Media Statistika

p-ISSN 1979 – 3693 e-ISSN 2477 – 0647
MEDIA STATISTIKA 16(1) 2023: 13-24
http://ejournal.undip.ac.id/index.php/media_statistika

MODELING OF FARMER EXCHANGE RATE IN ACEH PROVINCE USING LONGITUDINAL DATA ANALYSIS

Miftahuddin[1], Ziqratul Husna[2], Eddy Gunawan[3], Syawaliah Muchtar[4]
[1,2] Department of Statistics, Universitas Syiah Kuala, Indonesia
[3] Department of Economy and Development, Universitas Syiah Kuala, Indonesia
[4] Department of Chemical Engineering, Universitas Syiah Kuala, Indonesia

e-mail: miftah@unsyiah.ac.id

DOI: 10.14710/medstat.16.1.13-24

Article Info:
Received: 27 June 2022
Accepted: 9 June 2023
Available Online: 9 June 2023

Keywords: .
FER; IR; IP; CPI; Inflation.

Abstract: Farmer's Exchange Rate (FER) is one indicator to see the level of farmers' welfare. From 2014 to 2020, Aceh Province's FER was below 100 which indicates that farmers have not yet reached the level of welfare. This happens because of various factors including the price received by farmers (IR) is smaller than the price paid by farmers (IP). To find out the factors that influence the FER, it is necessary to do an analysis by forming a model. In this study, modeling of the FER data will be carried out, and see the factors that influence the index number with the longitudinal data regression approach. There are three estimation models, i.e. Common Effect Model, Fixed Effect Model, and Random Effect Model. Model selection of the best model is by using the Chow, Hausman, and Lagrange Multiplier tests. Furthermore, test the significance of the parameters using the simultaneous and partial tests and also see the value of the coefficient of determination (R^2). The results obtained indicate that the appropriate model for the IR and IP data is the Random Effect Model where the R^2 for the IR and IP models are 67.06% and 85.42 respectively.

1. INTRODUCTION

In an effort to achieve the SDGs (Sustainable Development Goals) in Indonesia, the agricultural sector has become a national development priority where the majority of Indonesians live as farmers. The agricultural sector is a sector that contributes to the formation of Gross Regional Domestic Product (GRDP), employment, sources of income, and production of agricultural products (Rusono, *et al*, 2013). BPS generates a formulation of one fundamental indicator nationally, which is named GRDP, as an outcome of system nation account/SNA which comply with the role from United Nations generally. In practically, in SNA 2008, there is a change in national statistical data, the primary year of 2000 to 2010, a change in nomenclature and its relation. GRDP shows a capability to result an added value in a time interval (usually in yearly or quarterly) in province level (BPS, 2022). GRDP is formulated in two methods, GRDP as stated by industrial or production and by spending. In this study, we used GRDP by production is a total of gross added values generated by all the industrial sectors derives from their productivity. In based year of 2010, this GRDP is having a change the number of classification, from 9 to 17 sectors. Aceh has been called as the rice granary, due to paddy production in several district such as Aceh Utara, Pidie, Aceh Besar, Aceh Timur and Bireuen. It means economic sector in Aceh is majority by the agricultural sector (more 30% compared to other sector) and it had a significant impact on improving the living standard of local society, the regional economy growth, and largest absorb employment. The research aims analyzing of agricultural contribution to Aceh GRDP and identify several factors that influence changed contribution of the agricultural subsectors.

The agricultural development goals to boost the welfare of the community, especially farmers. Welfare consists of welfare economically and socially (Martina and Praza, 2018). The welfare of farmers can be seen from the capability of farmers to get the fundamental needs of their lives and families. One indicator to see the level of farmers' welfare is the Farmer's Exchange Rate (FER). Aceh is a province dominated by three main jobs compared to other sectors, namely agriculture, forestry, and fisheries by 40.34% in 2019 and 36.99% in 2020. FER from 2014 to 2020 was below 100. In 2014 Aceh's FER was 98.15% from the previous year of 103.16% and in 2020 it was 98.74%. This indicates that farmers in Aceh have not yet reached the level of welfare that occurs due to a decrease in the selling price of farmers' production compared to the farmers' buying price (BPS, 2020 and 2022). The main factors influencing FER are the price index received by farmers (IR) and the price index paid by farmers (IP) which consist of their respective subsectors and commodities (Miska, 2017).

Differences this study uses data in the form of longitudinal data consisting of cross-section (individual units) and time series data, where the individual unit is a sub-sector (from 9 to 17 sectors) that makes up the FER and the time starts from 2014 to 2020 (six year with monthly data) with 23 districts/town in Aceh. Whereas (Nirmala *et al*, 2016) use multiple linear regression, showed that the factors that influence FER are the selling price of the product and the price of fertilizer. In (Falah *et al*, 2016) with a longitudinal data showed that the suitable model in the IR and IP data with 32 provinces from 2013 to 2015. (Tapamahu *et al*, 2021) shows that changes in agricultural structure and lag in FER have a positive effect, otherwise the inflation rate give a negative effect on FER, both significant effect.

2. LITERATURE REVIEW

2.1. Farmer Exchange Rate

FER is a measure of the capability to exchange agricultural products (goods or services) resulted by farmers needed for household consumption and the need to produce agricultural products. The higher the FER, the more prosperous the farmer's level of life (Mankiw, 2015). The concept of FER from BPS, the farmers in question are farmers who work in the Food Crops (FC), Horticultural Crops (HC), Smallholder Plantation Farmers (PC), Livestock, and Fisheries. The calculation of FER is formulated as follows:

$$\mathbf{FER} = \frac{\mathbf{IR}}{\mathbf{IP}} \times \mathbf{100}\% \qquad (1)$$

Given FER index in percentage (%); IP and IR both in % According to (BPS, 2020) concept, there are three types of FER index that describe the condition of farmers, namely: (a) If the FER > 100, the farmer has a surplus, meaning that the farmer's income is greater than the expenditure so that the level of welfare of the farmer is better. (b) If the FER = 100, the farmer experiences a break-even point, meaning that the farmer's income is the same as his expenditure and the level of farmer's welfare does not change. (c) If the FER < 100, the farmer experiences a deficit, meaning that the farmer's income is smaller than the expenditure so that the farmer experiences a loss and the level of farmer welfare has decreased. The indicators that make up the IR according to (BPS, 2020): (1) The Food Crops subsector (FC) consists of an index of the rice plant group and an index of the secondary crop group index. (2) The Horticultural Crops (HC) subsector consists of a group index of vegetables, fruits, and medicinal plants. (3) People's Plantation Crops Subsector (PC) consists of the PC index. (4) The livestock sub-sector consists of an index of large livestock groups, small livestock groups, poultry groups, and livestock product groups. (5) The Fisheries subsector consists of an index of capture and aquaculture groups. The indicators that make up the IP based on the BPS summary are the same as the IR component, but the IP consists of commodities from the Household Consumption (HH) group and the Production Costs and Capital Goods Additions group (known as PCCGA) in each of its subsectors. The HH commodity consists of the following components: Foodstuffs; Prepared Food, Beverages, Cigarettes & Tobacco; Housing, gas, electricity, etc.; Clothing; Health; Education, Recreation, Sports; Transportation & Communication. The PCCGA commodity consists of the following components: seeds; Fertilizers, Medicines, & Clothing; Rental costs & other expenses; Transportation; Addition of Capital Goods; & Labor Wages.

2.2. Consumer Price Index (CPI) and Inflation

The CPI is an index that counting the average price change of a product consumed by households over a certain time period (BPS, 2020). Changes in CPI from timely describe the inflation or the rate of decline (deflation) of products.

$$\mathbf{CPI}_n = \frac{\sum_{i=1}^{k} \frac{P_{ni}}{P_{(n-1)i}} P_{(n-1)i} Q_{0i}}{\sum_{i=1}^{k} P_{0i} Q_{0i}} \times 100\% \tag{2}$$

given *p*: price of item type; *q*: quantity of item type; *n*: total number of items.

Inflation is the percentage rate of increase in the price of the number of products that are generally consumed by households, namely the tendency to increase the prices of products in general which takes place continuously (BPS, 2020). An increase in the price of products causes a decrease in the value of money. The factor causing inflation is the demand for products tends to be higher than their availability.

$$\mathbf{Inflation_n} = \frac{\mathbf{CPI_n} - \mathbf{CPI_{(n-1)}}}{\mathbf{CPI_{(n-1)}}} \times 100\% \tag{3}$$

where Inflation_n:inflation in the n^{th} period; $\text{CPI}_{(n-1)}$:CPI_n:CPI in the *n-1*;& in the n^{th} period.

2.3. Regression Model of Longitudinal Data

Longitudinal data is a development of linear regression and has repeated measurements. There are three methods commonly used in estimating the longitudinal data regression model, namely the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM), (Sutradhar, 2011, Widarjono, 2013, Arya, 2019). The general form of longitudinal data is expressed in Eq. 4 (Greene, 2010):

$$Y_{it} = \beta_{0it} + \sum_{k=1}^{k} \beta_{ki} X_{kit} + \varepsilon_{it} \tag{4}$$

given i = 1,2,3, …, N and t = 1,2,3, ..., T. Y_{it} : the value of the *i*-th individual response for the *t-th* time. k : the number of regression parameters to be estimated. X_{kit}: the value of the *k*-th predictor for the *i*-th individual at time *t*. *β*: parameter coefficient; and ε_{it}: error for individual *i* at time *t*. The CEM is the simplest longitudinal model approach that does not consider time or individual dimensions. The general effects model of longitudinal data assumes that the intercept and slope values of each variable are the same for all cross-section and time-series units (Caraka & Yasin, 2018). One of the estimation methods that CEM can use is Ordinary Least Square (OLS) if it is homoscedastic and there is no cross-sectional correlation. The FEM is a model that estimates longitudinal data by using a dummy variable to detect differences in intercepts which is called the Least Square Dummy Variable model (Greene, 2010). One of the FEM parameter estimation methods uses the OLS method. The FEM model assumes that the slope coefficient of each variable is constant but has a different intercept for each unit cross-section (Yongmiao, 2020). The REM is a longitudinal model with the assumption that the slope coefficient is constant and the intercept differs between individuals and over time (random effect), (Ekananda, 2016). Parameter estimation in REM using Generalized Least Square (GLS) can increase the efficiency of the least square. The REM model will estimate longitudinal data in which disturbances may be related between individuals and over time. In the REM, parameters that differ between individuals and over time are included in the error. Therefore, the REM is also called the Error Component Model.

2.4. Model Selection

2.4.1. Chow Test, Hausman Test and Lagrange Multiplier (LM) Test

The Chow test (likelihood test ratio) is used to select one of the models in the longitudinal data, namely the FEM and the CEM. F_{count} for the Chow test (Greene, 2010) is

$$\boldsymbol{F_{count}} = \frac{(\boldsymbol{R^2_{LSDV}} - \boldsymbol{R^2_{Pooled}})/(\boldsymbol{n}-\mathbf{1})}{(\mathbf{1}-\boldsymbol{R^2_{LSDV}})/(\boldsymbol{nT}-\boldsymbol{n}-\boldsymbol{k})} \quad (5)$$

where: R^2_{LSDV} and R^2_{Pooled}: coefficient determination of the FEM and CEM models. n: number of individuals (*cross-section*); T: number of time series. Whereas the F_{table} is:

$$\boldsymbol{F_{table}} = |\boldsymbol{\alpha}: \boldsymbol{df}(\boldsymbol{n}-\mathbf{1}, \boldsymbol{nt}-\boldsymbol{n}-\boldsymbol{k})| \quad (6)$$

where α : the significance level; t: time period. Hypothesis H_0 is rejected if the *p-value* is smaller than (or $F_{count} > F_{table}$), meaning that the FEM model is the best model for estimating data. Hausman test aims to choose between FEM or REM which is appropriate to be used in the longitudinal model. The Wald criteria (Carter *et al*, 2011), the statistical value of the Hausman test follows a *Chi-Square* distribution with v degrees of freedom in equation is

$$\boldsymbol{W} = \boldsymbol{\chi^2(v)} = (\boldsymbol{b}-\boldsymbol{\hat{\beta}})'[\boldsymbol{var}(\boldsymbol{b}) - \boldsymbol{var}\,(\boldsymbol{\hat{\beta}})]^{-1}(\boldsymbol{b}-\boldsymbol{\hat{\beta}}) \quad (7)$$

given $\boldsymbol{b}$: Estimation vector REM parameter; $\boldsymbol{\hat{\beta}}$: Estimation vector FEM parameter. H_0 is rejected if $\chi^2_{calc} > \chi^2_{(v;\alpha)}$, meaning that the true model is the FEM. The LM test is a test to choose the right estimation model between REM and CEM. The statistical value of LM:

$$\boldsymbol{LM} = \frac{\boldsymbol{nT}}{\mathbf{2}(\boldsymbol{T}-\mathbf{1})}\left[\frac{\sum_{i=1}^{n}[\sum_{t=1}^{n}\boldsymbol{e_{it}}]^2}{\sum_{i=1}^{n}\sum_{t=1}^{T}\boldsymbol{e_{it}^2}} - \mathbf{1}\right]^{\mathbf{2}} \quad (8)$$

where e_{it} is the residual of the REM model. Reject H_0 if the LM value > chi-square (or *p*-value < α) means that the correct model is REM.

2.5. Parameter Significance Test

The simultaneous test (*F*-test) aims to determine the effect of the regression coefficient together on the response. The test is done by comparing F_{calc} with F_{table} or comparing *p-value* with α value (Gujarati, and Porter, 2012). Partial test (*t*-test) is used to see the effect of the predictors individually in explaining the response. The hypothesis on the *t*-test is to determine whether individually a predictor has a significant influence on the response. The R^2 to find out how big the proportion given by the predictor to explain the response (Widarjono, 2013).

3. MATERIAL AND METHOD

This study uses secondary data obtained from the Central Statistics Agency from

2014 to 2020 of Aceh Province and (Bank Indonesia, 2021). Software that used is R Studio 9.2 which is applicable with Big Data. Longitudinal data consists of individual data (cross-section data that consists of 5 subsectors where each subsector consists of each commodity. The variables used are index numbers (which are received and paid by farmers), subsector, commodity, CPI, and inflation. Data analysis was conducted with the following steps: (1) Conduct model selection using the Chow, Hausman test, and Lagrange Multiplier test.

Table 1. Commodities in Each Subsector

Subsector	IR Commodity	IP Commodity
Crops (C)	- Paddy - Palawija	- HH - PCCGA
Horticultural Plants (HP)	- Vegetables - Fruits - Medicinal plants	- HH - PCCGA
People's Plantation Crops (PPC)	- Plantation	- HH - PCCGA
Livestock (L)	- Large livestock - Small livestock - Poultry - Livestock products	- HH - PCCGA
Fishery (F)	- Catch - Cultivation	- HH - PCCGA

(2) Perform parameter estimation using the selected model. (3) Testing assumptions if the chosen model is CEM or FEM. If the REM is selected, then there is no need to test the assumption where REM uses the GLS estimation which is the Best Linear Unbiased Estimator (BLUE), (Gujarati, and Porter, 2012). (4) Estimating the model using the Feasible GLS method if CEM is selected and FEM does not meet the assumptions of homoscedasticity and autocorrelation. (5) Test the significance of the parameters using the simultaneous test (F-test), partial test (t-test), the R^2, and (6) Interpret the resulting model.

4. RESULTS AND DISCUSSION

Descriptive statistics on index numbers from price index data received by farmers (IR) based on commodities can be seen in Table 2.

Table 2. Summary of IR, IP, FER, CPI dan Inflation from the Year 2014 – 2020

Statistic	Index Value			CPI	Inflation
	IR	IP	FER		
Minimum	101.98	104.17	89.90	103.53	-1.26
Q1	109.55	111.69	94.54	111.85	-0.10
Q2	118.17	122.67	95.81	118.95	0.29
Q3	120.35	130.72	98.06	127.20	0.60
Maximum	126.19	136.90	101.09	131.87	2.12
Average	115.47	121.26	95.94	119.00	0.29
Range	24.21	32.73	11.19	28.34	0.86
Modus	121.01	132.83	98.06	125.07	-0.10
Standard Deviation	6.97	10.32	2.29	8.90	0.59
Variance	48.63	106.58	5.23	79.20	0.35

Table 2, it can be seen that: FER in Aceh has an average of 95.94 with the lowest and highest FER values of 89.90 and 101.09, respectively. In other words, the average FER is still below

100, so farmers experience a deficit, meaning that farmers' income is smaller than expenditure indicating that farmers experience losses and the level of farmer welfare has decreased during Jan 2014 - Dec 2020. The highest range for the IP index is 32.73, which is higher than the IR (24.21), CPI (28.34), and Inflation (0.86). This shows that the IP is greater than the IR with a difference in an index of 8.52. The variance of the FER of 5.23 indicates that the distribution of FER obtained is far, under the variance of IP (106.58), IR (48.63), and the CPI (79.20), except above the inflation rate (0.35).

Table 3. Statistics Summary of Commodity IP in 2014 - 2020

Subsector	Commodity	Min	Q_1	Q_2	Q_3	Max	Mean
Crops (C)	HC	104.38	113.96	126.26	135.54	142.53	124.35
	CPACG	103.77	106.98	116.65	122.98	129.78	115.99
Horticultural Plants (HP)	HC	104.52	112.86	125.06	130.93	139.91	122.77
	CPACG	102.98	107.36	112.22	119.26	131.93	113.98
People's Plantation Crops(PPC)	HC	104.46	112.59	124.42	134.84	145.18	124.10
	CPACG	102.68	107.15	116.25	119.72	130.97	115.40
Livestock (L)	HC	104.10	113.23	125.33	131.11	141.37	123.01
	CPACG	102.54	105.34	111.01	114.31	120.47	110.92
Fishery (F)	HC	104.60	113.13	124.41	135.88	141.74	123.83
	CPACG	102.10	106.20	112.20	114.75	117.48	111.07

Household Consumption (HC), Cost of Production, and Addition of Capital Goods (CPACG)

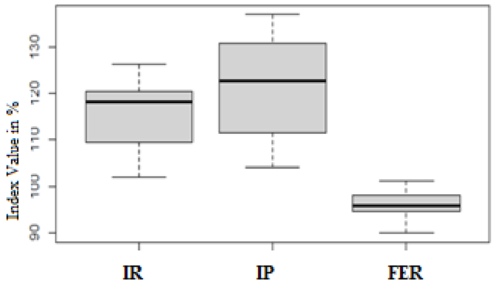

Figure 1. Boxplot of IR, IP, and FER Distribution in 2014 – 2020

The boxplot for IR, IP, and FER in Figure 1 shows that the distribution of each variable is not symmetrical and there is no outlier data. A comparison of the distribution of data for IR, IP, and FER numbers using a boxplot shows that the median (middle line of the box) for IP numbers is greater than the IR index. So, if the IR index is smaller than the IP number, the index number will be below 100% and farmers can be said to have a deficit or loss.

4.1 Model Selection

In model selection between common or fixed effects, we use the hypothesis,

H_0 : ($\sigma_{\mu}^2 \neq 0$) Appropriate model for data is CEM vs H_1 : ($\sigma_{\mu}^2 = 0$) The appropriate model is FEM

Table 4 show the longitudinal model selected in the Chow test is FEM for IR and IP data. Furthermore, we use the hypothesis by the Hausman test:

H_0: ($\sigma_{\mu}^2 \neq 0$) Appropriate model for data is REM vs H_1: ($\sigma_{\mu}^2 = 0$) The appropriate model is FEM

Table 4. Determination of the Longitudinal Model with the Chow Test

Index	P-value	Decision	Model
IR	7.7×10^{-5}	Rejected H_0	Fixed Effect Model (FEM)
IP	6.7×10^{-13}	Rejected H_0	Fixed Effect Model (FEM)

Significance: α = 5%

Table 5 shows the model selected in the Hausman test is the REM for both IR and IP data.

Table 5. Determination of the Longitudinal Model with the Hausman Test

Index	*P-value*	Decision	Model
IR	1	Accepted H_0	*Random Effect Model* (REM)
IP	1	Accepted H_0	*Random Effect Model* (REM)

To know if there is two-way effect, individual effect, and time effect in the model, we use the hypothesis by *Lagrange Multiplier* (LM) Test:

H_0 : $(\sigma_\mu^2 \neq 0)$ Appropriate model for data is CEM

H_1 : $(\sigma_\mu^2 = 0)$ The appropriate model for data is REM

The *p*-value obtained from the Lagrange Multiplier test is as follows:

Tabel 6. Determination of the Longitudinal Data Model with the LM Test

Index	P-value	Decision	Model
IR	0.021	Rejected H_0	*Random Effect Model* (REM)
IP	0.766	Accepted H_0	*Common Effect Model* (CEM)

Table 6 shows the longitudinal regression model selected for the LM test is the REM for IR data and CEM for IP data. Furthermore, the Breusch Pagan test is used to determine the existence of the two-way effect, individual effect, and time effect in the model. Breusch Pagan test is used for hypothesis test as follows:

H_0: No two-way effect vs H_1: There is a two-way effect

H_0^c: No individual effect vs H_1^c: There is an individual effect

H_0^d: No time effect vs H_1^d: There is a time effect

The results of the Breusch Pagan test are presented in Table 7.

Table 7. Model Effect Test with Breusch Pagan Test

Index	Test	P-value	Decision	Conclusion
IR	Two-way effect	1.6×10^{-4}	Rejected H_0	It has two-way effect
	Individual effect	2.0×10^{-4}	Rejected H_0	It has individual effect
	Time effect	0.057	Accepted H_0	No time effect
IP	Two-way effect	2.2×10^{-16}	Rejected H_0	It has two-way effect
	Individual effect	2.2×10^{-16}	Rejected H_0	It has individual effect
	Time effect	0.079	Accepted H_0	No time effect

Significance: α = 5%

Table 7 show the price received by the farmer's index (IR) and the price paid by the farmer's index (IP) have a two-way effect and an individual effect, respectively.

4.2 Assumption Test and Parameter Estimation for Longitudinal Data

Based on the selected model, REM, there is no need to test classic assumptions because the REM model uses a GLS estimation where each estimate gives the same weight to each observation. So that GLS produces an estimator that is BLUE (Gujarati, and Porter, 2012). The regression model estimation for IR longitudinal data using REM model is:

$$\boldsymbol{\hat{y}_{i,t} = -15.586 - 1.039\ \mathrm{Sub}_{(C,t)} + 11.994\ \mathrm{Sub}_{(HP,t)} + 4.183\ \mathrm{Sub}_{(L,t)}}$$
$$\boldsymbol{-6.034\ \mathrm{Sub}_{(PPC,t)} + 1.119\ \mathrm{CPI}_{(i,t)} - 3.105\ \mathrm{Inflation}_{(i,t)} + c_i + \varepsilon_i}$$

Based on the IR longitudinal model, the subsector variables in the food crops (C) and People's Plantation Crops (PPC) have a negative effect, respectively -1.039 and -6.034, meaning that if there are a one-unit decrease in the food crops (C) and (PPC) sub-sectors, there will be a decrease in the IR number, respectively -1.039 and -6.034 compared to the fisheries sub-sector. While the Horticultural Plants (HP) and Livestocks (L) subsectors have a positive influence of 11.994 and 4.183, respectively, meaning that if there is an increase of one unit from the Horticultural Plants and Livestock subsector, the IR number will increase by 11.994 and 4.183 respectively compared to the fisheries subsector.

Table 8. Commodities in Each Subsector

Subsector	IR Commodity	IP Commodity
Crops (C)	- Paddy - Palawija	- HH - PCCGA
Horticultural Plants (HP)	- Vegetables - Fruits - Medicinal plants	- HH - PCCGA
People's Plantation Crops (PPC)	Plantation	- HH - PCCGA
Livestock (L)	- Large livestock - Small livestock - Poultry - Livestock products	- HH - PCCGA
Fishery (F)	- Catch - Cultivation	- HH - PCCGA

The CPI has a positive effect of 1.119, meaning that if there is an increase of one unit from the CPI, the IR number will increase by 1.119. The inflation has a negative effect of -3.105, meaning that if there is a decrease of one unit from inflation, the IR number will decrease by -3.105. The difference in constant coefficients in the cross-section is as follows:

Table 9. Parameter Estimation of Individual Effect of IR Data

Commodity	Constant (C_i)	Commodity	Constant (C_i)
Paddy	0.216	Small livestock	-1.862
Palawija	-0.216	Large livestock	-1.096
Vegetables	-9.918	Poultry	2.763
Fruits	1.764	Livestock products	0.195
Medicinal plants	8.154	Catch	2.919
Plantation	-0.007	Cultivation	-2.919

In Table 9, it can be seen that the constant coefficient values are different for each cross-section which shows the magnitude of the influence of individuals in the model. The positive value of the cross-section constant-coefficient indicates the direction of increase if there is an increase of one unit of the commodity and the negative value indicates the direction of decrease if there is a decrease of one unit of the commodity to the index number. The equation of the IR longitudinal data for each cross-section is as follows:

$$\hat{y}_{Paddy,t} = -15,586 - 1,039\ \mathbf{Sub}_{(C,t)} + 11,994\ \mathbf{Sub}_{(HP,t)} + 4,183\ \mathbf{Sub}_{(L,t)} - 6,034\ \mathbf{Sub}_{(PPC,t)} + 1,119\ \mathbf{CPI}_{(i,t)} - 3,105\ \mathbf{Inflation}_{(i,t)} + C_i$$

$$\hat{y}_{Palawija,t} = -15,586 - 1,039\ \mathbf{Sub}_{(C,t)} + 11,994\ \mathbf{Sub}_{(HP,t)} + 4,183\ \mathbf{Sub}_{(L,t)} - 6,034\ \mathbf{Sub}_{(PPC,t)} + 1,119\ \mathbf{CPI}_{(i,t)} - 3,105\ \mathbf{Inflation}_{(i,t)} - C_i$$

In the IR model with a constant coefficient for the cross-section effect of paddy and secondary crops above, the constant values obtained are 0.206 and -0.206, respectively. This shows that rice has a positive effect of 0.206, meaning that if the paddy commodity increases by one unit, there will be an increase of 0.206 to the IR. Meanwhile, secondary crops have a negative effect of -0.206 meaning that if the palawija commodity decreases by one unit, there will be a decrease of -0.206 towards the IR.

4.2 Parameter Significance Test

The simultaneous significance test hypotheses for the predictors in the IR model:

H_0: Predictors simultaneity (Subsector, Consumer Price Index (CPI) and Inflation) does not have a significant effect on the index number variable

H_1: Predictors simultaneity (Subsector, CPI) and Inflation) have a significant effect on the index number variable

Simultaneous test results can be seen for IR parameter obtained that *p-value* < α = 5% which is 2.22 x 10^{-16} < 0.05, rejecting H_0 means that the predictors such as subsectors, CPI, and inflation altogether have a significant effect on the IR numbers. The results of the significance test as part of IR index number are shown in Table 10 as follows:

Table 10. Partial Test Results of IR Parameters

Parameter	p-value	Decision
Intercept Coefficient	0.305	-
X_1: Subsector (Fishery)		
Crops (C)	0.874	Accepted H_0
Horticultural Plants (HP)	0.045	Rejected H_0
Livestock (L)	0.462	Accepted H_0
People's Plantation Crops (PPC)	0.453	Accepted H_0
X_2: Consumer Price Index (CPI)	2.2 x 10^{-16}	Rejected H_0
X_3: Inflation	0.592	Accepted H_0

Significance: α = 5%

Table 10, the predictors used in the IR data model in the form of subsector variables of food crops, livestock, PPC, and inflation have no significant effect on the IR because they have a *p*-value > α. While the horticultural crop subsector and the CPI have a significant effect on the IR because it has a *p*-value < α.

4.3. Result of Parameter Estimation of IR Longitudinal Data

The results of estimation by using the REM model on the IR data in Table 11. Results of parameter estimation of IR data show that a positive parameter value means the direction of increase if there is an increase of one unit of the parameter and a negative value indicates the direction of decrease if there is a decrease of one unit of the parameter to the index number. Table 11, shows the estimation of the IR with REM are

$$\hat{y}_{i,t} = 3.555 + 2.722\ \mathrm{Sub}_{(FC,t)} + 0.931\ \mathrm{Sub}_{(HP,t)} - 1.096\ \mathrm{Sub}_{(L,t)}$$
$$+2.296\ \mathrm{Sub}_{(PPC,t)} + 0.967\ \mathrm{CPI}_{(i,t)} - 4.120\ \mathrm{Inflation}_{(i,t)} + c_i + \varepsilon_i$$

Table 11. Parameter Estimation of Individual Effect of IR Data

Commodity	**Constant (C_i)**
Household Consumption (HC Food)	4.003
Cost of Production and Addition of Capital Goods (CPACG Food)	-4.003
HC Horticultural	4.216
CPACG Horticultural	-4.216
HC PPC	4.169
CPACG PPC	-4.169
HC Livestocks	5.211
CPACG Livestocks	-5.211
HC Fishery	6.108
CPACG Fishery	-6.108

Based on the longitudinal IR model, the food crops subsector variable has a parameter coefficient of 2.722, HC of 0.931, and PPC of 2.296. If there is an increase in one unit of food crops, the IR number will increase by 2.722, if there is an increase in one unit of horticultural crops, the IR number will increase by 0.931 and if there is an increase in one unit of PPC, the IR number will increase by 2.296 compared to the fisheries subsector.

Meanwhile, the livestock subsector has a negative effect of -1.096, meaning that if there is a decrease of one unit from the livestock subsector, there will be a -1.096 decrease in the IR figure compared to the fishery subsector. The CPI has a positive effect of 0.967, while the It can be seen the constant coefficient for each cross-section is different. The positive value of the cross-section constant coefficient indicates the direction of increase if there is an increase of one unit of the commodity and the negative value indicates the direction of decrease if there is a decrease of one unit of the commodity to the index number. The equation of the IP model for each cross-section is as follows,

$$\hat{y}_{HC,t} = 3.555 + 2.722\ \textbf{Sub}_{(C,t)} + 0.931\ \textbf{Sub}_{(HP,t)} - 1.096\ \textbf{Sub}_{(L,t)} + 2.296\ \textbf{Sub}_{(PPC,t)} + 0.967\ \textbf{CPI}_{(i,t)} - 4.120\ \textbf{Inflation}_{(i,t)} + 4.003$$

$$\hat{y}_{CPACG,t} = 3.555 + 2.722\ \textbf{Sub}_{(C,t)} + 0.931\ \textbf{Sub}_{(HP,t)} - 1.096\ \textbf{Sub}_{(L,t)} + 2.296\ \textbf{Sub}_{(PPC,t)} + 0.967\ \textbf{CPI}_{(i,t)} - 4.120\ \textbf{Inflation}_{(i,t)} - 4.003$$

In the IB model with a constant coefficient for the *cross-section* effect for HC index and CPACG in the food crops subsector above, a constant value of is obtained successively 4.003 and -4.003. This shows that the HC of food crops has a positive effect, meaning that if there is an increase of one unit from the value of the KRT, the IB will increase by 4.003. CPACG for food crops has a negative effect, meaning that if there is a decrease of one unit from the CPACG value, the IB will decrease by -4.003.

a. Simultaneous Test Results on IB Longitudinal Data

The simultaneous significance test hypotheses are as follows:

H_0: Together, the predictors (subsector, Consumer Price Index (CPI), and inflation) have no significant effect on the index number variable

H_1: Together, the predictors (subsector, CPI, and inflation) have a significant effect on the index number variable

Simultaneous test results can be seen for IB parameter obtained p-value < α i.e. $2.2 \times 10^{-16} < 0.05$, then reject H_0 means that together the predictors in the form of subsector variables, CPI and inflation have a significant effect on the IB.

b. Partial Test Results on IB Longitudinal Data

The results of the partial parameter significance test of the IB index using the p-value and α 5% in the Table 12 which is the predictors used in the IT data, partially the food crops, horticultural crops, livestock, and smallholder crops (TPR) subsector have no significant effect on the IB because they have a higher p-value > α. The CPI has a significant effect on the IB, while the inflation has no significant effect on the IB model.

Table 12. Partial Test Results of IB Model

Parameter	P-Value	Decision
Intercept Coefficient	0.708	H_0 Accepted
X_1: Subsector (Fishery)		
Food Crops (FC)	0.702	H_0 Accepted
Horticultural Plants (HP)	0.896	H_0 Accepted
Livestock (L)	0.877	H_0 Accepted
People's Plantation Crops (PPC)	0.746	H_0 Accepted
X_2: Consumer Price Index (CPI)	2.2×10^{-16}	H_0 Rejected
X_3: Inflation	0.202	H_0 Accepted

4.4 Coefficient of Determination Value (R^2)

To determine the capability of the model to explain how much influence the predictors has on the response, use the R^2 and the adjusted R^2 values are as follows:

Table 13. The value of the coefficient of determination (R^2)

Model	Index	R-Square (R^2)	Adjusted R-Square (Adj-R^2)
Common Effect	IT	64.47	61.17
Model (CEM)	IB	68.16	65.13
Fixed Effect	IT	67.90	61.93
Model (FEM)	IB	86.40	83.82
Random Effect	IT	67.06	64.49
Model (REM)	IB	85.42	84.03

Table 13 shows that the value of the R^2 for the CEM, FEM, and REM models on longitudinal data of the IR and the IP. Based on the Adjusted R^2 values in the three models, the best model for IR and IP data modeling is the REM with the Adjusted R^2 value greater than CEM and FEM respectively 64.49% and 84.03%. So the REM model is very appropriate to be used to estimate IR and IP model. The R^2 value in the REM model of IR data of 67.06% can be classified as a strong criterion where the predictors used in the model can explain the IR value of 74.74%. The R^2 value in the IP model of 85.42% can be classified into very strong criteria where the predictor used in the model can explain the IP value of 85.42% and the rest is explained by variables not included in the model.

4.5 Comparison of BPS Index Figures and REM Model

A comparison of the real FER with the index numbers analyzed using the REM can be seen in Figure 2.

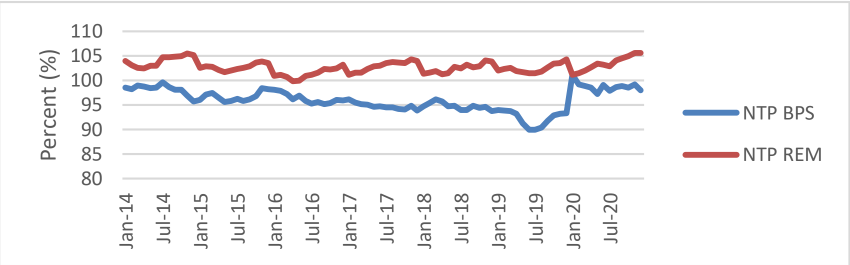

Figure 2. Comparison Graph of FER from BPS and REM

It can be seen that from January 2014 to December 2020, BPS FER has the lowest index of 89.90% which occurred in June 2019, and the highest of 101.09% which occurred in January 2020. While the FER with the REM model has the lowest index of 99.94% in May 2016 and the highest of 105.58% was in December 2020, both pattern similar directions. However, index value of FER REM is higher more than FER BPS.

5. CONCLUSION

The REM is an appropriate model for Farmer's Exchange Rate (FER) on the price index received by farmers (IR) and the index price paid by farmers (IP) in Aceh with 23 districts/town characteristics. The factors that have a significant effect on IR are food crops, livestock, horticultural crops, and smallholder plantations subsector variables, cultivation commodities, livestock products, vegetables, medicinal plants, large livestock, small livestock, and the Consumer Price Index (CPI) variable. While the factors that have a significant effect on IP are food crops subsector, horticultural crops and smallholder plantation crops, household consumption commodities, and CPI and inflation. By looking at the value of the R^2, 67.06% for IR and 85.42% for IP, both can be explained by predictors, respectively.

ACKNOWLEDGMENT

The authors would like to thank the Department of Statistics and Department of Economy Development, Faculty of Mathematics and Sciences, Faculty of Economy and Business, Institute for Research & Community Service Universitas Syiah Kuala (USK), Directorate of Research and Community Service Ristekdikti, 2022 in lector research scheme.

REFERENCES

Arya Fendha Ibnu Shina. (2019). Estimasi Parameter Pada Sistem Model Persamaan Simultan Data Panel Dinamis Dengan Metode 2 SLS GMM-AB. Media Statistika, 11(2) 2018: 79-91

Bank Indonesia. (2021). *Laporan Perekonomian Provinsi Aceh Februari 2021*. 92.

BPS. (2020). *Provinsi Aceh Dalam Angka 2020*. Badan Pusat Statistik Aceh. Banda Aceh.

BPS. (2022). *Provinsi Aceh Dalam Angka 2023*. Badan Pusat Statistik Aceh. Banda Aceh.

Caraka, R. E., & Yasin, H. (2018). *Spatial Data Longitudinal*. Jawa Timur. Wade Group.

Ekananda, M. (2016). *Analisis Ekonometrika Data Longitudinal edisi 2*. Penerbit Mitra Wacana Media, Jakarta.

Falah, B. Z., Mustafid, & Sudarno. (2016). *Model Regresi Data Longitudinal Simultan Dengan Variabel Indeks Harga Yang Diterima & Yang Dibayar Petani*. *5*, 611–621.

Greene, W. H. (2010). *Econometric Analysis 7 th ed*. Prentice Hall, New Jersey.

Gujarati, D. N., and Porter, D. C. (2012). *Dasar-dasar Ekonometrika edisi 5*. Penerbit Salemba Empat, Jakarta.

B.C. Sutradhar. 2011. Dynamic Mixed Models for Familial Longitudinal Data. Springer Series in Statistics. Springer Science.

Martina and Praza, R. (2018). *Analisis Tingkat Kesejahteraan Petani Padi Sawah Di Kabupaten Aceh Utara*. *3*(2), 27–34.

Miska, H. A. (2017). *Analisis Indeks Harga Yang Diterima Petani Dan Indeks Harga Yang Dibayar Petani Terhadap Nilai Tukar Petani Di Provinsi Aceh Menggunakan Generalized Linier Model*. *Skripsi*. Statistika, FMIPA USK.

Nirmala, A. R., Hanani, N., & Muhaimin, A. W. (2016). *Analisis Faktor Faktor yang Mempengaruhi Nilai Tukar Petani Tanaman Pangan di Kabupaten Jombang Analysis of Factors that Affecting Farmers Exchange Rage of Food Crops in Jombang*. *27* (2), 66–71.

N. Gregory Mankiw. (2015). Principles of Micro Economics. Cengage Learning.

Posit PBC. (2022). R Studio software: https://rstudio.com/products/rstudio/. R-tools technology Inc

R. Carter Hill, William E. Griffiths, and Guay C. Lim. (2011). Principles of Econometrics. Fourth Edition. John Wiley and Sons, Inc.

Rusono, N., Sunari, A., Candradijaya, A., Martino, I., & Tejaningsih. (2013). *Analisis Nilai Tukar Petani sebagai bahan penyusunan RPJMN Tahun 2015-2019*.

Tupamahu, M. K., Hanoeboen, B. R. A., Cliff, J., & Rijoly, D. (2021). *The Effect Of Inflation And Economic Structure Changes On Farmer Exchange Value (FER) In Eastern Indonesia*. *15*(1), 33–42.

Widarjono, A. (2013). *Ekonometrika Pengantar dan Aplikasinya.* Ekonisia. Yogyakarta.

Yongmiao Hong. (2020). Fondations of Modern Econometrics. A Unified Approach. World Scientific Publishing.