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RESEARCH ARTICLE

Regional Analysis of Inflation and Unemployment: Toward Inclusive Economic Growth Strategies

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KEYWORDS
Domestic direct investment; Economic growth; Inflation; Panel ARDL; Regional development; Unemployment

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ABSTRACT
This study examines the short-run and long-run determinants of inflation and unemployment across nine provinces in Sumatra, Indonesia, addressing the limited regional evidence on macroeconomic dynamics in resource-dependent economies. Using annual panel data from 2016 to 2024, the study employs a Panel Autoregressive Distributed Lag (ARDL) model with the Pooled Mean Group (PMG) estimator to analyse the relationships among inflation, unemployment, global oil prices, Gross Regional Domestic Product (GRDP), and Domestic Direct Investment (DDI). The findings reveal significant temporal and regional differences. Global oil prices are positively associated with inflation in the short run ($\beta = 0.016$, $p = 0.044$), whereas GRDP exhibits a significant positive long-run association ($\beta = 0.266$, $p < 0.01$). GRDP is negatively associated with unemployment in the short run ($\beta = -2.066$, $p = 0.044$) but positively associated in the long run ($\beta = 0.535$, $p < 0.01$), suggesting patterns consistent with jobless growth. Conversely, DDI exhibits a significant negative long-run association with unemployment ($\beta = -5.920$, $p = 0.001$), although provincial responses remain heterogeneous. The study contributes to regional macroeconomic literature by integrating external energy shocks and domestic economic factors within a dynamic provincial framework. Its findings question the uniform applicability of conventional growth–employment relationships and highlight the importance of regionally differentiated policies that combine inflation management, productive investment, and employment-oriented structural transformation to support inclusive economic development.

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1. INTRODUCTION

Unemployment and inflation are among the most fundamental macroeconomic indicators, as they reflect the effectiveness of public policies in promoting economic stability and societal welfare (Hester & Okun, 1982). The relationship between these variables has long occupied a central position in macroeconomic debate, particularly following the introduction of the Phillips Curve by Phillips (1958), which identified an inverse relationship between inflation and unemployment. This proposition was subsequently reinforced by Samuelson & Solow (1960), who interpreted the Phillips Curve as a short-run policy trade-off, suggesting that policymakers could reduce unemployment through expansionary policies at the cost of higher inflation. However, the validity of this trade-off has been extensively contested. Friedman (1968) and Phelps

(1967) challenged the notion of a stable long-run relationship between inflation and unemployment by introducing the concept of adaptive inflation expectations. They argued that as economic agents gradually adjust their expectations in response to inflationary pressures, the effectiveness of expansionary monetary policy in reducing unemployment diminishes. Consequently, any short-run gains in employment are temporary, while inflation persists. Under this framework, the Phillips Curve becomes vertical in the long run, implying that attempts to reduce unemployment below its natural rate ultimately result only in higher inflation without generating sustained improvements in labor market conditions (Dadam & Viegi, 2024).

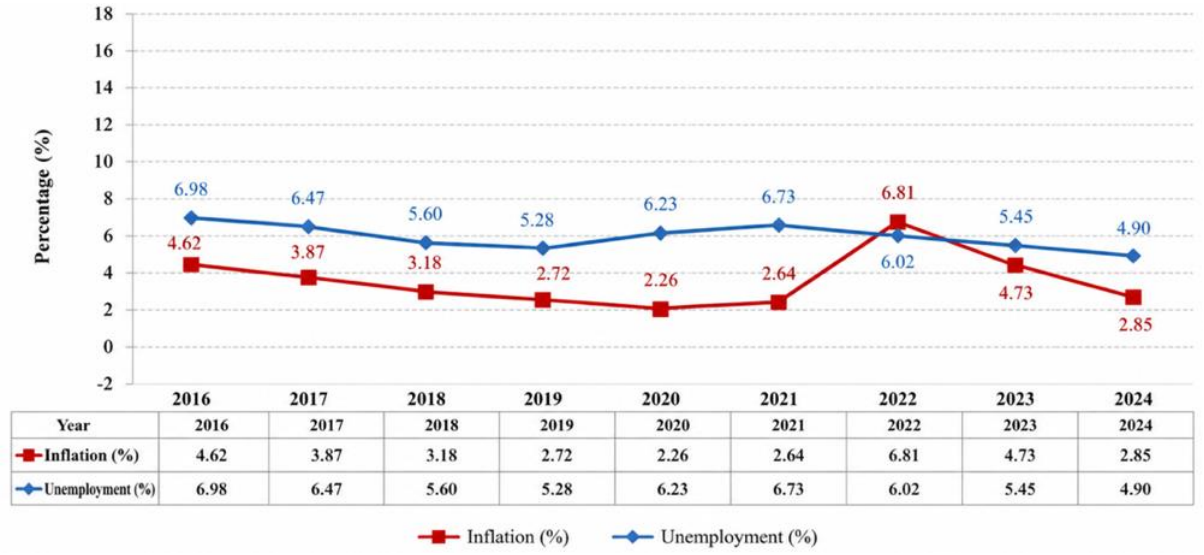
The debate surrounding the inflation–unemployment nexus intensified during the stagflation episode of the 1970s, when rising inflation coincided with increasing unemployment, directly contradicting the predictions of the traditional Phillips Curve (Asako, 1981). This experience highlighted the limitations of the conventional framework and revealed that the relationship between inflation and unemployment is considerably more complex than originally assumed. It also underscored the importance of factors such as economic structure, inflation expectations, and external shocks in shaping macroeconomic outcomes.

More recent studies argue that inflation and unemployment dynamics cannot be explained solely by fluctuations in aggregate demand. Instead, they are increasingly influenced by supply-side disturbances, including volatility in global energy and commodity markets (Bańbura et al., 2023; Wahyudi, 2025). Empirical evidence further indicates that the inflation–unemployment relationship has become less stable, particularly in developing economies where structural rigidities and external vulnerabilities play a more prominent role Uddin & Rahman, 2023; Azam & Khan (2022). For example, recent evidence suggests that the Phillips Curve has substantially "flattened" over recent decades, implying that inflation has become less responsive to changes in unemployment. These studies also contend that factors such as commodity price volatility, regional disparities, and uneven economic development significantly shape the inflation–unemployment relationship in developing countries

In the Indonesian context, particularly on the island of Sumatra, these dynamics are even more complex. Sumatra contributes substantially to the national economy, especially through natural resource-based sectors such as oil and gas, coal, and palm oil plantations. Nevertheless, this considerable economic contribution has not been consistently accompanied by improvements in labor market conditions (Salfina et al., 2023). This phenomenon is consistent with jobless growth, whereby economic expansion does not proportionally generate employment opportunities.

Furthermore, recent empirical evidence suggests that inflation and unemployment dynamics in Sumatra do not consistently conform to the traditional Phillips Curve framework. As illustrated in Figure 1, both inflation and unemployment increased simultaneously in 2022, a pattern consistent with stagflationary pressures. This pattern coincided with external shocks, including rising global oil prices and persistent post-pandemic supply chain disruptions (Bernanke & Blanchard, 2025). Such developments

imply that the transmission mechanism linking inflation and unemployment in the region is shaped by a complex interplay of domestic structural conditions and external economic factors.



Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
Inflation (%)	4.62	3.87	3.18	2.72	2.26	2.64	6.81	4.73	2.85
Unemployment (%)	6.98	6.47	5.60	5.28	6.23	6.73	6.02	5.45	4.90

Figure 1. Tren Inflation and Unemployment in Sumatra Island (2016-2024)
Source: Statistics Indonesia (BPS), processed by the author

Data from Statistics Indonesia (BPS) further indicate that increases in global oil prices have frequently contributed to higher inflation in several provinces, including North Sumatra, Bangka Belitung, and South Sumatra. However, these inflationary pressures have not been consistently associated with declining unemployment rates. This divergence raises important concerns regarding the effectiveness of regional development strategies and the resilience of local economies to external shocks (Mahmood et al., 2024). It also highlights the limitations of conventional macroeconomic policies that prioritize price stability while paying insufficient attention to structural and sectoral dimensions of economic development.

Despite the growing relevance of these issues, most existing studies on inflation and unemployment in Indonesia continue to rely on national-level time-series analyses (e.g., Salfina et al., 2023; Wahyudi, 2025), thereby overlooking substantial interregional heterogeneity. Furthermore, studies that examine external shocks, such as global oil prices rarely integrate them with domestic determinants like regional output and investment within a single empirical framework. This limitation is particularly important in the case of Sumatra, where provinces differ considerably in terms of industrial composition, investment intensity, labor market characteristics, and dependence on global commodity markets. Consequently, the existing literature provides only a limited understanding of the regional dynamics underlying the inflation–unemployment relationship.

To address this gap, the present study employs a Panel Autoregressive Distributed Lag (ARDL) approach, which enables the examination of both short-run and long-run relationships while accounting for cross-sectional and temporal variations across

provinces (Pesaran et al., 2001). This framework is particularly suitable for capturing heterogeneous regional dynamics and complex macroeconomic interactions. In addition, the analysis incorporates global oil prices, Gross Regional Domestic Product (GRDP), and Domestic Direct Investment (DDI), variables that remain relatively underexplored in the Indonesian Phillips Curve literature despite their critical importance in resource-based economies such as Sumatra. Accordingly, this study seeks to reassess the validity of the Phillips Curve within a regional context and identify the structural factors shaping the inflation–unemployment relationship.

This study offers three main contributions to the literature. First, unlike previous studies that primarily employ national-level time-series data, it provides provincial-level panel evidence that more accurately captures regional heterogeneity in Indonesia. Second, it integrates both external factors, represented by global oil prices, and domestic economic variables, namely GRDP and DDI, within a unified Panel ARDL framework, thereby enabling a more comprehensive assessment of short-run and long-run macroeconomic dynamics. Third, the study generates context-specific policy insights that can support the design of more inclusive and adaptive development strategies in regions characterized by diverse economic structures.

Ultimately, if the inflation–unemployment relationship in Sumatra no longer conforms to the predictions of the conventional Phillips Curve, this may indicate the presence of deeper structural challenges that cannot be adequately addressed through traditional macroeconomic policy instruments alone. By examining these dynamics from a regional perspective, this study aims to contribute to both the empirical literature and the formulation of more effective policy responses for managing increasingly complex regional economic conditions.

2. LITERATURE REVIEW

The relationship between inflation and unemployment has long occupied a central place in macroeconomic theory and policy debates. The traditional foundation of this relationship is rooted in the Phillips Curve, which posits an inverse relationship between inflation and unemployment in the short run. Originally developed by Phillips (1958), and later popularized by Samuelson & Solow (1960), the framework suggested that policymakers could exploit this trade-off by stimulating aggregate demand to reduce unemployment at the cost of higher inflation. Within the Keynesian paradigm, this relationship was considered sufficiently stable to serve as a practical instrument for macroeconomic stabilization. However, subsequent economic developments exposed important limitations of this framework, raising questions about the universality and stability of the inflation–unemployment relationship across different economic contexts.

The emergence of stagflation during the 1970s posed a significant challenge to the conventional Phillips Curve. The simultaneous occurrence of high inflation and high unemployment contradicted the predicted trade-off and stimulated the development of

alternative theoretical explanations. Friedman (1968) and (Phelps 1968), introduced the expectations-augmented Phillips Curve and the concept of the Natural Rate of Unemployment, later formalized as the Non-Accelerating Inflation Rate of Unemployment (NAIRU). These perspectives argued that the inverse relationship between inflation and unemployment exists only in the short run and disappears once economic agents adjust their inflation expectations. Consequently, attempts to maintain unemployment below its natural rate through expansionary policies would ultimately generate accelerating inflation without producing sustained gains in employment.

Subsequent advances in the Rational Expectations framework further weakened the explanatory power of the traditional Phillips Curve. Lucas (1972) and Sargent & Wallace (1975), argued that individuals and firms systematically incorporate available information into their decision-making processes, rendering predictable policy interventions largely ineffective in influencing real economic variables in the long run. From this perspective, unemployment outcomes depend not only on aggregate demand conditions but also on the credibility of policy actions and the expectations formed by economic agents. These developments shifted attention away from conventional demand-management policies and highlighted the importance of structural and institutional factors in shaping labor market dynamics.

Building upon these critiques, more recent theoretical contributions emphasize that the inflation–unemployment relationship is conditioned by the structural characteristics of an economy. Hysteresis theory, advanced by Blanchard & Summers (1986), posits that temporary economic shocks can generate persistent effects on unemployment, particularly in labor markets characterized by rigidities and adjustment constraints. Similarly, Search and Matching Theory highlights the role of labor market frictions in determining employment outcomes. According to Pissarides (2000) and Shimer (2005), mismatches between job seekers and vacancies, information asymmetries, and hiring costs can sustain unemployment even during periods of relatively low inflation. These perspectives suggest that unemployment dynamics cannot be fully explained by aggregate demand conditions alone but must also account for labor market efficiency and structural constraints.

The complexity of the inflation–unemployment relationship becomes even more pronounced in developing economies. Unlike advanced economies, developing countries are often characterized by commodity dependence, structural dualism, labor market informality, and greater exposure to external shocks. Consequently, inflation frequently originates from supply-side disturbances rather than excess aggregate demand. Empirical evidence indicates that fluctuations in global commodity and energy prices can generate substantial inflationary pressures without producing corresponding increases in employment opportunities (Uddin & Rahman (2023; Azam & Khan 2022). As a result, the conventional trade-off predicted by the Phillips Curve often appears weak, unstable, or even absent in many developing-country contexts.

These challenges are particularly relevant in resource-dependent regions, where economic growth does not necessarily translate into broad-based employment creation.

The jobless growth hypothesis argues that economic expansion driven by capital-intensive sectors can increase output without generating proportional labor absorption (Caballero & Hammour, 1998). Under such conditions, economic growth may coexist with persistent unemployment despite favorable macroeconomic performance. This phenomenon is especially evident in regions where natural-resource extraction dominates economic activity, as production expansion relies more heavily on capital accumulation and technological inputs than on labor-intensive processes.

The case of Sumatra provides a particularly relevant setting for examining these theoretical propositions. As one of Indonesia's major economic regions, Sumatra possesses abundant natural resources and relies heavily on commodity-based sectors such as palm oil, mining, and energy production. While these sectors contribute substantially to regional output, their capital-intensive nature limits their capacity to absorb labor on a large scale. At the same time, the region remains highly vulnerable to fluctuations in global commodity and energy prices, which can generate inflationary pressures independently of domestic demand conditions. These characteristics suggest that the conventional inflation–unemployment relationship may not operate in the manner predicted by standard macroeconomic theories.

Moreover, substantial heterogeneity across provinces in Sumatra further complicates the transmission mechanisms linking inflation and unemployment. Differences in industrial structure, investment patterns, infrastructure development, labor market conditions, and institutional capacity may generate divergent responses to similar economic shocks. Consequently, inflation may coincide with declining unemployment in some provinces, while in others both variables may increase simultaneously. Such variations suggest that the inflation–unemployment nexus is shaped not only by aggregate macroeconomic conditions but also by regional structural characteristics that influence local adjustment processes.

Empirical findings on the inflation–unemployment nexus in developing economies remain mixed. Empirical Uddin & Rahman (2023) find that inflation and unemployment jointly constrain economic growth, whereas Azam & Khan (2022) report a threshold-dependent relationship that weakens at higher inflation levels. This inconsistency suggests that the nexus is highly context-dependent and may not be adequately captured by national-level or single-equation approaches—an issue that becomes especially salient in resource-rich regions with heterogeneous provincial structures.

The unemployment model is primarily grounded in Okun's Law, which predicts an inverse relationship between economic growth and unemployment, implying that higher output growth should contribute to job creation and lower unemployment levels (Gumata & Ndou, 2020). However, the jobless growth hypothesis offers an alternative perspective, suggesting that this relationship may weaken in economies dominated by capital-intensive sectors. Consequently, the effect of GRDP on unemployment may differ between the short run and the long run. In addition, the crowding-in hypothesis provides a theoretical justification for including Domestic Direct Investment, as investment expansion is expected to increase productive capacity and generate employment

opportunities. Finally, hysteresis theory supports the examination of dynamic adjustment processes by recognizing that economic shocks may exert persistent effects on unemployment over time. Collectively, these considerations justify the application of a Panel Autoregressive Distributed Lag (ARDL) framework, which enables the simultaneous investigation of short-run dynamics and long-run equilibrium relationships. The mapping of these theoretical propositions onto the empirical specification is summarized as follows: in the inflation model (Equation 1), cost-push theory predicts a positive effect of global oil prices (COL) on inflation, while demand-pull theory predicts a positive effect of GRDP on inflation; in the unemployment model (Equation 2), Okun's Law predicts a negative effect of GRDP on unemployment, whereas the jobless growth hypothesis allows for a positive long-run effect, and the crowding-in hypothesis predicts a negative effect of Domestic Direct Investment (DDI) on unemployment. These expected signs guide the interpretation of the estimated coefficients in the Panel ARDL specification.

Despite extensive theoretical and empirical discussions on inflation and unemployment, several important gaps remain in the literature. Existing studies continue to focus predominantly on national-level analyses, often overlooking substantial regional heterogeneity within countries. Furthermore, many empirical investigations examine either domestic macroeconomic factors or external shocks in isolation, limiting understanding of how these forces interact in shaping inflation and unemployment dynamics. Such limitations are particularly relevant in resource-dependent regions, where global commodity and energy markets exert considerable influence on local economic conditions. For instance, Salfina et al. (2023 examined the effect of inflation and government spending on growth in West Sumatra using provincial time-series data, while Wahyudi (2025) analyzed national-level policy uncertainty and financial stability. Neither study simultaneously modeled inflation and unemployment across Sumatra's provinces, nor integrated external shocks with domestic investment within a unified panel framework.

Another important limitation concerns methodological approaches. Many previous studies rely on conventional time-series or static panel estimators that are unable to simultaneously capture short-run dynamics, long-run equilibrium relationships, and cross-sectional heterogeneity. Consequently, empirical findings regarding the inflation–unemployment nexus remain inconsistent across countries and regions. Addressing these limitations requires an analytical framework capable of accounting for both temporal dynamics and regional diversity.

Accordingly, this study contributes to the literature in three important ways. First, it adopts a regional perspective by examining provincial-level data across Sumatra, thereby capturing heterogeneity that is frequently overlooked in national-level studies. Second, it integrates external factors, represented by global oil prices, with domestic factors, including GRDP and domestic investment, within a unified analytical framework. Third, it employs a Panel Autoregressive Distributed Lag (ARDL) approach, which facilitates the simultaneous estimation of short-run and long-run relationships while accommodating

regional heterogeneity. Through these contributions, the study advances understanding of inflation–unemployment dynamics in resource-based economies and provides empirical insights relevant to the formulation of more adaptive and inclusive regional development policies.

3. METHODOLOGY

3.1. Data and Variables

This study examines the determinants of inflation and unemployment across nine provinces in Sumatra over the 2016–2024 period using annual panel data obtained from Statistics Indonesia (BPS). The study period was selected based on data availability and its capacity to capture economic dynamics both before and after major global shocks, including the COVID-19 pandemic. The dependent variables consist of inflation (INF), measured as the annual percentage change in prices, and the open unemployment rate (UNP), measured as a percentage of the total labor force. The independent variables include global oil prices (COL), which serve as a proxy for external shocks; Gross Regional Domestic Product (GRDP), representing regional economic growth; and domestic direct investment (DDI), reflecting regional investment activity.

From a theoretical perspective, global oil prices are expected to exert a positive effect on inflation through a cost-push mechanism. GRDP is hypothesized to positively affect inflation through demand-pull effects, while simultaneously exerting a negative effect on unemployment, consistent with Okun's Law. Meanwhile, domestic investment is expected to reduce unemployment by stimulating employment creation and expanding productive economic activity. The variables employed in this study are presented in the table below:

Table 1. Variable Description

Variable	Symbol	Measurenment	Source
Dependent			
Inflation	INF	Annual percentage change in the consumer price index (%)	Statistics Indonesia
Unemployment	UNP	Open unemployment rate (% of total labor force)	Statistics Indonesia
Independent			
Crude Oil Price	COL	Average annual global crude oil price (US$/barrel)	Statistics Indonesia
Domestic Direct Investment	DDI	Realized domestic investment (trillion IDR)	Statistics Indonesia
Gross Regional Domestic Product	GRDP	Provincial GRDP at constant prices (trillion IDR)	Statistics Indonesia

Source: Computed by Authors

3.2. Model Specifications

To examine the dynamic relationships among the variables, this study employs the Panel Autoregressive Distributed Lag (Panel ARDL) approach. This model is selected because it can accommodate variables with mixed orders of integration, namely I(0) and I(1), while simultaneously enabling the estimation of both short-run and long-run relationships within a panel data framework (Magweva & Sibanda, 2020; Öztürk & Özdil, 2020):

The full ARDL specification for the inflation model with appropriate lag structure is formulated as follows:

$$INFit = \alpha i + \sum j = 1p\phi ijINFi, t - j + \sum j = 0q\beta 1ijCOLi, t - j + \sum j = 0r\beta 2ijGRDPi, t - j + \mu i + \varepsilon it \quad (1)$$

where i denotes province (i= 1 ,....,. 9), t denotes time (t=2016,...,2024), p, q, and r are the optimal lag lengths, ϕij are the coefficients of lagged inflation, β1ij and β2ij are the short-run coefficients for COL and GRDP, μi represents province-specific fixed effects, and εit is the error term

Similarly, the ARDL specification for the unemployment model is:

$$UNPit = \alpha i + \sum j = 1p\gamma ijUNPi, t - j + \sum j = 0q\delta ijGRDPi, t - j + \sum j = 0r\theta ijDDIi, t - j + \mu i + \varepsilon it \quad (2)$$

To capture short-term and long-term dynamics simultaneously, the ARDL model is transformed into an Error Correction Model (ECM) as follows:

For Inflation model:

$$\Delta INFit = \alpha i + \lambda i(INFi, t - 1 - \psi 1COLi, t - 1 - \psi 2GRDPi, t - 1) + \sum j = 1p - 1\phi ij * \Delta INFi, t - j + \sum j = 0q - 1\beta 1ij * \Delta COLi, t - j + \sum j = 0r - 1\beta 2ij * \Delta GRDPi, t - j + \varepsilon it \quad (3)$$

For Unemployment model:

$$\Delta UNPit = \alpha i + \lambda i(UNPi, t - 1 - \psi 1GRDPi, t - 1 - \psi 2DDIi, t - 1) + \sum j = 1p - 1\gamma ij * \Delta UNPi, t - j + \sum j = 0q - 1\delta ij * \Delta GRDPi, t - j + \sum j = 0r - 1\theta ij * \Delta DDIi, t - j + \varepsilon it \quad (3)$$

In Equations (3) and (4), λ_i represents the error correction term (ECT), which indicates the speed of adjustment toward long-run equilibrium. A negative and statistically significant λ_i confirms the existence of a long-run cointegrating relationship among the variables. The terms enclosed in parentheses represent the long-run equilibrium relationship, while the differenced terms capture the short-run dynamics of the model. Equations (3) and (4) therefore provide a reduced-form representation of the inflation–unemployment nexus, in which the Phillips Curve and Okun's Law are assessed indirectly through the estimated signs and significance of the long-run coefficients rather than through a direct structural specification of the wage–price mechanism.

The estimation procedure in this study employs the Pooled Mean Group (PMG) estimator developed by (Pesaran et al. (2001), which imposes homogeneity on long-run

coefficients across provinces while allowing heterogeneity in short-run dynamics and adjustment processes. This approach is particularly appropriate for the context of Sumatra, where substantial structural differences exist across provinces despite operating within a relatively unified national macroeconomic policy framework. Accordingly, the PMG estimator effectively captures the balance between long-run structural convergence and short-run adjustment heterogeneity.

Given the relatively short time dimension of the panel (nine annual observations per province), several specification choices merit explicit justification. First, the PMG estimator remains consistent and asymptotically efficient in panels with moderate T provided that N is sufficiently large relative to the number of parameters, and it is specifically designed for panels where T is small to moderate (Pesaran et al., 1999). Second, the lag order for each variable is selected using the Akaike Information Criterion (AIC), with a maximum lag of one given the annual frequency and the limited number of observations; this choice avoids over-parameterization while preserving the dynamic structure of the model. Third, because the nine provinces share a common national monetary and fiscal policy environment and are exposed to common external shocks such as global oil price fluctuations, cross-sectional dependence cannot be ruled out; this possibility is acknowledged as a limitation and is discussed further in the Limitations section, and future work may employ cross-sectionally augmented estimators (CS-ARDL or CCEMG) as robustness checks.

The empirical analysis is conducted in several stages to ensure the robustness of the model estimation. First, panel unit root tests are performed to assess the stationarity properties of the variables and to confirm that none are integrated of order two, I(2), which would invalidate the ARDL framework.

Following standard econometric practice, this study employs the Levin, Lin, and Chu (LLC) test, the ADF-Fisher test, and the PP-Fisher test (Levin et al., 2002; Im et al., 2003). All variables are tested at both level form, I(0), and first-difference form, I(1), to determine their order of integration. Second, panel cointegration tests are conducted to examine the existence of long-run relationships among the variables. The null hypothesis of no cointegration is tested using the Kao residual cointegration test, including both the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics (Dickey & Fuller, 1979). To strengthen the robustness of the cointegration analysis, the Pedroni and Westerlund panel cointegration tests are also considered, as they accommodate heterogeneous slopes and cross-sectional dependence more flexibly than the Kao test alone. Rejection of the null hypothesis ($p < 0.05$) indicates the presence of a stable long-run equilibrium relationship among the variables. Third, the Panel ARDL model is estimated to obtain both short-run and long-run coefficients, including the error correction term (ECT), which reflects the speed of adjustment toward long-run equilibrium following short-term shocks. Fourth, the Hausman test is employed to determine the most appropriate estimator among the Pooled Mean Group (PMG), Mean Group (MG), and Dynamic Fixed Effects (DFE) estimators (Nickell, 1981).

A statistically insignificant Hausman test result ($p > 0.05$) supports the selection of the PMG estimator as both efficient and consistent. As an additional robustness check, the MG and DFE estimators are also estimated and compared with the PMG results; a sensitivity analysis excluding the COVID-19 years (2020-2021) is likewise conducted to assess whether the main findings are driven by pandemic-related shocks.

The Panel ARDL framework offers several methodological advantages for analyzing complex regional economic dynamics. Specifically, it accommodates variables with mixed orders of integration and enables the simultaneous estimation of short-run and long-run relationships. Moreover, it accounts for cross-sectional heterogeneity, which is particularly relevant in regions such as Sumatra, where economic structures differ substantially and are shaped by both domestic and external economic forces (Galí et al., 2011).

4. RESULTS

4.1. Descriptive Statistics

Table 1 presents the descriptive statistics for all variables used in this study over the 2016–2024 period across nine provinces in Sumatra. The statistics include the mean, median, maximum, minimum, and standard deviation for each variable. The probability (Prob.) column reports the p-value from the Jarque-Bera normality test, where a significant value ($p < 0.05$) indicates that the variable deviates from a normal distribution.

Table 1. Descriptive Statistic

Variable	Mean	Median	Maximum	Minimum	Prob
Inflation	2.15	1.99	7.43	0.03	0.000
Unemployment	5.23	5.53	9.91	0.17	0.020
Crude Oil	63.82	63.53	80.45	49.10	0.035
Domestic Direct Investmen	3.70	4.39	61.10	0.30	0.000
Gross Regional Domestic Product	106.81	75.61	610.97	2.97	0.000

Notes: INF = inflation rate (annual percentage); UNP = open unemployment rate (% of labor force); COL = global crude oil price (US$/barrel); DDI = domestic direct investment realization (trillion IDR); GRDP = gross regional domestic product (trillion IDR, constant prices). The probability column reports the p-value of the Jarque-Bera normality test. All values are rounded to two decimal places for readability. Source: Data Processed.

The descriptive statistics reveal substantial variation in economic performance across provinces in Sumatra during the study period. The average inflation rate across all provinces and years is 2.15%, with values ranging from 0.03% (Aceh, 2016) to 7.43% (North Sumatra, 2017). This wide range suggests considerable differences in inflationary pressures across provinces, reflecting variations in local economic structures and price dynamics. The unemployment rate averages 5.23%, with a minimum of 0.17% (Jambi, 2019) and a maximum of 9.91% (Riau Islands, 2021). The broad dispersion in unemployment rates indicates substantial heterogeneity in labor market conditions across the region.

Global crude oil prices exhibit considerable volatility throughout the observation period, with an average price of US$63.82 per barrel. Prices reached a peak of US$80.45 in 2022 amid the post-pandemic recovery and heightened geopolitical tensions, while falling to a low of US$49.10 in 2020 during the sharp decline in global demand caused by the COVID-19 pandemic. The substantial variation in oil prices provides sufficient dispersion to capture the influence of external energy shocks on regional economic conditions.

Domestic Direct Investment (DDI) exhibits the highest degree of disparity among the variables. The average level of DDI is 3.70 trillion IDR, with values ranging from 0.30 trillion IDR (Bengkulu, 2017) to 61.10 trillion IDR (Riau, 2024). The large gap between the mean and maximum values, together with the high standard deviation (8.95), indicates that investment activity is unevenly distributed across provinces. This pattern suggests that investment remains concentrated in a limited number of economically strategic regions, while several provinces continue to attract relatively low levels of domestic investment.

Similarly, Gross Regional Domestic Product (GRDP) demonstrates substantial heterogeneity across provinces. The average GRDP amounts to 106.81 trillion IDR, ranging from 2.97 trillion IDR (Bangka Belitung, 2016) to 610.97 trillion IDR (North Sumatra, 2024). Moreover, the large standard deviation (125.40), which exceeds the mean value, further confirms the existence of considerable disparities in economic output across provinces. These differences likely reflect variations in industrial structure, resource endowments, and levels of regional economic development.

4.2. Unit Root Test

Prior to estimating the Panel ARDL model, it is essential to examine the stationarity properties of all variables to ensure that none are integrated of order two, I(2), which would invalidate the applicability of the ARDL approach. Accordingly, this study employs three widely used panel unit root tests: the Levin, Lin, and Chu (LLC) test, the ADF-Fisher test, and the PP-Fisher test. Each variable is tested at both the level form, I(0), and the first-difference form, I(1), to determine its order of integration. Table 3 presents the results of the panel unit root tests. The findings indicate that all variables are stationary at level I(0) based on all three testing approaches, as evidenced by statistically significant p-values ($p < 0.01$) for each variable. Specifically, inflation (INF), unemployment (UNP), crude oil prices (COL), domestic direct investment (DDI), and gross regional domestic product (GRDP) all reject the null hypothesis of a unit root at the 1% significance level. Importantly, no variable is found to become stationary only after first differencing, and none exhibits integration of order two, I(2). These results confirm the suitability of the Panel ARDL model for the present analysis.

Table 2. Stationary Test Result

Variabel	LLC	ADF	PP-Fisher
INF	-5.640***	36.55***	82.72***

	(0.000)	(0.006)	(0.000)
UNP	-6.409***	49.90***	117,2***
	(0.000)	(0.000)	(0.000)
COL	-6.201***	46.32***	119.3***
	(0.000)	(0.000)	(0.000)
DDC	-9.378***	61.96****	84.19***
	(0.000)	(0.000)	(0.000)
GRDP	-8.116***	62.51***	138.2***
	(0.000)	(0.000)	(0.000)

Notes: *** denotes statistical significance at the 1% level. Values in parentheses are p-values. All tests reject the null hypothesis of a unit root at level I(0). LLC = Levin, Lin, and Chu; ADF = Augmented Dickey-Fuller; PP = Phillips-Perron-Fisher. Source: Data Processed.

4.3. Cointegration Test

To determine whether a stable long-run equilibrium relationship exists among the variables, panel cointegration tests are conducted (Kao, 1999). This study employs the Kao residual cointegration test, including the Dickey–Fuller (DF) and Augmented Dickey–Fuller (ADF) statistics. The null hypothesis (H_0) states that no cointegration exists among the variables, implying the absence of a long-run equilibrium relationship. Conversely, the alternative hypothesis (H_1) posits the existence of cointegration among the variables. Table 4 presents the results of the panel cointegration tests. The ADF test statistic is −3.489 with a p-value of 0.000, indicating statistical significance at the 1% level. Accordingly, the null hypothesis of no cointegration is rejected, suggesting the presence of a stable long-run equilibrium relationship among the variables in both the inflation and unemployment models. These findings provide empirical justification for estimating the long-run coefficients using the Panel ARDL framework.

Table 3. Cointegration Test

ADF	**t-statistic**	**Prob.**
	-3.489	
Residual Variance	4.248	0.000
HAC variance	3.077	

Notes: Null hypothesis: No cointegration. Rejection of H0 ($p < 0.05$) indicates the presence of a long-run equilibrium relationship. Source: Data Processed

4.4. Panel ARDL Estimation Result

After confirming stationarity and cointegration, the Panel ARDL model was estimated using the Pooled Mean Group (PMG) estimator. This allows homogeneous long-run coefficients across provinces while permitting short-run coefficients and adjustment dynamics to vary—a theoretically appropriate choice for Sumatra, where provinces share national policies but differ in short-run adjustments. The Hausman test ($chi^2 = 2.847$, $p = 0.416$) confirmed that PMG is consistent and efficient compared to MG or DFE estimators.

Table 4. Inflation Panel ARDL Result

Inflation Dependen Variable		
Variable	**Coeficient**	**Prob**
Long Run Estimation		
Crude Oil (COL)	0.024	0.101
Gross Regional Domestic Product (GRDP)	0.266***	0.000
Short Run Estimation		
Crude Oil	0.016**	0.044
Gross Regional Domestic Product (GRDP)	0.095	0.365
Error Correction Term (ECT)	-0.284***	0.000

Notes: *** p < 0.01, ** p < 0.05. ECT = Error Correction Term, representing the speed of adjustment to long-run equilibrium. A negative and significant ECT confirms cointegration. Source: Data Processed

The long-run estimation results indicate that inflation dynamics in Sumatra are driven more by domestic factors than by external shocks. Global oil prices exert a positive but statistically insignificant effect on inflation (p = 0.101), suggesting that cost-push pressures from global energy markets are not a primary long-run determinant. This insignificance may reflect two structural characteristics: first, policy interventions such as energy subsidies and price controls may dampen the pass-through of international oil price fluctuations; second, Sumatra's natural resource-based economy is not fully aligned with domestic consumption patterns, weakening price transmission channels (Rawashdeh & Campbell, 2022).

In contrast, Gross Regional Domestic Product (GRDP) exhibits a positive and statistically significant effect on inflation (p = 0.000), supporting the demand-pull inflation framework. In the short run, crude oil prices are positively and significantly associated with inflation (p = 0.044), whereas the short-run effect of GRDP on inflation is not statistically significant (p = 0.365). Sustained economic growth intensifies aggregate demand but has not been accompanied by proportional increases in production capacity or distribution efficiency. Growth in Sumatra's capital-intensive and commodity-driven sectors rarely translates into broad-based productivity improvements, particularly in domestically oriented sectors. As a result, increases in regional income are not matched by commensurate supply expansion, generating persistent structural inflationary pressures.

Consistent with the theoretical framework, these results confirm two hypotheses: (1) the demand-pull effect of GRDP on inflation is supported in the long run; and (2) the cost-push effect of global oil prices is observed only in the short run and is not sustained in the long run. The conventional Phillips Curve trade-off between inflation and unemployment cannot be directly assessed from the inflation equation alone, given that unemployment is not included as a regressor; the assessment of the Phillips Curve in this study is therefore indirect, based on the joint behavior of the inflation and unemployment models.

From a policy perspective, inflation control in Sumatra cannot rely solely on energy price stabilization or interest-rate policy. A structural approach is required, enhancing

production capacity, strengthening the real sector, and improving distribution systems. Moreover, because economic growth is a key driver of inflation, development strategies should prioritize not merely growth expansion but also its quality, inclusiveness, and productive capacity.

Table 5. Unemployment Panel ARDL Result

Unemployment Dependen Variable		
Variable	**Coeficient**	**Prob**
Long Run Estimation		
Gross Regional Domestic Product	0.535***	0.000
Domestic Direct Investment	-5.920***	0.001
Short Run Estimation		
Gross Regional Domestic Product	-2.066**	0.044
Domestic Direct Investment	-1.541	0.130
Error Correction Term (ECT)	-0.412***	0.000

Notes: *** p < 0.01, ** p < 0.05. ECT = Error Correction Term, representing the speed of adjustment to long-run equilibrium. A negative and significant ECT confirms cointegration. Source: Data Processed.

The estimation results reveal contrasting short-run and long-run dynamics between economic growth, domestic investment, and unemployment in Sumatra. GRDP exerts a negative and statistically significant effect on unemployment in the short run (coef. = −2.066, p = 0.044), but the relationship reverses in the long run, where GRDP exhibits a positive and significant effect (coef. = 0.535, p = 0.000). Domestic Direct Investment (DDI), by contrast, is negatively and significantly associated with unemployment in the long run (coef. = −5.920, p = 0.001), whereas its short-run effect is not statistically significant (coef. = −1.541, p = 0.130). The error correction term (ECT = −0.412, p = 0.000) indicates that approximately 41.2% of short-run disequilibrium is corrected within one year. This relatively rapid adjustment process suggests that labor market imbalances converge toward their long-run equilibrium relatively quickly, although a formal comparison with the adjustment speed in the inflation model is not undertaken here.

The positive long-run effect of GRDP on unemployment contradicts the conventional prediction of Okun's Law and may be indicative of a jobless growth phenomenon, whereby economic expansion does not translate into proportional employment creation (Islam & Sahajalal, 2019). This finding is consistent with the structural characteristics of Sumatra's economy, which remains heavily dependent on capital-intensive sectors such as mining, energy, and large-scale plantations. In such sectors, output growth is often driven by capital accumulation, technological upgrading, and productivity improvements rather than by labor expansion. Consequently, economic growth may coexist with limited employment generation, weakening the capacity of growth to reduce unemployment over the long run.

In contrast, the negative short-run effect of GRDP reflects cyclical adjustments commonly associated with increases in aggregate demand. During periods of economic expansion, firms may temporarily increase labor utilization through additional hiring,

longer working hours, or more intensive use of existing labor resources. However, these effects may diminish over time as production processes become increasingly capital-intensive and productivity-oriented (Ozili & Oladipo, 2025). Accordingly, the short-run relationship appears to capture temporary demand-driven adjustments rather than long-term structural changes in the labor market.

Domestic Direct Investment (DDI) significantly reduces unemployment in the long run, supporting the crowding-in hypothesis. Increased investment expands productive capacity and can stimulate job creation, particularly when investment is directed toward sectors with relatively high labor absorption. The absence of a significant short-run effect likely reflects the implementation lag associated with investment activities, as the transition from project planning and construction to full-scale production often requires considerable time. Consequently, the employment benefits of investment are more likely to materialize over longer time horizons.

Taken together, these findings provide several important insights. First, the results offer short-run support for Okun's Law, although this relationship does not persist in the long run. Second, the positive long-run association between GRDP and unemployment suggests the presence of jobless growth dynamics. Third, DDI plays an important role in promoting long-run employment creation. Fourth, the significant and negative error correction term supports the relevance of hysteresis and dynamic adjustment mechanisms in explaining unemployment behavior. Overall, unemployment dynamics in Sumatra appear to be shaped more strongly by structural characteristics, capital intensity, and labor market adjustment processes than by conventional cyclical fluctuations alone.

From a policy perspective, these findings imply that economic growth alone may be insufficient to achieve sustained reductions in unemployment. Development strategies should therefore prioritize structural transformation toward sectors with greater labor absorption capacity. In addition, investment policies should encourage productive activities that generate broad-based employment opportunities. Strengthening human capital through vocational education, workforce training, and skills development is equally important to ensure that labor supply remains aligned with evolving economic structures. Ultimately, the evidence suggests that unemployment in Sumatra reflects not merely the pace of economic growth, but also the extent to which the structure of growth is capable of generating inclusive employment opportunities.

Table 6. Short Run Specific Province

Province	Dependen	Independen	Prob
Aceh	Inflation	Crude Oil	0.002***
			(0.000)
		Gross Regional Domestic Product	-0.077***
			(0.000)

	Unemployment	Gross Regional Domestic Product	-0.168***
			(0.000)
		Domestic Direct Investment	1.750***
			(0.000)
North Sumatra	Inflation	Crude Oil	0.084***
			(0,000)
		Gross Regional Domestic Product	-0.478***
			(0.000)
	Unemployment	Gross Regional Domestic Product	-0.193***
			(0,000)
		Domestic Direct Investment	-1.220***
			(0.000)
West Sumatra	Inflation	Crude Oil	-0.008
			(0.424)
		Gross Regional Domestic Product	-0.156
			(0.312)
	Unemployment	Gross Regional Domestic Product	0.145***
			(0.000)
		Domestic Direct Investment	-2.880***
			(0.000)
Riau	Inflation	Crude Oil	0.097***
			(0.001)
		Gross Regional Domestic Product	-0.687**
			(0.045)
	Unemployment	Gross Regional Domestic Product	-0.349***
			(0.000)
		Domestic Direct Investment	4.490***
			(0.000)
Riau Islands	Inflation	Crude Oil	-0.079***
			(0.000)
		Gross Regional Domestic Product	-0.033
			(0.172)
	Unemployment	Gross Regional Domestic Product	-0.149**
			(0.011)
		Domestic Direct Investment	-0.012***
			(0.000)
Jambi	Inflation	Crude Oil	-0.110***
			(0.000)
		Gross Regional Domestic Product	0.292*
			(0.068)
	Unemployment	Gross Regional Domestic Product	-2.461**
			(0.011)

		Domestic Direct Investment	-0.001***
			(0.000)
South Sumatra	Inflation	Crude Oil	-0.060***
			(0.000)
		Gross Regional Domestic Product	0.066
			(0.189)
	Unemployment	Gross Regional Domestic Product	-0.166***
			(0.000)
		Domestic Direct Investment	-1.080***
			(0.000)
Bengkulu	Inflation	Crude Oil	-0.066***
			(0.003)
		Gross Regional Domestic Product	0.181
			(0.354)
	Unemployment	Gross Regional Domestic Product	-1.232***
			(0.001)
		Domestic Direct Investment	0.012***
			(0.000)
Bangka Belitung	Inflation	Crude Oil	-0.004**
			(0.049)
		Gross Regional Domestic Product	0.039
			(0.106)
	Unemployment	Gross Regional Domestic Product	-0.090***
			(0.000)
		Domestic Direct Investment	-0.021***
			(0.000)

Notes: *** p < 0.01, ** p < 0.05, * p < 0.10. Values in parentheses are p-values. Source: Data Processed.

The province-specific results reveal substantial heterogeneity across Sumatra. Three major findings emerge. First, regarding inflation dynamics, global oil prices are positively and significantly associated with inflation in energy-dependent provinces (Aceh, North Sumatra, Riau), consistent with direct cost-push transmission. In contrast, the effect is negative and statistically significant in the Riau Islands, Jambi, South Sumatra, Bengkulu, and Bangka Belitung, suggesting that local factors—such as administered prices or region-specific supply conditions—may buffer external shocks. GRDP reduces inflation in Aceh, North Sumatra, and Riau, indicating that growth there improves production capacity. However, GRDP increases inflation in Jambi and South Sumatra, where aggregate demand outpaces supply capacity.

Second, regarding unemployment dynamics, GRDP reduces unemployment in most provinces (consistent with Okun's Law). West Sumatra is a notable exception: GRDP positively affects unemployment (coef. = 0.145, p = 0.000), a pattern consistent with short-run jobless growth driven by capital-intensive sectors with limited labor absorption. Third, domestic direct investment (DDI) reduces unemployment in most

provinces, as expected. However, three provinces show the opposite pattern: in Aceh (coef. = 1.750, p = 0.000), Riau (coef. = 4.490, p = 0.000), and Bengkulu (coef. = 0.012, p = 0.000), DDI is positively and significantly associated with unemployment. This pattern may be consistent with a resource-curse-like mechanism, where investment concentrates in capital-intensive extractive industries (oil, gas, mining, palm oil) that generate few jobs; however, because the model does not directly measure sectoral composition or resource rents, this interpretation should be regarded as a plausible hypothesis rather than a demonstrated causal mechanism. Meanwhile, in the Riau Islands, Jambi, and Bangka Belitung, DDI coefficients are very small in magnitude, suggesting low employment multipliers in service-oriented economies.

Regarding policy implications, a uniform approach is unlikely to be effective across Sumatra. Energy-dependent provinces (Aceh, North Sumatra, Riau) may benefit from stronger price stabilization. Provinces exhibiting patterns consistent with jobless growth (West Sumatra) may require structural transformation toward labor-intensive sectors. Provinces where investment is positively associated with unemployment (Aceh, Riau, Bengkulu) may need investment restructuring away from extractive industries. Provinces with low employment multipliers (Riau Islands, Jambi, Bangka Belitung) may benefit from skills-training programs to align labor capabilities with investment demand; however, these recommendations are indicative and subject to further cost–benefit and political-feasibility assessment.

5. CONCLUSION

This study provides evidence that inflation and unemployment dynamics across Sumatra are shaped by distinct short-run and long-run relationships, highlighting the limitations of uniform macroeconomic interpretations in resource-dependent regional economies. The Panel ARDL–PMG results indicate that global oil prices are significantly associated with inflation in the short run, whereas Gross Regional Domestic Product (GRDP) exhibits a positive long-run relationship with inflation. More importantly, GRDP is negatively associated with unemployment in the short run but positively associated in the long run, suggesting a growth–employment disconnect consistent with the jobless growth hypothesis. In contrast, Domestic Direct Investment (DDI) exhibits a significant negative long-run association with unemployment, although provincial-level results reveal considerable heterogeneity. These findings contribute to regional macroeconomic literature by demonstrating the importance of distinguishing temporal dynamics and regional economic structures when assessing growth, price stability, and employment outcomes. They also suggest that conventional growth–employment relationships may not apply uniformly across resource-dependent economies.

The findings underscore the need for regionally differentiated development strategies that integrate price stability with employment-oriented economic transformation. Policymakers should consider strengthening productive capacity, improving distribution efficiency, and directing investment towards sectors with greater

employment potential, supported by workforce development and stronger regional economic linkages. However, the findings should be interpreted cautiously given the short annual panel, potential cross-sectional dependence, and unresolved endogeneity concerns. Moreover, sectoral composition and labour-market mechanisms are not directly examined, limiting causal interpretations of jobless growth. Future research should employ longer provincial panels, alternative dynamic estimators, and sector-specific employment and investment data to validate these relationships and identify the conditions under which economic growth translates into more inclusive employment outcomes.

Author Contributions

E. K. L.: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Validation, Resources, Conceptualization, Supervision, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing.

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