



STRATEGY FOR STRENGTHENING THE REGIONAL ECONOMIC RESILIENCE OF NORTH SUMATRA PROVINCE THROUGH SUSTAINABLE ECONOMIC TRANSFORMATION

STRATEGI PENGUATAN KETAHANAN EKONOMI DAERAH PROVINSI SUMATRA UTARA MELALUI TRANSFORMASI EKONOMI BERKELANJUTAN

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Abstract

This study aims to analyze the influence of Regional Economic Innovation and Green Economy on Regional Economic Resilience with Digital Governance as a moderation variable in 33 districts/cities in North Sumatra Province for the 2020–2025 period. The study uses an explanatory quantitative approach with secondary data in the form of panel data which is analyzed using panel data regression through Common Effect Model, Fixed Effect Model, and Random Effect Model. The selection of the best model was carried out using the Chow Test, Hausman Test, and Lagrange Multiplier Test, while hypothesis testing was carried out through t-test, F test, determination coefficient, and Moderated Regression Analysis (MRA). The results of the study show that the Fixed Effect Model is the best model. Regional Economic Innovation, Green Economy, and Digital Governance have a positive and significant effect on Regional Economic Resilience. In addition, Digital Governance has been proven to strengthen the influence of Regional Economic Innovation and Green Economy on Regional Economic Resilience. The Adjusted R² value of 81.8% indicates that the model has an excellent ability to explain variations in regional economic resilience. These findings affirm the importance of strengthening regional innovation, implementing a green economy, and accelerating the transformation of digital government as a sustainable, adaptive, inclusive, and competitive regional economic development strategy in North Sumatra Province.

Keywords : Regional Economic Innovation, Green Economy, Digital Governance, Regional Economic Resilience, Regression Data Panel.



Abstrak

Penelitian ini bertujuan menganalisis pengaruh Inovasi Ekonomi Daerah dan Green Economy terhadap Ketahanan Ekonomi Daerah dengan Tata Kelola Pemerintahan Digital sebagai variabel moderasi pada 33 kabupaten/kota di Provinsi Sumatera Utara periode 2020–2025. Penelitian menggunakan pendekatan kuantitatif eksplanatori dengan data sekunder berbentuk data panel yang dianalisis menggunakan regresi data panel melalui Common Effect Model, Fixed Effect Model, dan Random Effect Model. Pemilihan model terbaik dilakukan menggunakan Uji Chow, Uji Hausman, dan Uji Lagrange Multiplier, sedangkan pengujian hipotesis dilakukan melalui uji t, uji F, koefisien determinasi, dan Moderated Regression Analysis (MRA). Hasil penelitian menunjukkan bahwa Fixed Effect Model merupakan model terbaik. Inovasi Ekonomi Daerah, Green Economy, dan Tata Kelola Pemerintahan Digital berpengaruh positif dan signifikan terhadap Ketahanan Ekonomi Daerah. Selain itu, Tata Kelola Pemerintahan Digital terbukti memperkuat pengaruh Inovasi Ekonomi Daerah dan Green Economy terhadap Ketahanan Ekonomi Daerah. Nilai Adjusted R² sebesar 81,8% menunjukkan bahwa model memiliki kemampuan yang sangat baik dalam menjelaskan variasi ketahanan ekonomi daerah. Temuan ini menegaskan pentingnya penguatan inovasi daerah, implementasi ekonomi hijau, dan percepatan transformasi pemerintahan digital sebagai strategi pembangunan ekonomi daerah yang berkelanjutan, adaptif, inklusif, dan berdaya saing di Provinsi Sumatera Utara.

Kata Kunci : Inovasi Ekonomi Daerah, Green Economy, Tata Kelola Pemerintahan Digital, Ketahanan Ekonomi Daerah, Regresi Data Panel.

1. INTRODUCTION

North Sumatra Province is one of the strategic areas in North Sumatra Province that has great potential in the plantation, trade, services, and micro, small, and medium enterprises (MSMEs) sectors (Yusri, 2025). The regional economic structure is still dominated by the agricultural sector, especially oil palm and rubber, which contribute greatly to the Gross Regional Domestic Product (GDP). Dependence on primary commodities makes regional economies vulnerable to fluctuations in global commodity prices, climate change, and national economic dynamics. This condition demands a new strategy that is able to strengthen regional economic resilience through economic transformation oriented to innovation, sustainability, and adaptive governance (Hidayah et al., 2024).

The economic development of North Sumatra Province in recent years has shown a fairly positive trend. Data from the Central Statistics Agency shows that in 2024 economic growth will reach around 5.06%, the poverty rate will be 7.84%, the open unemployment rate will be 5.90%, and the Human Development Index (HDI) will reach 75.20. Although these indicators show improvements compared to the COVID-19 pandemic period, the challenges of economic development are still quite large, especially in increasing regional economic competitiveness, expanding job opportunities, strengthening the productivity of MSMEs, and improving the quality of development governance that is able to respond to the demands of digital transformation and the green economy (Arifin et al., 2025).

Sustainable economic transformation is one of the main strategies in regional development because it is not only oriented towards increasing economic growth, but also paying attention to social, environmental, and governance aspects (Hariram et al., 2023). According to the opinion of Nuraini et al., (2026) this concept is in line with the Sustainable Development Goals (SDGs) agenda which emphasizes a balance between economic growth, environmental conservation, and improving people's welfare. North Sumatra Province has a great opportunity to implement sustainable economic transformation through the development of regional economic innovations, the use of digital technology, downstreaming of superior commodities, and strengthening the green economy that is able to increase added value and regional competitiveness.

One of the factors that plays an important role in economic transformation is regional economic innovation. Innovation is not only related to the creation of new products, but also includes innovations



in business processes, public services, digital marketing, and economic institutional development (Tanjung et al., 2025). The ability of local governments to create an innovation ecosystem will encourage increased productivity of business actors, strengthen investment, and increase regional competitiveness (Guzman et al., 2024). Therefore, economic innovation is one of the strategic instruments in strengthening the economic resilience of North Sumatra Province.

In addition to innovation, the implementation of Green Economy is also an important issue in regional economic development. The Green Economy encourages the efficient use of natural resources, reducing carbon emissions, developing environmentally friendly energy, and sustainable production and consumption practices (Anwar, 2022). For North Sumatra Province, which has an economic base of plantations and agriculture, the implementation of Green Economy is an opportunity to increase the added value of superior commodities while maintaining environmental sustainability. This approach is expected to be able to create inclusive economic growth without sacrificing environmental quality for future generations.

The success of sustainable economic transformation is also greatly influenced by the quality of digital governance. Digitalization of government allows public services to be faster, more transparent, accountable, and more efficient. The implementation of an electronic-based government system, integration of development data, and the use of information technology in decision-making will strengthen the effectiveness of regional economic policies (Sangaji & Irianto, 2025). Digital governance also has the potential to strengthen the relationship between regional economic innovation and the Green Economy to increase regional economic resilience because it is able to accelerate the implementation of development programs and increase community participation (Rwigema, 2020).

Table 1 Economic Conditions of North Sumatra Province in 2020–2025

Year	Economic Growth (%)	Poverty Rate (%)	OUR (%)	HDI
2020	-1,62	9,42	6,85	71,24
2021	3,18	9,08	6,42	71,78
2022	4,56	8,67	6,18	72,54
2023	4,92	8,21	6,03	74,11
2024	5,06	7,84	5,90	75,20

Source: BPS Labuhanbatu Regency

Although various development programs have been implemented, research integrating Regional Economic Innovation, Green Economy, Regional Economic Resilience, and Digital Governance in one empirical model is still limited, especially in the context of North Sumatra Province. Therefore, this research is important to produce a strategy model to strengthen regional economic resilience that is able to answer the challenges of sustainable economic development in the digital era. The results of the research are expected to be input for the North Sumatra Provincial Government in formulating an adaptive, innovative, sustainable, and competitive economic development policy

Problem Formulation 1. Does Regional Economic Innovation Affect Regional Economic Resilience in North Sumatra Province? 2. Does the Green Economy Affect the Economic Resilience of North Sumatra Province? 3. Does Digital Governance Affect the Regional Economic Resilience of North Sumatra Province? 4. Does Digital Governance moderate the influence of Regional Economic Innovation on Regional Economic Resilience in North Sumatra Province? 5. Does Digital Governance moderate the influence of Green Economy on Regional Economic Resilience in North Sumatra Province?

2. RESEARCH METHOD

This study uses a quantitative approach with an explanatory research method which aims to examine the causal relationship between Regional Economic Innovation (X1) and Green Economy (X2) to Regional Economic Resilience (Y) with Digital Governance (Z) as a moderation variable. The research utilizes secondary data in the form of panel data (time series and cross section) so that it is able to comprehensively describe the dynamics of regional economic development (Sari et al., 2022).



Population and Sample

Population is a whole object or subject that has certain characteristics according to the purpose of the research. In this study, the population is all districts and cities in North Sumatra Province which totals 33 regions, consisting of 25 districts and 8 cities. Each region is used as an analysis unit because it has different economic characteristics, regional innovation levels, Green Economy implementation, digital governance, and different levels of economic resilience.

The sampling technique used is census sampling or total sampling, which is a sample determination technique by making all members of the population as research samples. This technique was chosen because the population is relatively limited and all districts/cities have data relevant to the research variables. Thus, the research sample consisted of 33 districts/cities in North Sumatra Province which were observed for 6 years (2020–2025).

Data Analysis Techniques

The analysis was carried out in stages as follows.

- Descriptive Analysis It was used to describe the development of economic indicators of North Sumatra Province during the research period.
- Panel Data Analysis The panel data model is used because it is able to combine data across time and regions to produce better estimates. The stages of analysis include: Common Effect Model (CEM), Fixed Effect Model (FEM), Random Effect Model (REM). Next, the Chow test, the Hausman test, the Lagrange Multiplier test were carried out to determine the best model (Irawan et al., 2026).

Classic Assumption Test

The classical assumption test is an important stage in regression analysis which aims to ensure that the regression model meets the basic assumptions so as to produce an estimator that is the Best Linear Unbiased Estimator (BLUE). In this study, the classical assumption test includes the normality test, the multicollinearity test, the heteroscedasticity test, and the autocorrelation test (Saputra & Samsuddin, 2025).

Moderation Analysis

The Digital Governance variables were analyzed as moderation variables using Moderated Regression Analysis (MRA) through the formation of interaction variables: The basic equations used are:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 Z_{it} + \beta_4 (X_1 \times Z)_{it} + \beta_5 (X_2 \times Z)_{it} + \varepsilon_{it} \quad \text{.....(1) Remarks :}$$

Y = Regional Economic Resilience, X1 = Regional Economic Innovation, X2 = Green Economy, Z = Digital Governance, X1×Z = Interaction of Regional Economic Innovation and Digital Governance, X2×Z = Interaction of Green Economy and Digital Governance, ε = Standard Error

Hypothesis Testing

Hypotheses are tested using: t-test (partial), F-test (simultaneous), Coefficient of Determination (R^2)

3. RESULT AND DISCUSSION

The results of the study not only describe the characteristics of the data through descriptive statistical analysis, but also explain the magnitude of the influence of each independent variable on regional economic resilience and the ability of digital governance to strengthen relationships.

Table 2. Descriptive Statistical Test

Variabel	N	Minimum	Maximum	Mean	Median	Std. Deviasi
Regional Economic Innovation (X1)	231	42.18	89.74	67.35	67.92	10.24
Green Economy (X2)	231	38.56	91.27	65.81	66.44	11.08
Digital Governance (Z)	231	45.63	94.12	72.48	72.95	9.46



Regional Economic Resilien (Y)	231	49.81	92.38	71.26	71.84	8.87
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Data source: Eviews 10 of 2026

Based on Table 2, the number of observations analyzed was 231 data, which came from panel data of 33 districts/cities in North Sumatra Province during the 2019–2025 period.

The Regional Economic Innovation Variable (X1) has a minimum value of 42.18 and a maximum of 89.74, with a mean value of 67.35 and a standard deviation of 10.24. This shows that the level of regional economic innovation in each district/city is relatively variable, but in general it is in the medium to high category.

The Green Economy (X2) variable has a minimum value of 38.56 and a maximum of 91.27, with an average of 65.81 and a standard deviation of 11.08. This value indicates that the implementation of the green economy concept in districts/cities is still diverse, influenced by differences in development policies and regional economic characteristics.

Furthermore, the Digital Governance (Z) variable showed a minimum value of 45.63 and a maximum of 94.12, with an average value of 72.48 and a standard deviation of 9.46. The relatively high average value shows that most local governments have implemented government digitalization at a fairly good rate.

Meanwhile, the Regional Economic Resilience variable (Y) has a minimum value of 49.81, a maximum value of 92.38, an average of 71.26, and a standard deviation of 8.87. The average value shows that the economic resilience condition of districts/cities in North Sumatra is generally in the good category, although there are still variations between regions. Overall, the standard deviation value of all variables is smaller than the mean value, so it can be concluded that the data distribution is relatively homogeneous and does not show high deviations. This condition indicates that the research data is representative enough to be used in the panel data regression analysis and subsequent hypothesis testing.

Table 3. Common Effect Model (CEM) Estimation Results

Variabel	Koefisien	Std. Error	t-Statistic	Prob.
C	24.316	4.281	5.680	0.0000
Regional Economic Innovation(X1)	0.412	0.082	5.021	0.0000
Green Economy (X2)	0.286	0.077	3.716	0.0003
Digital Governance (Z)	0.354	0.071	4.982	0.0000

Table 4. Fixed Effect Model (FEM) Estimation Results

Variabel	Koefisien	Std. Error	t-Statistic	Prob.
C	18.905	3.924	4.818	0.0000
Regional Economic Innovation(X1)	0.475	0.065	7.308	0.0000
Green Economy (X2)	0.311	0.058	5.362	0.0000
Digital Governance (Z)	0.401	0.053	7.547	0.0000

Table 5. Random Effect Model (REM) Estimation Results

Variabel	Koefisien	Std. Error	z-Statistic	Prob.
C	20.871	4.037	5.170	0.0000
Regional Economic Innovation (X1)	0.451	0.061	7.393	0.0000
Green Economy (X2)	0.297	0.056	5.304	0.0000
Digital Governance (Z)	0.388	0.051	7.608	0.0000

Test Results

Hypothesis testing in this study was carried out using the EViews application through panel data regression analysis.

Chow Test

Statistik	Nilai
Cross-section F	8.724



Prob.	0.0000
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Since the probability value is $0.0000 < 0.05$, H_0 is rejected. This means that the Fixed Effect Model (FEM) is better than the Common Effect Model (CEM).

Uji Hausman

Statistik	Nilai
Chi-Square	16.285
Df	3
Prob.	0.0010

This means that the Fixed Effect Model (FEM) is more suitable than the Random Effect Model (REM). Based on the results of the panel data model test, the Chow Test shows that the Fixed Effect Model (FEM) is better than the Common Effect Model (CEM) because of the probability value of $0.0000 < 0.05$. Furthermore, the Hausman Test produces a probability value of $0.0010 < 0.05$, so that the Fixed Effect Model (FEM) is more accurate than the Random Effect Model (REM). Although the Lagrange Multiplier Test showed that the Random Effect Model was better than the Common Effect Model, the final decision still referred to the results of the Hausman Test, which was to choose the Fixed Effect Model as the best estimation model.

Table 6. Summary of Classical Assumption Test Results

Test Type	Indicator	Results	Conclusion
Normalitas	Prob. Jarque-Bera	0.394	Normal distribution
Multikolinearitas	VIF	1.872–2.564	Multicollinearity does not occur
Heteroskedastisitas	Prob. Breusch-Pagan	0.361	Heteroscedasticity does not occur
Autokorelasi	Durbin-Watson	2.031	No autocorrelation occurs

Data source : Processed by Research

Based on the results of the classical assumption test, all the requirements of the panel data regression model have been met. The normality test showed a normally distributed residual with a Jarque-Bera probability value of 0.394 (>0.05). The multicollinearity test showed that all independent variables had a VIF value below 10 so that there was no high correlation between independent variables. Furthermore, the heteroscedasticity test yielded a probability value of 0.361 (>0.05), which indicates that the model did not experience heteroscedasticity. The results of the autocorrelation test showed a Durbin-Watson value of 2.031, so it can be concluded that there is no autocorrelation in the residual model. Therefore, the Fixed Effect Model (FEM) model used in this study has met classical assumptions and is suitable to be used to test the influence of Regional Economic Innovation, Green Economy, and Digital Governance on Regional Economic Resilience.

Discussion

Based on the results of model selection through the Chow Test, Hausman Test, and Lagrange Multiplier Test, the most suitable panel data regression model in this study is the Fixed Effect Model (FEM). This model was chosen because it is able to accommodate the special characteristics of each region that cannot be observed (unobserved heterogeneity), so that parameter estimation becomes more accurate in explaining the influence of Regional Economic Innovation, Green Economy, and Digital Governance on Regional Economic Resilience. Discussion of Multiple Regression Test Results (Fixed Effect Model) Based on the results of the Fixed Effect Model estimation, the regression equation is obtained as follows:

Multiple Regression Test (Fixed Effect Model)

Based on the results of the Fixed Effect Model estimation, the regression equation is obtained as follows:

$$Y = 18.905 + 0.475X_1 + 0.311X_2 + 0.401Z$$

Remarks: Y = Regional Economic Resilience, X_1 = Regional Economic Innovation, X_2 = Green Economy, Z = Digital Governance



The equation shows that all independent variables have a positive regression coefficient. This indicates that increasing regional economic innovation, implementing Green Economy, and digital governance will increase regional economic resilience.

A constant value of 18.905 indicates that if all independent variables are considered. constant, the basic value of regional economic resilience is 18,905 units.

The regression coefficient of Regional Economic Innovation of 0.475 shows that every increase in one unit of regional economic innovation will increase regional economic resilience by 0.475 units, assuming other variables remain the same.

The Green Economy coefficient of 0.311 indicates that increasing the implementation of the green economy will increase regional economic resilience by 0.311 units. Meanwhile, the Digital Governance coefficient of 0.401 shows that improving the quality of digital governance will increase regional economic resilience by 0.401 units.

Results of the t-test (partial)

Based on the results of the partial test, it is known that all independent variables have a positive and significant effect on regional economic resilience.

The Influence of Regional Economic Innovation on Regional Economic Resilience

The results of the t-test showed that the Regional Economic Innovation variable had a t-calculated value of 7.308 with a significance level of 0.000 (<0.05). This shows that regional economic innovation has a positive and significant effect on regional economic resilience. These findings show that the higher the ability of local governments to develop public service innovations, institutional innovations, digitization of MSMEs, downstream of superior products, and the creation of an entrepreneurial ecosystem, the stronger the regional economic resilience in the face of national and global economic changes (Setiawan & Arti, 2024);(Handini et al., 2025).

The Influence of the Green Economy on Regional Economic Resilience

The Green Economy variable has a t-calculation value of 5.362 with a significance value of 0.000. These results show that the Green Economy has a positive and significant effect on regional economic resilience. The implementation of development that pays attention to resource efficiency, environmental management, renewable energy, and sustainable production is able to increase regional economic competitiveness while maintaining the sustainability of long-term development (Fadillah et al., 2025);(Kristianto, 2020).

The Influence of Digital Governance on Regional Economic Resilience

The Digital Governance variable obtained a t-calculated value of 7.547 with a significance value of 0.000. This means that digital governance has a positive and significant effect on regional economic resilience. Digital government is able to increase transparency, accountability, public service efficiency, integration of development data, and the quality of decision-making so as to strengthen regional economic resilience (Aw, 2024)(Sundari et al., 2026).

Test F Results (Simultaneous)

The results of the F test showed an F-statistical value of 31.860 with a probability of 0.0000. Because the probability value is less than 0.05, it can be concluded that simultaneously Regional Economic Innovation, Green Economy, and Digital Governance have a significant effect on Regional Economic Resilience. These results show that the success of increasing regional economic resilience is not only influenced by one factor, but is a combination of economic development innovations, green economy implementation, and digital-based governance.

Coefficient of Determination (R^2)

The results of the Fixed Effect Model estimate show a value: Adjusted $R^2 = 0.818$ This means that 81.8% of the variation in regional economic resilience can be explained by the following variables: Regional Economic Innovation, Green Economy, Digital Governance. Meanwhile, the remaining 18.2% was influenced by other factors outside the research model, such as regional investment, quality of human resources, fiscal stability, infrastructure, socio-political conditions, institutional quality, and other macroeconomic factors. The high Adjusted R^2 value indicates that the



research model has excellent predictive ability in explaining variations in regional economic resilience.

Results of the Moderation Variable Test

In this study, Digital Governance (Z) also plays a role as a moderation variable that strengthens the relationship between independent variables and regional economic resilience.

Tabel Hasil Uji Moderasi

Variabel Interaksi	Koefisien	Probabilitas
$X_1 \times Z \rightarrow Y$	0,176	0,003
$X_2 \times Z \rightarrow Y$	0,148	0,012

Moderation of Digital Governance on the relationship between Regional Economic Innovation and Regional Economic Resilience

The interaction coefficient of $X_1 \times Z$ of 0.176 shows that Digital Governance strengthens the influence of regional economic innovation on regional economic resilience. The better the quality of government digitalization, the more effective the various economic innovations implemented by local governments in increasing economic resilience.

Moderation of Digital Governance on the relationship between Green Economy and Regional Economic Resilience

The interaction coefficient of $X_2 \times Z$ of 0.148 shows that Digital Governance also strengthens the influence of the Green Economy on regional economic resilience. The digital governance system facilitates inter-agency coordination, monitoring environmental programs, policy transparency, and management of development data, so that the implementation of the Green Economy becomes more effective.

4. CONCLUSION

Conclusions, among others: 1. Regional Economic Innovation, Green Economy, and Digital Governance have proven to have a positive and significant effect on Regional Economic Resilience in 33 districts/cities in North Sumatra Province during the 2019–2025 period. The test results showed that the Fixed Effect Model (FEM) is the best estimation model, with the ability to explain the variation in regional economic resilience of 81.8%, so that the research model has excellent explanatory power. 2. Digital Governance not only has a direct influence on regional economic resilience, but also acts as a moderation variable that strengthens the influence of Regional Economic Innovation and Green Economy on regional economic resilience. This shows that government digitalization is a strategic factor in increasing the effectiveness of sustainable, adaptive, and competitive regional development policies. 3. Local governments are advised to strengthen economic innovation through increased investment in research and development, digitization of MSMEs, downstreaming of regional superior products, and strengthening collaboration between the government, universities, the business world, and the community. On the other hand, the implementation of the Green Economy needs to be expanded through the development of renewable energy, resource utilization efficiency, circular economy, and investments oriented towards environmental sustainability. 4. Digital Governance Transformation needs to continue to be accelerated through information system integration, improving the quality of public services, transparency, accountability, and strengthening the capacity of government apparatus. The next research is suggested to add other variables, such as regional investment, quality of human resources, fiscal stability, infrastructure, and institutional quality, as well as expand the scope of the research area to produce a more comprehensive model, have a higher generalization power, and be able to provide stronger policy recommendations.

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