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# A Comparison of GTWR and Robust GTWR Modelling

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**ABSTRACT**

The family planning program is one of the programs carried out by the government in order to reduce the rate of population growth, improve the quality of maternal and child health, which in turn is expected to produce quality human beings. One indicator to measure the success of a family planning program is through the number of active KB participants. This study uses GTWR and RGTWR to model the number of family planning participants in East Java in 2009-2016. From the research conducted, it is shown that RGTWR produces better modeling because it produces parameter estimators that are more in line with the actual data and data plot and have a smaller MAD value.

**Keywords :** Family Planning Program, GTWR, MAD, Robust GTWR

## I. INTRODUCTION

Population growth in Indonesia is increasing over the years. According to the Central Bureau Statistics of Indonesia [1], population growth in Indonesia is faster than Indonesia's economic growth. If this phenomenon is left continuously and not immediately overcome, it will adversely affect national development, because the government will be overwhelmed in providing economic facilities, health facilities, educational facilities, tourist attractions and other facilities. One of the steps in order to overcome the rate of population growth is by holding a family planning program.

The family planning program is one of the programs carried out by the government in order to reduce the rate of population growth, improve the quality of maternal and child health, which in turn is expected to produce quality human beings. One indicator to measure the success of a family planning program is through the active family planning participants. The number of family planning participants presented according to the regions allows each district and city to know the distribution of the family planning participants so that each region could create appropriate program for the realization of quality human beings which in turn can reduce poverty in Indonesia.

In this study, the number of active family planning participants in 38 districts and cities in East Java in 2009-2016 was modelled using GTWR and RGTWR with M-estimators. The GTWR modelling is the development of GWR with the addition of time element in it. The GTWR modelling is considered to produce more representative modelling, because it not only produces modelling based on location but also produces time-based modelling.

Research on GTWR has been widely applied in various fields, from the environment to the economy. In the environmental field, Winarso and Yasin [2] modelled air pollution containing compounds S02 using mixed RTG, GTWR and GTWR. In the economic field, Fotheringham *et al.* [3] and Huang *et al.* [4] developed GTWR using house price data variables. In addition, Sholihin [5] researched economic growth by using spatial and temporal distance interactions in GTWR. In other hand, the development of Robust GTWR has been done by Erda *et al.* [6] in handling outliers of the GTWR modelling. Thus, researcher are interested to compare between GTWR and Robust GTWR with M-estimators modelling.

## II. METHODS AND MATERIAL

### A. Data

The data used in the study were secondary data from the publication of Central Bureau Statistics of Indonesia [1] and Health Office [7] from 2009 to 2016. There were 38 districts and cities as observation locations in which the number of active participants in the family planning as dependent variables (Y) and the number of fertile couples ($X_1$), per capita expenditure ($X_2$), average school length ($X_3$), and number of health facilities ($X_4$) as independent variables.

### B. Modelling

Geographically and temporally weighted regression is an extension of the GWR model in order to account for variations of data from both the spatial and temporal sides simultaneously [8]. The GTWR model for $p$ explanatory variables with $y_i$ as response variable from $(u_i, v_i, t_i)$ location or each observation can be written as follows:

$$y_i = \beta_0(u_i, v_i, t_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i, t_i) x_{ik} + \varepsilon_i$$

Where:

$i = 1,2, \dots n, k = 1,2, \dots, p,$

$(u_i, v_i, t_i)$ is the coordinate point and time for location *i*,

$\beta_0(u_i, v_i, t_i)$ is intercept coefficient,

$\beta_k(u_i, v_i, t_i)$ is estimator coefficient for each variable *k.*

The coefficients $\hat{\beta}_k(u_i, v_i, t_i)$ can be expressed as follows:

$$\widehat{\boldsymbol{\beta}}(u_i, v_i, t_i) = [\boldsymbol{X}'\boldsymbol{W}(u_i, v_i, t_i)\boldsymbol{X}]^{-1}\boldsymbol{X}'\boldsymbol{W}(u_i, v_i, t_i)\boldsymbol{y}$$

Where:

$\boldsymbol{W}(u_i, v_i, t_i) = diag(w_{i1}, w_{i2}, \dots, w_{in}),$

$\boldsymbol{W}(u_i, v_i, t_i)$ is matrix weighting for observation $(u_i, v_i)$ and time $t_i$.

### C. Analysis Methodology

The analysis steps are as follows:

1. Exploring the number family planning participants
2. Analyzing mode using GTWR using exponential kernel function [3]

$$w_{ij}^{ST} = w_{ij}^{S} \times w_{ij}^{T}$$

with:

$$w_{ij}^{S} = exp\left\{-\frac{\left(d_{ij}^{S}\right)^2}{h_S^2}\right\} \text{ and } w_{ij}^{T} = exp\left\{-\frac{\left(d_{ij}^{T}\right)^2}{h_T^2}\right\}$$

$$\left(d_{ij}^{S}\right)^2 = \left(u_i - u_j\right)^2 + \left(v_i - v_j\right)^2$$

$$\left(d_{ij}^{T}\right)^2 = (t_i - t_j)^2$$

$$\left(d_{ij}^{ST}\right)^2 = \varphi^S\left[\left(u_i - u_j\right)^2 + \left(v_i - v_j\right)^2\right] + \varphi^T\left[(t_i - t_j)^2\right]$$

$$h_S^2 = \frac{h_{ST}^2}{\varphi^S}, h_T^2 = \frac{h_{ST}^2}{\varphi^T} \text{ and } \tau = \frac{\varphi^T}{\varphi^S}$$

4. Analyzing RGTWR with M-estimator for each location and time by:
   i. Calculating:

   $$\widehat{\boldsymbol{y}}_i = \boldsymbol{x}_i^T\, \widehat{\boldsymbol{\beta}}\,(u_i, v_i, t_i)^0$$

   for each location and time with $\widehat{\boldsymbol{\beta}}\,(u_i, v_i, t_i)^0$ is from GTWR modeling.

   ii. Calculating weighted value $w_i$ using Tukey's bisquare weighted function by:

$$w_i = \begin{cases} \left(1 - \left(\frac{\varepsilon_i^*}{c}\right)^2\right)^2, & |\varepsilon_i^*| \le c \\ 0 & |\varepsilon_i^*| > b \end{cases}$$

with:

$c = 4.685$

$\varepsilon_i^* = \frac{\varepsilon_i}{\hat{\sigma}},$

$\hat{\sigma} = \frac{median\,|\,\varepsilon_i - median(\varepsilon_i)|}{0.6745}$

$\varepsilon_i = y_i - \hat{y}_i$

iii. Calculating

$$\hat{\beta}(u_i, v_i, t_i)^m = (X_i' W^{m-1} X_i)^{-1} X_i' W^{m-1} y_i$$

iv. Repeating step (i) until (iii) to obtain a convergent $\hat{\beta}_M$

## III. RESULTS AND DISCUSSION

### A. Data Exploration

The distribution of number of family planning participants in each regency of East in 2016 is shown in Figure 1.

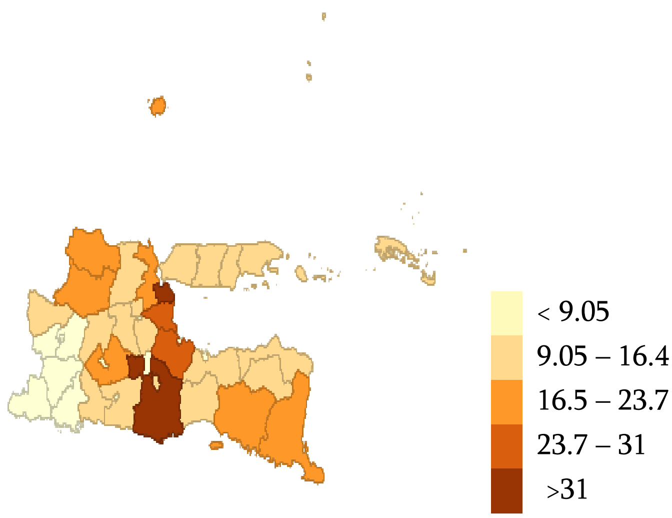


**Figure 1 :** Map Distribution Number of Family Planning Participants in East Java (in Ten Thousand People)

All districts in the province are grouped into five groups based on the lowest and the highest number of family planning participants. It can be seen that there were variances of number of family planning participants in East Java in which adjacent districts tend to have the same number of active family planning participants. Regency with the highest number of family planning participants in 2016 were in Malang and Surabaya. Meanwhile, the lowest number of family planning participants were in several locations in south east of East Java that were Pacitan, Ponorogo, Trenggalek, Magetan,, Madiun and Batu.

**Table 1 :** Statistical Descriptive of Family Planning Participants

| Tahun | Mean | StDev | Minimum | Maximum |
|---|---|---|---|---|
| 2009 | 160320 | 93355 | 17436 | 382730 |
| 2010 | 146120 | 100164 | 985 | 352681 |
| 2011 | 155181 | 92613 | 17426 | 348981 |
| 2012 | 157080 | 93179 | 14052 | 353333 |
| 2013 | 148869 | 90925 | 14451 | 374299 |
| 2014 | 150943 | 94454 | 15016 | 361175 |
| 2015 | 130084 | 104787 | 1664 | 392124 |
| 2016 | 130895 | 83959 | 15360 | 367755 |

Table 1 shows that there was an increase and decrease in the average number of active family planning participants in East Java during the time period studied. From 2009 to 2016, there was a decrease in the average number of active family planning participants in East Java. The lowest number of active family planning participants was 985 people which occurred in 2010 in Sampang, while the highest number of active family planning participants in Surabaya in 2015 that was 392124 people.

### B. Comparison between GTWR and RGTWR modelling

GTWR and RGTWR modelling produced 190 models from 38 locations with each location having 9 different models (based on years). In GTWR modelling, the parameter coefficients for the number of fertile age pairs showed negative results in several districts and cities, such as in Nganjuk, Madiun and

Jember but after modelling with RGTWR, it was found that RGTWR modelling succeeded in changing the parameter coefficients in Nganjuk and Madiun to be positive so that it was more fitted with the linear relationship plot.

Meanwhile, the parameter coefficients for per capita expenditure from GTWR and RGTWR modelling shows variety results. This is mainly because of the low correlation value between per capita expenditure with the number of active participants in the family planning. Overall, the estimators for this variable tends to give a negative value, but the coefficient that is negative in RGTWR modelling is more than the GTWR modelling results. RGTWR modelling is able to change the direction of the coefficient of Tuban and Blitar City from positive to negative so that it is more appropriate with the direction of linear relationships.

The estimated value for average school length of GTWR and RGTWR modelling also shows the variation in parameter coefficients. Same as per capita expenditure estimators, this independent variable generated by GTWR and RGTWR modelling tends to give a negative value, but RGTWR modelling is able to change the direction of the estimated parameter coefficient from positive to negative so that it is more proper with direction of linear relationships, as happened in Malang City.

Estimation of the number of health facilities of GTWR and RGTWR modelling shows that overall the parameter coefficient gives a positive direction of coefficient, only Blitar which has a different direction. Blitar that has positive estimators in GTWR modelling becomes negative estimators in RGTWR modelling. Changes in the direction of the parameter coefficients at this location are followed by a change in direction at the intercept coefficient.

In GTWR modelling, each location and time can be classified into five groups that are locations influenced by:

1. The number of fertile couples
2. The average length of school and the number of health facilities
3. The number of fertile couples, average length of school and number of health facilities
4. The expenditure per capita, average length of school and number of health facilities
5. The number of fertile couples, per capita expenditure, average length of school and number of health facilities

Whereas in RGTWR, the per capita expenditure is not statistically significant at each time and location that is examined, so that there are only the first three groups formed which are the location influenced by:

1. The number of fertile couples
2. The average length of school and number of health facilities
3. The number of fertile couples, average length of school and number of health facilities.

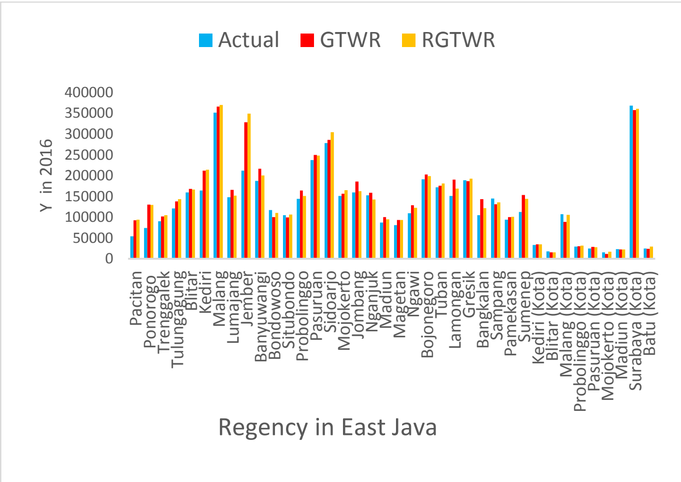


**Figure 2:** Actual data plot, prediction results of GTWR and GTWR from the number of active participants in East Java 2012 KB

The comparison of actual and prediction data of the number of family planning participants in East Java year 2016 using GTWR and RGTWR model is illustrated in Figure 5. The RGTWR modelling results estimators are closer to the actual values meaning the RGTWR modelling is able to improve the predictive value.

Meanwhile, the comparison of the goodness statistic model between GTWR and RGTWR based on the Mean Absolute Design (MAD) is presented in Table 2. RGTWR modelling produces the lowest MAD value, meaning the diversity value resulting from the estimation is closest to actual data.

**Table 2:** Comparison of MAD

| Model | MAD |
|---|---|
| GTWR | 18217.240 |
| RGTWR | 17909.512 |

## IV. CONCLUSION

The results of this study show that RGTWR with M-estimator is more effective to model the number of family planning participants in East Java from 2009 until 2016. It is indicated by the change the direction of the parameter estimator coefficient which is more appropriate with the data plot, result the approximate value that is closer to the actual value, create residual that has range tending to be smaller and decrease the MAD value in the model.

## V. ACKNOWLEDGEMENTS

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