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Aggregate supply and demand determinants of economic growth in West Sumatra, Indonesia: A dynamic panel approach

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ABSTRACT

This study investigates the determinants of economic growth in West Sumatra Province over the period 2011–2023, focusing on both supply- and demand-side factors. A dynamic panel regression model is employed using the Generalized Method of Moments approach, which is particularly suitable for addressing potential endogeneity issues and capturing temporal dynamics in panel data analysis. The explanatory variables include aggregate supply-side factors, namely lagged economic growth, investment, labor, technology, and the Human Development Index (HDI), as well as aggregate demand-side factors, consisting of household consumption, government expenditure, and net exports. The estimation results reveal that, on the supply side, previous economic growth, investment, technology, and HDI exert a positive and statistically significant impact on regional economic growth, while labor does not show a significant effect. On the demand side, household consumption and government expenditure are found to have significant positive influences, whereas net exports are not statistically significant, reflecting the limited contribution of export activities to the regional economy. These findings highlight the dual importance of supply-side improvements and demand-side reinforcement in sustaining economic growth.

Contribution/ Originality: Many previous studies have examined regional economic growth, but research that simultaneously analyzes the determining factors from the aggregate supply and demand sides remains relatively limited, especially in the context of West Sumatra Province, Indonesia. This study offers an original contribution by integrating both approaches using a dynamic panel regression method, thereby providing a more comprehensive understanding of the determinants of economic growth at the regional level.

1. INTRODUCTION

An ideal pattern of economic growth should reflect a sustainable increase in a region's production capacity, which directly contributes to the improvement of societal welfare. In the context of regional development, economic growth should not merely be assessed by the magnitude of the Gross Regional Domestic Product (GRDP), but also by the quality of that growth, specifically, whether it can create employment opportunities, reduce poverty, enhance

productivity, and promote equitable distribution of development outcomes across regions and populations (Mora & Olabisi, 2023). Sound economic growth should also be accompanied by structural transformation, namely a shift in contributions from low-value-added sectors toward more productive and innovation-based sectors such as manufacturing and modern services (Jump & Kohler, 2022).

Furthermore, the desired condition of economic growth should demonstrate stability over time and not be overly vulnerable to external shocks such as global crises, natural disasters, or commodity price fluctuations (Liu, Ibrahim, & Chin, 2025). Regions that successfully build a robust economic structure supported by high-quality human resources, adequate infrastructure, and a conducive investment climate tend to possess stronger economic resilience and more inclusive growth. Therefore, the direction of economic development should not only aim for short-term growth targets but also strengthen long-term foundations by integrating both aggregate supply and demand sides within the regional economic system (Ma, Tam, Le, & Osei-Kyei, 2023).

However, the reality on the ground does not always align with the ideal conditions described earlier (Clarke, Xu, & Zou, 2024; Li et al., 2023). Not all regions are capable of achieving high-quality and sustainable economic growth. On the aggregate supply side, constraints such as low levels of productive investment, limited adoption of technology, stagnation in labor quality, and weak human development hinder regional production capacity. Meanwhile, on the aggregate demand side, unstable household consumption growth, ineffective government spending, and the limited contribution of regional exports weaken the overall demand for goods and services. This imbalance and lack of synergy between supply and demand factors create a fragile economic structure, ultimately impeding long-term economic transformation. These conditions are clearly reflected in the economic dynamics of West Sumatra Province over the past decade.

Theoretical models often fail to perfectly match real-world situations, which Mania and Rieber (2019) and Eftimoski and Josheski (2021) examined in their 2019 research, along with their 2021 findings. Regions throughout the nation lack the necessary elements to reach both sustainable and quality economic expansion. Production capacity in regions suffers from supply-side limitations that include inadequate investment levels, slow technological adoption, deteriorating labor standards, and insufficient human development. The total demand for goods and services decreases because of unstable household consumption patterns, ineffective government spending, and minimal regional export contributions. The mismatch between supply and demand creates an unstable economic framework that blocks sustainable economic evolution. The economic patterns in West Sumatra Province during the past decade demonstrate these conditions clearly.

West Sumatra's economic growth has exhibited a consistently declining trend over the past decade. In 2011, the province recorded a growth rate of 6.34%, but this gradually declined to only 5.05% by 2019, indicating structural deceleration even before the onset of the COVID-19 pandemic. When the pandemic struck in 2020, the province's economy contracted by -1.61%, which was slightly better than the national contraction. However, its recovery has lagged behind the national average. In 2022, West Sumatra's growth reached only 4.36%, well below the national Figure 1 of 5.31%, placing it 27th out of 34 provinces. Although there was a slight rebound in 2023, the province still fell short of the national average. Furthermore, in 2024, West Sumatra's economic growth declined again. These facts indicate the presence of structural issues in the regional economy, such as dependency on low-value-added sectors and weak economic transformation, which have caused the province to fall behind in the race for regional economic acceleration.

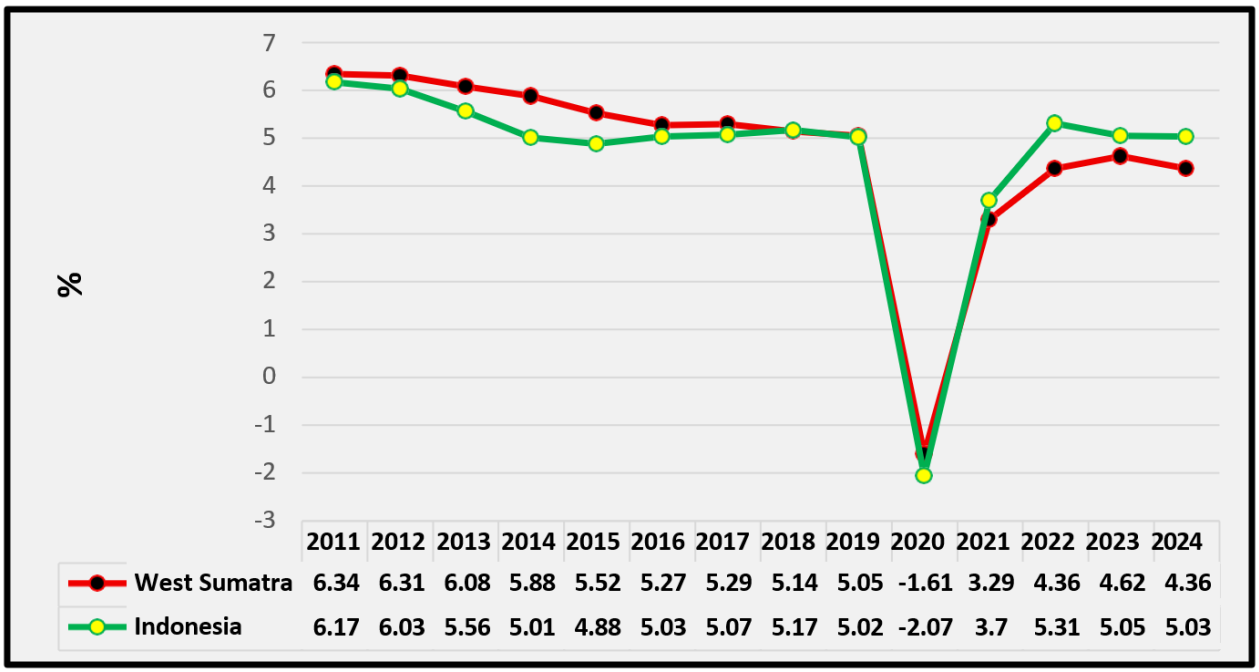

Figure 1. Economic growth of West Sumatra and Indonesia from 2011 to 2024.

Source: Central Bureau of Statistics (2024).

Efforts have been made to analyze the very internal factors, such as human capital and domestic investment, as well as external factors like trade openness and the inflow of capital, which can foster economic growth. A case in point is the research conducted by Okunade, Alimi, and Olayiwola (2022), which brings to the forefront the role of human capital formation, defined in terms of education and health, on the economic growth in Sub-Saharan African countries. The research indicates that human capital has a significant positive impact on growth over the long haul and underscores the importance of government investment in the social sector. However, this study overlooks the interplay of various economic factors by focusing on a single sector.

Zeng (2023) felt that the impact of Foreign Direct Investment (FDI) and international trade on Vietnam's economic growth had been less researched. The study also found that an open and integrated economy in developing countries leads to development. However, the study gives scant recognition to determinant characteristics at home, such as the quality of work skills, utilization of local technology, and government expenditure, which lead to inclusive and sustainable development.

The research of Gonzales (2023) based on South Eastern Europe countries, the Generalized Moment Method (GMM) was used, and it was found that investment, labor, and human capital are important determinants of economic growth. The results of this investigation advocate for both external and domestic factors. The discussion is far from the viewpoint of aggregate supply and demand; the time lag effect of policies on the rate of growth is not taken into account.

The two studies cited above, influenced and affect by Tipayalai (2020) examination on government spending in developing countries, have concluded that government expenditures directed toward productive sectors, such as infrastructure and education, have a positive effect on economic growth. However, these studies tend to be sectoral in nature and do not fully capture the dynamic interactions among macroeconomic variables.

Sarker (2024) contends that human capital and trade openness are important growth determinants in the Asian region but are found to vary in their level of influence across different countries. What this implies is that sensitivity to growth variables is highly contextual, demanding a flexible methodology and space approach. Meanwhile, Lugina, Mwakalobo, and Lwesya (2022) extended classical growth theory with respect to Arab states,

focusing on sustainable development policies and flexible economic structures. Although made from a long-term perspective, it sheds less light on the regional interplay between aggregate supply and demand variables.

Overall, these studies still have differing points but mainly agree with the fact that economic growth heavily depends on internal factors such as human capital, investment, and public spending, and external factors such as trade and FDI. However, most of them are limited in taking a simultaneous approach to aggregate supply and aggregate demand, especially at subnational or provincial levels in developing countries like Indonesia.

To overcome these limitations, a wider and more integrative approach is needed, which considers not only the supply side (e.g., human capital, investment, labour, and technology) but also the demand side (e.g., household consumption, government expenditure, and net exports) of the economy. It is important to note that aggregate demand is the main driver for production incentives, as higher demand will lead to an increase in production capacity in the real sector. Hence, the dual aggregate approach to economic growth will be a better reflection of the regional economic dynamics.

Based on the background above, this research aims to examine how much the factors on the supply side (Economic growth, capital, labor, technology, and human development if left unchanged, how they would have affected the economic growth of West Sumatra Province) and the factors on the demand side (Household consumption, government expenditure, and net exports) influence regional economic growth during the specified period.

2. LITERATURE REVIEW

The long-term rise in a nation's production capacity, which results from the expansion of production factors, is highlighted by the theory of economic growth from the aggregate supply perspective. According to this theory, economic growth occurs when physical capital accumulation, labor supply and quality, and technological development all increase. This viewpoint primarily focuses on how improvements in the inputs available within an economic system can continuously enhance the production of goods and services.

The most classic model within this approach is the Solow-Swan growth model, which assumes an aggregate production function in the form of a Cobb-Douglas function as follows:

$$Y(t) = A(t) \cdot K(t)^{\alpha} \cdot L(t)^{1-\alpha} \quad (1)$$

Where:

Y(t) = Output or real GDP at time t.

K(t) = Stock of physical capital.

L(t) = Quantity of labor.

A(t) = Technological progress (Total Factor Productivity).

$\alpha \in (0,1)$ = Output elasticity with respect to capital.

In this model, increases in output (economic growth) can occur through three main channels: capital accumulation (K), labor expansion (L), and technological progress (A). However, since capital accumulation and labor experience diminishing returns to scale, in the long run, only technological progress A(t) can drive sustainable growth in output per capita.

To analyze per capita growth, the model is often expressed in intensive form:

$$y = A \cdot k^{\alpha} \quad (2)$$

With:

y = Y/L = Output per labor. k = K//L = Capital per labor.

In the long run, the growth of y (Output per worker) will depend solely on the growth of A, making technological progress the primary determinant of long-term economic growth.

As an extension of the Solow-Swan model, which treats technological progress as exogenous (originating outside the economic system), endogenous growth models were developed, notably by Romer (1990). In these models, technological progress is no longer considered an external factor but is generated within the economic system itself through activities such as:

- Investment in human capital (Education and training).
- Research and development (R&D).
- Learning by doing.
- Knowledge spillover effects.

Romer's model, for instance, states that economic growth can be expressed as:

$$Y = A \cdot K^{\alpha} \cdot H^{\beta} \quad (3)$$

Where:

H = Human capital.

A = The result of accumulated knowledge through investment in R&D and education.

$\alpha + \beta \geq 1$, indicates the possibility of increasing returns to scale.

This model emphasizes that the government plays a vital role in promoting long-term growth through education policies, innovation incentives, and investment in sectors that generate positive externalities for economic productivity.

In a regional context such as West Sumatra Province, the aggregate supply theory is relevant for assessing how far economic growth is supported by the availability and quality of production factors. Low investment, technological stagnation, or limited labor quality can be major constraints to increasing regional output. Therefore, strengthening the supply structure through increased capital, technology, and human resource quality is a necessary condition for promoting long-term sustainable growth at the regional level.

The theory of economic growth from the perspective of aggregate demand begins with the view that an economy's output growth can be stimulated by increasing the total demand for goods and services. Aggregate demand itself consists of four main components.

$$AD = C + I + G + (X - M) \quad (4)$$

With:

C = Household consumption.

I = Investment (Expenditure by the business sector).

G = Government expenditure.

X = Exports.

M = Imports.

This theory is rooted in the Keynesian school of thought, which emphasizes that aggregate demand plays a central role in determining the level of economic activity, especially in the short term. When aggregate demand increases, producers respond by increasing production and employment, thereby driving economic growth. Conversely, a decline in aggregate demand can lead to a recession.

Based on this approach, economic growth can be achieved if aggregate demand increases sustainably, thereby encouraging an expansion of production capacity. This is often referred to as growth driven by demand. In situations where production capacity is underutilized, an increase in aggregate demand will directly trigger output growth. However, in the long run, demand must be balanced with production capacity to prevent inflation.

In a regional context, components of aggregate demand such as household consumption and government spending become highly significant because they can create a multiplier effect in real sectors such as trade, construction, and services. However, weak net export contributions and low household purchasing power can hinder growth acceleration. Therefore, policies aimed at

boosting aggregate demand through strengthening consumption, optimizing regional spending, and improving export performance are essential strategies to promote regional economic growth.

2.1. Previous Research

Several studies have shown that both foreign and domestic investment have a significant impact on economic growth. For example, the econometric analyses conducted by Owolabi, Adedeji, Aderounmu, Oku, and Ogunbiyi (2023) and Wagle (2024) concluded that foreign investment, domestic investment, and per capita income significantly affect economic growth. However, not all studies report consistent results. A study by Mora and Olabisi (2023) stated that investment does not have a significant effect on economic growth. This observed discrepancy may be attributed to a multitude of variables influencing economic growth, including but not limited to the efficiency of investment allocation and the prevailing institutional frameworks.

The employment of a dynamic panel for the data methodology facilitates a comprehensive analysis of both the short-term and long-term ramifications of investment on economic growth. The dynamic panel approach allows for the analysis of both short-term and long-term effects of investment on economic growth. Research by Zardoub and Sboui (2023) found that both foreign and domestic investment positively and significantly impact Gross Domestic Product (GDP) growth, with domestic investment showing a greater effect. However, domestic investment demonstrates a greater effect than foreign investment. In a regional context, investment has been found to significantly influence economic growth in the respective area.

According to research by Kuang, Liang, Zhao, and Cai (2023) technology investment is the main factor that leads to the growth of the economy; however, that influence is less strong in developing countries. Realizing the same, Owolabi et al. (2023) by means of the dynamic panel GMM method, the conclusion that the effect of technology on real output is very clear in countries with a well-educated population and good infrastructure. However, if the capacity for technological adaptation is low and there is weak investment in human resources, this effect becomes insignificant. This situation highlights the necessity of the most important supporting components for technology, in an economic manner, to be more efficient and to further accelerate growth.

On the other hand, the adoption of industrial automation technology, according to the studies of Sultanuzzaman, Fan, Mohamued, Hossain, and Islam (2019) has a varied impact on economic growth: on the one side, it can enhance the productivity of the economy, but on the other side, there is a possibility that the number of jobs in certain sectors decreases in the short run. The application of the dynamic panel method enabled them to arrive at the conclusion that technology has different effects under different circumstances and is largely influenced by labor policies and market flexibility.

In research concerning economic growth with the use of dynamic panel methods, the majority of authors have pointed out the Human Development Index (HDI) as one of the main features that influence the economic growth rate across countries. For example, the research of Jemiluyi and Jeke (2024) as well as Okunade et al. (2022) has come to the conclusion that HDI maintains a positive and significant relation with economic growth. An increase in the quality of human capital, which is shown through HDI, is a direct source of productivity and economic output. Despite that, some studies, however, find quite different results.

The findings of Jemiluyi and Jeke (2024) and Musibau, Yusuf, and Gold (2019) lead to the conclusion that the impact of HDI on economic growth is not always significant. At the same time, the authors emphasize the role of other structural factors, such as political stability and fiscal policy, which are not only behind economic growth but may also obscure the effect of HDI in the model. Moreover, suppose we consider the point made by Eftimoski and Josheski (2021) and Onabote, Ohwofasa, and Ogunjumo (2023) that, in the case of developed economies where HDI is already high, rather than the absolute level of HDI, it is the marginal or incremental effect of HDI on economic growth that matters. Consequently, in those countries, HDI is not the most distinguishable feature of growth; the

changes in the progress of the economy would mostly come from technological advances and strategically planned human capital investments.

Numerous research studies utilizing dynamic panel methods have demonstrated that consumption positively and significantly influences economic growth. For illustration, works (Al Rasasi, Alzahrani, & Alassaf, 2021) and Sinha (2023) have led to the conclusion that although factors like investment and exports are also relevant, household consumption is the main source of aggregate demand that energizes the economy. These results are in line with the Keynesian model, which identifies consumption as the key factor for the levels of short-term growth.

Yet, a few studies have been reported to have produced little or no significant results or even negative results. For example, a study by Dempere and Pauceanu (2022) that compared developing and developed nations using dynamic panel data revealed that domestic consumption is likely to have a more significant impact on developing countries than on developed ones. The interrelationship between consumption and growth in developed economies appears to be no different from saturation; thus, the incremental impact shrinks. On the other hand, consumption growth in developing countries may become the leading source of economic expansion.

Dynamic panel models, e.g., System GMM, have been widely used in many studies to address the problems of endogeneity and heterogeneity in panel data. A study by Wagle (2024) revealed that government expenditure has a statistically significant positive influence on the economic growth of developing countries. Government spending targeted at infrastructure and education not only increases the production capacity of the economy but also the efficiency of the labor force, which thereby establishes a process of sustainable economic growth. These findings indicate that the role of the government is instrumental in energizing the growth process, especially in countries that still have to climb the development ladder. On the other hand, some research results indicate insignificant or even inversely proportional relationships between government spending and economic growth. Taha, Aydin, Lasisi, Bekun, and Sethi (2023), for instance, pointed out that an increase in government expenditure beyond the optimum level may lead to a heavy fiscal burden on the economy and a decrease in the efficiency of resource allocation; thus, it has a very limited impact on growth. The researchers note that it is the quality and efficiency of spending that contribute more to the effectiveness of a given amount of money.

Besides, a study by Parui (2021) and Onabote et al. (2023) shows a positive impact of public expenditure in the social sector, such as health and education, on economic growth, while government consumption is the main cause of the decrease in GDP. So, this study reveals that whether government spending will be a driver for growth largely depends on the category of expenditure rather than the size of the spending. Several studies have also examined the influence of net exports on economic growth within the context of dynamic panel models. In theory, it is expected that a good net export balance (the difference between exports and imports) would invigorate a country's income and lead to growth via the external demand channel. Among other studies, as well as Sultanuzzaman et al. (2019) and Mora and Olabisi (2023) came up with results arguing that net exports exert a positive, statistically significant impact on economic growth, especially in the cases of developing countries that are extremely dependent on primary export sectors. Besides, exports will draw domestic production capacity, create more jobs, and open the road to wider markets. However, these results also fail to be consistent all the time. For instance, in the research work of Akter, Hasan, Akter, and Jui (2024) and Blavasciunaite, Garsviene, and Matuzeviciute (2020), it is concluded that net exports have no substantial influence on economic growth in some contingencies. This is especially true if the exports are made up of raw commodities, the prices of which are highly volatile, or when the importation of capital goods and raw materials continues to damage local industrial productivity.

3. METHODOLOGY

The data used in this study are secondary data obtained from the Central Bureau of Statistics (BPS) of West Sumatra Province. The type of data employed is panel data, which is a combination of time series and cross-

sectional data. The time series data spans the period from 2011 to 2024, while the cross-sectional data covers 19 regencies/cities in West Sumatra. Thus, the total number of observations in this study is 266 (14 years × 19 districts/cities).

The dynamic panel regression will be employed to address the research problems. Panel data regression is a technique used to model the relationship between predictor variables and the response variable across different sectors over a specified time period. Broadly, panel data models can be classified into two categories: static panel regression models and dynamic panel regression models. Some of the static panel regressions include the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). In contrast, dynamic panel regression utilizes the Generalized Method of Moments (GMM) as its parameter estimation technique. There are mainly two types of GMM models: Difference GMM and System GMM (Pesaran, 2015).

Thus, multicollinearity and heteroskedasticity tests are some of the classical assumptions that need to be satisfied in panel data regression. According to econometric experts, such tests are essential for ensuring the validity of the regression results as Pesaran (2015) and Studenmund (2016) when the time dimension (t) exceeds the number of individuals (i), the Fixed Effects procedure is recommended. Conversely, if the number of individuals (i) exceeds the time dimension (t), then the Random Effects model is appropriate. Due to these restrictions, Ordinary Least Squares (OLS) often falls short in analyzing all forms of panel data, as some key assumptions for OLS, such as homoskedasticity and no autocorrelation, are difficult to satisfy in panel settings because of the inherent features of both individual and time dimensions. The Generalized Method of Moments (GMM) is then employed to estimate the parameters of the models for panel data. GMM is a parameter estimation approach primarily focused on minimizing a quadratic loss function.

The use of this model serves to illustrate the correlation between independent variables, which in reality are often dynamic in nature. Independent variables are not only influenced at the same point in time but are also affected by their previous values (lags). The general form of the GMM model can be written as follows:

$$y_{it} = \delta y_{i,t-1} + x'_{it}\beta + \mu_{it} \qquad ; i = 1,2, \dots, N \; ; t = 1,2, \dots, T \qquad (4)$$

Explanation:

y_{it} = The dependent variable observed for cross-sectional unit i at time t.

x'_{it} = The lagged value of the dependent variable for unit i at time $t-1$.

δ = Scalar coefficient representing the impact of the lagged dependent variable.

β = $k \times 1$ vector of parameters to be estimated.

μ_{it} = The error term captures unobserved effects and random shocks.

Based on the general form of the GMM model, the dynamic panel regression equation using the GMM approach in this study is formulated as follows:

$$EG_{i,t} = \delta EG_{i,t-1} + \beta_1 INV_{i,t} + \beta_2 L_{i,t} + \beta_3 TECH_{i,t} + \beta_4 HDI_{i,t} + \beta_5 CONS_{i,t} + \beta_6 GE_{i,t} + \beta_7 NX_{i,t} + \mu_i + \varepsilon_{i,t} \qquad (5)$$

Explanation of notation:

EG = Economic Growth.

EG_{t-1}= Previous Year's Economic Growth.

INV= Investment.

L = Labor.

TECH=Technology.

HDI= Human Development Index.

CONS= Consumption.

GE = Government Expenditure.

NX = Net Exports.

δ= Coefficient measuring the persistence of economic growth over time.

$\beta_1, \ldots \beta_7$= Coefficients of estimation.

μ_i= Unobserved individual effect.

$\varepsilon_{(i,t)}$ = Error Term.

i = Cross-Section Unit.

t = Time-Series Unit.

In estimating the dynamic panel regression model using GMM, several tests are conducted, including the Arellano-Bond Test, the Sargan Test, and the Unbiasedness Test. The Arellano-Bond Test is used to examine whether the estimates are consistent. The Sargan Test is used to determine whether the instruments used are valid. The Unbiasedness Test serves to strengthen the assumption that GMM estimators are more consistent and unbiased.

Table 1 presents the operational definitions of the variables employed in this study. The definitions are aligned with the regression model to ensure clarity and consistency. All monetary variables are expressed in constant 2010 prices to control for the effect of inflation and allow for comparability across regions and time periods. The monetary unit used is the Indonesian Rupiah (IDR), the official currency of Indonesia.

Table 1. Operational definitions of variables.

No.	Variable	Symbol	Operational definition	Unit
1	Economic growth	$EG_{i,t}$	Regency/City GDP growth based on constant prices 2010	Percent
2	Economic growth in the previous year	$EG_{i,t-1}$	Regency/City GDP growth based on constant prices in the previous year period 2010.	Percent
3	Investment	$INV_{i,t}$	Gross fixed capital formation of regency/City based on constant prices 2010	Million IDR
4	Labor	$L_{i,t}$	Workforce working in each regency/City	Person
5	Technology	$TECH_{i,t}$	The number of residents aged 5 years and over who access the internet in each regency/city.	Percent
6	Human Development Index	$HDI_{i,t}$	Human Development Index for each regency/City	Point
7	Consumption	$CONS_{i,t}$	Household consumption based on constant 2010 prices for each regency/city.	Million IDR
8	Government expenditure	$GE_{i,t}$	Government consumption based on constant 2010 prices for each regency/city.	Million IDR
9	Net export	$NX_{i,t}$	The difference between exports and imports based on constant 2010 prices for each regency/city.	Million IDR

4. RESULTS AND DISCUSSIONS

To resolve potential endogeneity issues, this study employs a GMM dynamic panel regression approach to account for intertemporal dynamics. The initial step in model estimation involves dynamic specification testing using the Arellano-Bond tests for first-order and second-order residual autocorrelation, as well as the Sargan or Hansen tests to verify instrument validity. This methodology enables the analysis to capture both short-run and long-run effects of the explanatory variables on economic growth, providing robust estimates of simultaneity bias and cross- sectional heterogeneity across districts and cities in West Sumatra.

4.1. Model Specification Test

4.1.1. Arellano-Bond Test

The Arellano-Bond test is a method used to verify whether the estimations obtained from the GMM are reliable. The test operates as follows: if the probability value of AR(2) is greater than 0.05, then the GMM equation is considered consistent; otherwise, if the AR(2) probability is less than 0.05, the GMM is deemed inconsistent. In this research, the AR(2) probability value is 0.9945, which is greater than 0.05, indicating the consistency of the GMM estimation results for further analysis. Table 2 presents the results of this Arellano-Bond test.

Table 2. Arelano-Bond test.

Test order	m-Statistic	Rho	SE(rho)	Prob.
AR(1)	-0.00	-0.00	0.00	0.99
AR(2)	-0.00	-0.00	0.00	0.99

4.1.2. Sargan Test

The Sargan test is a diagnostic that indicates whether the set of instruments used in a model is valid when their number exceeds the number of estimated parameters. A probability value of the J-statistic greater than 0.05 suggests that the model is acceptable. Conversely, if the probability value of the J-statistic is less than 0.05, the model is incompatible. After estimation, the probability value of the J-statistic was found to be 0.12, which is greater than 0.05, indicating that the instruments used in this GMM equation are valid. Table 3 presents the results of this Sargan test.

Table 3. Sargan test.

J-statistic	19.45
Prob (J-statistic)	0.12

4.2. Unbiasedness Test

If Ordinary Least Squares (OLS) is used to estimate a dynamic panel regression, it will result in biased and inconsistent estimators due to the correlation between the lagged dependent variable and the error term. Therefore, the GMM is used as a solution, producing estimators that are unbiased, consistent, and efficient. The criterion of unbiasedness is derived by evaluating the estimator for the lagged dependent variable from the GMM against that of the CEM, which is generally biased upwards, and the FEM, which is usually biased downwards. Theoretically, an unbiased estimator should be neither greater nor less than the estimates of the CEM and FEM models.

Table 4 presents the results of the unbiasedness test for this model. The test results show that the GMM coefficient lies between those of the CEM and FEM. This finding reinforces the indication that the GMM estimator is consistent and unbiased.

Table 4. Unbiasedness test.

CEM	GMM	FEM
0.94	0.65	0.51

4.3. GMM Estimation

After conducting the dynamic panel model specification tests, this section elaborates on the research findings. Table 5 presents the GMM estimation results for the economic growth of West Sumatra Province.

The past year's economic growth remarkably influences the current year's economic growth, as evidenced by the coefficient value of the lagged economic growth variable (EG(-1)) of 0.65 with a probability value of 0.04, significant at the 5% level. This confirms the presence of an inertia effect or path dependence, suggesting that past economic conditions have a strong impact on current economic performance. To put it differently, a region's sustained or improved economic performance hinges on strong prior growth.

In theory, this finding aligns with the assumptions made in dynamic growth models, such as the dynamic panel regression approach (Dynamic Panel GMM), which assumes that the dependent variable responds to contemporaneous factors as well as its historical values. The policy implications derived from this finding indicate that regional governments need to sustain the growth momentum already attained, for instance, by providing macroeconomic stability, reinforcing policies for long-term investments, and maintaining the continuity of productive development initiatives. Stability in the preceding periods of economic growth enhances investor

confidence and seamless economic activity, thereby augmenting future development.

The conclusion that previous economic growth strongly impacts current growth status fits with many other studies that focus on economic growth from a more dynamic perspective. As an example, the study conducted by Dempere and Pauceanu (2022) as well as Rahman, Rana, and Barua (2019), which applied the GMM in the case of the Southeast European countries, showed that the lagged variable of economic growth positively and significantly impacts current growth. This implies the existence of inertia effects in the growth process, suggesting that economic achievement in one period tends to carry over to the succeeding period in the absence of major shocks from outside the economy.

The results of the study indicate that investment (INV) has a positive and significant effect on economic growth in West Sumatra, with a coefficient of 0.33 and a probability of 0.00. This means that the rise of investment, both domestic and foreign direct investment, will lead to an increase in production capacity, the creation of new jobs, and the use of efficient technologies, which would positively affect the overall economic output. Investment plays a central role in building physical and economic infrastructure, increasing the productive capacity of the real sector, and improving the region's competitiveness.

Table 5. GMM estimation.

Variable	Coefficient	Std. Error	t-Statistic	Prob
Eg(-1)	0.65	0.31	2.09	0.04
INV	0.33	0.09	3.86	0.00
L	0.17	0.06	2.91	0.00
TECH	0.29	0.07	4.21	0.00
HDI	0.58	0.14	4.08	0.00
CONS	0.63	0.10	6.29	0.00
GE	0.19	0.09	2.73	0.02
NX	0.21	0.12	1.80	0.07
Effect specification				
Cross-section fixed (Dummy variable)				
Mean dependent var	-0.17	S.D. dependent var		2.73
S.E. of regression	1.37	Sum of squared residuals		3.75
J-statistic	19.45	Instrument rank		19
Prob (J-statistic)	0.12			

These conclusions match the research carried out by Liu et al. (2025), which looked into Vietnam's economic growth and came up with the result that foreign direct investment (FDI) is the main factor that leads to growth along the line of technological advancement and production efficiency. In the same manner, Okunade, Olayiwola, Joseph, and Olawunmi (2025) in their study of the Saharan Africa countries, recognized that capital injection is one of the main variables that influence short-, medium-, and long-term economic development. Besides that, Kuang et al. (2023) made it clear that the turning point in government spending and the productive investment in the renovation of infrastructure and strategic sectors would be the source of economic efficiency and the extension of the national production base.

As shown by the research data, the variable of man labor (L) has a significantly positive effect on the growth of the West Sumatra economy, with an interpretative coefficient of 0.17 and a p-value of 0.00. The data indicate that a worker engaged in economic activities will, therefore, contribute to increasing regional output. Man labor is the main factor of production in an economy, with its contribution being highly significant in labor-intensive sectors such as agriculture, trade, and small-to-medium industries, which are the dominant sectors in the region's economic structure. The participation of the workforce will raise the economic value-added either through the productive use of existing workers or the creation of new jobs.

These findings are consistent with the study by Gonzales (2023) and Samal, Petrović, and Marković (2022)

analyzed the determinants of economic growth in Southeast European countries and found that labor has a significant effect on regional economic growth. He emphasized that both the quality and quantity of labor are key factors in the success of regional economic development. In a similar vein, the research of Tipayalai (2020) and Poledna et al. (2024) focused on countries of Sub-Saharan Africa. It has been revealed that work, particularly when supported by solid human capital (good quality education and health), is the main source of sustainable economic growth.

The results further show that the technology variable (TECH) has a positive and significant effect on economic growth, with a coefficient of 0.29 and a probability of 0.00. This finding indicates that technological progress, whether through digitalization, adoption of new production methods, or research-based innovations, contributes substantially to productivity improvements in West Sumatra. Technology enables firms to produce more efficiently, optimize resource use, and create new business opportunities that enhance long-term growth. This revelation is supported by the works of Dempere and Pauceanu (2022), Eisenbarth and Chen (2022) and Su, Wu, Choguill, Luo, and Yu (2024), which indicates that nations implementing new technology are likely to have a quicker pace of their GDP growth. The concept of technology in this model is a result of the company or country's investment in research and development (R&D) and human capital. Consequently, the growth in the levels of human capital raises the possibility of economic growth through faster technology adoption. The researchers mean that a strong demographic is much more ready for technological changes and thus can utilize the new technology more effectively, which will increase labor productivity and, as a result, economic growth. The main factors behind the countries' economic growth are the leaders' decisions to invest in technology and innovation. The studies of Zeng (2023) and Sultanuzzaman et al. (2019) show that technological advances contribute to the improvement of the market, thus the faster flow of information and the lower information asymmetry between buyers and sellers. This results in more efficient use of resources that, eventually, leads to an increase of economic growth. In addition to that, technology makes it easier for the structural change from the agricultural sector to the industrial and service sectors, which is of great importance because these sectors are normally more productive and, hence, give rise to economic growth.

Similarly, the Human Development Index (HDI) has a strong positive and significant effect, with a coefficient of 0.58 and a probability of 0.00. This suggests that better education, health, and income outcomes directly support higher productivity and growth. Human capital development provides a skilled, healthier, and more innovative labor force, which is essential for sustaining inclusive and competitive economic performance. These results are consistent with studies by Elgin (2025) and Nchor (2020), which show that improvements in health, measured by life expectancy, have a positive and significant effect on economic growth. A healthy population contributes to a more productive workforce and reduces the economic burden of illness and premature death. A higher standard of living, measured by per capita income, also contributes to economic growth. Improved living standards boost domestic consumption and investment, which stimulate economic growth through increased aggregate demand. Research by Okunade et al. (2022); Shen, Zhang, and Li (2022) and Younsi, Bechtini, and Lassoued (2024) emphasizes that human development, as reflected in rising living standards, is a fundamental foundation for sustainable economic growth.

Consumption (CONS) is the key factor that leads economic growth to increase most significantly, as it has a coefficient of 0.63 and a probability of 0.00. The description fits the role of domestic demand in West Sumatra province, where household spending activates supply, solidifies small and medium enterprises, and generates the multiplier effect across diverse sectors. Increasing buying power through social protection and job opportunities will be a very important part of maintaining this growth engine. Sixteen studies, such as those by Nawir, Bakri, and Syarif (2023) have cited that domestic consumption is the main source of economic growth, particularly in the case of countries or regions where consumption represents the largest share of GDP. Several other studies also reveal that the use of goods mainly produced for consumption purposes, which are focused on productive areas, leads to an increase in production capacity or the so-called long-term productivity. In detail, the findings of Okunade et al. (2025) and Sinha (2023) indicate that while household consumption tends to grow in the long run, this growth being

channeled into productive goods is the only way for the positive spillover effect on long-term economic growth to become significant.

The impact of Government expenditure (GE) on a positive significant change is highlighted by the results of the regression analysis, showing a coefficient of 0.19 and a probability of 0.01. This finding clearly indicates the importance of economic policy as a tool to support regional development. Effective government spending, especially in the areas of infrastructure, education, and public services, can not only generate large multiplier effects but also increase private sector participation by reducing their costs through attracting efficiency. So, according to Mendoza (2023); Osei-Assibey and Dikgang (2020) and Parui (2021) as well, government expenditure is the main macroeconomic stabilization instrument, mainly when a crisis situation or economic deceleration occurs. Through fiscal stimulus, governments are able to raise aggregate demand by public spending, hence creating jobs and sustaining the purchasing power of households. When the private sector is hesitant to invest in a project because they are uncertain about it, then government spending becomes very important to keep economic activities going. This has been the case in many low-income countries, which have been able to sustain growth through productive government spending. Several studies, namely by Elgin (2025) and Taha et al. (2023) also point out that government spending can attract social inclusion and fair development. Through the allocation of budgets to disadvantaged areas or marginalized groups, governments not only diminish economic and social gaps but also establish a more solid base for sustained growth.

Meanwhile, net exports (NX) have a positive but not statistically significant effect on economic growth, with a coefficient of 0.21 and a probability of 0.07 (above the 5% significance level). This can be explained by several structural factors and characteristics of the region's trade. First, West Sumatra's export structure is still heavily reliant on primary commodities such as agricultural products, forestry, and mining, which are primarily raw materials. These products typically have low added value, are seasonal, and are highly vulnerable to global market price fluctuations. As a result, they do not provide consistent or stable contributions to economic growth. When global commodity prices decline or international demand slows, export revenues decrease without adequate compensation from other sectors.

Second, the manufacturing sector in West Sumatra remains relatively underdeveloped. As a result, the region's ability to process local raw materials into value-added export goods is limited. Consequently, most exports are still in raw form, while consumer and capital goods are largely imported. This makes net exports (X–M) volatile and sometimes even negative. Third, inadequate logistics infrastructure, such as export ports, distribution roads, and cold storage facilities, also hampers the region's ability to improve export competitiveness in international markets. In addition, the lack of an integrated regional trade policy and the suboptimal practice of local economic diplomacy hinder the development of non-traditional export markets.

This finding is consistent with studies by Akter et al. (2024) and Mania and Rieber (2019), which indicate that in many regions whose exports are dominated by raw materials, net exports do not significantly impact growth due to the absence of strong domestic value chains. With increasing globalization, the effects of net exports on economic growth can become more complex. Studies by Okunade et al. (2022) and Akter et al. (2024) emphasize that export contributions become significant only when a region possesses comparative advantages and strong processing capabilities.

5. CONCLUSIONS

In terms of supply, the study found that the previous year's economic growth variable would positively and significantly affect the present, signifying inertia or intertemporal dependence, where previous readings of economic performance influence current economic outcomes. It is also found that the investment variable significantly and positively impacts growth, reaffirming the critical role of capital accumulation in expanding

production capacity and strengthening regional economic competitiveness. Additionally, it has been discovered that labor has a significant positive impact on both regional output growth. Technological progress and the Human Development Index (HDI) are also major factors contributing to the economic growth of the region, with results showing that the quality of human capital and the adoption of technology are the main contributors to productivity and economic efficiency.

While household consumption and government spending contributed positively to demand, it is worth noting that these two variables had a significant positive influence on GDP growth. The implication is that increasing household consumption, induced by sound fiscal policies at the local government level, would be the main driver of economic activities. Nevertheless, net exports did not show a significant impact on the regional economy, which means that exports from the region have not yet been a source of growth. Probably because exported products are mainly raw materials, the region has a weak industrial processing sector, and the logistics infrastructure is not sufficient to support efficient exports.

The discovered data insist that the economic policy of West Sumatra is required to deal with both the supply and the demand sides, not separately. The main task on the supply side should be deepening productive investments by cultivating a business climate that is favorable, giving the right kind of incentives, and accelerating the development of strategic infrastructure. Labor quality must be enhanced for sure through professional training, education that is linked with the industry, and also digital skills, together with the growth of innovation and the use of technology through the establishment of a strong partnership between the government, universities, and businesses.

On the demand side, household consumption and government spending remain key drivers of growth. Thus, policies should focus on enhancing household purchasing power through social protection and local economic empowerment, while directing public expenditure toward high-multiplier sectors such as infrastructure, education, and public services. In addition, boosting export competitiveness via resource-based industrial development and improved logistics is crucial. By integrating these supply- and demand-side strategies, West Sumatra can foster more inclusive, resilient, and sustainable economic growth.

This study has limitations: first, the data spans the period 2011-2023, which means it cannot capture all existing phenomena. Second, the research variables do not cover all variables influencing economic growth, such as regional inequality, institutional structure, and others. The GMM model in this study still depends on the validity and strength of the instrument. Future researchers should expand the research period, add more research variables, and use spatial econometric models to examine interregional dependencies.

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