MODELLING THE AVERAGE SCORES OF NATIONAL EXAMINATION IN WEST JAVA

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Abstract

Formal education in Indonesia is commonly divided into stages such as preschool, primary school (SD), Secondary School (SMP-SMA), and universities/colleges. Indonesian government has been taking serious efforts on how to improve the quality of education in Indonesia. The roadmap for continuous improvement of education quality can be designed based on the results of National Examination (UN) taken regularly by high school students.

This research was aimed at exploring information on how the scores of UN can be linked with other explanatory variables. A panel data which consists of average scores of UN for all public senior high schools (SMA Negeri) in West Java Provinces during 2011-2013 and other related variables such as total scores of accreditation, regional domestic product, human development index, scores of school’s facilities and its infrastructure, scores of school’s educators, average scores of final school exams, were used in this research. The average scores of UN in this case were dependent on variations between high schools and time periods as well as other explanatory variables in which the effects were either fixed or random. The data of this research was modelled with linear mixed models and using the Generalized Estimating Equation (GEE) approach. Both linear mixed models and GEE have been commonly used to analyse the panel data.

This paper showed that the GEE provided a model of better performance than the linear mixed models in explaining the variability of the response variable which was the average scores of UN. The GEE also showed significant correlation between explanatory variables and the response.

Keywords: fixed effects, GEE, linear mixed model, national examination, random effects.

INTRODUCTION

Background

Education plays important roles for the national development. Quality of human resources can be improved through better quality of education continuously. In Indonesia, there are several types of education namely formal, non-formal and informal education which are complemented each other. The level of formal education comprises of elementary education, high school or intermediate education, and higher education. A good quality school must provide quality teaching, curriculum, management, and facilities. The quality of a school can be reflected by the national examination (UN) scores and the school examination (US) scores.

UN is a standard evaluation system of primary and secondary education in Indonesia. In order to control the quality of education nationwide, UN has been conducted once in a year. The results was not only used as a consideration for students to continue to the next level of study but also for a basis of government policy in assisting education units as well as for the quality
This research aimed at analyzing the data of UN scores for all public senior high schools, commonly abbreviated in Indonesia as SMA, in West Java. These SMAs have been be referred as observation units. This kind of data is panel data, since the data is a combination of cross sectional data and time series data. Data was taken in four years from 2011-2014. A Linear Mixed Model has been used since the response variable is assumed normally distributed. Linear mixed models have been widely used in analysis of panel data, where each time series constitutes an individual curve as a cluster. The model accommodates both fixed effects and random effect, since the unit and time effects can be assumed to be random.

Another approach used in this research was the Generalized Estimating Equation (GEE). The GEE has been commonly used to model correlated data from repeated measures such as panel data. The quasi likelihood method is usually employed for estimating the model parameters. GEE covers the extentions of Generalized Linear Model (GLM) to panel data.

It is important to mention this research considered that UN scores can be affected by internal factors as well as external factors. The external factors are the factors within school, education system, and the effect of school policies. Economics condition of each regency/city in West Java where the schools are located may affect the quality of education. Hence, it will affects the UN scores of the schools. This economic condition can be measured by the gross regional income per capita (commonly mentioned as PDRB in Indonesia) just like what Ahmad (2011) has stated that the government funds allocated for education sector can affect economic growth or PDRB and vice versa. According to Statistics Indonesia (2008), the growth rate of PDRB also influences human development index (IPM) through household expenditures for daily primary needs including foods, medicines, and school stuffs. The growth rate of PDRB may also influence IPM through government domestic expenditure policies including priority funds for social aspects. Moreover IPM may influence PDRB through qualified human resources in terms of good health and quality education.

Based on the above discussion it is interesting to find the best model for the average scores of UN all public SMAs that could be explained by its explanatory variables such as IPM, PDRB, average scores of US, total accreditation scores, educators scores, school facilities scores, teaching content scores, teaching process scores, school management scores, school finance scores, and graduates competence scores. Moreover, we need to know which ones of the explanatory variables have significant effects on the average scores of UN.

Objectives
1. To develop the best model for modelling between average scores of UN all public SMAs for both natural science major and social science major and another explanatory variables mentioned above.
2. To evaluate which explanatory variables contribute significantly to the average scores of UN.

LITERATURE REVIEWS
Panel Data
A panel data set is one that follows a given sample of individuals over time, and thus provides multiple observations on each individual on the sample (Hsiao, 2003). Observing a panel data set is basically observing a broad section of subjects over time, and thus allows us to study dynamic, as well as cross sectional, aspects of a problem (Frees, 2004).

The general panel data model for observation $y_{it}$ of cross section data i at time t can be defined as

$$y_{it} = \alpha + X_{it}\beta + \epsilon_{it}$$

$\alpha$ is a scalar of overall intercept coefficient, $\beta$ is a vector of slope coefficient with K x 1 where K is number of explanatory variables, $y_{it}$ is a vector response variable observed for individual unit i at time t, $X_{it}$ is a matrix of explanatory variables individual unit i at time t, $\epsilon_{it}$ is the error
term vector ~ $N(0, \sigma^2)$.

**Linear Mixed Model**

Jiang (2007) used a linear mixed model which takes a general form as

$$y = X\beta + Z\alpha + \epsilon$$  \hspace{1cm} (2.1)

where $y$ is observation vector dimension $n$, $X$ is known covariate matrix, $\beta$ is regression coefficient vector (fixed effect), $Z$ is design matrix that contains only 1 and 0, $\alpha$ is normally distributed random effect vector, $\epsilon$ is error vector.

Basic assumption that should not be violated in linear mixed model is the first, random effect and error have mean zero and certain variances, e.g. $\text{var}(\alpha) = \text{matrix } G$ and $\text{var}(\epsilon) = \text{matrix } R$. The second assumption, $\alpha$ and $\epsilon$ must be uncorrelated. If random effect and error are assumed normally distributed, then the assumptions can be written as

$$\alpha \sim N(0, G)$$

$$\epsilon \sim N(0, R)$$

and the distribution of response variable is $y \sim N(X\beta, V)$, with $V = \text{Var}(y) = ZGZ' + R$. Moreover if the random effect and error is not assumed normally distributed, then model (2.1) becomes non Gaussian linear mixed model.

Jiang (2007) also stated that estimation in linear mixed model consists of estimating both the fixed and random effects as explained below.

Estimating fixed effect is Best Linear Unbiased Estimator (BLUE):

$$\hat{\beta}_{\text{BLUE}} = (X'X)^{-1}X'y$$

and random effect prediction which is Best Linear Unbiased Prediction (BLUP) can be written as

$$\hat{\alpha} = \text{BLUP}(\alpha) = GZV^{-1}(y - X\hat{\beta})$$

In fact, variance component $V$ is unknown therefore, in estimating fixed effect and random effect, $V$ is replaced by the estimator $\hat{V}$ and the estimation result is empirical best linear unbiased predictor (EBLUP).

$$\hat{V} = Z\hat{G}Z' + \hat{R}$$

where $\hat{G}$ and $\hat{R}$ are estimators using Maximum Likelihood Estimation (MLE) or Restricted Maximum Likelihood (REML).

Henderson (1959) introduced the solutions which can produce simultaneously the GLS estimator of $\beta$ and BLUP of $\alpha$.

$$y|\alpha \sim N(X\beta + Z\alpha, R)$$

and $\alpha \sim N(0, G)$ the joint density of $y$ and $\alpha$ is

$$f(y, \alpha) = f(y|\alpha) \cdot f(\alpha)$$

$$= \left(2\pi\right)^{-\frac{n+q}{2}} |R|^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}(y - X\beta - Z\alpha)'R^{-1}(y - X\beta - Z\alpha)\right\}$$

$$\times \left(2\pi\right)^{-\frac{q}{2}} |G|^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}\alpha'G^{-1}\alpha\right\}$$

$$= \exp\left\{-\frac{1}{2}\left[(y - X\beta - Z\alpha)'R^{-1}(y - X\beta - Z\alpha) + \alpha'G^{-1}\alpha\right]\right\}$$

find the log of $f(y, \alpha)$:

$$\log f(y, \alpha) = -\frac{n+q}{2}\log(2\pi) - \frac{1}{2}\log|R| - \frac{1}{2}\log|G|$$

$$-\frac{1}{2}\left[(y - X\beta - Z\alpha)'R^{-1}(y - X\beta - Z\alpha) + \alpha'G^{-1}\alpha\right]$$

then calculate the partial derivatives of log of $f(y, \alpha)$ with respect to $\beta$ and $\alpha$:

$$\frac{\partial \log f(y, \alpha)}{\partial \beta} = X'R^{-1}(y - X\beta - Z\alpha)$$
\[ \frac{\partial \log f(y, \alpha)}{\partial \alpha} = Z'R^{-1}(y - X\beta - Z\alpha) - G^{-1}\alpha \]

Those results are set to zero and the equations that are obtained:

\[
\begin{align*}
X'R^{-1}X\beta + X'R^{-1}Z\alpha &= X'R^{-1}y \\
Z'R^{-1}X\beta + Z'R^{-1}Z\alpha + G^{-1}\alpha &= Z'R^{-1}y
\end{align*}
\]

write the equations above in matrix form:

\[
\begin{bmatrix}
X'R^{-1} & X'R^{-1}Z \\
Z'R^{-1}X & Z'R^{-1}Z + G^{-1}
\end{bmatrix}
\begin{bmatrix}
\beta \\
\alpha
\end{bmatrix}
= \begin{bmatrix}
X'R^{-1}y \\
Z'R^{-1}y
\end{bmatrix}
\]

Estimating The Model Parameters

Some approaches used to estimate the model parameters in linear mixed model are the traditional approach, MLE, and REML.

Restricted Maximum Likelihood

REML can produce the unbiased or nearly estimator for variance and it doesn’t require more complex computation just like the ML estimators. Searle (1992) stated that the REML approach is now more preferable to estimate the variance parameters in mixed model.

\[ y \] is response vector that normally distribute which is transformed for \[ z = \Lambda'y \] which has distribution \[ z \sim N(0, \Lambda'\Lambda) \]. Define a non-zero \( n \times (n-p) \) matrix \( \Lambda \) for \( \Lambda'X = 0 \) so then \( \Lambda'\Lambda = Q \) where \( Q = I - X(X'X)^{-1}X' \) and \( \Lambda'\Lambda = I \) then define \( z = \Lambda'y = A(y - \hat{\beta}_{GLS}) \).

The expected value of \( z \) is \( 0 \) and covariance matrix is \( \Lambda'\Lambda \). The density of \( z \) is

\[
f_z(z) = (2\pi)^{-\frac{n-p}{2}} |A\Lambda A'|^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} z'(A\Lambda A')^{-1}z \right\}
= (2\pi)^{-\frac{n-p}{2}} |A\Lambda A'|^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} (y - \hat{\beta}_{GLS})'(A\Lambda A')^{-1}(y - \hat{\beta}_{GLS}) \right\}
\]

According to Rao (1973) that

\[
(y - \hat{\beta}_{GLS})'(A\Lambda A')^{-1}(y - \hat{\beta}_{GLS}) = (y - \hat{\beta}_{GLS})'V^{-1}(y - \hat{\beta}_{GLS})
\]

then we come to the final expression of the desity of \( z \).

\[
f_z(z) = (2\pi)^{-\frac{n-p}{2}} |X'X|^{-\frac{1}{2}} |Z'V^{-1}Z|^{-\frac{1}{2}} V^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} (y - \hat{\beta}_{GLS})'V^{-1}(y - \hat{\beta}_{GLS}) \right\}
\]

the final density of \( z \) leads to the restricted or residual log likelihood which written below.

\[
\log L_{REM}(\sigma) = const - \frac{1}{2} \log|X'V(\sigma)^{-1}X| - \frac{1}{2} \log|V(\sigma)| - \frac{1}{2} r(\sigma)V(\sigma)^{-1}r(\sigma)
\]

Just like estimating using MLE, log likelihood REML is maximized also requires numerical technique for example Newton Raphson with minor adaptations (Longford 2003). By substituting the estimator \( \hat{V}_{MLE} = V(\hat{\sigma}_{MLE}) \) into GLS formula.

\[
\hat{\beta}_{REML} = (XV^{-1}_{REML}X)^{-1}XV^{-1}_{REML}Y
\]

\( \hat{\beta}_{REML} \) is not identical \( \hat{\beta}_{MLE} \) even though \( y \) is normal distribution.

Generalized Estimating Equation

Zeger & Liang (1986) introduced an alternative approach to estimate the parameter in maximum likelihood case. This approach is usually known as generalized estimating equation (GEE). Basically, GEE is an extention of generalized linear model using quasi likelihood estimation.

\( y_{it}, x_{it} \) are observations with \( t = 1, 2, \ldots n_i \) and \( i = 1, 2, \ldots k \). \( y_{it} \) is response variable and \( x_{it} \) is covariate vector \( p \times 1 \) so that \( Y_i(n \times 1) \) and \( x_i(n \times p) \) for object \( i \). Assumes that response variable is a member of exponential family distribution, so that
\[ E(y_{it}) = b'(\theta_{it}) = \mu_{it} \]

\[ \text{Var}(y_{it}) = b'\,(\theta_{it})a_{it}(\phi) \] where \( \phi \) a possibly unknown scale parameter.

For \( Y_i \), the variance of \( y_{it} \) as a function of the mean, \( V_i = \left( A_i^{1/2}R_i(\alpha)A_i^{1/2} \right) \phi \), where \( A_i \) is a diagonal matrix \( n \times n \) with diagonal element \( t \) is \( b'(\theta_{it}) \) and \( R_i(\alpha) \) is \( n \times n \) working correlation matrix.

Where \( \alpha \) can be obtained by approaching by

\[ \hat{\alpha} = \phi \sum_{i=1}^{k} \sum_{t=t_i}^{t_{t_i}} \frac{\hat{\rho}_{it} \hat{\rho}_{it}'}{\sum_{i=1}^{k} \sum_{t=t_i}^{t_{t_i}} \left[ \frac{1}{2} \eta_i(n_i - 1) - P \right]} \]

Some general forms of structure of working correlation matrix can be known in the table 1 as follow.

<table>
<thead>
<tr>
<th>Structures Name</th>
<th>Structures</th>
<th>Structures Name</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independence</td>
<td>(1 0 ( \cdots ) 0)</td>
<td>Autoregressive</td>
<td>(1 ( \rho ) ( \cdots ) ( \rho^{t-1} ))</td>
</tr>
<tr>
<td></td>
<td>(0 1 ( \cdots ) 0)</td>
<td></td>
<td>(( \rho ) 1 ( \cdots ) ( \rho^{t-2} ))</td>
</tr>
<tr>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
</tr>
<tr>
<td>Exchangeable</td>
<td>(1 ( \rho ) ( \cdots ) ( \rho ))</td>
<td>M-dependent</td>
<td>(1 ( \rho_1 ) ( \cdots ) ( \rho^{t-1} ))</td>
</tr>
<tr>
<td></td>
<td>(( \rho ) 1 ( \cdots ) ( \rho ))</td>
<td></td>
<td>(( \rho_1 ) 1 ( \cdots ) ( \rho^{t-2} ))</td>
</tr>
<tr>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
</tr>
<tr>
<td>Unstructured</td>
<td>(1 ( \rho_{1,2} ) ( \cdots ) ( \rho_{1,t} ))</td>
<td>Fixed</td>
<td>(1 ( \tau_{1,2} ) ( \cdots ) ( \tau_{1,t} ))</td>
</tr>
<tr>
<td></td>
<td>(( \rho_{1,2} ) 1 ( \cdots ) ( \rho_{2,t} ))</td>
<td></td>
<td>(( \tau_{1,2} ) 1 ( \cdots ) ( \rho_{2,t} ))</td>
</tr>
<tr>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
<td></td>
<td>(( \vdots ) ( \vdots ) ( \ddots ) ( \vdots ))</td>
</tr>
<tr>
<td></td>
<td>(( \rho_{1,t} ) ( \rho_{2,t} ) ( \cdots ) 1)</td>
<td></td>
<td>(( \tau_{1,t} ) ( \tau_{2,t} ) ( \cdots ) 1)</td>
</tr>
</tbody>
</table>

GEE is arranged as \( U_G(\beta) = \sum_{i=1}^{k} D_i V_i^{-1}(Y_i - \mu_i) \) with \( D_i = \frac{\partial \mu_i}{\partial \theta_i} \frac{\partial \eta_i}{\partial \theta_i} \frac{\partial \eta_i}{\partial \beta} \).

**RESEARCH METHOD**

Average score of \( UN \) and \( US \) all \( SMANs \) in West Java 2011-2014. Data was accessed from Educational Research Center, Ministry of Education and Culture. Data of total accreditation scores, educators scores, school facilities scores, teaching content scores, teaching process scores were accessed in National Accreditation Institution. Data of human development index and gross regional product in West Java were accessed through Statistics Indonesia Website. Variables used in this research are

- \( Y \) : Average scores of \( UN \) all \( SMANs \) for both natural and social science major (UN).
- \( X_1 \) : Educators scores all \( SMANs \) in West Java (EDS)
- \( X_2 \) : School facilities scores all \( SMANs \) in West Java (FSS)
- \( X_3 \) : Average scores of \( US \) all \( SMANs \) in West Java (US)
- \( X_4 \) : \( IPM \) scores all regencies/cities in West Java (IPM)
- \( X_5 \) : \( PDRB \) all regencies/cities in West Java (PDRB)
- \( X_6 \) : Total accreditation scores all \( SMANs \) in West Java (TAS)
- \( X_7 \) : Teaching content scores all \( SMANs \) in West Java (CSS)
- \( X_8 \) : Teaching process scores all \( SMANs \) in West Java (TPS)

Steps in data analysis process in this research are.
1. Data Exploration
2. Building the initial model.
   The model which has been built as the initial model based on the linear mixed model:
   \[ y_{it} = X\beta + u_i + v_{it} \]
Modelling With Linear Mixed Model

Panel data which is both of natural and social science disciplines is modelled with linear mixed model. The intention of using linear mixed model instead of using another method for the analysis is the response variable (the average scores of UN) is normally distributed \( \mathcal{N}(0, \sigma_y^2) \) and the model has random effect which is school gives an effect randomly in this reasearch. The model which has been built as the initial model based on the linear mixed model:

\[
\begin{align*}
\mathbf{y}_{it} &= \mathbf{X\beta} + \mathbf{u}_i + \mathbf{v}_{it} \\
\mathbf{UN}_{it} &= \beta_0 + \beta_1 EDS + \beta_2 FSS + \beta_3 US + \beta_4 IPM + \beta_5 PDRB + \beta_6 TAS + \beta_7 CSS + \beta_8 IPS \\
&+ \mathbf{u}_i + \mathbf{v}_{it}
\end{align*}
\]

The estimation result by modelling the data for the natural science disciplines which is analysed using R software, package ‘lme4’ represents as follows.
Table 1. Modelling in Random Effect Model for Natural Science Major

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std.Error</th>
<th>t.value</th>
<th>p.z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>136.7899325</td>
<td>13.4292312</td>
<td>10.185983</td>
<td>0.000000e+00</td>
</tr>
<tr>
<td>rata_US</td>
<td>-1.02293870</td>
<td>0.10902801</td>
<td>-9.382348</td>
<td>0.000000e+00</td>
</tr>
<tr>
<td>akre</td>
<td>0.193228429</td>
<td>0.17103648</td>
<td>1.1297498</td>
<td>2.585817e-01</td>
</tr>
<tr>
<td>ipm</td>
<td>-0.144725934</td>
<td>0.08365559</td>
<td>-5.013788</td>
<td>5.336877e-07</td>
</tr>
<tr>
<td>pdrb</td>
<td>-0.144725934</td>
<td>0.08365559</td>
<td>-5.013788</td>
<td>5.336877e-07</td>
</tr>
<tr>
<td>ISI</td>
<td>-0.004182185</td>
<td>0.08082400</td>
<td>-0.051744</td>
<td>9.587324e-01</td>
</tr>
<tr>
<td>PRS</td>
<td>-0.058661240</td>
<td>0.06268280</td>
<td>-0.935843</td>
<td>3.493542e-01</td>
</tr>
<tr>
<td>TEN</td>
<td>0.090488615</td>
<td>0.06256899</td>
<td>1.446221</td>
<td>1.481151e-01</td>
</tr>
<tr>
<td>SAR</td>
<td>0.070093554</td>
<td>0.05291827</td>
<td>1.324563</td>
<td>1.853163e-01</td>
</tr>
</tbody>
</table>

Table 1 shows that the estimated value of the parameters in linear mixed model. Judging by the software output, it seems that there are only the scores of US and PDRB which affect significantly the scores of UN.

Based on the table 1. The model which is used to predict the estimation of the scores of UN in a certain school i and at a certain year t.

\[ \hat{NN}_{it} = 136.8 + 0.09EDS + 0.07FSS - 1.02US - 0.02IPM - 0.14PDRB + 0.19TAS \\
- 0.004CSS - 0.06TPS + u_i + v_{it} \]

The estimation result by modelling the data for the social science disciplines which is also analysed using R software, package 'lme4' represents as follows.

Table 2. Modelling in Random Effect Model for Social Science Major

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std.Error</th>
<th>t.value</th>
<th>p.z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>95.5113357</td>
<td>11.5978112</td>
<td>8.2352898</td>
<td>2.220446e-16</td>
</tr>
<tr>
<td>rata_US</td>
<td>-0.6946077</td>
<td>0.09168786</td>
<td>-7.5757874</td>
<td>3.574918e-14</td>
</tr>
<tr>
<td>akre</td>
<td>0.22027012</td>
<td>0.15009680</td>
<td>1.4675204</td>
<td>1.422345e-01</td>
</tr>
<tr>
<td>ipm</td>
<td>0.05405338</td>
<td>0.12738235</td>
<td>0.4243396</td>
<td>6.713182e-01</td>
</tr>
<tr>
<td>pdrb</td>
<td>-0.13995148</td>
<td>0.02537485</td>
<td>-5.5153623</td>
<td>3.480622e-08</td>
</tr>
<tr>
<td>ISI</td>
<td>-0.02559474</td>
<td>0.07096874</td>
<td>-0.3606481</td>
<td>7.183625e-01</td>
</tr>
<tr>
<td>PRS</td>
<td>-0.01861390</td>
<td>0.05514847</td>
<td>-0.3375234</td>
<td>7.357224e-01</td>
</tr>
<tr>
<td>TEN</td>
<td>0.09839509</td>
<td>0.05501004</td>
<td>1.7886751</td>
<td>7.366715e-02</td>
</tr>
<tr>
<td>SAR</td>
<td>0.04780935</td>
<td>0.04703454</td>
<td>1.0164731</td>
<td>3.094041e-01</td>
</tr>
</tbody>
</table>

Table 2 shows that the estimated value of the parameters in linear mixed model. Judging by the software output, it seems that there are only the scores of Educator, US and PDRB which affect significantly the scores of UN.

Based on the table 2. The model which is used to predict the estimation of the scores of UN in a certain school i and at a certain year t.

\[ \hat{NN}_{it} = 95.5 + 0.1EDS + 0.05FSS - 0.7US + 0.05IPM - 0.14PDRB + 0.22TAS \\
- 0.03CSS - 0.01TPS + u_i + v_{it} \]

Modelling With GEE

Modelling with GEE estimation approach does not have coefficient or variable which represents the random effect as school effect (u_i) like either in the fixed effect model or random effect model.

Model which is obtained by using GEE in this research converts the school effect into the form of dummy variables. The number of dummy variables is k - 1, where k is the number of schools which have been observed that can be seen in the table 3. Those variables are included into the model.
The result of estimation with GEE for the data of natural science and social science can be seen in the table 4 and table 5, working correlation matrix which is used this model estimation is autoregressive because of the panel data which is analysed in this research is the data that the research objects were observed at several time points. The estimation result by modelling the data for the natural science diciplines with GEE which is analysed using SAS software represents as follows.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>StdError</th>
<th>95% confLimits</th>
<th>Z</th>
<th>Pr &gt;</th>
<th>Z</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1884.384</td>
<td>38.6640</td>
<td>1808.604 1960.164</td>
<td>48.74</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no 1</td>
<td>88.3460</td>
<td>2.6646</td>
<td>83.1236 93.5684</td>
<td>33.16</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no 2</td>
<td>89.6727</td>
<td>3.0777</td>
<td>83.6405 95.7048</td>
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GEE yields the form of model as follows.

\[ \hat{\mu}_{it} = 1884.4 + 88.3D1 + 89.7D2 + \cdots + 0.71D420 + 0.24EDS - 0.21FSS - 0.23US - 24.9IPM + 0.45PDRB - 0.11TAS - 0.27CSS - 0.12TPS + v_{it} \]

There are only 419 public schools which have the specific diciplines like social science. The estimation result by modelling the data for the social science diciplines with GEE which is also analysed using SAS software represents as follows.

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<th>Parameter</th>
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<th>95% confLimits</th>
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</table>

GEE yields the form of model as follows.
\[
U_{\text{Nlt}} = 1061.45 + 80.99D1 + 82.3D2 + \cdots - 0.19D418 + 0.02EDS + 0.04FSS \\
- 0.38US - 13.34IPM - 0.79PDRB + 0.24TAS - 0.1CSS + 0.02TPS \\
+ \psi_{lt}
\]

Model Comparison
The comparison between the first model which is built with linear mixed model and the second model with GEE has been done in seeing its value of R-square and MSE. For the natural science disciplines, R-square of the first model is 76.7% and its MSE value is 1.46 however R-square of the second model is 84.5% and its MSE value is 1.06. For the social science disciplines, R-square of the first model is 72.3% and its MSE value is 2.12 however R-square of the second model is 80.92% and its MSE value is 1.9. It means that GEE is the best model that can be implemented for this research case of UN Both for natural science disciplines and social science disciplines.

Conclusion
It was concluded from this research that the UN scores could be modeled using the GEE approaches. Factors which were significantly affecting the score include the average scores of US, accreditation scores, and IPM. This model could be used for predicting future results of UN as well as for a basis of improvement of school learning activities.

REFERENCES


No. 1 Agustus 2012, 59-63.