (i.e. The World Bank, IMF, OECD).

In common, anti-corruption strategies are executed in various way i.e.:
(a) economic development;
(b) democratic reform, such make reform in parliament and judicial system;
(c) a strong civil society with access to information and a mandate to oversee the state with make empowerment in civil society, particularly by strengthening non-governmental organization (NGO's) and the media in hope they can participate to watching and preventing the corrupt behavior, and
(d) the presence of rule of law and perform law enforcement. In figure 1 we can see a model of anti-corruption strategy as an example.

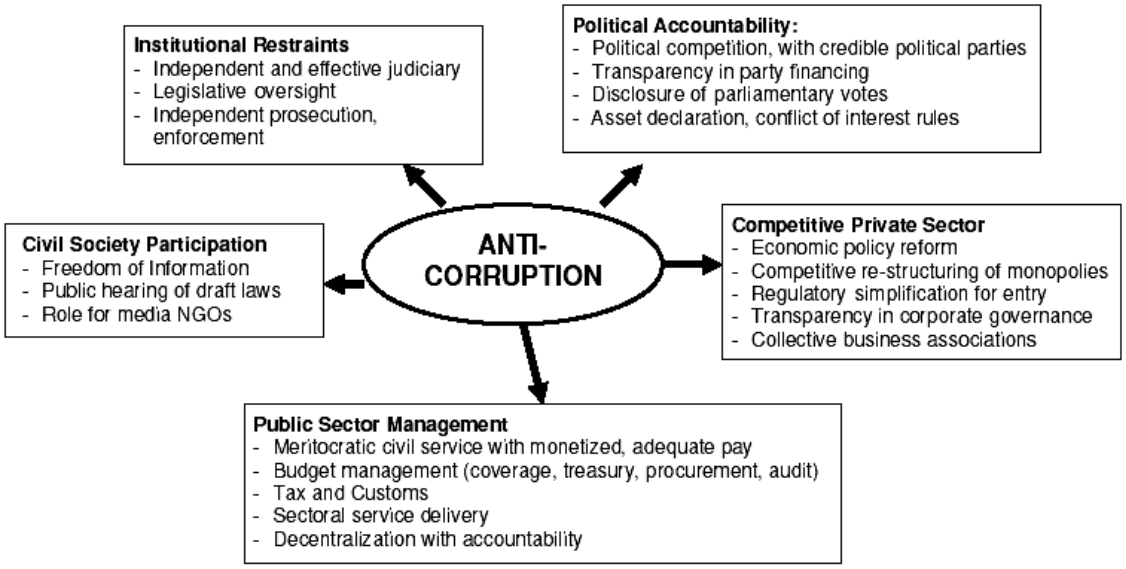

Figure1
Multi-Pronged Strategy: Addressing State Capture and Administrative Corruption
Source: "Anti-Corruption in Transition

Since corruption existed as a multi-involving factors problem, thus many hands set anti-corruption strategy. In advanced, this anti-corruption strategy is implemented by grounding related programs. This paper aims to give an offer of utilization of fuzzy logic as a frame of thinking to evaluate the implementation of anti-corruption program itself. The model offered here is neuro fuzzy model.

2. A Frame of Thinking use neuro-fuzzy model

2.1. Brief Introduction to Fuzzy Logic

In process evaluates, which means give a judgment to the process, actually we must make interpretation to the process. Interpretation usually used natural language. Language as our tools to construct meaning repeatedly can not give single meaning and embedded fuzziness. By this reason, it is important to used non-standard logic, which can be effective in the face of fuzziness.

Fuzzy logic as one of non-standard logic, provable can used in the effort to explain the thing that embedded fuzziness and also had yet been applied in engineering field as powerful methodology in control system.

The primary goal of fuzzy logic is to develop an alternative to mathematical modeling for systems which either lack a proper mathematical model because it is either too ill-defined, or the model is so complicated that it is of no practical use. The importance of fuzzy logic derives from the fact that most modes of human reasoning are approximate in nature. Fuzzy Logic is a calculus of compatibility. Unlike probability which is based on frequency distribution in a random population, fuzzy logic deals with describing the characteristics of properties. Fuzzy logic describes properties that have continuously varying values by associating partitions of these values with a semantic label. Much of the descriptive power of fuzzy logic comes from the fact that these semantic partitions can overlap. This overlap corresponds to the transition from one state to the next. These transitions arise from the naturally occurring ambiguity associated with the intermediate states of the semantic labels.

Practically, the basic principles of fuzzy logic are:

1. In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
2. In fuzzy logic everything is a matter of degree.
3. Any logical system can be fuzzified
4. In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently, fuzzy constraint on a collection of variables.
5. Inference is viewed as a process of propagation of elastic constraints

Basically, fuzzy logic used fuzzy sets, as introduced by Lofti Zadeh, a professor at the University of California at Barkley, in 1965. Fuzzy sets can be seen as an *infinite-valued logic*; set, the belongingness to which is measured by membership function whose value are in interval between 1 (full-belongingness) and 0 (*non-belongingness*). In formal, the definition can describe like this:

1. Let X be some set of objects, with elements noted as x. Thus,
   $X = \{x\}$.
2. A fuzzy set A in X is characterized by a membership function
   mA(x) which maps each point in X onto the real interval [0.0, 1.0]. As mA(x) approaches 1.0, the "grade of membership" of x in A increases

The fuzzy systems are capable to integrate information from different sources, such as physical laws, empirical models, or measurements. Fuzzy models can be seen as logical models which use "if-then" rules stated in human language to establish qualitative relationships among the variables. Fuzzy logic is the approach the human logic works, and we can mimic this in the models, so they will perform somewhat like we predict.

In order to automatically generate the fuzzy models from measurements, a comprehensive methodology is developed. It employs the fuzzy clustering techniques to partitioning the available data into subsets, characterized by a linear behavior. The fuzzy logic analysis is including, briefly : (1) receiving data or assessments in order to classification, (2) processing all these inputs according to human criteria fuzzy "*If-Then*" rules, (3) averaging and weighting the resulting outputs from all the individual rules into one single output decision. The output eventually is a precise defuzzified and "crisp" value.

2.2. Neuro-Fuzzy Model

Neuro-fuzzy modeling is based on combination of neural network and fuzzy model. It is a way to create a fuzzy model “from data by someone kind of learning that is motivated by learning procedures used in neural network” (Bezdek et al, 1999). The fuzzy models can be used as a means of capturing human’s expert knowledge about the process, in terms of fuzzy (if-then) rules like: *if* the temperature is cold, *then* the motor speed slow

The fuzzy inference system can initialize and learn linguistic and semi-linguistic (Sugeno) rules (Takagi, T. and Sugeno, M., 1985), therefore it can be considered as direct transfer knowledge, which is the main advantage of fuzzy inference systems over classical learning

systems and neural-networks. This suggests that the fuzzy process models can be initialized by expert knowledge and can be adapted by the use of process data. Often the rules of the fuzzy system are designed a priori and the parameters of the membership functions are adapted in the learning process from input-output data sets.

In this paper, we will use neuro-fuzzy model that implement a Takagi-Sugeno fuzzy inference system. In Takagi- Sugeno fuzzy inference system the conclusion of a fuzzy rule is constituted by a weighted linear combination of the crisp inputs rather than a fuzzy set. The fuzzy model can be formulated with a set of rules as follows:

Rule 1: if x is A_1 and y is B_1 and z is C_1, then $f_1 = a_1x + b_1y + c_1z + r_1$
Rule 2: if x is A_2 and y is B_2 and z is C_2, then $f_2 = a_2x + b_2y + c_2z + r_2$

where,
x, y and z are linguistic variables and A_1, A_2, B_1, B_2 are corresponding fuzzy sets and a_1, b_1, c_1, r_1 and a_2, b_2, c_2, r_2 are linear parameters.

In figure 2 we can see the structure of fuzzy network. In this structure we find 5 layers, which connecting one each other. The first layer receives the input information. Usually, this input used linguistic variables. Then, in layer 2, the input information in layer 1, we transformed to fuzzy membership degree, to which the input values belong to predefined fuzzy membership functions. Every node in this layer has a node function; usually the node function can be any parameterized function. We used a Gaussian membership function which specified by two parameters c (membership function center) and σ (membership function width).

Gaussian $(x, c, \sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2}$

We can call this as fuzzification process.

The third layer is the rule's layer, the layer which represented the association between input variable and output variable. Every node in this layer multiplies the incoming signal and send the product out. Each node output represents the firing strength of a rule.

$$w_i = \mu_{A_i}(x) \times \mu_{B_i}(y) \times \mu_{C_i}(z),\ i = 1,2,3,\ldots$$

Then, after the association between rules, we can look the output in layer four. Every node *i* in this layer is with a node function:

$$\overline{w_i} f_i = \overline{w_i}(a_i x + b_i y + c_i z),$$

where $\overline{w_i}$ is the output of layer 3, and $\{a_i, b_i, c_i\}$ is the parameter set.

The output is still in fuzzy membership function. To take the output into real condition, we must do the defuzzification process, and we do this in layer five. Neuro fuzzy models have several advantages when compared with traditional connectionist systems, or with fuzzy inference systems: (Kasabov, Nikola.K, 2000):

1. They are both statistical and knowledge engineering tools.
2. They are relatively resistant to catastrophic forgetting, i.e., when they are further trained on new data, they do not forget much about the previously used data
3. They interpolate and extrapolate well regions where data is sparse
4. They accept both real input data and fuzzy input data.

Neuro fuzzy models was using to support of knowledge management in social regulation (e.g. see Petrovic-Lazarevicc, S., Coghill, K., Abraham, A., 2002). This model can improved as evolutionary model in effort to get global optimization for the decision making process so we can get the most fitness regulation in specific space and time.

In the next part, we will give an example using neuro-fuzzy model as a frame of thinking to evaluate anti corruption program.

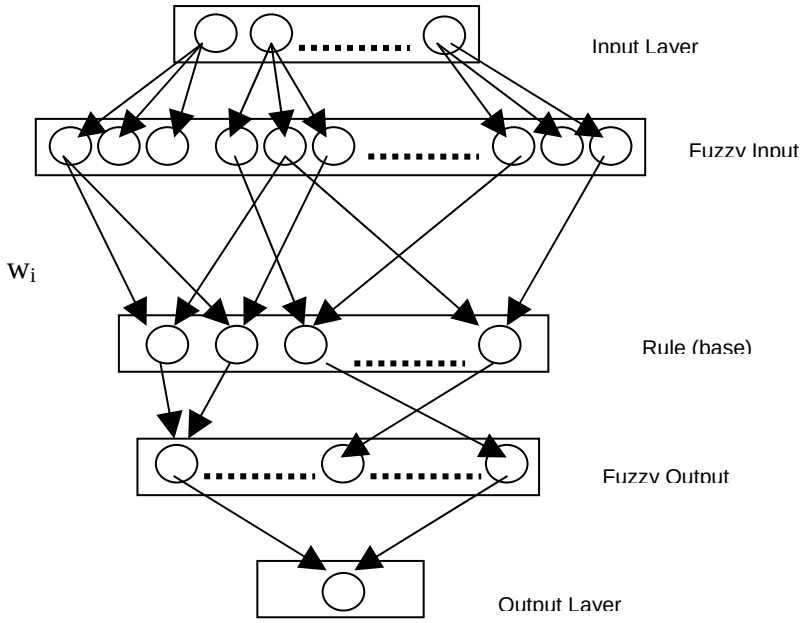

Figure 2. Structure of the fuzzy network

3. Simulation Example

In this simulation, we will find out the effect of implementation anti-corruption program to societies where corruption viewed as endemic problem. This effect will be evaluated to see whether the program gives effect on preventing corruption to occur. We will pick some instance programs in anti-corruption strategy. Those programs in further become input in neuro fuzzy model. Some of those programs are:

1. ***Rule of Law***
   Rule of Law is essential for any progress in anti corruption strategy. Rule of law is important and reduces corruption as confirmed by Goel and Nelson (1998), Ades and Di Tella (1996). To make membership function in fuzzy set in this simulation, rule of law we look as the existence of legal defined for corruption and we divided into 2 categories, *clear legal defined* and *no clear legal defined*. This input in further named LD.
2. ***Judicial independence***
   In this simulation, judicial independence refers to the capability of judicial institution (court and police) to make prosecution and punishment to corruptor. These input will divided into 2 categories fuzzy variables, *exist* and *no exist*. Input in further named Jl.
3. ***Media Participation***
   Brunetti and Weder said that freedom of press is positively correlated with the level of corruption (Brunetti and Wedder, 1998), in this paper, we will see media participation is a tool to publicity the legal rule of anti corruption and to make pressure to the government to take serious action in combating corruption. The media participation will divided into 2 categories, *high* and *low*. In further, this input called MP.

Now, we have 3 inputs information with 2 membership functions per input variable. Every quality in membership function is constructed by using the standard symmetric Gaussian curve built by the function:

$$f\left(x\middle|\sigma,c\right)=e^{\frac{-(x-c)^2}{2\sigma^2}}$$

We choose the standard Gaussian function to construct the input and output membership function as a dummy analytical method. Then, we will take the effect of the anti-corruption program

in prevention corruption as the output. The effect will divided into 3 quality categories, good effect, no effect and bad effect and. We, in further will name the output ACP.
Figure 3, 4, and 5 illustrates the curve of membership functions of the input.

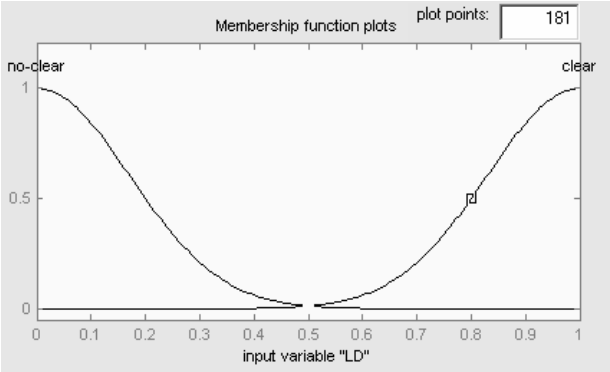

Figure 3
MFs input variable LD

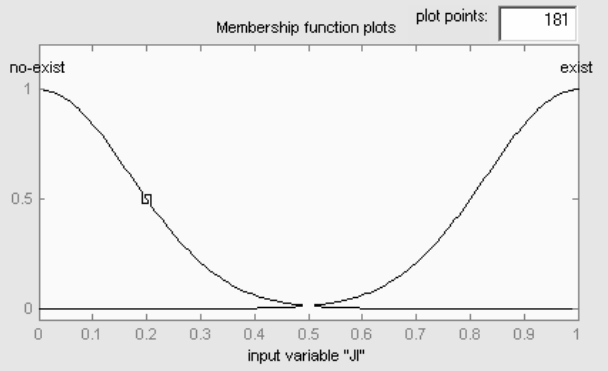

Figure 4
MFs input variable JI

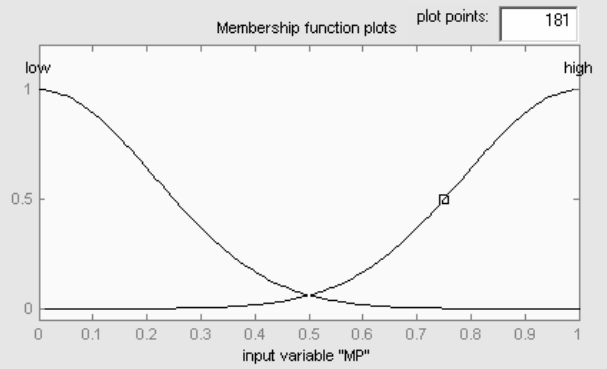

Figure 5
MFs input variables MP

In this simulation, we developed Takagi-Sugeno's fuzzy inference system. As an example, we will make 14 rules to build the simulation, as we can see in table 1. The weigh of the connection =1

RULE		LD	JI	MP		ACP
1		No Clear	-	Low		No Effect
2		No Clear	No Exist	-		No Effect
3		Clear	Exist	-		Good Effect
4		Clear	-	Low		No Effect
5		Clear	-	High		Good Effect
6	**I**	-	Exist	High	**T**	Good Effect
7	**F**	No Clear	No Exist	Low	**H**	No Effect
8		No Clear	No Exist	High	**E**	Bad Effect
9		No Clear	Exist	Low	**N**	No Effect
10		No Clear	Exist	High		Bad Effect
11		Clear	No Exist	Low		No Effect
12		Clear	Exist	Low		No Effect
13		Clear	No Exist	High		Bad Effect
14		Clear	Exist	High		Good Effect

Table 1
The fuzzy rules

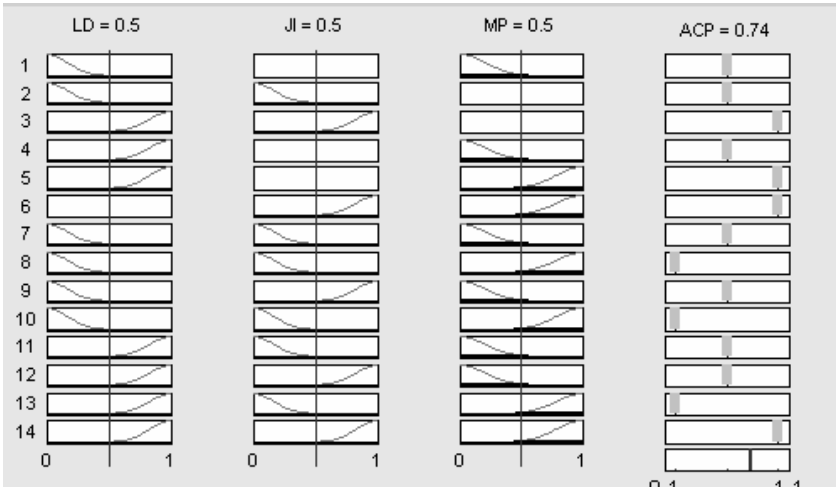

Figure 6
Develop Takagi-Sugeno FIS

Henceforth, the analytical picture of the interplay between the variables regarding the effect of anti corruption program can be seen in figure 7.

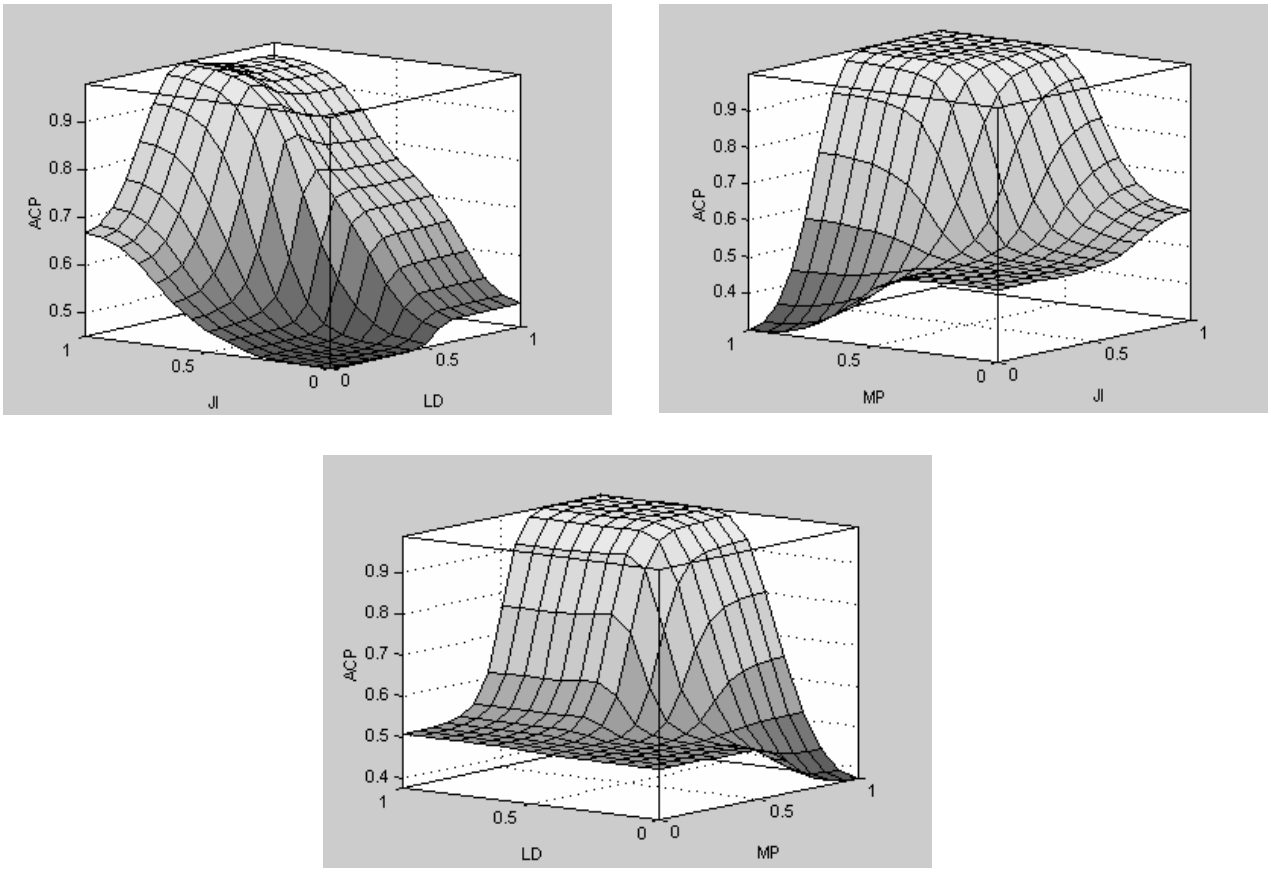

Figure 7
The interplay between the variables regarding the effect of anti corruption program.

From figure 7, we can see there is “wavy” interplay between the variables, either between Legal Defined (LD) and Judicial Independence (JI), Judicial Independence (JI) and Media Participation (MP) or between Media Participation (MP) and Legal Defined (LD). This can be understood as there are different importances of each of the condition elements for the rule output. From this understanding, we can say that every program and the combination in anti corruption

strategy have their own strength which different with others and then we can make evaluation and make decision which program can we use in specific condition.

4. Conclusion

Fuzzy models use knowledge from human experts to present a system based on input-output measurements. That is, linguistic information that provides qualitative instructions and descriptions about the system can be usefully applied when the input-output measurements are not easy to obtain. In this paper, the utilization of the neuro-fuzzy model was presented. Neuro-fuzzy system makes use of linguistic knowledge of fuzzy interference system and the learning capability of neural network. Thus we are able to precisely model the uncertainty and imprecision within the data as well as to incorporate the learning ability of neural network. This technique is simple and efficient to do, in face of decision-making or evaluate problem, which based on *if-then* rules framing.

From the example, simulation, to evaluate or design anti corruption program, as something based on *if-then* rules, can be expressed with this neuro-fuzzy model. Applied in evaluate process the neuro-fuzzy creates fuzzy rules, which are easy to comprehend because of its linguistic terms and structure of *if-then* rules. However, it will be more interesting if we have some real data about the implementation of anti corruption program so we can measure the effectiveness of the program.

5. Further Work

In our future work we would like to develop this neuro-fuzzy model become an evolutionary model. This evolutionary model can be potential tools to optimize the learning system which have open structure, i.e., it grows and shrink according to data distribution and to the problem under consideration.

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