A Measurement Model based on Fuzzy Weighted Index to Examine the Socioeconomic Inequality (Case Study: Urban Village Sawah, Ciputat, Indonesia)

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Abstract

The Williamson index (WI) is generally utilized to measure the regional socioeconomic inequality. The parameter of fiscal capacity per capita is theoretical foundation of measurement. By using the desk based research, the extended version of WI measurement model was constructed. Based on WI that is as a basic method to measure the regional's economical gap, parameters education and health were embedded inside. Another method fuzzy-logic was used as well to hypothetically prioritize the parameters involved. Thus, the proposed measurement model will be able to methodically quantify either both or combination of both education and health inequalities of regional (urban village).Paper represents the construction of proposed model (based on fuzzy index)that is possible able to examine the region inequality. The empirical data coming from case study in urban village Sawah, Ciputat (Indonesia) were used to realize the measurement.

Keywords: Williamson index, socioeconomic inequality, fuzzy-logic, health, education

Introduction

In fact, a socioeconomic inequality in one community or country (region) is an ordinary condition. It cannot be avoided or even reduced simply. Numerous efforts have been done already to degrade the gap; however on the contrary, the gap grows day by day significantly. In addition, the economic sector can influence the other sectors. Sectors education and health are two of some sectors as example. Income strongly relates to education and health level. This condition inspires several researchers to use income parameter in calculating the socioeconomic inequality.

Mosquera et al. (2016) conducted study to analyze the relationship between income inequalities with disease (cardiovascular, CVD) increase. They concluded that there is an increase in income inequality in CVD during the period middle to old age. This condition was affected by income inequality. Specifically in education gap, Tomul (2009), by using Gini index, studied to measure an index of education inequality in Turkey. The study tried to determine the relationship between a gap of education and the average years of schooling in Turkey.

The study found a positive relationship between increase of average years of schooling and decrease of Gini index of education. Also Gegel et al. (2015) who the study focused on social inequality of education aspect only, exclusively in modern higher education.

Furthermore, Wroblowsky and Yin (2016) analyzed the income inequality, exclusively in China, that was compared with two other countries (USA and Germany) by using Gini coefficient. They used two ordinary dimensions among the regions and between the urban and rural areas to observe 32 provinces' per capita gross as a basic parameter of gap index measurement. In fact, the Chinese inequality is strongly related to the economic growth. Both points showed the similar pattern of growth graph. And when it was compared with two other countries, China has the highest economical gap. So this condition was investigated as a factual problem in China. In addition, Bambra et al. (2015) assessed the relationship between Brownfield land and spatial inequalities in health. This assessment was conducted specifically for mortality and morbidity for national level (case study in England). The study concluded that the brown field has relationship with regional inequalities in mortality and morbidity within regions, especially in the North West; with inequalities between regions, especially in North West – South West; however in whole England, it only makes a small independent contribution to the North-South health divide.

This paper recommends an extended model to examine the education and health inequalities based on fuzzy-index. It is an expanded version of Williamson index measurement essentially. Here, the introduction part is followed by succeeding sections; research methodology, result and discussion, and conclusion. And for experimental implementation, the urban village Sawah (Ciputat, Indonesia) is chosen as a research object that the empirical data are coming from.

Research Methodology

Indeed, the research was conducted in three main steps which generated outputs, i.e. WI method understanding, proposed model, and model implementation respectively. To produce the understanding of WI method, three methods were operated here; desk based research, WI method, and literature study. Furthermore, to create the proposed measurement model, methods fuzzy-logic and WI were benefitted mainly. A fuzzy-logic itself is the way to transform the bias value (human language) to precise value (Zadeh, 1996). It was used to convert the expert judgment of parameters to precise value in obtaining their priority.

The basic idea of WI method (Williamson, 1965) is that the inequalities calculation is based on income computation (see equation (1), where y_i represents regional (i) income on average, $\bar{y}$ characterizes regional income on average, P_i symbolizes the total population (i), n is a number of region, and P is total population). In this research, we took other parameters into account that their priorities have been judged by experts (through fuzzy-logic scheme) and then embedded to the current method (WI method) as strong considered indexes.
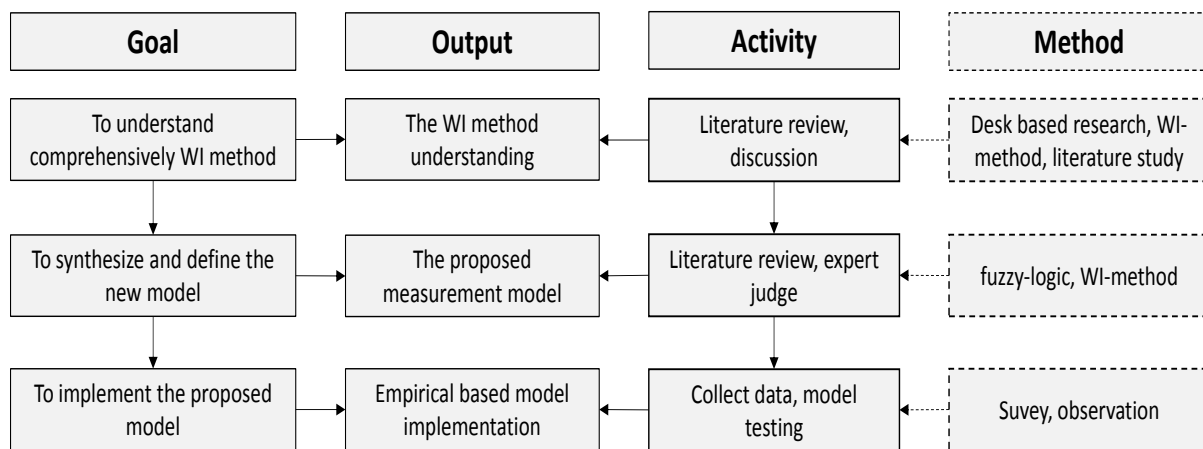
Goal	Output	Activity	Method
To understand comprehensively WI method	The WI method understanding	Literature review, discussion	Desk based research, WI-method, literature study
To synthesize and define the new model	The proposed measurement model	Literature review, expert judge	fuzzy-logic, WI-method
To implement the proposed model	Empirical based model implementation	Collect data, model testing	Suvey, observation

Figure 1: Research Structure

The sample size of survey was based on Slovin estimate method (Guilford and Frucher, 1973) with 0.5 used as margin on error. According to 6,552family cards (where one card describes a group consisting family members) in urban village Sawah, the sample of survey was 385family cards that are clustered into 12 hamlets (Rukun Warga / RW in Indonesian) and 54 neighborhoods (Rukun Tetangga / RT in Indonesian).

Empirically, the income comparison and contrast between income and health or education consumption (on average) are illustrated in Figure 3 and 4 respectively.

$$WI = \frac{1}{\bar{y}} \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2 \frac{P_i}{P}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$
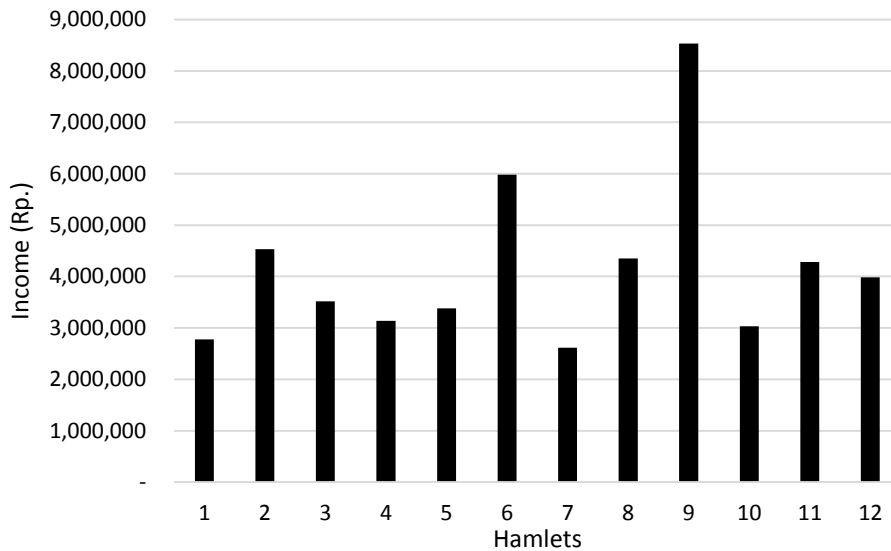

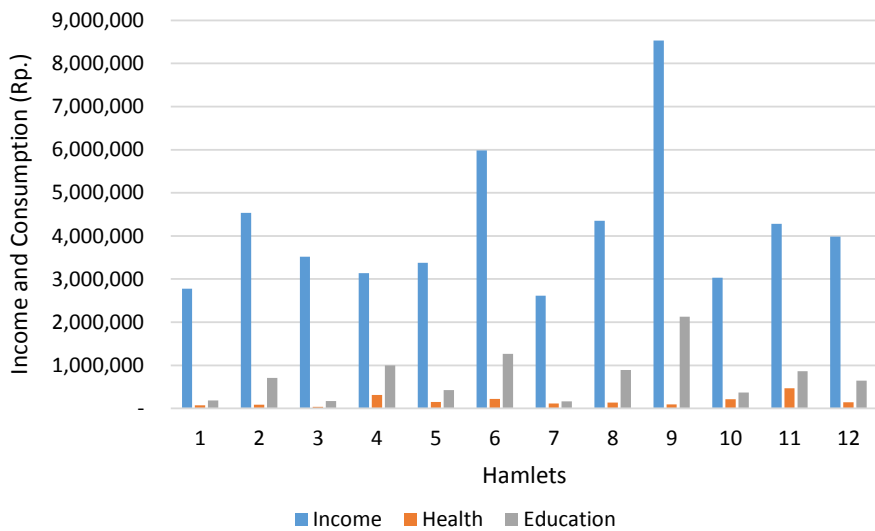**Figure 2: Income comparison among hamlets in urban village Sawah**

Figure 3: the contrast between income and health or education consumption in urban village Sawah

Result and Discussion

Constructed Model

In this paper, we do not only propose the new method to measure a socioeconomic inequalities index, however we constructed an innovative model as a whole measuring mechanism as well, where the method of inequality measurement is only a part of the constructed model. In the proposed method, two additional parameters (i.e. health and education) are taken into account. Empirically, they were derived from the consumption of health and education purposes that are practically occupied from basic income. To define the coefficient value of the parameters, the concept of fuzzy logic is used here. Based on multi expert judgment and transformed to crisp output value then, parameters health and education are weighted, with the weighted values 0.47 and 0.53 respectively. In conceptual view, the constructed model is represented in Figure 4.
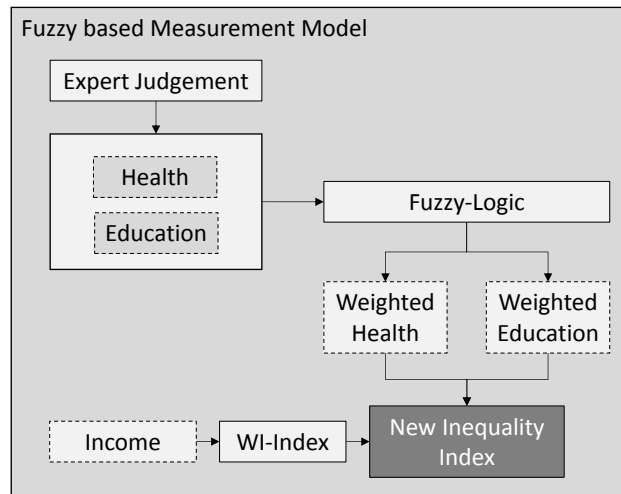
Figure 4: The Conceptual View of Proposed Model

Three experts have already adjudged the urgency of proposed parameters in examining the inequality index. For two parameters health and education, the experts assessed 90 and 80, 80 and 100, and 70 and 90 respectively. The triangular membership function of judgment used is signified in Figure 5 (with five linguistic variables: low, more/less low, medium, more/less high, and high); where, based on the concept fuzzy-logic, the fuzzy values that can technically be generated for each parameter coming from each expert assessment is given in Table 1.
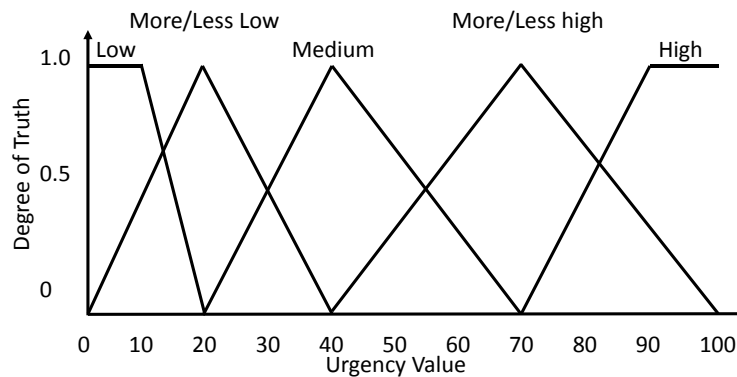

Figure 5: Triangular Membership Function of Fuzzy Logic

According to Table 1, the values of crisp output (on average) for each parameter (health and education)are77.98 and 87.98individually. On percentage, the weighted values are 0.47 for parameter health and 0.53 for parameter education. It means, in inequality measurement, the parameter education is expertly appraised more important than parameter health. Where, these values are used as a coefficient of mathematical formulation (see equation (6)).

Table 1: Fuzzy Values of Parameter Urgency Assessment for Inequality

No.	Expert	Health Parameter	Education Parameter
1.	Expert 1	0.33 more/less high 1.0 high	0.5 high 0.67 more/less high
2.	Expert 2	0.5 high 0.67 more/less high	1.0 high
3.	Expert 3	1.0 more/less high	0.33 more/less high 1.0 high

The mathematical model for calculating the regional index of inequality based on parameters health and education was theoretically formulated. The constructed measurement model consists of three types of inequality index measurement for health, education, and health-education integration. The inequality index for parameter health (XI_h) depends on total consumption for health purpose and also region population (based on basic model).

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It is formulated by equation (4); where $\bar{y}_h$ represents an average of health consumption, y_{hi} is an average of health consumption of ith region. Similarly, for calculating the inequality index for parameter education (XI_e) can be done by using equation (5); where an average of education consumption and an average of education consumption of ith region are symbolized by $\bar{y}_e$ and y_{ei} respectively. Finally, based on process of fuzzy-logic concept, the integrated index (health-education combination) of inequality is formulated in equation (6); where a and b are 0.47 and 0.53 respectively. Or in general mathematical equation, it can be stated in equation (7), where m is a number of parameter and c represents a fuzzy coefficient.

$$XI_h = \frac{1}{\bar{y}_h}\sqrt{\sum_{i=1}^{n}(y_{hi} - \bar{y}_h)^2 \frac{P_i}{P}} \quad \text{...(4)}$$

$$XI_e = \frac{1}{\bar{y}_e}\sqrt{\sum_{i=1}^{n}(y_{ei} - \bar{y}_e)^2 \frac{P_i}{P}} \quad \text{...(5)}$$

$$FXI_{he} = aXI_h + bXI_e \quad \text{...(6)}$$

$$FXI = \sum_{i=1}^{m} c_i XI_i \quad \text{...(7)}$$

Basically, the mathematical model can be used to measure the inequality index for detailed region, even until individual level (equation (5)). This way will be fruitful, as it can be used to conduct the individual based treatment in solving the inequality problem in one region.

Empirical Implementation of Measurement

The result of inequality measurement is clearly depicted in Figure 6. Based on the consumption for health purpose with value 309,726 Indonesian Rupiah / month and 90,000 Indonesian Rupiah / month (on average) for hamlets number 4 (RW4) and number 9 (RW9) respectively, they have the highest value of health inequality index (0.87). On the other hand, RW10 has the lowest value; it is 0.25 value of inequality in parameter health. Moreover, in the consumption for education purpose, with value 173,941 Indonesian Rupiah / month, hamlet number 3 (RW3) has the highest value of education inequality index (0.89).Instead; RW1 has the smallest value in education inequality index (0.23). According to the empirical data, the values of inequality for both parameters health and education (for urban village Sawah, Ciputat, Indonesia) can academically be measured, they are 0.68 and 0.62 respectively, or the integrated value of inequality index (measured by using equation (6)) is 0.65.
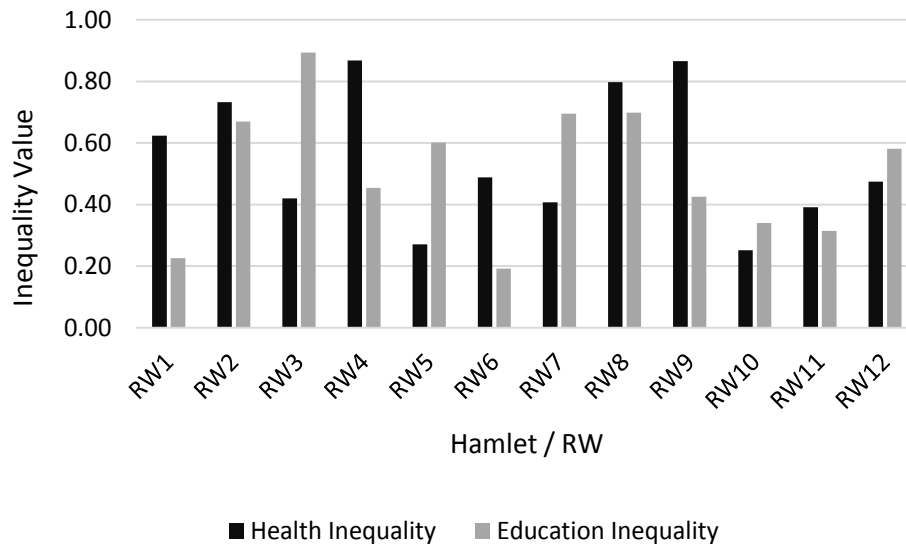

Figure 6: the Composition of both Health and Education Inequalities for each Neighborhood in urban village Sawah, Ciputat, Indonesia

Discussion

The model is proposed to examine the regional inequality in urban village Sawah. The fuzzy-logic concept was used to parameterize the parameters occupied; the result is that the parameters were identified by determining the fuzzy coefficient value for each parameter.

In this research, two parameters health and education embedded in to model, where the model itself constructed based on the concept of Williamson index measurement (Williamson, 1965). Furthermore, the measurement is based on income value. This is similar to several measurements that technically have been done (Mosquera et al. 2016; Tomul, 2009; Gegel et al. 2015; etc.).Interestingly here, we tried to operate fuzzy-logic concept to define the coefficient value of parameters involved. The coefficients operated to develop the equation in calculating the integrated value of inequality index. Moreover, in this study, we used two parameters, health and education, to be inserted in the measurement. These parameters are academically stated as the most important characteristics of the human capital (Groot and Brink, 2006). Indeed, we can consider other parameters as a sector to see the socioeconomic inequality in detail practically. Additionally, the inequality index has weakness concerning income or consumption (economic) growth (Wroblowsky and Yin, 2016), so is the proposed model. The growth can theoretically influence the gap, if the growth is not followed by the region's population increase. This condition hypothetically proven, because the values of income or consumption and population are similarly proportionate to the gap.

Acknowledgment

Conclusion

The novel model for measuring an inequality index for multi parameters (intensely for health and education) has been theoretically proposed. The parameters involved are weighted through the concept of fuzzy-logic, and then the weighted values are operated to become a coefficient value.

Practically, the model was benefitted to measure the region inequality index of health and education sectors in urban village Sawah, Tangerang Selatan, province Banten, Indonesia. The result concluded that the village has 0.68 and 0.62 inequality index for sectors health and education respectively, and 0.65 for integrated index value.

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