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A Comparative Analysis of First-Difference GMM and System GMM Approaches on Economic Growth

Ni Putu Nanik Hendayanti[1*], Maulida Nurhidayati[2], Siti Soraya[3], Suliadi Firdaus Sufahani[4], Muhaimin Ismoen[5]
[1]Faculty of Informatics and Computer, Institut Teknologi dan Bisnis STIKOM Bali, Indonesia
[2]Faculty of Economics and Islamic Business, Institut Agama Islam Negeri Ponorogo, Indonesia
[3]Faculty of Engineering, Universitas Bumigora, Indonesia
[4]Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, Malaysia
[5]School of Applied Sciences and Mathematics, Universiti Teknologi Brunei, Brunei Darussalam
nanik@stikom-bali.ac.id

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ABSTRACT

One of the critical causes of Indonesia's economic growth is the presence of the Covid-19 Pandemic which has resulted in a decline in public consumption and investment interest at the household level in each region. One of the areas with a decrease in the number of affected tourist visits is Bali Province. This is because Bali is an icon of Indonesia and is the best tourist destination. The purpose of this study is to obtain the most suitable model to model economic growth with the FD-GMM and Sys-GMM approach meeting the criteria of validity, consistency, and unbiased. This type of research is quantitative research with data sourced from the central statistical agency of Bali Province. The method used in this study is to compare the First-Difference Generalized Method of Moment (FD-GMM) and System Generalized Method of Moment (Sys-GMM) on economic growth data in Bali Province. The result of this study is the estimation of model parameters with the approach FD- GMM meets valid, consistent, and unbiased criteria. In contrast, the estimation of model parameters with the Sys-GMM meets validity and consistency criteria. However, the unbiased criteria are not met because the resulting model has a biased coefficient. The best model used to model Bali's economic growth data is the FD-GMM model. The above results imply that the existence of the population categorized as poor and the existence of the workforce are still a special concern. So, the suggestion in this study is that it is necessary to conduct a policy analysis from the Bali Provincial Government in dealing with poverty rates. Furthermore, employment management in Bali will be reorganized to be more directed and measurable in increasing the economic growth of Bali Province.

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A. INTRODUCTION

Economic growth is the problem of a country's economy in the long term towards a better state over a certain period. This can also be attributed to an increase in economic production capacity which is manifested as an increase in national income (Apriliansah, 2024). Economic growth is an indication of the success of a country's economic development which ultimately has an impact on the welfare of a region. Economic movements are characterized by the number of goods and services produced. The measure of economic growth is the Gross Regional Domestic Product (GDP) (Soraya et al., 2021). A stable and strong GDP can also increase

investor interest in investing. The factors that are estimated to be affected by GDP are the Human Development Index (HDI), Foreign Investment, Domestic Investment, Inflation, Net Exports, Labor Participation Rate, and Government Spending (Wicaksono, Maruddani, et al., 2023).

Economic growth in all countries has declined since the COVID-19 pandemic, especially in Indonesia. The cause of low economic growth in Indonesia is the decline in public interest in consumption and investment, both in the household and government sectors (Purnomo et al., 2023; Satoto, 2023). One of the regions in Indonesia with low public interest in consumption and investment after COVID-19 is Bali Province (Antara & Sumarniasih, 2024). Economic growth in Bali Province has become the center of attention after COVID-19, because it is one of the tourist destinations and a province contributing to national GDP (Atmojo & Fridayani, 2021; Surwandono & Yanuar, 2021). The number of tourism visitors in Bali has declined sharply, which has an impact on reducing the workforce in various tourism industries in Bali (Technica, 2016).

The COVID-19 pandemic is fatal because economic growth in Bali Province depends on the tourism sector. The contribution of tourism to economic growth in Bali Province is more than 50%, which is 76.61%. Meanwhile, the economic contributor to the agricultural sector is only 15% and industry 7.7%. This means that the main source of income for the people of Bali Province is centered on tourism. Figure 1 is the economic growth data of Bali Province in 2012-2023. Based on Figure 1, the economic growth of Regencies/Cities in Bali Province appeared stable in 2012-2019, but declined sharply in 2020 and 2021 until it reached negative growth and began to bounce back in 2022 and 2023.

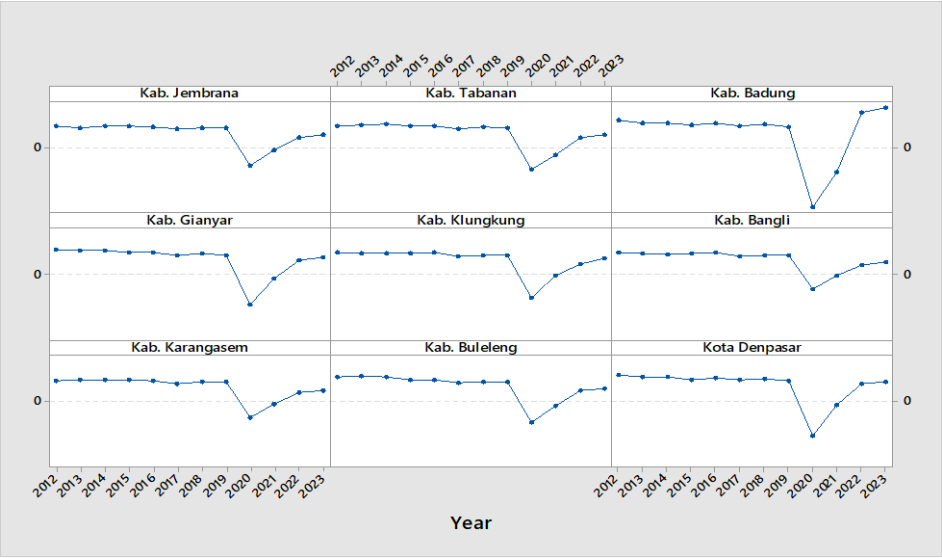

Figure 1. Economic Growth of Bali Province in 2012-2023

Several studies to obtain empirical results have been carried out related to economic growth, including by (Gunawan et al., 2023) With the results that the human development index, poverty level, agglomeration have a significant positive effect on economic growth. Then other research was carried out by (Wau et al., 2022) stated that increasing inflation, investment and labor force participation are able to encourage economic growth in the ASEAN Region.

Furthermore, research related to economic growth was also carried out by (Sherly Helma Putri & Helma, 2023). The result is that the human development index and state spending affect economic growth. All the studies that have been carried out use a multiple linear regression approach with panel data so that only static models are obtained.

In modeling economic growth data, of course, empirically many economic variables are dynamic, meaning that the value of a variable can be influenced by the value of other variables and influenced by the value of the variable in question in the previous or previous period (Gunawan et al., 2023). So the purpose of this research is to model economic growth with a dynamic panel data model. This is done because of the advantages of a dynamic panel data model that can overcome endogenous problems related to the use of variable lag dependencies. In contrast, in static panel data models, the use of dependent variable lag causes the estimation results to be biased and inconsistent. Since the early 1990s, the development of the panel data method has entered a new phase with the publication of Arellano and Bond (1991). Along with the popularity of time series models at the time, the idea of formulating a panel data model that included the lag of dependent variables as regressors in regression also emerged. This results in the emergence of endogenity problems, so that if the model is estimated with a fixed effect or random effects approach, it will produce biased and inconsistent predictors (Richard, 2022). To overcome this problem, Arellano and Bond proposed a method of approaching the moment or commonly called the Generalized Method of Moments (GMM) (Siddiqui & Ahmed, 2013).

Previous research related to this study is about a Dynamic Panel Data Regression Model with Estimation of Arellano-Bond Parameters on Economic Growth in Indonesia with the results of this study showing that this study produces a model of the variables that influence Indonesia's economic growth, HDI, and Government Expenditure (Asih et al., 2023). The following research on GMM is the research on inflation rate panel data using FD-GMM Arellano-Bond estimation and System Generalized Method of Moment (Sys-GMM) with the best dynamic panel data model results using SYS-GMM (Dendo & Suryowati, 2021). Nabilah and Setiawan researched "Modeling Indonesia's Economic Growth Using Dynamic Panel Data with the Generalized Method of Moment Arellano-Bond Approach," where the results of the study showed that the variables that had a significant influence on economic growth were foreign investment and government expenditure (Nabilah & Setiawan, 2016).

Based on the above background, the purpose of this study is to model economic growth using the dynamic panel data regression method with the FD-GMM Arellano-Bond approach and the System Generalized Method of Moment (Sys-GMM). So, the novelty of this study is the FD-GMM Arellano-Bond approach and the System Generalized Method of Moment (Sys-GMM) in modeling economic growth in Bali Province during Covid-19. This research is expected to help the government determine policies for tourism progress and economic improvement in Bali Province after the Covid-19 Pandemic.

B. METHODS

1. Data and Variables Study

The data in this study was obtained from the central statistical agency of Bali Province at https://bali.bps.go.id/. This type of research is a quantitativ research. The data collected is annual data taken from 2012-2023, capturing key economic trends before, during, and after the COVID-19 pandemic. The method used in this study is to compare the First-Difference Generalized Method of Moment (FD-GMM) and System Generalized Method of Moment (Sys-GMM) on economic growth data in Bali Province. The dataset covers all regencies and cities in Bali, ensuring geographic comprehensiveness, which include Jembrana Regency, Tabanan Regency, Badung Regency, Gianyar Regency, Klungkung Regency, Bangli Regency, Karangasem Regency, Buleleng Regency, Denpasar City. The variables involved in this study are shown in Table 1.

The primary reason for choosing FD-GMM and Sys-GMM is their ability to address endogeneity issues in dynamic panel regression models. In this study, there is a possibility that the independent variables are correlated with the error term, especially since the lagged dependent variable is included as a predictor. The FD-GMM method, developed by Arellano and Bond (1991), is designed to handle endogeneity by utilizing valid internal instruments. FD-GMM and Sys-GMM are particularly well-suited for dynamic panel data models that include both time-series and cross-sectional dimensions (e.g., regencies/cities in Bali). These methods can capture temporal dynamics, such as how current economic growth is influenced by past economic growth (lagged effect). This capability provides an advantage over static models, such as fixed effects or random effects, which are unable to account for temporal dynamics effectively.

FD-GMM employs differencing to remove unobserved fixed effects that could bias the estimations. Meanwhile, Sys-GMM, as developed by Blundell and Bond (1998), addresses the limitations of FD-GMM in cases where the instruments are weak. Sys-GMM combines information from two moments (levels and first-differences), resulting in more efficient estimations, particularly for datasets with a limited number of observations, such as in this study. Both methods leverage internal instruments derived from the data itself, which are more effective than external instruments that are often difficult to obtain and validate. The Sargan test performed in this study confirms that the instruments used are valid, thereby supporting the credibility of the estimation results. The dataset used in this study spans a relatively long period (2012–2023), making it likely that Bali's economic growth dynamics are influenced by historical factors. Therefore, dynamic panel data models employing FD-GMM and Sys-GMM are well-suited to depict the relationships among the variables analyzed in this study, as shown in Table 1 and Figure 2.

Table 1. Variable Study

Variable	Symbol	Definition	Units
Dependent	EG	Economic growth is an increase in the ability of an economy to produce goods and services. Economic growth is measured using Gross commodity product data or per capita output income (Wijaya, 2024).	Percent
Independent	PR	PR (Poverty Rate) is the percentage of the population that is below the Poverty Line (GK)(*Badan Pusat Statistik Provinsi Bali*,	Percent

Variable	Symbol	Definition	Units
		n.d.-a).	
	HDI	HDI (Human Development Index) explains how residents can access development results in obtaining income, health, and education(*Badan Pusat Statistik Provinsi Bali*, n.d.-b).	Percent
	LFPR	LFPR (Labor Force Participation Rate) is a measure used to compare the labor force and the working-age population(Alam S., 2006).	Percent
	P2	The Poverty Severity Index (P2) provides an overview of expenditure distribution among the poor. The higher the index value, the higher the expenditure inequality among the poor(*Badan Pusat Statistik Provinsi Bali*, n.d.-a).	Percent

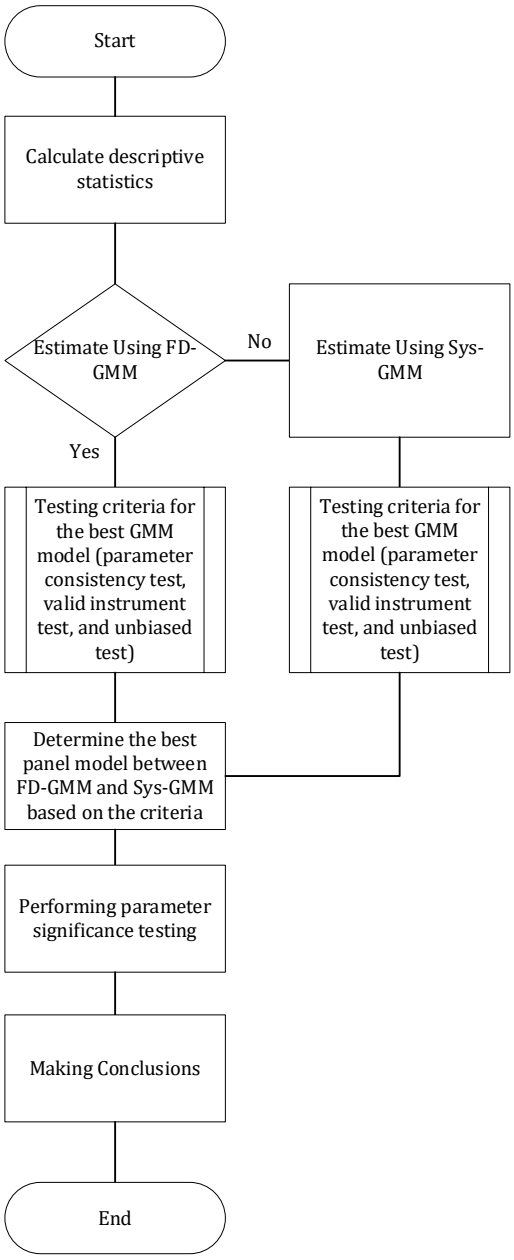

Figure 2. Analysis stages

Based on Figure 2, the analysis steps that will be carried out in this study are as follows:

a. Calculate descriptive statistics from economic growth data and the factors that influence it.
b. Evaluate dynamic panel data models with FD-GMM. (1) Conducting a parameter consistency test of the FD-GMM model with the Arellano-Bond test; (2) Conducting a valid instrument test using the Sargan test; and (3) Perform an unbiased test by calculating the parameters of *the pooled least square* and *fixed effect* models and comparing them with the estimator values obtained from the FD-GMM model.
c. Evaluate dynamic panel data models with Sys-GMM: (1) Conducting a Sys-GMM model parameter consistency test with the Arellano-Bond test; (2) Conducting a valid instrument test using the Sargan test; and (3) Carry out an unbiased test by calculating the parameters of *the pooled least square* and *fixed effect* models and comparing them with the estimator values obtained from the Sys-GMM model.
d. Determine the best panel model between FD-GMM and Sys-GMM based on the criteria of parameter consistency, valid instruments, and unbiased parameters.
e. Performing parameter significance testing as well as the best model interpretation.
f. Making Conclusions based on the best model obtained.

2. Dynamic Panel Data Regression Model

Dynamic panel data regression is a regression method that adds lag to dependent variables are makes independent variables. The equation of the model can be written in equation (1):

$$y_{i,t} = \delta y_{i,t-1} + \boldsymbol{x'}_{i,t}\boldsymbol{\beta} + u_{i,t} \tag{1}$$

With i values 1, 2, ..., n and t values 1, 2, ..., T. Index i shows the cross-section dimensions, while the t index shows the time series dimensions. If $y_{i,t}$ is a function of $u_{i,t}$ then $y_{i,t-1}$ is also a function of $u_{i,t}$. The regressor on the right side (explanatory endogenous) $y_{i,t-1}$ correlates with $u_{i,t}$. Static panel estimation models such as OLS in dynamic panel equation models will be biased and inconsistent(Baltagi, 2021).

3. First-Difference GMM (FD-GMM)

First, Difference can overcome the correlation problem between the lag of bound variables and the error component. This aims to eliminate the individual effects of μi on the model. By making the first difference in the dynamic panel model above it can be written as equation (2):

$$y_{i,t} - y_{i,t-1} = \delta\left(y_{i,t-1} - y_{i,t-2}\right) + \left(v_{i,t} - v_{i,t-1}\right) \tag{2}$$

With i values 1, 2, ..., n and t values 1, 2, ..., T. Therefore, the variable instrument matrix for the first differencing model is defined in equation (3):

$$Z_{diff} = \begin{bmatrix} [\Delta y_{i,2}] & 0 & \cdots & o \\ 0 & [\Delta y_{i,3}] & \vdots & o \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & [\Delta y_{i,T-2}] \end{bmatrix} \quad (3)$$

Parameter estimation by Arellano and Bond uses the GMM principle to obtain a consistent estimate. GMM estimator for δ to be obtained by minimizing the square function so that.

$$\hat{\delta} = \left[\left(N^{-1}\sum_{i=1}^{N} Z_i \, \Delta y'_{i,t-1}\right)\widehat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_i \, \Delta y_{i,t-1}\right)\right]^{-1}\left[\left(N^{-1}\sum_{i=1}^{N} Z_i \, \Delta y'_{i,t-1}\right)\widehat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_i \, \Delta y_i\right)\right] \quad (4)$$

So, based on the moment of condition and the variable instrument matrix of the first differencing model above, an estimate is obtained, namely:

$$\hat{\delta}_{diff} = \left[\left(N^{-1}\sum_{i=1}^{N} \Delta y'_{i,t-1} \, Z_{diff}\right)\widehat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_{diff} \, \Delta y_{i,t-1}\right)\right]^{-1}\left[\left(N^{-1}\sum_{i=1}^{N} \Delta y'_{i,t-1} \, Z_{diff}\right)\widehat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_{diff} \, \Delta y_{i,t}\right)\right] \quad (5)$$

$\hat{\delta}$ is a consistent estimate for any W weight matrix. This estimate was obtained by conducting the GMM Arellano-Bond one step consistent estimator estimation method. So, to get a consistent estimate for δ(a two-step efficient estimator), substituting the weight $\widehat{W}$ with $\widehat{\Lambda}^{-1}$, so that the results of the GMM Arellano-Bond estimate are as follows:

$$\hat{\delta}_{diff} = \left[\left(N^{-1}\sum_{i=1}^{N} \Delta y'_{i,t-1} \, Z_{diff}\right)\widehat{\Lambda}^{-1}\left(N^{-1}\sum_{i=1}^{N} Z'_{diff} \, \Delta y_{i,t-1}\right)\right]^{-1}\left[\left(N^{-1}\sum_{i=1}^{N} \Delta y'_{i,t-1} \, Z_{diff}\right)\widehat{\Lambda}^{-1}\left(N^{-1}\sum_{i=1}^{N} Z'_{diff} \, \Delta y_{i,t}\right)\right] \quad (6)$$

The equation above is an unbiased, consistent, and efficient estimate of the Arellano-Bond GMM.

4. System Generalized Method of Moment (Sys-GMM)

The System Generalized Method of Moments estimation method from Blundell Bond (Sys-GMM) estimates the equation system using a combination of the first difference moment and the level condition moment. The GMM estimator δ obtained by minimizing the squared function weighted J(δ) as in equation (7) (Arellano & Bond, 1991).

$$\begin{aligned} \frac{\partial J(\hat{\delta})}{\partial \hat{\delta}} &= 2\left[\left(N^{-1}\sum_{i=1}^{N} \varphi'_{i,-1} Z_{sys}\right)\hat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_{sys}\varphi_i\right)\right] \\ &+2\left[\left(N^{-1}\sum_{i=1}^{N} \varphi'_{i,-1} Z_{sys}\right)\hat{W}\left(N^{-1}\sum_{i=1}^{N} Z'_{sys}\varphi_i\hat{\delta}\right)\right] = 0 \end{aligned} \quad (7)$$

Then, a *one-step consistent estimator* is obtained for the system, namely

$$\hat{\delta} = \left[\left(N^{-1} \sum_{i=1}^{N} \varphi_{i,-1}^{'} Z_{sys} \right) \hat{W} \left(N^{-1} \sum_{i=1}^{N} Z_{sys}^{'} \varphi_i \right) \right]^{-1} \left[\left(N^{-1} \sum_{i=1}^{N} \varphi_{i,-1}^{'} Z_{sys} \right) \hat{W} \left(N^{-1} \sum_{i=1}^{N} Z_{sys}^{'} \varphi_i \right) \right] \tag{8}$$

So, a *two-step efficient Blundell and Bond* GMM System estimator is produced, which is as follows:

$$\hat{\delta} = \left[\left(N^{-1} \sum_{i=1}^{N} \varphi_{i,-1}^{'} Z_{sys} \right) \hat{\psi}^{-1} \left(N^{-1} \sum_{i=1}^{N} Z_{sys}^{'} \varphi_{i,-1} \right) \right]^{-1} \left[\left(N^{-1} \sum_{i=1}^{N} \varphi_{i,-1}^{'} Z_{sys} \right) \hat{\psi}^{-1} \left(N^{-1} \sum_{i=1}^{N} Z_{sys}^{'} q_i \right) \right]. \tag{9}$$

The two-step efficient Blundell and Bond GMM System Estimator estimation results in equation (9) above are more efficient than the one-step efficient Arellano and Bond Estimator.

C. RESULT AND DISCUSSION

1. Data

In this study, the data used be secondary data collected through https://bali.bps.go.id/ from 2012 to 2023. The results of each variable's descriptive statistical test are shown in Table 2.

Table 2. Descriptive Statistics of Research Data

	PR	HDI	LFPR	P2	EG
Min	1.52	62.95	67.36	0.01	-16.55
Max	7.44	84.73	88.06	0.36	11.29
Mean	4.76	73.42	76.65	0.11	4.08
StDev	1.54	5.62	4.64	0.06	4.36

Economic Growth is improving an economy's ability to produce goods and services. Economic growth is measured using Gross commodity product data or per capita output income(Wijaya, 2024). The minimum EG value of -16.55 indicates that economic growth has experienced a considerable decline. This decline occurred in 2020 and 2021, when the COVID 19 pandemic occurred, which resulted in the cessation of various economic activities, including the economy in Bali Province, which relies on the tourism sector. However, this situation then began to improve as the pandemic condition subsided.

PR (Poverty Rate) is the percentage of the population that is below the Poverty Line (GK) (*Badan Pusat Statistik Provinsi Bali*, 2024). The results of descriptive statistics show that the percentage of poor people has an average value of 4.76%, which means 4.76% of the total population in Regencies/Cities in Bali Province is below the poverty line. This is the percentage of people with less than what is considered enough to meet basic needs such as food, housing, and clothing. This figure shows that the poverty rate is relatively low in the population. Although several people still face poverty, this percentage indicates that most of the population

can access basic needs adequately. A higher poverty rate reduces household consumption, weakening economic activity. In Bali, where tourism dominates, reduced household spending negatively affects service demand.

HDI (Human Development Index) explains how the population can access development results in obtaining income, health, and education (Central Statistics Agency of Bali Province, 2024). Average grade The HDI of 73.42% shows that Regencies/Cities in Bali Province can achieve a relatively high level of human development. The higher the HDI value, the better the population's health, education, and living standards. HDI reflects access to education and health services, which influence workforce productivity. A decline in HDI could limit economic recovery post-pandemic.

LFPR (Labor Force Participation Rate) is The size used to know the Comparison between the labor force and the working-age population (Alam S., 2006). Refers to the percentage of the labor force (the number of people working or looking for work) of the total working-age population (usually those aged 15 years and above) within a given country or region. This means that of the working-age population in the country or region, around 76.65% of them are economically active, either working or looking for work. A high LFPR indicates potential economic activity, but in Bali, its impact is contingent on tourism-driven job opportunities.

The Poverty Severity Index (P2) provides an overview of expenditure distribution among the poor. The higher the index value, the higher the expenditure inequality among the poor (Central Statistics Agency of Bali Province, 2024). The average value of P2 is 0.11%, indicating that poverty's severity is relatively low. This means that people who live below the poverty line, although they exist, are close to below the poverty threshold in an extreme way. This means most individuals below the poverty line may be near or slightly below the poverty threshold. A high P2 indicates unequal resource distribution among the poor, amplifying economic disparities and limiting inclusive growth.

2. Model Estimation with GMM Difference Approach

First-Difference GMM uses the Arellano-Bond approach (Firdaus, 2020). The GMM First Difference model is said to be appropriate when it meets the criteria of a valid, consistent, and unbiased instrument. The results of the model estimation with the First Difference GMM approach are shown in Table 3.

Table 3. Parameter Estimation with FD-GMM Approach

Variable	Estimate	Std. Error	Statistics	P-value
Lag(EG)	0.399	0.078	5.126	0.000
PR	4.307	1.545	2.788	0.005
HDI	-0.124	0.670	-0.185	0.853
LFPR	0.164	0.306	0.536	0.592
P2	-7.698	21.341	-0.361	0.718
AR(1) test			-2.540	0.011
AR(2) test			-1.374	0.169
Sargan test			8.758(54)	1.000

Criterion-valid instruments can be tested using the Sargan Test. The Sargan test determines the validity of instrument variables that exceed the estimated parameters (overidentifying

restriction condition). The valid instrument of Sargan test jigs fails to reject the null hypothesis (Firdaus, 2020). The hypothesis null of the instrument test is valid. Ini is the condition of over identifying restriction in the valid model estimate. The results of the Sargan test in Table 3 show that the p-value is 1.000>0.05, so it fails to reject the null hypothesis, and it is concluded that it is an over identifying restriction condition in the valid model estimation, which means that the criteria for a valid instrument are met.

The second criterion that must be met in the FD-GMM test is consistency. The criterion is consistent; this can be tested using the Arellano-Bond test. The Arellano-Bond test was carried out to determine the correlation between one residual component and another in the FD-GMM model. The estimator will be consistent when the m1 statistic rejects the hol hypothesis and the m2 statistic fails to reject the null hypothesis (Firdaus, 2020). The results of the autocorrelation test in Table 3 show that the test results of the AR(1) test result obtained a value of prob=0.011<0.05 so that H is rejected$_0$, and the results of the AR(2) test obtained a prob value = 0.169>0.05 so that it failed to reject H_0. This shows that the estimation with the FD-GMM approach is consistent, and no autocorrelation occurs.

Table 4. Estimation Parameter fixed effect model and pooled least square model

Model	Variable	Estimate	Std. Error	Statistics	P-value
fixed effect	lag(EG)	0.389	0.121	3.220	0.002
	PR	3.715	1.272	2.920	0.004
	HDI	-0.193	0.382	-0.505	0.615
	LFPR	0.166	0.172	0.967	0.336
	P2	-5.868	9.052	-0.648	0.519
pooled least square	(Intercept)	-21.286	23.424	-0.909	0.366
	lag(EG)	0.428	0.104	4.127	0.000
	PR	0.713	0.700	1.019	0.311
	HDI	0.198	0.203	0.974	0.333
	LFPR	0.067	0.124	0.541	0.590
	P2	2.682	8.939	0.300	0.765

A good estimator is an unbiased estimator. In a dynamic panel model, the estimator is said to be unbiased if the estimator value of the model is in between the fixed effect model and pooled least square models (Firdaus, 2020). The results of the estimation are shown in Table 4. Based on Table 3 and Table 4, it is known that the lag coefficient (EG) in the FD-GMM model is 0.399, the lag coefficient (EG) in the fixed effect model is 0.389, and the lag value (EG) in the Pooled Least Square model is 0.428. Based on these results, the coefficient value of the lag(EG) of the FD-GMM model of 0.399 is between the lag coefficient(EG) of the fixed effect model and the lag coefficient (EG) of the Pooled Least Square model (0.389<0.399<0.428) which means that the model estimate is not biased.

3. Model Estimation with System GMM Approach

The system GMM is an approach based on the reforms carried out by Blundell and Bond (1998) (Firdaus, 2020). This System GMM model is appropriate when it meets the criteria of valid, consistent, and unbiased instruments. The results of the model estimation with the Difference GMM approach are shown in Table 5. The criteria for a valid instrument can be tested using the Sargan test. The results of the Sargan test in Table 5 show that the p-value is

1.000>0.05, so it fails to reject the null hypothesis, and it is concluded that it is an overidentifying restriction condition in the valid model estimation, which means that the criteria for a valid instrument are met.

Table 5. Parameter Estimation with the Sys-GMM Approach

Variable	Estimate	Std. Error	Statistics	P-value
Lag(EG)	0.337	0.027	12.346	0.000
PR	-0.467	0.267	-1.749	0.080
HDI	-0.190	0.142	-1.332	0.183
LFPR	-0.100	0.087	-1.137	0.255
P2	-3.957	3.464	-1.142	0.253
AR(1) test			NaN	NA
AR(2) test			-1.180	0.238
Sargan test			9.00(54)	1.000

The second criterion that must be met on the Sys-GMM test is consistency. This consistent criterion can be tested using the Arellano-Bond Test. The Arellano-Bond test was carried out to determine the correlation between one residual component and another in the FD-GMM model. The results of the autocorrelation test in Table 5 show that the test results of the AR(2) test results obtained a prob value = 0.169>0.05 so that it failed to reject H_0. This shows that the estimation with the FD-GMM approach is consistent, and no autocorrelation occurs. A good estimator is an unbiased estimator. Based on Table 3 and Table 5, it is known that the lag coefficient (EG) in the Sys-GMM model is 0.337, the lag coefficient (EG) in the *fixed effect model* is 0.389, and the lag value (EG) in the *Pooled Least Square* model is 0.428. Based on these results, the coefficient value of the lag (EG) of the Sys-GMM model of 0.337 is less than the coefficient *of the fixed effect* model of 0.389, which means the estimated bias model.

4. Comparison of Model Estimation with FD-GMM and Sys-GMM Approaches

Table 6. Comparison of FD-GMM and Sys-GMM Methods

Criterion	FD-GMM	Sys-GMM
Valid Instruments (Sargan)	Valid	Valid
Consistent	Consistent	Consistent
Unbiased	Unbiased	Bias

Based on Table 6, the best model for modeling economic growth is the FD-GMM dynamic panel regression model because the FD-GMM model meets all the criteria of the model. This study's results contradict previous research, which showed that Sys GMM gave better results than FD-GMM in modeling the female labor force and economic growth (Yıldırım & Akinci, 2021).

5. Significance Testing and Interpretation of best Model results

The best model used to model the economic growth of Bali Province is the FD-GMM dynamic panel regression model. The best model is created based on the FD-GMM equation model shown in Equation (10).

$$EG_{i,t} = 0{,}399 * EG_{i,t-1} + 4{,}307 * PR_{i,t} - 0{,}124 * HDI_{i,t} + 0{,}164 * LFPR_{i,t} - 7{,}698 * P2_{i,t} + e_{i,t} \quad (10)$$

From the model in Equation (10) and the results of the parameter significance in Table 2, it can be explained as follows:

a. EG(-1) has a prob=0.000<0.05 value, so it can be concluded that lag(EG) has a significant effect on the EG of districts/cities in Bali Province for the 2012-2023 period. The value of the EG coefficient (-1) shows a value of 0.399, indicating that EG(-1) positively influences EG. The coefficient value of 0.399 explains that if economic growth in the previous period increased by 1%, then economic growth in this period will increase by 0.399%, assuming other variables are fixed/unchanged. The results of this research follow research by Khan (2008), which states that the short-term economic growth in the previous period affects the current economic growth in Pakistan (Khan, 2008). This result appears counterintuitive and warrants further exploration.
b. PR (Poverty Rate) has a prob=0.005<0.05 value, so it can be concluded that PR significantly affects the EG of districts/cities in Bali Province for 2012-2023. The value of the PR coefficient shows a value of 4.307, which explains that if the percentage of the poor population increases by 1%, economic growth will increase by 4.307%, assuming other variables are fixed/unchanged. It is likely that government interventions targeting poverty alleviation (e.g., subsidies or income assistance) indirectly stimulate economic activity by increasing household consumption. Future research could explore the channels through which poverty-related policies contribute to economic recovery, particularly in the context of Bali's tourism-driven economy.
c. HDI (Human Development Index) has a prob value = 0.853>0.05, so it can be concluded that HDI does not significantly affect the EG of districts/cities in Bali Province for the 2012-2023 period. The value of the HDI coefficient shows a value of -0.124, which explains that if the human development index increases by 1%, then economic growth decreases by 0.124%, assuming other variables are fixed/unchanged. This research results align with Tamrin et al., which concluded that HDI did not affect EG in the East Kutai District (Tamrin et al., 2022). This result suggests that improvements in HDI indicators, such as education and health, may not translate directly into short-term economic gains in Bali. However, in the long term, HDI improvements could enhance workforce productivity and competitiveness, especially in sectors like tourism and services. Further investigation is needed to understand this dynamic fully.
d. LFPR (Labor Force Participation Rate) has a prob=0.592>0.05 value, so it can be concluded that LFPR does not significantly affect the EG of districts/cities in Bali Province for the 2012-2023 period. The value of the LFPR coefficient shows a value of 0.164, which explains that if the Labor Force Participation Rate increases by 1%, economic growth will increase by 0.164%, assuming other variables remain unchanged. This finding indicates that while the labor force in Bali is active, the quality of employment and job opportunities, particularly in the tourism sector, may not fully leverage this potential. Policy efforts to create more high-value jobs in the region could amplify the positive effects of labor force participation.

e. P2 (Poverty severity index) has a prob value = 0.718>0.05, so it can be concluded that the poverty severity index does not significantly affect the EG of districts/cities in Bali Province for the 2012-2023 period. The value of the Poverty Severity Index coefficient shows a value of -7.698 which explains that if the Poverty Severity Index increases by 1%. Economic growth will decrease by 7.698%, assuming other variables are fixed/unchanged. The poverty severity index (P2) has a negative and insignificant impact on economic growth, reflecting the challenges of income inequality among the poor. Addressing these disparities is crucial for fostering inclusive economic development in Bali.

The results of this study show that the estimation of model parameters with the FD-GMM approach meets the criteria of validity, consistency, and unbiased. Then, the estimation of model parameters with the Sys-GMM approach meets valid and consistent criteria. This seems different from the research Richard (2022) and Yıldırım & Akinci (2021) which showed that Sys GMM gave better results than FD-GMM in modeling the female labor force and economic growth. The research we conducted showed that the First-Difference Generalized Method of Moment (FD-GMM) model is the best model in analyzing economic growth with a parameter measure reflected by the percentage of poverty rate, Human Development Index, Labor Force Participation Level, Poverty Severity Index, which is able to meet valid, consistent and impartial criteria, this is in line with the research that has been conducted (Dendo & Suryowati, 2021). The weakness of our study is that we have not evaluated the suitability of the data using RMSE values. In addition, studies have not focused on datasets with similar trends during the pandemic period to build comparable analyses. However, we conducted the study by utilizing: the Sargan Test Instrument to test valid parameter criteria, fixed effect and pooled least square to indicate bias conditions and using the Arellano-Bond Test test to test the consistency of the model, as has been done (Firdaus, 2020).

D. CONCLUSION AND SUGGESTIONS

Based on the results of the study, it was concluded that the estimation of model parameters with the FD-GMM approach met the criteria of validity, consistency, and unbiased. Then, the estimation of model parameters with the Sys-GMM approach meets valid and consistent criteria. However, the unbiased criteria must still be met because the resulting model has a biased coefficient. So, the best model used to model Bali's economic growth data is the FD-GMM model with significance tests and model interpretation showing that economic growth in the previous period and poverty rates have a positive and significant influence on economic growth. In addition, the Labor Force Participation Rate has a positive and insignificant effect on economic growth. Meanwhile, the Human Development Index has a negative and insignificant effect on economic growth.

The conclusion above implies that the existence of the population categorized as poor and the existence of the workforce is still a special concern and further studies are needed related to the contribution in improving the economy in the Bali Provincial government. So, the suggestion in this study is that it is necessary to conduct a policy analysis from the Bali Provincial Government in dealing with the poverty rate. Next, labor management in Bali to be

reorganized to be more directed and measurable in increasing the economic growth of Bali Province. This is because Bali is one of the regions with workers from various regions throughout Indonesia.

Future research should consider evaluating the goodness of data fit using RMSE values, rather than relying solely on model fit metrics. Additionally, studies could focus on datasets with similar tendencies during pandemic periods to build comparable analyses. Incorporating variables such as tourist arrivals, government policy expenditures, and currency exchange rates would provide a more holistic understanding of Bali's economic growth. The complexity of interactions between internal and external variables could also be better analyzed through advanced multivariate techniques, such as structural equation modeling (SEM) or cross-sectoral approaches. Furthermore, employing granular temporal analyses, such as quarterly or monthly data, could yield deeper insights into the immediate and lagging effects of policy interventions and global economic fluctuations on Bali's economy.

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