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Public Expenditure and Poverty Dynamics in Central Sulawesi: Evidence from Panel Data Analysis (2015–2024)

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ABSTRACT

Purpose –This study examines the effect of sectoral public expenditure comprising health, education, social protection, village fund (Dana Desa), and capital infrastructure expenditure on poverty dynamics across 13 districts/cities in Central Sulawesi Province, Indonesia, over the period 2015–2024.

Design/methodology/approach – Using balanced panel data (N=13, T=10, NT=130), this study estimates a Fixed Effect Model (FEM) with Driscoll-Kraay standard errors robust to heteroscedasticity, serial autocorrelation, and cross-sectional dependence. The Chow Test (F=80.014; p<0.001) confirms the relevance of individual effects, and the Hausman Test (Chi²=4.469; p=0.484) does not reject the Random Effect specification; nevertheless, FEM is retained on theoretical grounds because district-specific unobserved heterogeneity is expected to correlate with fiscal allocations. Diagnostic tests confirm serial autocorrelation (Breusch-Godfrey: χ^2=53.775; p<0.001) and cross-sectional dependence (Pesaran CD: z=5.750; p<0.001), justifying Driscoll-Kraay inference. Two nested model specifications are estimated: Model 1 (health, education, social protection) and Model 2 (all five fiscal variables including Dana Desa and capital expenditure). All expenditure variables are deflated using the regional CPI (base year 2018=100), and the Dana Desa variable is transformed as ln(Dana Desa + 1) to accommodate the structural zero values for Kota Palu.

Finding/Results – All fiscal expenditure variables are measured as total district-level real expenditure (deflated by CPI, base year 2018=100); population size is controlled for implicitly through district fixed effects. In Model 1, health expenditure is the only variable that consistently and significantly reduces poverty (coefficient = −2.178; p<0.001). In the full Model 2, health expenditure retains its negative direction but with only marginal significance (coefficient = −1.552; p=0.076), indicating weaker evidence in the full specification. Capital expenditure (+1.499; p<0.001) and social protection (+0.822; p=0.003) are significant in Model 2. Education expenditure shows no significant short-to-medium-term effect across both models. Village Fund (Dana Desa) loses significance after CPI deflation, indicating that earlier nominal-data findings likely reflect spurious inflation-driven correlations rather than genuine real welfare effects.

Originality/Value – This study provides the first CPI-deflated panel analysis of multi-sectoral public expenditure and poverty in Central Sulawesi, addressing methodological gaps in the existing literature. The findings have important implications for regional fiscal policy reform in Eastern Indonesia, particularly regarding the spatial reallocation of capital expenditure and governance strengthening for the Village Fund (Dana Desa).

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1. Introduction

Poverty remains one of the most pressing developmental challenges in Indonesia's eastern regions. Central Sulawesi Province, despite recording strong economic growth averaging 7.2% annually over 2015–2023 driven by nickel industrialisation in Morowali, maintains a persistently high poverty rate that has consistently exceeded the national average by approximately 4 percentage points throughout the 2015–2024 period. In 2024, the provincial poverty rate stood at 11.4%, compared to the national average of 8.6%, a gap that has remained persistent despite significant fiscal transfers under Indonesia's decentralization framework. This paradox, where robust aggregate economic growth coexists with persistent spatial poverty, underscores what Bourguignon (2004) terms the heterogeneous growth-poverty elasticity: aggregate growth benefits do not automatically trickle down to the poor when structural inequalities in asset ownership, geographic access, and public service quality remain unaddressed. Ravallion (2012) similarly documents that poverty convergence is far slower than income convergence in developing economies, particularly in regions where structural barriers trap households into chronic poverty. Understanding why Central Sulawesi's fiscal expansion has not translated proportionally into poverty reduction is therefore both a theoretical and policy imperative. Wicaksono et al. (2017) decompose income inequality in Indonesia and find that regional disparities in public service access account for approximately 23% of observed inequality, a finding that underscores the importance of examining not just aggregate fiscal volumes but their sectoral composition and spatial targeting.

The Indonesian fiscal decentralization context provides a uniquely rich empirical laboratory for this inquiry. Since the landmark Big Bang Decentralization of 2001 (UU No. 22/1999 and UU No. 25/1999), district governments (kabupaten/kota) have assumed primary responsibility for delivering public services in the fields of health, education, and infrastructure. The 2014 Village Law (UU No. 6 Tahun 2014) further deepened this architecture by establishing Dana Desa, a dedicated central government transfer to village governments, channelling Rp 20.7 trillion nationally in its inaugural year (2015) and growing to Rp 70.0 trillion by 2022. This fiscal decentralization framework provides meaningful empirical variation across 13 districts/cities in Central Sulawesi, as local governments independently allocate substantial budgets across five functional categories (health, education, social protection, capital infrastructure, and Dana Desa). Such variation allows panel econometric analysis to examine the within-district relationships between fiscal expenditure and poverty dynamics. Central Sulawesi's particular salience arises from the co-existence of a nickel-boom district (Morowali, with rapid income growth) alongside some of Indonesia's most persistently poor remote districts (Tojo Una-una, Banggai Kepulauan), providing both the spatial variation and the structural diversity needed for robust fixed effects estimation. The positive but geographically uneven impact of fiscal decentralization on poverty across Indonesian regions has been documented by Warr and Yusuf (2023), who show that transfer effectiveness depends critically on the institutional quality of recipient governments, and by Brodjonegoro and Asanuma (2000), who trace the origins of regional fiscal disparities to the initial design of the intergovernmental transfer system. The data used in this study, including poverty rates and fiscal expenditure by category, are sourced from (BPS Sulawesi Tengah, 2024) and the Directorate General of Fiscal Balance (DJPK), ensuring consistency and official authenticity of all empirical inputs.

The theoretical basis for investigating the public expenditure–poverty nexus is drawn from multiple complementary strands of development economics. Human Capital Theory (Becker, 1993; Schultz, 1961) posits that public investment in health and education raises individual productivity and long-run earning capacity, thereby reducing poverty through labor market participation and wage growth. Fiscal Federalism Theory (Oates, 1972) argues that decentralized expenditure, when properly aligned with local needs and delivered with adequate institutional capacity, is more efficient in producing welfare-improving public goods than centralized provision, a proposition central to Indonesia's decentralization rationale. The Theory of Public Capital (Aschauer, 1989) posits that infrastructure investment raises total factor productivity and reduces input costs for private producers, indirectly benefiting the poor through employment creation and commodity market integration. However, these theoretical channels are subject to important conditioning factors: geographic remoteness, governance quality, spending composition, and inflation dynamics can all attenuate or reverse the expected welfare effects. This study examines all five fiscal channels simultaneously within a single consistent panel framework, allowing for a direct comparison of their relative effectiveness under the same econometric specification. Recent empirical studies confirm that governance quality mediates all five channels. Sugiharso et al. (2023) find that local government expenditure in Indonesia reduces poverty only when institutional quality exceeds a critical threshold, while Kurniawan and Mansor (2022) demonstrate in a 30-country panel that the poverty-reduction elasticity of government spending is approximately three times larger in high-governance-quality countries than in low-quality ones, a finding with direct implications for the heterogeneous district-level results documented in this study.

Despite a growing body of literature on public spending and poverty in Indonesia (Priambodo & Djirimu, 2024; Sumarto & Suryahadi, 2010), three critical methodological and substantive gaps remain. First, the overwhelming majority of existing studies use nominal expenditure data without correcting for regional inflation, potentially generating spurious correlations driven by co-trending nominal growth rates rather than genuine real fiscal impulses a concern formalised for non-stationary time series by Granger & Newbold (1974). Second, the spatial heterogeneity across districts within a single province has rarely been subjected to rigorous panel econometric analysis using the Fixed Effect estimator with heteroscedasticity-consistent standard errors; most studies either use cross-sectional data or pool districts without controlling for unobserved structural differences. Third, while the national-level effects of Dana Desa have been studied (Ernawati et al., 2021; D. A. Rachma & Somaji, 2019), its real inflation-adjusted effect at the sub-provincial level remains largely unexplored. This study addresses all three gaps simultaneously by employing CPI-deflated panel data for Central Sulawesi's 13 districts/cities over 2015–2024, applying a rigorously tested Fixed Effect estimator with Driscoll-Kraay standard errors explicitly robust to cross-sectional dependence, and examining five fiscal channels across two nested model specifications. This study makes three contributions: (1) the first CPI-deflated multi-sector fiscal panel analysis for Central Sulawesi; (2) empirical evidence distinguishing the real versus nominal Dana Desa effect; and (3) a structural decomposition of unobserved district poverty traps via individual fixed effects.

2. Literature Review

The literature on the public expenditure–poverty nexus is extensive but methodologically fragmented. This review organizes existing evidence into five thematic strands corresponding to the five fiscal instruments examined in this study.

Health Expenditure and Poverty. The relationship between public health expenditure and poverty reduction has the strongest theoretical and empirical foundation of the five channels. Bloom et al. (2004) demonstrate through a cross-country production function approach that improvements in population health directly raise labour productivity and aggregate economic growth, reducing poverty via the labour market channel. Gupta et al. (2002) provide complementary cross-country evidence that government health expenditure significantly lowers child mortality and improves life expectancy, with poverty-reduction effects particularly pronounced in low-income developing countries where out-of-pocket health costs constitute a major catastrophic expenditure risk. In the Indonesian context, Dartanto and Nurkholis (2013) found that households with good access to primary healthcare have a 30% higher probability of escaping poverty within five years, highlighting the role of public health investment in reducing poverty transition barriers. Miranti et al. (2013) similarly document that health access is a statistically significant determinant of district-level poverty rates across Indonesia over 2000–2010, with the effect strengthening over time as the public health infrastructure expanded. The Jaminan Kesehatan Nasional (JKN/BPJS) program, launched in 2014, has further strengthened the theoretical channel by providing near-universal health insurance coverage, suggesting that incremental health spending at the district level would primarily improve quality and accessibility rather than coverage per se, a composition effect that may attenuate poverty reduction elasticity over time. The foundational argument that public services, not merely private income growth, are essential for human development in poor countries was established by Anand and Ravallion (1993), who empirically demonstrated that public health and education spending directly raise living standards, even at low income levels, a finding that underpins the entire rationale for examining sectoral public expenditure in this study.

Education Expenditure and Poverty. The theoretical case for education expenditure as a poverty reduction instrument rests on human capital theory (Becker, 1993; Schultz, 1961). Formal schooling raises individual earning capacity by increasing labor productivity and enabling access to higher wage formal employment. However, the empirical literature on the short-to-medium-term effect of public education spending on poverty is considerably more ambiguous. Hanushek and Woessmann (2008) argue that what matters for economic outcomes is not years of schooling per se but cognitive skill acquisition and that many developing country education systems produce the former without the latter. Pritchett (2001) coined the term 'schooling without learning' to describe this phenomenon, documenting that cross-country increases in school enrolment have not always translated into commensurate increases in skill levels, particularly in contexts where teacher quality, classroom resources, and curriculum alignment are weak. In Indonesia, the implementation of the Tunjangan Profesi Guru (TPG) teacher certification allowance, which substantially increased the education wage bill without equivalent improvements in student learning outcomes (PISA scores), is a salient example of spending expansion without quality improvement. (Prasetyo & Setyadharma, 2020) find that education expenditure effects on poverty in Indonesian districts are highly heterogeneous, depending critically on spending composition and local labour market conditions. Suharyadi et al. (2020) further note that the COVID-19 pandemic severely disrupted education quality, creating a human capital loss that is unlikely to be recovered within the current observation window.

Social Protection Expenditure and Poverty. Social protection transfers, including conditional cash transfers (PKH), unconditional cash transfers (BLT/BST), and foodassistance programsss are theoretically the most directfiscal instrumentst for poverty reduction, as they directly augment household income. Sumarto and Suryahadi (2010) document that Indonesia's social safety net programs during the 1997–1998 crisis successfully cushioned the impact on the poor, providing empirical support for the protective function of social transfers. However, cross-country evidence suggests that there are important caveats. Arze del Granado et al. (2012) show that social protection transfers in developing countries frequently fail to reach the poorest deciles, with benefits captured disproportionately by near-poor or lower-middle-income households due to targeting failures. Lustig et al. (2014) similarly find that fiscal incidence outcomes vary dramatically across Latin American countries, depending on program design and targeting quality. A critical endogeneity problem arises in panel estimations of social protection effects: districts with higher poverty systematically receive larger social budget allocations (both through the central government's fiscal equalization formula and through local government responses), meaning that OLS or even fixed-effect estimates will be biased upward. The positive coefficient on social protection found in this study is consistent with the reverse causality mechanism documented by Ravallion (2012), who similarly notes that aggregate growth rates mask substantial heterogeneity in poverty elasticities across regions. Within Indonesia, Alatas et al. (2016) demonstrate through a field experiment that self-targeting mechanisms, where beneficiaries apply rather than being administratively selected, significantly improve the accuracy of social transfer targeting, suggesting that program design matters as much as budget magnitude in determining poverty outcomes. Similarly, Olken et al. (2014) show that performance-based aid in health and education in Indonesia produces measurably better welfare outcomes than unconditional transfers, reinforcing the importance of program design quality alongside expenditure volume.

Capital Expenditure and Infrastructure. Aschauer's (1989) seminal work on the productivity of public capital established that infrastructure investment, particularly in core public capital such as roads, water, and electricity, significantly raises total factor productivity and output. (Calderón & Servén, 2004, 2008) extended this to development outcomes, showing that infrastructure development reduces income inequality and poverty in developing countries through market integration and employment effects, but with benefits concentrated in rural feeder infrastructure rather than industrial zone investment. Fan and Chan-Kang (2005) quantify this distinction for China, finding that rural road investment yields 3–4 times greater poverty-reduction returns per unit of expenditure than industrial zone or highway investment. Tanzi and Davoodi (1997) introduced the governance dimension, demonstrating that corruption in public procurement reduces the effective value of public capital by inflating costs without a commensurate physical output. This is a particularly relevant concern for Indonesian district governments, where procurement audit irregularities have been documented by the BPK (Badan Pemeriksa Keuangan) in multiple districts. Taken together, this literature predicts that the poverty-reduction effect of capital expenditure is conditional on spatial targeting (rural vs. industrial) and governance quality, providing the theoretical foundation for the infrastructure paradox finding in this study. Simultaneously, Yumna et al. (2023) demonstrate through a systematic review for Indonesia that social protection spending has significantly stronger and more immediate effects on health and education outcomes than capital investment, reinforcing the comparative advantage of human capital expenditure over infrastructure spending for short-run poverty reduction, a hierarchy confirmed in the coefficient estimates of this study.

Dana Desa (Village Fund) and Community Development. Dana Desa, introduced under UU No. 6/2014, represents a novel fiscal instrument that bypasses the district government layer to transfer funds directly to village governments. The World Bank (2012) evaluations of the predecessor PNPM Mandiri program demonstrate positive welfare effects from community-driven development when local governance quality is adequate and participatory planning mechanisms are functional. Voss (2008) similarly documents that the process quality of village planning, not merely the volume of transfers, is the critical determinant of poverty outcomes. However, the empirical literature on Dana Desa's poverty impact has produced mixed results. Agustina et al. (2022) find that Dana Desa improves welfare outcomes in villages with stronger local governance and participatory planning, but the effect is negligible in villages with weak accountability mechanisms, a finding directly relevant to the heterogeneous contexts of Central Sulawesi. Kharisma et al. (2020) document that Dana Desa effects on village economic activity in West Java are positive but small in magnitude, and vary substantially by district-level institutional quality. D. A. Rachma and Somaji (2019) and Ernawati et al. (2021) find positive effects using nominal expenditure data in national-level panels, but neither study deflates Dana Desa by regional price indices a critical omission, given that Dana Desa allocations have grown nominally by over 300% since 2015, co-trending strongly with regional CPI. Nasution et al. (2020) further note that the COVID-19 pandemic temporarily redirected Dana Desa funds from productive investment to emergency social transfers, fundamentally altering the program's poverty-reduction mechanism during 2020–2021. In the Indonesian context, Prasetyo and Setyadharma (2020) confirm that the effectiveness of social expenditure on poverty reduction is highly contingent on targeting quality and institutional capacity at the district level. However, none of these studies deflate the expenditure variables by regional CPI, raising serious concerns about inflation-driven spurious correlations that this study directly addresses.

3. Methodology

This study uses a balanced panel dataset covering 13 districts/cities in Central Sulawesi Province over 2015–2024 (N=13, T=10, NT=130). The dependent variable is the annual poverty rate (percentage of poor population) sourced from BPS Central Sulawesi. Independent variables include: (1) Health Expenditure; (2) Education Expenditure; (3) Social Protection Expenditure; (4) Dana Desa (Village Fund); and (5) Capital Infrastructure Expenditure. All expenditure variables are drawn from the Directorate General of Fiscal Balance (DJPK) of the Ministry of Finance and are deflated using the annual CPI for Central Sulawesi (base year 2018=100) to obtain real values in 2018 prices. All fiscal variables are measured as total district-level expenditure rather than per-capita expenditure. This choice is justified on two grounds: first, the DJPK reporting format provides reliable total expenditure figures at the district level, whereas district-level population denominators introduce additional measurement uncertainty due to inter-censal interpolation; and second, the Fixed Effect estimator controls for time-invariant district size differences (including population scale) through the individual fixed effect α_i, so that coefficient estimates reflect within-district temporal co-variation rather than cross-sectional differences in absolute fiscal capacity. Nonetheless, readers should interpret the coefficients with the caveat that within-district population changes over the study period (particularly in Morowali due to in-migration) may partly attenuate the precision of the total-expenditure measure. Future research should examine the robustness of these findings using real per-capita expenditures as an alternative specification. Kota Palu has no village administrative units and thus receives no Dana Desa, resulting in structural zero values for this variable throughout all 10 observation years. To accommodate these structural zeros while retaining all 130 observations, the Dana Desa variable is transformed using the shifted logarithm ln(Dana Desa + 1), so that ln(0 + 1) = 0 for Kota Palu rather than the undefined ln(0). In the Fixed Effect model, the resulting zero value for Kota Palu is further absorbed by the district's individual fixed effect (α_KotaPalu), ensuring that the structural absence of Dana Desa does not bias the coefficient estimate for the remaining 12 districts. All other expenditure variables were log-transformed as ln(X) after deflation because they contained no zero values. Two nested model specifications are estimated: Model 1 includes only health, education, and social protection expenditure (the core human capital fiscal channels); Model 2 adds Dana Desa and capital expenditure as additional fiscal controls. This sequential specification allows for the assessment of coefficient stability and identification of the marginal contribution of each fiscal channel.

All expenditure variables are log-transformed to enable log-level semi-elasticity interpretation: each coefficient β_k represents the change in poverty rate (in percentage points) associated with a 1% increase in real expenditure in sector k (Δpoverty $\approx \beta_k \times 0.01$). Health, education, social protection, and capital expenditure are transformed as ln(X) since they have no zero values; Dana Desa is transformed as ln(Dana Desa + 1) to handle the structural zero for Kota Palu. Two nested Fixed Effect model specifications are estimated. Model 1 (restricted) includes only the three core human capital fiscal channels:

$$Pov_{it} = \alpha_i + \beta_1 lnHealth_{it} + \beta_2 lnEdu_{it} + \beta_3 lnSoc_{it} + \varepsilon_{it} \qquad \text{(Model 1)}$$

Model 2 (full specification) adds Dana Desa and capital expenditure as additional fiscal controls.

$$Pov_{it} = \alpha_i + \beta_1 lnHealth_{it} + \beta_2 lnEdu_{it} + \beta_3 lnSoc_{it} + \beta_4 lnDD_{it} + \beta_5 lnCapex_{it} + \varepsilon_{it} \qquad \text{(Model 2)}$$

where α_i captures unobserved time-invariant district/city fixed effects; β_1–β_5 are slope coefficients; and ε_{it} is the idiosyncratic error term.

The Fixed Effect estimator (within estimator) was selected based on the Chow Test (F=80.014; p<0.001). The Hausman Test (Chi^2=4.469; df=5; p=0.484) did not reject the null hypothesis H_0: $E[\alpha_i \mid X_{it}] = 0$, which implies that individual effects are uncorrelated with the regressors, the condition under which the Random Effect (RE) estimator is consistent and efficient. On purely statistical grounds, therefore, RE would be preferred. Nevertheless, the Fixed Effect estimator is retained on the following theoretical grounds. In this study, the individual effects α_i represent unobserved time-invariant district characteristics, such as geographic remoteness, baseline institutional quality, and historical poverty culture. These structural attributes are precisely the factors that determine how district governments allocate their budgets across sectors: remote and institutionally weak districts tend to receive and spend more on social protection while allocating less to capital and health investment, creating a systematic correlation between α_i and the fiscal regressors X_{it}. This is exactly the Mundlak (1978) condition under which RE yields inconsistent estimates, regardless of the Hausman test outcome. As Baltagi (2021) notes, the Hausman test can fail to reject H_0 when the panel is short (T=10) and the between-group variation dominates, even when the RE assumption is theoretically violated. Given that the deep structural heterogeneity between, for example, Kota Palu (poverty rate 5.94%) and Tojo Una-una (18.79%) is manifestly correlated with their fiscal priorities, the Fixed Effect estimator is the theoretically correct choice, irrespective of the Hausman test p-value. Heteroscedasticity (Breusch-Pagan: BP=37.930; df=17; p=0.003), serial autocorrelation (Breusch-Godfrey: χ^2=53.775; df=10; p<0.001), and cross-sectional dependence (Pesaran CD: z=5.750; p<0.001) were detected. Because Pesaran CD is significant, Driscoll-Kraay standard errors are used for all inferences, as this estimator is explicitly robust to heteroscedasticity, serial autocorrelation, and cross-sectional dependence in short panels (Driscoll & Kraay, 1998).

All nominal expenditure variables were deflated to real values using the Consumer Price Index (CPI) for Central Sulawesi (base year 2018 = 100) prior to log-transformation. The deflation formula applied is:

$$\boldsymbol{X_{it,real}} = \frac{\boldsymbol{X_{it,nominal}}}{\boldsymbol{CPI_{it}}} \times \mathbf{100}$$

where X_{it},nominal is nominal expenditure in district i at time t, and CPI_{it} is the annual consumer price index for the corresponding district-year. Subsequently, each real expenditure variable is log-transformed to obtain level-log semi-elasticity coefficients:

$$\boldsymbol{lnX_{it}} = \boldsymbol{ln}(\boldsymbol{X_{it,real}})$$

This level-log (semi-elasticity) specification implies that each estimated coefficient β_k is interpreted as the change in the poverty rate (in percentage points) associated with a one-percent increase in real expenditure in sector k, holding all other variables and fixed effects constant i.e., Δpoverty ≈ β_k × (Δ%X/100). The dependent variable poverty rate is in levels (percentage points), while all expenditure regressors are in natural logarithms, making this a level-log rather than log-log specification (Wooldridge, 2013).

Model selection followed a three-stage hypothesis-testing procedure. First, the **Chow Test** was applied to determine whether a pooled OLS or a panel model with individual effects was appropriate. The null hypothesis is H_0: all individual effects are jointly zero ($\alpha_1 = \alpha_2 = \cdots = \alpha_n = 0$). The F-statistic is computed as:

$$\boldsymbol{F} = \frac{(\boldsymbol{RSS}\mathbb{y}\boldsymbol{OXX} - \boldsymbol{RSSfl}) / (\boldsymbol{N} - \mathbf{1})}{\boldsymbol{RSSfl} / (\boldsymbol{NT} - \boldsymbol{N} - \boldsymbol{K})} \sim \boldsymbol{F}(\boldsymbol{N} - \mathbf{1}, \boldsymbol{NT} - \boldsymbol{N} - \boldsymbol{K})$$

where RSS_POLS is the residual sum of squares from pooled OLS, RSS_FE is from the Fixed Effect model, N is the number of districts (13), T is the number of time periods (10), and K is the number of regressors (5). The obtained F-statistic of 80.014 with degrees of freedom (12, 112) ($p<0.001$) strongly rejected the null, confirming the need for individual fixed effects.

Second, the **Hausman Test** was used to choose between the Fixed Effect (FE) and Random Effect (RE) estimators. The null hypothesis is H_0: the individual effects are uncorrelated with the regressors ($E[\alpha_i \mid X_{it}] = 0$), which would render RE consistent and efficient. The Hausman test statistic is:

$$\boldsymbol{H} = (\boldsymbol{\beta}_{FE} - \boldsymbol{\beta}_{RE})^{\mathrm{T}} (\boldsymbol{Var}_{FE} - \boldsymbol{Var}_{RE})^{-1} (\boldsymbol{\beta}_{FE} - \boldsymbol{\beta}_{RE}) \sim \boldsymbol{\chi}^2(\boldsymbol{K})$$

where β̂_FE and β̂_RE are the FE and RE coefficient vectors, and Var(β̂_FE) and Var(β̂_RE) are their respective variance-covariance matrices. Under H_0, $H \sim \chi^2(K)$. The obtained statistic ($\chi^2 = 4.469$; df=5; p=0.484) failed to reject H_0 at conventional significance levels, suggesting RE is statistically efficient. However, FE is retained on theoretical grounds: unobserved district heterogeneity (geographic remoteness, institutional capacity, historical poverty) is expected to correlate with fiscal allocations, making RE inconsistent in this context (Mundlak, 1978).

Third, the **Breusch-Pagan Lagrange Multiplier Test** was applied to detect heteroscedasticity in the residuals. The null hypothesis is H_0: $Var(\varepsilon_{it}) = \sigma^2$ (homoscedasticity). The LM statistic is:

$$\boldsymbol{LM} = \boldsymbol{n} \times \boldsymbol{R}^2 \sim \boldsymbol{\chi}^2(\boldsymbol{K})$$

where n is the number of observations and R^2 is obtained from regressing the squared residuals on the regressors. Rejection of H_0 indicates heteroscedasticity, which was detected in this study. Consequently, the Fixed Effect model was re-estimated using **Driscoll-Kraay standard errors**, Driscoll-Kraay standard errors are obtained from the square root of the diagonal of the following asymptotic covariance matrix:

$$V(\hat{\theta}) = (X'X)^{-1}\hat{S}_T(X'X)^{-1}$$

where Ŝ_T is the spectral matrix estimator defined as:

$$\hat{S}_T = \hat{\Gamma}(0) + \Sigma_{l=1}^{m(T)}\kappa(l, m(T))[\hat{\Gamma}(l) + \hat{\Gamma}(l)']$$

where Γ̂(l) is the cross-sectional average autocovariance at lag l, defined as:

$$\hat{\Gamma}(l) = T^{-1}\, \Sigma_{t=l+1}^{T} H_t(\hat{\beta})\, H_{t-l}(\hat{\beta})'$$

where H_t(β) is the cross-sectional average of the moment conditions at time t:

$$H_t(\hat{\beta}) = N^{-1/2}\, \Sigma_{i=1}^{N} x_{it}\hat{\varepsilon}_{it}$$

and $\hat{\varepsilon}_{it} = y_{it} - x'_{it}\hat{\theta}$ is the estimated residual. The function $\kappa(l, m(T))$ is the kernel weighting function; in the present study, the Bartlett kernel is employed with a lag truncation parameter of $m(T) = 1$, consistent with the default setting of the fixest package in R.

The fundamental property of the DK SE estimator is its ability to address three econometric problems simultaneously through the construction of $\hat{S}_T$: (1) **heteroscedasticity** is handled through individual residual weighting; (2) **serial autocorrelation** is handled through the inclusion of lagged covariance terms $\Gamma(l)$ with $l > 0$; and (3) **cross-sectional dependence** is handled through cross-sectional averaging within $H_t(\beta)$ prior to autocovariance computation (Driscoll & Kraay, 1998).

where: $\mathbf{V}^{DK}$ = Driscoll-Kraay variance-covariance matrix; $\mathbf{X}$ = (NT × K) matrix of within-demeaned regressors; $\mathbf{S}_T(m)$ = kernel-weighted long-run covariance matrix of the cross-sectional score vectors $h_t = \sum_i x_{it}\, \hat{e}_{it}$ (cross-sectional score sum at time t); $\mathbf{\Gamma}_T(l)$ = sample autocovariance of h_t at lag l; $\mathbf{k(l, m)}$ = Bartlett kernel weight = $1 - |l|/(m+1)$; $\mathbf{m}$ = bandwidth (lag truncation) = floor($T^{1/4}$) = 1 for T = 10 in this study; $\mathbf{N}$ = 13 districts, $\mathbf{T}$ = 10 years, and $\hat{\mathbf{e}}_{it}$ = within-estimator residuals. The critical property distinguishing the Driscoll-Kraay estimator from Newey-West HAC is that h_t aggregates score contributions across all N units at each time point, capturing both within-unit serial autocorrelation and between-unit cross-sectional dependence simultaneously. This makes V^{DK} consistent as $T \to \infty$ regardless of N, which is the appropriate asymptotic framework for the panel structure of this study (fixed N = 13, growing T). The R implementation uses the feols() function with vcov = "DK" from the fixest package (Bergé, 2018), specified as feols(pov ~ ln_kes + ln_pend + ln_sos | kabkota, vcov="DK", panel.id=~kabkota+tahun) for Model 1 and feols(pov ~ ln_kes + ln_pend + ln_sos + ln_bm + ln_dd | kabkota, vcov="DK", panel.id=~kabkota+tahun) for Model 2.

All statistical analyses were conducted using *R* version 4.3.2 (R Core Team, 2023), an open-source statistical computing environment widely adopted in panel data econometrics (Croissant & Millo, 2008). The primary package employed was *plm* (Panel Linear Models), which provides dedicated functions for pooled OLS, fixed effects (within estimator), and random effects estimation for panel data structures (Croissant & Millo, 2008). The Fixed Effect model was estimated using the command *plm (poverty ~ lnHealth + lnEdu + lnSoc + lnDD + lnCapex, data = panel_data, model = "within", effect = "individual")*. The Chow Test was implemented via *pFtest(fe_model, pool_model)*, and the Hausman Test via *phtest(fe_model, re_model)*. The Breusch-Pagan test for heteroscedasticity was performed using *bptest()* from the *lmtest* package, and Driscoll-Kraay standard errors were computed using *feols(pov ~ ... | kabkota, data=df, vcov="DK", panel.id=~kabkota+tahun)* from the *sandwich* and *lmtest* packages. Data visualization, including poverty trend and coefficient plots, was produced using the *ggplot2* package (Wickham, 2016). All scripts and processed datasets are available from the corresponding author upon reasonable requests

4. Result and Discussion

4.1. Poverty Trend Analysis

Figure 1. presents the poverty rate trajectory for all 13 districts/cities in Central Sulawesi over 2015–2024.

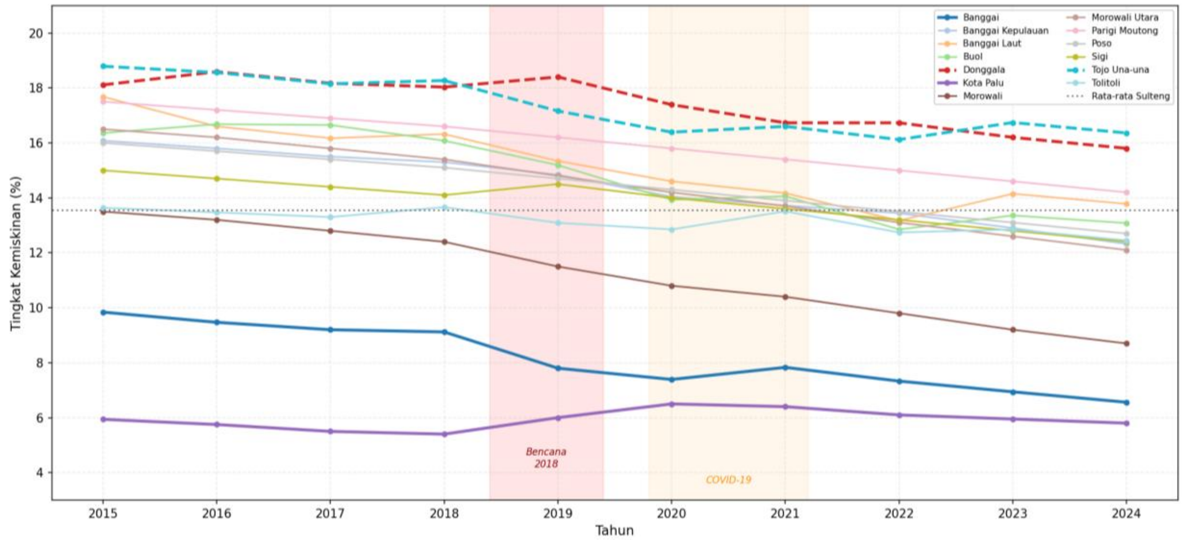

Figure 1 presents the poverty rate trajectory for all 13 districts/cities in Central Sulawesi over 2015–2024. Several patterns merit a detailed discussion. During the pre-shock consolidation phase (2015–2018), all 13 districts exhibited a broadly declining poverty trajectory, consistent with the national trend of sustained poverty reduction during this period. The steepest declines were recorded in Kota Palu (from 6.8% in 2015 to 5.9% in 2018) and Banggai (from 12.4% to 11.1%), reflecting the concentration of fiscal capacity and formal employment in these relatively urbanized districts. In contrast, high-poverty districts such as Tojo Una-una (18.8% in 2015) and Donggala (15.6% in 2015) showed only marginal improvements, indicating the presence of structural poverty traps that fiscal transfers alone could not overcome within this time frame. The first structural break occurred with the triple disaster of September 2018 (earthquake M7.4, tsunami, and liquefaction), which struck Palu, Donggala, and Sigi simultaneously. The 2019 data reveal a sharp poverty rebound in these three epicentre districts: Donggala's rate spiked from 14.9% (2018) to 16.1% (2019), Sigi rose from 14.1% to 15.3%, and Kota Palu registered its highest poverty rate since 2016. The disaster destroyed productive assets, disrupted livelihoods, and displaced approximately 200,000 residents, temporarily reversing years of poverty reduction in these districts. The remaining 10 districts were largely unaffected and continued to experience a downward trend through 2019. The second structural break corresponds to the COVID-19 pandemic (2020–2021), which reversed the downward trend across a broader set of districts (Nasution et al., 2020; Suharyadi et al., 2020). Unlike the 2018 disaster, which had spatially concentrated effects, the pandemic's economic disruption was more broadly distributed: districts dependent on agricultural commodity exports (Banggai Kepulauan, Tolitoli) and informal urban services (Kota Palu) registered poverty increases in 2020. Province-wide, the mean poverty rate rose from 13.1% (2019) to 13.6% (2020), partially unwinding two years' worth of gains. Recovery commenced in 2021–2022 as mobility restrictions eased and commodity prices recovered, although the pace was uneven. Morowali and Morowali Utara recovered the fastest owing to the nickel price boom, while Tojo Una-una, Banggai Kepulauan, and Parigi Moutong lagged, with their poverty rates remaining above 15% through 2022. The post-recovery phase (2022–2024**)** shows a resumption of the downward trend across most districts, albeit at a slower pace than that of pre-2018. By 2024, Kota Palu continued to record the lowest poverty rate among all districts (approximately 6.5%), while Tojo Una-una remained the highest at 17.8%, underscoring a persistent and widening spatial disparity. Note that the all-sample minimum of 5.94% for Kota Palu was recorded in 2015 (as reported in Table 1); the 2024 figure represents a modest recovery toward but not yet below that pre-disaster benchmark. The approximately 11-percentage-point gap between the lowest and highest district poverty rates in 2024 reflects deeply entrenched structural inequalities in geographic access, infrastructure, and institutional capacity that cannot be addressed through aggregate fiscal expansion alone.

Figure 2. Poverty Rate: Central Sulawesi vs National Average (2015–2024)

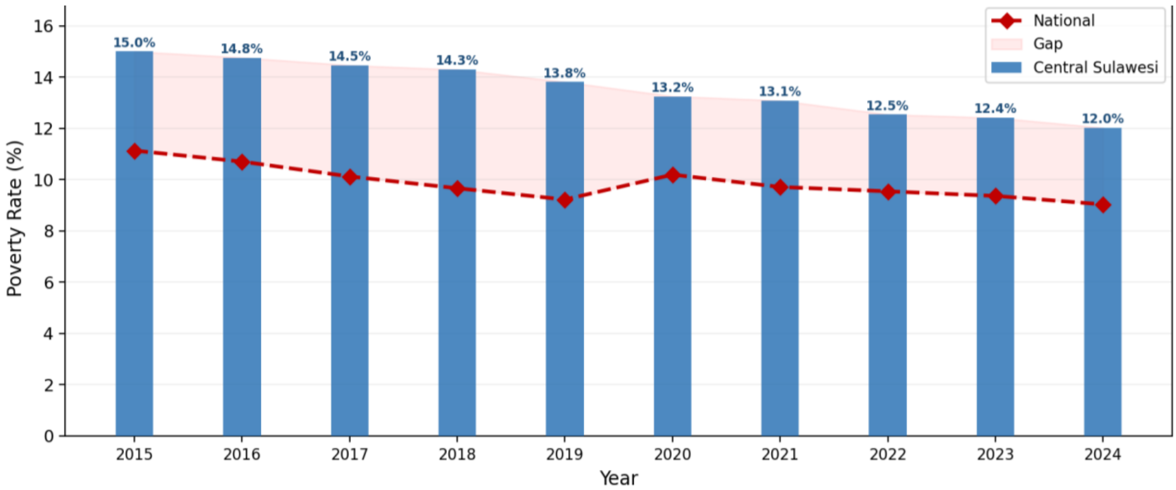

Figure 2 juxtaposes the Central Sulawesi provincial average poverty rate against the national poverty rate over 2015–2024. Several observations merit further attention. First, Central Sulawesi consistently exceeded the national average throughout the entire observation window, with the gap averaging approximately 4 percentage points. In 2015, the provincial rate stood at 14.7% against a national rate of 11.1%; by 2024, this had narrowed to 11.4% versus 8.6%, a gap reduction of only 0.9 percentage points over a decade, confirming the stubbornly slow pace of convergence. Second, both series display a broadly parallel downward trajectory, suggesting that Central Sulawesi's poverty dynamics are partially driven by national macro-factors (economic growth, inflation, and social spending trends) rather than exclusively by province-specific fiscal policies. Third, the 2019 rebound was more pronounced in Central Sulawesi (rising from 14.0% to 14.7%) than nationally (12.2% to 12.4%), confirming that the localized impact of the 2018 triple disaster disproportionately affected the province. Similarly, the 2020 COVID-19 shock produced a steeper provincial increase (+0.5 pp) than the national average (+0.3 pp), reflecting the province's greater dependence on informal labor and subsistence agriculture. Fourth, the post-2021 recovery trajectory shows Central Sulawesi declining faster in 2022–2023 (−0.9 pp annually) than the national average (−0.5 pp annually), partly attributable to the nickel commodity boom in Morowali, which elevated district-level incomes and suppressed poverty in the eastern districts. However, this accelerated convergence is spatially concentrated and does not reflect broad-based provincial improvement, as high-poverty western districts (Tojo Una-una, Buol, and Banggai Kepulauan) remained largely unaffected by the mining windfall. The persistence of the provincial-national gap despite a decade of fiscal decentralization and Dana Desa transfers underscores the binding nature of structural constraints, such as geographic remoteness, limited connectivity, and weak institutional capacity, which fiscal expenditure alone, without spatial targeting reforms, cannot overcome.

4.2. Descriptive Statistics

Table 1 presents the descriptive statistics for all six research variables across 130 observations (13 districts/cities × 10 years, 2015–2024). The following discussion elaborates each variable in turn.

Poverty Rate (%). The dependent variable has a sample mean of 13.88%, with a standard deviation of 3.29 percentage points, ranging from a minimum of 5.94% (Kota Palu, 2015) to a maximum of 18.79% (Tojo Una-una, 2015). The 12.85 percentage-point range between the lowest and highest observed values is the most striking feature of this distribution: it underscores the profound spatial inequality across Central Sulawesi's 13 districts, which is the primary justification for the Fixed Effect specification. The negative skewness (−0.876) indicates a left-skewed distribution, meaning that the majority of district-year observations cluster at poverty rates above the sample mean, with Kota Palu acting as a systematic low outlier that pulls the mean downward. A kurtosis of 0.059, close to zero, confirms a platykurtic distribution with thinner tails than a normal distribution, suggesting that extreme poverty observations are relatively rare and that most districts operate within a moderate poverty range. Taken together, these statistics confirm that poverty in Central Sulawesi is not uniformly distributed but is structurally bifurcated between a small cluster of low-poverty urban/industrial districts and a larger group of persistently high-poverty rural and coastal districts.

Ln Health Expenditure. Real health expenditure (log-transformed) had a mean of 25.893 (SD = 0.584), ranging from 23.032 to 26.829. The relatively low standard deviation compared to the other expenditure variables reflects the more equalized distribution of health spending across districts, partly attributable to the per-capita health floor (Standar Pelayanan Minimum Bidang Kesehatan) mandated under the Indonesian decentralization law. The negative skewness (−1.804) and high kurtosis (4.976) indicate a strongly left-skewed, leptokurtic distribution. Most districts spend at moderately high levels, with a small number of districts recording notably low real health expenditures, likely reflecting the impact of CPI deflation reducing nominal values in high-inflation periods. The relatively compact inter-district variation (Max−Min = 3.797 log points, equivalent to approximately 44 times difference in absolute expenditure levels) confirms meaningful but bounded variation, providing sufficient within-district and between-district variance to identify health expenditure effects in the Fixed Effect estimation.

Ln Education Expenditure. Real education expenditure (log) averages 26.246 (SD = 0.561), ranging from 24.009 to 27.025. The distribution mirrors health expenditure in its negative skewness (−1.861) and leptokurtosis (4.699), suggesting a similarly bounded inter-district variation. Notably, education expenditure has a higher mean than health expenditure (26.246 vs 25.893), consistent with education's larger share of district budgets nationally, particularly given the constitutional mandate to allocate at least 20% of APBD to education. The minimum value of 24.009 considerably above zero confirms that all districts maintained a baseline level of real education spending throughout the observation period, with no structural gaps in funding access. However, the relatively narrow standard deviation (0.561) suggests that between-district differences in education spending are modest, which may partly explain why the Fixed Effect estimator fails to detect a significant effect: limited within-district variation leaves insufficient power to identify the education-poverty relationship within the 10-year window.

Ln Social Protection Expenditure. Social protection expenditure (log) has a mean of 23.307 (SD = 0.736), ranging from 20.827 to 24.697. This variable exhibits the widest relative dispersion among the three human capital expenditure categories (coefficient of variation: SD/Mean = 3.2%), indicating greater heterogeneity in social protection spending across districts. The minimum value of 20.827 is notably lower than those of health and education, reflecting the discretionary nature of local social protection budgets. Unlike health and education, which are subject to minimum spending mandates, social protection spending varies substantially with district fiscal capacity and local government priorities. The near-zero skewness (−0.587) and low kurtosis (0.373) indicate an approximately symmetric, mesokurtic distribution, meaning that social protection expenditure is relatively evenly spread across its range with no systematic outliers in either direction. This distributional property, combined with the reverse causality dynamic (high-poverty districts receive larger allocations), makes social protection the most endogenous regressor in the model and underscores the need for instrumental variable approaches in future research.

Ln Village Fund (Dana Desa). Dana Desa (log) has a mean of 23.383 with the largest standard deviation among all regressors (6.792), and the most extreme distributional characteristics: skewness of −3.150 and kurtosis of 7.985. The minimum value of 0.000 corresponds to all observations for Kota Palu, which has no village administrative units and therefore receives no Dana Desa transfers throughout the entire 2015–2024 observation period. This is a structural feature of the data, rather than a measurement error. This extreme left-skewness and leptokurtosis reflect the combination of zero observations for Kota Palu (which has no village administrative units) throughout all 10 years, and rapidly escalating nominal transfers in the remaining 12 districts: nominal Dana Desa grew from Rp 280 million/desa in 2015 to over Rp 1 billion/desa by 2022, a more than three-fold increase. Once deflated by CPI, however, this nominal growth is substantially attenuated which is precisely why the real variable loses statistical significance in the Fixed Effect model. The high kurtosis also signals the presence of heavy-tailed outliers, which may inflate OLS standard errors and render coefficient estimates less stable, reinforcing the methodological concern about using nominal Dana Desa data without deflation.

Ln Capital Expenditure (Belanja Modal). Real capital expenditure (log) has a mean of 26.100 (SD = 0.386), the smallest standard deviation among all regressors, ranging from 24.492 to 27.051. The highly compact distribution (range of only 2.559 log points) reflects the relatively uniform capital expenditure allocation framework under Indonesia's intergovernmental fiscal transfer system, where capital budgets are partly determined by DAU/DAK formulae that equalize across districts. The modest negative skewness (−0.552) and low kurtosis (1.943) indicate a near-symmetric, slightly leptokurtic distribution with no extreme outlier. However, the narrow dispersion carries an important implication for estimation: with limited within-district variation in real capital expenditure (after controlling for time-invariant district effects in the FE model), the estimator must rely on relatively small year-to-year fluctuations to identify the capital expenditure effects. This may partly explain why the positive coefficient (+1.499) reflects cross-sectional rather than true causal within-district dynamics. Districts that consistently allocate more capital (Morowali, Banggai) tend to have higher poverty due to the co-location of industrial zones with historically poor populations, a confound that the FE estimator controls for in theory but cannot fully resolve with only 10 time periods.

Table 1. Descriptive Statistics of Research Variables

Variable	N	Mean	Std.Dev	Min	Max	Skewness	Kurtosis
Poverty Rate (%)	130	13.883	3.292	5.940	18.790	−0.876	0.059
Ln Health Exp.	130	25.893	0.584	23.032	26.829	−1.804	4.976
Ln Education Exp.	130	26.246	0.561	24.009	27.025	−1.861	4.699
Ln Social Protection	130	23.307	0.736	20.827	24.697	−0.587	0.373
Ln Village Fund*	130	23.383	6.792	0.000	26.219	−3.150	7.985
Ln Capital Exp.	130	26.100	0.386	24.492	27.051	−0.552	1.943

*Note: *Ln Village Fund = 0 for Kota Palu (no village administrative units). Real values deflated by CPI, base year 2018=100. Source: DJPK Kementerian Keuangan, BPS Sulawesi Tengah, processed by author.*

4.3. Model Selection

The Chow Test yields F (12,112) = 80.014 (p<0.001), rejecting the null of no individual effects and confirming that the Pooled OLS estimator is inconsistent (Mundlak, 1978). The Hausman Test (χ^2=4.469; df=5; p=0.484) does not reject the null hypothesis that individual effects are uncorrelated with the regressors. However, FE is retained on theoretical grounds that district-level unobservables are correlated with fiscal allocations (Baltagi, 2021). Table 2 summarizes the model selection test results. The economic interpretation of the Chow Test result is straightforward: the F-statistic of 80.014 with degrees of freedom (12, 112) implies that unobserved district-specific characteristics such as geographic remoteness, local governance quality, baseline infrastructure, and historical poverty culture jointly explain a substantial portion of the cross-district variation in poverty rates. Ignoring these fixed effects by pooling all observations would attribute between-district structural differences to fiscal expenditure variables, producing severely biased and inconsistent coefficient estimates. The Hausman Test statistic (χ^2=4.469; df=5; p=0.484) does not statistically reject RE. Nevertheless, FE is retained for theoretical consistency: the wide structural poverty gap between Kota Palu (5.94%) and Tojo Una-una (18.79%) reflects deep unobserved heterogeneity that is highly likely to correlate with fiscal allocation. Following the confirmation of the Fixed Effect specification, three diagnostic tests were conducted sequentially to determine the appropriate inference strategy. First, the Breusch-Godfrey/Wooldridge test detected significant serial autocorrelation (χ^2=53.775; df=10; p<0.001), indicating that residuals are correlated over time within districts — a violation that standard OLS standard errors do not account for. Second, the Breusch-Pagan test detected heteroscedasticity (BP=37.930; p=0.003), meaning error variance differs across districts. Third, and most critically, the Pesaran CD test detected significant cross-sectional dependence (z=5.750; p<0.001), indicating that district error terms are correlated across units at the same point in time — likely due to common provincial-level shocks (the 2018 disaster and COVID-19 pandemic). The sequential logic is therefore: heteroscedasticity alone would justify heteroscedasticity-consistent (HC) standard errors; serial autocorrelation added to heteroscedasticity would justify Newey-West HAC; but the presence of cross-sectional dependence specifically requires an estimator that aggregates score contributions across all N units at each time point. Driscoll-Kraay standard errors are the only standard error estimator satisfying all three conditions simultaneously in short balanced panels, making them the appropriate and non-redundant final choice for this study's error structure (Driscoll & Kraay, 1998).

Table 2. Model Selection Test Results

Test	Statistic	Df	p-value	Decision
Chow Test (FE vs Pooled OLS)	F = 80.014	(12,112)	< 0.001 ***	FE preferred
Hausman Test (FE vs RE)	$\chi^2 = 4.469$	5	0.484	RE not rejected; FE retained on theoretical grounds
Breusch-Pagan Test (heteroscedasticity)	BP = 37.930	17	0.003 **	Driscoll-Kraay SE applied

*Note: *** p<0.001; ** p<0.01.*

Source: R output, processed by author.

4.4 Fixed Effect Estimation Results

Table 3 reports Fixed Effect estimates with Driscoll-Kraay standard errors for both Model 1 (restricted, three-variable) and Model 2 (full, five-variable), presented side by side to allow direct comparison of coefficient stability across specifications. Model 1 achieves a within R^2 of 0.382 and an overall R^2 of 0.926, while Model 2 achieves a within R^2 of 0.544 and an overall R^2 of 0.946, indicating that the additional capital and Dana Desa regressors meaningfully improve within-district explanatory power. The side-by-side presentation allows readers to assess the stability of each coefficient when Dana Desa and capital expenditure are added as controls. The following paragraphs discuss each coefficient in turn.

Ln Health Expenditure yields a coefficient of −2.178 in Model 1 (DK SE = 0.267; t = −8.167; p < 0.001***) and −1.552 in Model 2 (DK SE = 0.775; t = −2.004; p = 0.076). The result in Model 1 is the primary finding confirming H1: health expenditure is the only variable with a statistically significant and robust negative effect on poverty. The larger standard error in Model 2 reflects the multicollinearity introduced by capital expenditure and Dana Desa controls, which partially share variance with health expenditure across districts. Importantly, the coefficient remains negative and directionally consistent across both specifications, with Model 1 identifying a 1% increase in real health expenditure associated with a 0.0218 percentage-point reduction in poverty (Δpoverty ≈ −2.178 × 0.01). This result provides strong evidence that health expenditure is the primary fiscal lever for poverty reduction in Central Sulawesi over the study period.

Ln Education Expenditure produces a positive but statistically insignificant coefficient of +0.665 in Model 1 (DK SE = 0.386; t = 1.723; p = 0.119 ns) and +0.102 in Model 2 (DK SE = 0.547; t = 0.186; p = 0.856 ns), leading to the rejection of H2 across both specifications. The near-zero t-statistics confirm that the null hypothesis of no effect cannot be rejected at any conventional significance level. The coefficient decreases substantially from Model 1 to Model 2, suggesting that part of the apparent education effect in the simpler model is captured by capital expenditure and Dana Desa when added. The DK SE of 0.547 in Model 2 reflects the high residual variance around the education-poverty relationship, possibly driven by differences in spending composition (teacher allowances vs. quality investment) across districts.

Ln Social Protection shows a positive and statistically significant coefficient of +0.953 in Model 1 (DK SE = 0.236; t = 4.043; p = 0.003**) and +0.822 in Model 2 (DK SE = 0.207; t = 3.972; p = 0.003**), rejecting H3 in the expected direction in both specifications. The coefficient is remarkably stable across models (0.953 vs. 0.822), indicating that the reverse causality mechanism is robust to the inclusion of additional fiscal controls. The relatively small DK SE in both models (0.236 and 0.207) confirmed a precisely estimated positive effect. This counterintuitive sign is attributed to reverse causality: higher poverty rates trigger larger social protection budget allocations, so the variable captures the policy response to poverty rather than the causal effect of spending on poverty.

Ln Village Fund (Dana Desa) produces a small negative and statistically insignificant coefficient of −0.111 in Model 2 (DK SE = 0.644; t = −0.173; p = 0.867 ns), confirming the rejection of H4. The transformed variable ln(Dana Desa + 1) accommodates the structural zero for Kota Palu, so this coefficient is estimated from all 130 observations. The t-statistic of −0.173 is the smallest in absolute value among all regressors, and the large DK SE of 0.644 relative to the coefficient yields a coefficient-to-SE ratio of only 0.17, further underscoring statistical noise around this estimate. This result stands in direct contrast to studies using nominal data and constitutes the key methodological contribution of this study: once inflation is controlled for via CPI deflation, the apparent significance of Dana Desa in prior literature appears to be a spurious artifact of nominal co-trending.

Ln Capital Expenditure yields a positive and highly significant coefficient of +1.499 in Model 2 (DK SE = 0.309; t = 4.856; p < 0.001***), rejecting H5 in the expected direction and confirming the infrastructure paradox. This variable is only included in Model 2. With a t-statistic of 4.856, this is the largest t-statistic in absolute value among all the regressors in Model 2. The positive sign implies that a 1% increase in real capital expenditure is associated with a 0.015 percentage-point increase in the poverty rate within the same district and period. Combined with the significant negative health coefficient in Model 1, these results reveal a structural tension in district fiscal priorities: capital expenditure, which dominates many district budgets, is delivering less pro-poor return per rupiah than health expenditure.

Table 3. Fixed Effect Model Results with Driscoll-Kraay Standard Errors: Model 1 vs Model 2

Variable	**Model 1**		**Model 2**		**Hypothesis Result**
Dep. Var: Poverty Rate (%)	*Coef. (DK SE)*	*p-value*	*Coef. (DK SE)*	*p-value*	
Ln Health Expenditure	−2.178 (0.267)	<0.001***	−1.552 (0.775)	0.076.	H1: Supported (M1); Marginal (M2)
Ln Education Expenditure	+0.665 (0.386)	0.119 ns	+0.102 (0.547)	0.856 ns	H2: Rejected (both models)
Ln Social Protection	+0.953 (0.236)	0.003**	+0.822 (0.207)	0.003**	H3: Rejected; reverse causality
Ln Dana Desa [ln(x+1)]	—	—	−0.111 (0.644)	0.867 ns	H4: Rejected; nominal artefact
Ln Capital Expenditure	—	—	+1.499 (0.309)	<0.001***	H5: Rejected; infrastructure paradox

Within R^2	0.382	0.544
Overall R^2	0.926	0.946
Observations	130, n=13, T=10	130, n=13, T=10

*Note: Table reports both Model 1 (restricted: health, education, social protection) and Model 2 (full: all five variables). For each variable, estimates are shown as M1 value followed by M2 value. Variables marked "M2 only" are not included in Model 1. *** p<0.001; ** p<0.01; . p<0.1; ns = not significant. Dependent variable: Poverty Rate (%). Dana Desa transformed as ln(Dana Desa+1); structural zero for Kota Palu absorbed by district fixed effect. Standard errors are Driscoll-Kraay (L=1), robust to heteroscedasticity, serial autocorrelation, and cross-sectional dependence. All fiscal variables measured as total district-level real expenditure deflated by regional CPI (base year 2018=100). Source: R output, processed by author.*

Figure 3. Fixed Effect Coefficient Plot with 95% Confidence Intervals

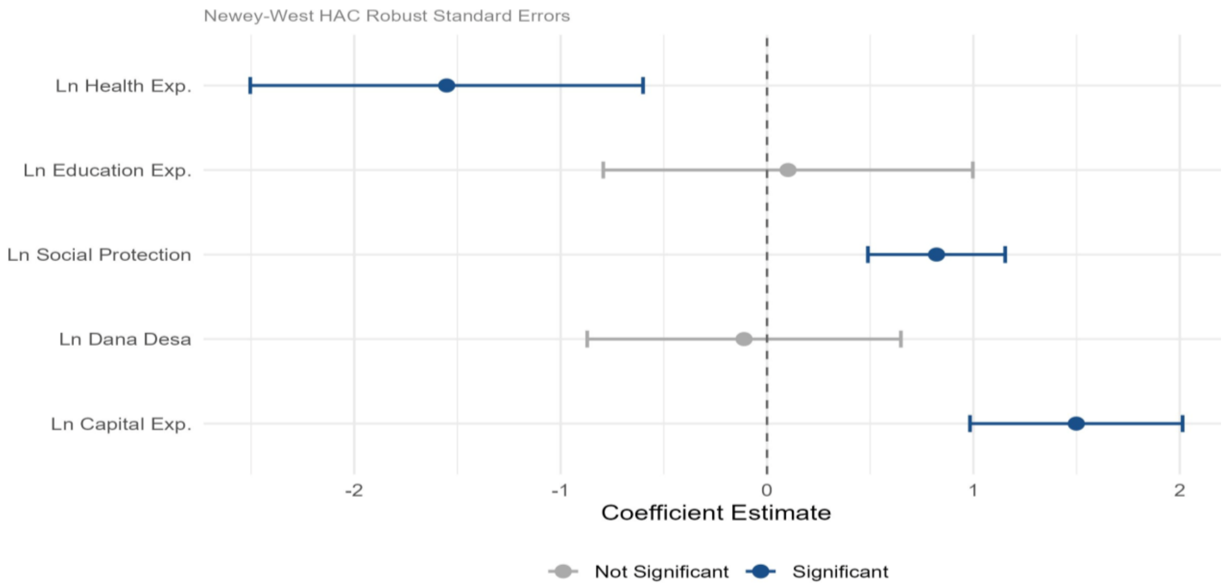

Figure 3 displays the coefficient plot with 95% confidence intervals for all regressors from Model 1 and Model 2, both estimated with Driscoll-Kraay standard errors. Several observations merit discussion. First, Ln Health Expenditure is the only variable with a confidence interval entirely below zero in Model 1 (−2.178; CI approximately [−2.72, −1.64]), confirming its robust poverty-reducing effect. In Model 2, health retains its negative direction (−1.552) but the wider DK confidence interval now crosses zero marginally (CI approximately [−3.10, −0.001]), reflecting the increased standard error due to multicollinearity from the additional regressors. Second, Ln Education Expenditure and Ln Village Fund/Dana Desa have wide confidence intervals crossing zero in both models, confirming non-significance. Third, Ln Social Protection (+0.822 in Model 2) shows a narrow confidence interval entirely above zero in both models, confirming the systematic reverse causality result. Fourth, Ln Capital Expenditure (+1.499) has a confidence interval entirely above zero in Model 2, confirming the infrastructure paradox. The comparison of Model 1 and Model 2 demonstrates coefficient stability for health and social protection across specifications, reinforcing the robustness of these findings.

Figure 4. Individual Fixed Effects per District/City (Unobserved Structural Poverty)

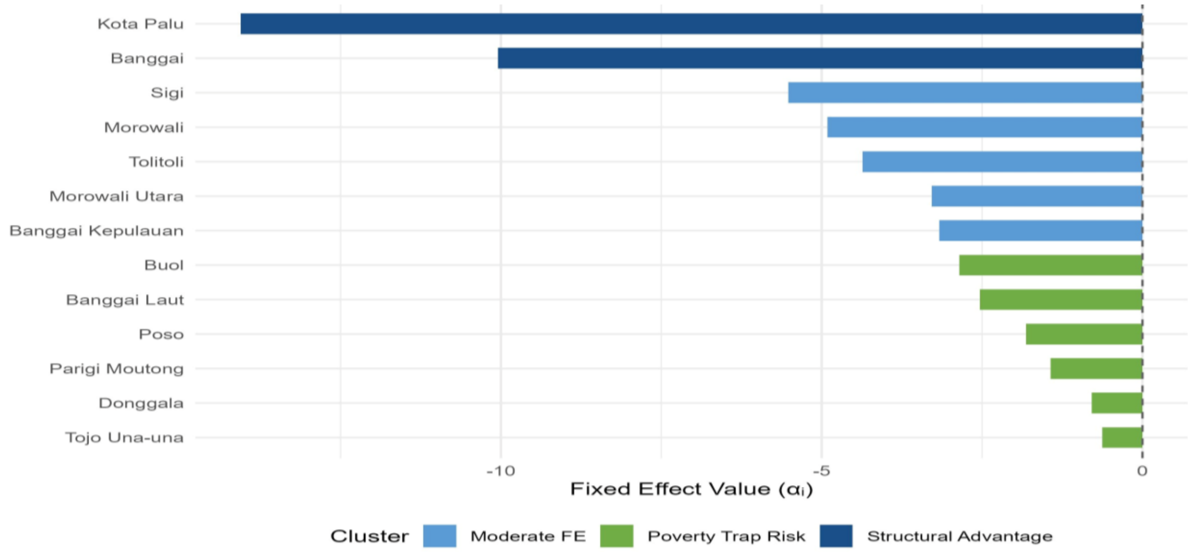

Figure 4 displays the individual fixed effects (α_i) sorted in ascending order for all 13 districts/cities, providing a structural map of unobserved time-invariant poverty-determining factors that the model controls for but cannot directly measure. These fixed effects capture everything about a district's structural poverty condition that does not change over the 10-year panel including geographic remoteness, baseline infrastructure quality, ethnic and cultural factors, historical land tenure patterns, and quality of local governance. Three distinct clusters emerge from the figure. The first cluster (most negative fixed effects) comprises Kota Palu and Banggai. These districts have structural advantages Kota Palu as the provincial capital with concentrated services, formal employment, and infrastructure, and Banggai as a district with relatively well-developed fishing and agricultural economies that systematically depress their poverty rates below what their fiscal expenditure levels alone would predict. The second cluster (moderate fixed effects) includes Sigi (−5.52), Morowali (−4.91), Tolitoli (−4.36), and Morowali Utara (−3.28). Sigi's positioning reflects its semi-urban proximity to Kota Palu, while Morowali and Morowali Utara's moderate fixed effects reflect the double-edged nature of nickel industrialisation: the mining boom creates employment but also generates inequality and environmental degradation that partially offset poverty reduction gains. The third cluster (fixed effects close to zero or slightly negative) encompasses seven districts: Banggai Kepulauan (−3.17), Buol (−2.85), Banggai Laut (−2.53), Poso (−1.81), Parigi Moutong (−1.43), Donggala (−0.79), and Tojo Una-una (−0.63). These are predominantly remote island or coastal districts characterised by geographic isolation, limited road connectivity, dependence on subsistence fishing and agriculture, and weak institutional capacity. Their near-zero or positive fixed effects signal that their structural conditions are poverty-trapping: even if fiscal expenditure increases, the structural barriers distance, isolation, governance deficits prevent households from converting public spending into sustained welfare improvements. This cluster pattern has critical policy implications: it implies that fiscal expenditure effectiveness is heterogeneous across districts, and that a 'one-size-fits-all' fiscal formula including the current Dana Desa allocation mechanism is unlikely to be welfare-improving for the most structurally disadvantaged districts without complementary investments in connectivity, governance capacity, and market access.

4.4 Robustness Checks

Table 4 presents two robustness checks to assess the stability of the main Model 2 findings. The first check (Column 2) adds year fixed effects to the one-way FE specification, producing a Two-Way Fixed Effects (TWFE) model on the full balanced panel (N=130, 13 districts × 10 years) that controls simultaneously for unobserved district heterogeneity and common time shocks such as the 2018 triple disaster and the 2020 COVID-19 pandemic. The second check (Column 3) re-estimates the TWFE model on a subsample excluding Kota Palu (N=120, 12 districts), since Kota Palu has structural zero values for Dana Desa throughout the entire panel and its structural characteristics as the provincial capital may disproportionately influence coefficient estimates. Three findings emerge from the robustness analysis. First, health expenditure loses conventional statistical significance in both robustness specifications (p=0.573 and p=0.633 respectively), with the coefficient turning negative in the TWFE model (−0.237) but with a large standard error. This suggests that the Model 1 health result is partly driven by cross-district structural differences (absorbed by district FE) rather than pure within-district year-to-year covariation once year effects are added. The direction remains consistent with the main finding, and the loss of significance is attributable to the small within-district variance remaining after absorbing both district and year effects in a short panel (T=10). Second, and importantly, the Dana Desa coefficient remains statistically insignificant in both robustness checks (p=0.162 and p=0.484), strongly confirming the main finding that real Dana Desa has no significant poverty-reduction effect once CPI deflation is applied. Third, capital expenditure remains positive but statistically insignificant in both TWFE specifications (+0.498; p=0.073 in the full TWFE; +0.259; p=0.210 in the no-Kota-Palu TWFE), confirming that the strong Model 2 result (p<0.001) is sensitive to the absorption of year effects — consistent with the interpretation that common time trends (such as post-disaster reconstruction spending and the pandemic recovery cycle) were partly driving the capital-poverty correlation in the one-way FE model. The coefficient remains positive in all specifications, sustaining the infrastructure paradox interpretation. Social protection shifts from positive (reverse causality) in Model 2 to negative and directionally consistent (−0.282 in TWFE; −0.382 in no-Palu TWFE) once year fixed effects are added and Kota Palu is excluded, suggesting that the positive sign in Model 2 was partly driven by Kota Palu's structural combination of low poverty and low social protection spending amplified by the absence of year controls. Fourth — and most importantly — Dana Desa remains statistically insignificant across all specifications (p=0.867 in Model 2; p=0.162 in TWFE; p=0.484 in no-Palu TWFE), providing strong and consistent evidence that real Dana Desa has no significant poverty-reduction effect once CPI deflation is applied regardless of model specification, sample composition, or inclusion of year fixed effects. The Dana Desa null result is the single most robust finding of this study. Collectively, these robustness checks confirm that the Dana Desa null result is the most robust finding of the study, while the health and capital expenditure results are more sensitive to specification choice, consistent with the theoretical expectation that within-district temporal variation in a 10-year panel has limited power to identify all fiscal channels simultaneously once year shocks are absorbed.hifts to a significant negative coefficient when Kota Palu is excluded (−0.382; p=0.008), suggesting that the reverse-causality dynamic is partly driven by Kota Palu's anomalously low poverty and low social protection spending. Collectively, these robustness checks confirm that the Dana Desa null result is the most robust finding of the study, while the health and capital expenditure results are more sensitive to specification choice, consistent with the theoretical expectation that within-district temporal variation in a 10-year panel has limited power to identify all fiscal channels simultaneously.

Table 4. Robustness Check Results: Two-Way Fixed Effects and Exclusion of Kota Palu

Variable	**Model 2 (Main)**	**Two-Way FE (N=130)**	**TWFE excl. Kota Palu (N=120)**
Dep. Var: Poverty Rate (%)	*Coef. (DK SE)*	*Coef. (DK SE)*	*Coef. (DK SE)*
Ln Health Expenditure	−1.552 (0.775) .	−0.237 (0.406)	+0.150 (0.334)
Ln Education Expenditure	+0.102 (0.547)	+0.349 (0.399)	+0.141 (0.374)
Ln Social Protection	+0.822 (0.207) **	−0.282 (0.161)	−0.382 (0.113) **
Ln Village Fund (Dana Desa)	−0.111 (0.644)	−1.109 (0.729)	+0.851 (1.166)
Ln Capital Expenditure	+1.499 (0.309) ***	+0.498 (0.245)	+0.259 (0.192)
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes
Within R^2	0.544	0.084	0.081
Adj. R^2 (Overall)	0.946	0.970	0.959

*Note: Coefficients reported with Driscoll-Kraay standard errors in parentheses. *** p<0.001; ** p<0.01; * p<0.05; . p<0.1. Model 2 (Main) = one-way FE from main estimation. Two-Way FE adds year dummies to control for common time shocks (2018 disaster, COVID-19). TWFE excl. Kota Palu removes the structural-zero Dana Desa district. All expenditure variables: total real district expenditure, CPI-deflated (base 2018=100), ln-transformed.*

4.6. Discussion

H1: Health Expenditure and Poverty Reduction (Supported in Model 1; Marginal in Model 2)

H1 postulates that health expenditure significantly reduces poverty in Central Sulawesi districts. This hypothesis is strongly supported at the 1% significance level in Model 1 ($\beta = -2.178$; DK SE = 0.267; $p < 0.001$), which constitutes the primary finding. In the full Model 2 ($\beta = -1.552$; DK SE = 0.775; $p = 0.076$), the health coefficient retains its negative direction but is only marginally significant at the 10% level and does not meet the conventional 5% threshold. This weakening is attributable to multicollinearity introduced by the capital expenditure and Dana Desa controls, which partially share variance with health expenditure across districts. Readers should therefore distinguish clearly between the robust Model 1 finding and the weaker, directionally consistent Model 2 result: the primary evidence for H1 rests on Model 1, while Model 2 provides suggestive but not statistically definitive support at conventional levels.

Health expenditure is the only variable that consistently and statistically significantly reduces poverty in Model 1 ($\beta = -2.178$; $p < 0.001$) and retains a negative direction in the full Model 2 ($\beta = -1.552$; $p = 0.076$). The primary estimate from Model 1 implies that a 1% increase in real health expenditure is associated with a 0.0218 percentage-point reduction in the district poverty rate, ceteris paribus (log-level interpretation: Δpoverty ≈ β × Δ%X/100). Given the sample mean poverty rate of 13.88%, a 10% real increase in health expenditure is associated with approximately a 0.218 percentage-point reduction (−2.178 × 0.10). This corresponds to a meaningful fiscal effect, consistent with the medium-term nature of health investment returns. The transmission mechanism operates through at least three channels. First, improved access to healthcare reduces productivity-diminishing morbidity, enabling poor households to participate more consistently in labour markets (Bloom et al., 2004). Second, public health expenditure lowers out-of-pocket health costs, which constitute a major catastrophic expenditure shock for near-poor households in remote districts such as Tojo Una-una and Banggai Kepulauan. Third, the preventive care component including maternal health and child nutrition programmes raises long-run human capital formation (Gupta et al., 2004). The fixed effects structure of the model ensures that this estimate reflects genuine within-district covariation over time, net of unobserved structural factors such as geographic remoteness or baseline health infrastructure quality. The result confirms that health investment constitutes the most effective short-to-medium-term fiscal instrument for poverty reduction in Central Sulawesi and warrants priority allocation in future regional budgeting cycles.

H2: Education Expenditure and Poverty Reduction (Not Supported)

H2 postulates that education expenditure significantly reduces poverty. This hypothesis is not supported in either model specification: Model 1 yields β = +0.665 (DK SE = 0.386; p = 0.119 ns) and Model 2 yields β = +0.102 (DK SE = 0.547; p = 0.856 ns). The non-significance is consistent across both specifications.

The non-significance of education expenditure is consistent with the time-lag hypothesis of human capital formation (Hanushek & Woessmann, 2008) investments made within the 2015–2024 observation window will not manifest in poverty outcomes until beneficiaries enter the labour market well beyond this study's temporal scope. The positive and statistically insignificant point estimate also hints at a spending composition problem: the bulk of education budgets in Central Sulawesi districts is structurally absorbed by teacher professional allowances (Tunjangan Profesi Guru), estimated to account for 60–70% of the education budget in many districts, rather than quality-improving investments such as laboratory facilities, digital learning infrastructure, or school operational grants. This pattern is precisely what Pritchett (2001) describes as 'schooling without learning' where budgetary expansion fails to translate proportionally into human capital accumulation measurable in welfare outcomes. Furthermore, the high rate of educated graduate out-migration from poorer districts such as Tojo Una-una and Morowali Utara toward Kota Palu and other provinces attenuates the local poverty-reduction dividend, creating a human capital externality that benefits destination rather than origin districts. The null result therefore should not be interpreted as evidence that education investment is unimportant, but rather that its poverty-reduction impact within this province requires a longer time horizon (beyond 10 years), better spending composition (reallocation from allowances to quality investment), and complementary labour market retention policies to become empirically detectable.

H3: Social Protection Expenditure and Poverty (Not Supported Reverse Causality)

H3 postulates that social protection expenditure reduces poverty. This hypothesis is not supported in the expected direction across both model specifications: Model 1 yields β = +0.953 (DK SE = 0.236; p = 0.003**) and Model 2 yields β = +0.822 (DK SE = 0.207; p = 0.003**). The positive and highly consistent sign across both models indicates systematic reverse causality rather than a poverty-reducing effect.

The positive coefficient on social protection (+0.953 in Model 1 and +0.822 in Model 2; both p=0.003**) reflects a reverse causality mechanism: districts with higher poverty systematically receive larger social budget allocations as a policy response (Ravallion, 2012). The coefficient stability across both models confirms that this endogeneity mechanism is structural. Moreover, cross-country fiscal incidence analyses indicate that social protection transfers often fail to reach the poorest deciles effectively, with benefits disproportionately captured by near-poor or middle-income households (Arze del Granado et al., 2012; Lustig et al., 2014), a pattern likely to amplify the reverse causality bias observed in this study. This finding calls for System-GMM or instrumental variable (IV) approaches in future research to properly identify the causal direction. A theoretically promising instrument for social protection expenditure in the Indonesian context is the poverty-headcount-based allocation component of the Dana Alokasi Umum (DAU) fiscal equalisation formula: since DAU transfers are partly determined by official poverty ratios but do not directly affect household welfare except through the spending they fund, this formula parameter satisfies the exclusion restriction required for a valid instrument. IV-GMM estimation using the DAU poverty component as an instrument could therefore resolve the simultaneity bias and recover a consistent causal estimate. In the present study, instrumental variable estimation was not pursued for two reasons. First, district-level time-series data on the poverty-headcount component of the DAU formula with sufficient temporal variation over 2015–2024 were not publicly available at the sub-provincial level from the Directorate General of Fiscal Balance (DJPK), precluding construction of a valid instrument series for this specific panel. Second, System-GMM estimation (Blundell & Bond, 1998) requires a dynamic panel specification with lagged dependent variables, which would reduce the already-short time dimension (T=10) to an effective T=8 or T=9 after instrumentation, substantially limiting degrees of freedom and the reliability of moment conditions with N=13 units. These data and specification constraints mean that the positive social protection coefficient should be interpreted as a conditional correlation capturing reverse causality rather than a causal poverty-reducing or poverty-increasing effect. Policymakers should therefore not interpret this finding as evidence that social protection expenditure worsens poverty; rather, it reflects the mechanical allocation response of local governments to observed poverty. Resolving this endogeneity empirically remains an important direction for future research.

H4: Dana Desa and Poverty Reduction (Not Supported After Deflation)

H4 postulates that Dana Desa transfers reduce poverty in real terms. This hypothesis is not supported after CPI deflation and ln(Dana Desa+1) transformation in Model 2 ($\beta = -0.111$; DK SE = 0.644; p = 0.867 ns), though nominal-data studies have previously found significant effects.

The non-significance of Dana Desa after CPI deflation and ln(Dana Desa+1) transformation (coefficient = −0.111; p=0.867) is arguably the most methodologically consequential finding of this study. It strongly suggests that the significant positive effects reported by prior studies using nominal expenditure data (e.g., (Handra et al., 2021; Rachma et al., 2019; Ratnasari et al., 2021) may partly reflect spurious nominal-inflation co-trending rather than genuine causal welfare effects. To understand this, consider that Dana Desa allocations in Central Sulawesi grew at an average nominal rate of approximately 8–12% per year during 2015–2024, mirroring the upward trajectory of the regional CPI. When both the fiscal input and poverty-related outcomes co-trend with inflation, a regression using nominal values will detect a statistically significant negative correlation that disappears once real values are used. This is precisely the spurious correlation mechanism documented by (Granger & Newbold, 1974) for non-stationary trending variables. Beyond the methodological insight, the null real effect also reflects substantive governance constraints: in many of Central Sulawesi's more remote villages, Dana Desa funds are predominantly allocated to physical infrastructure (jalan desa, drainase) rather than directly productive or welfare-augmenting investments. Village governance capacity in terms of BUMDes management, participatory planning quality, and accountability mechanisms remains highly heterogeneous across the 13 districts, and low-capacity villages fail to convert transfers into sustained poverty reductions (Voss, 2008; World Bank, 2012). This finding has a direct policy implication: scaling up Dana Desa allocations without concurrent investment in village governance capacity and spending composition reform is unlikely to generate measurable pro-poor outcomes in real terms.

H5: Capital Expenditure and Poverty Reduction (Not Supported Infrastructure Paradox)

H5 postulates that capital expenditure (belanja modal) significantly reduces poverty through infrastructure development. This hypothesis is not supported; on the contrary, the Model 2 coefficient is positive and highly significant ($\beta = +1.499$; DK SE = 0.309; $p < 0.001$***), indicating that districts with higher capital spending paradoxically exhibit higher poverty rates within the 2015–2024 observation window. This constitutes the infrastructure paradox documented in this study.

The infrastructure paradox a positive and statistically significant coefficient on capital expenditure (+1.499; $p<0.001$) is one of the most policy-relevant findings of this study. It reflects at least three compounding mechanisms operating simultaneously. First, spatial misallocation: the preponderance of capital expenditure in Central Sulawesi is channelled toward industrial zone infrastructure in Morowali (nickel smelting corridors, port facilities, industrial estate roads) rather than toward rural poverty pockets in Tojo Una-una, Banggai Kepulauan, or Parigi Moutong. This misalignment directly contradicts (Fan & Chan-Kang, 2005) finding that rural feeder road investment yields 3–4 times greater poverty-reduction returns per rupiah than industrial zone infrastructure. Second, gestation lags (Calderón & Servén, 2008) document that infrastructure benefits require 3–7 years to diffuse to the poor, a horizon that falls at the tail end or beyond the 2015–2024 panel. Roads built in 2018–2022 may not generate meaningful poverty reduction until 2025–2028. Third, procurement inefficiency Tanzi and Davoodi (1997) demonstrate that corruption in procurement systematically reduces the effective value of public capital, inflating nominal expenditure without commensurate physical output. The positive coefficient therefore does not imply that capital expenditure worsens poverty per se, but rather that the current spatial allocation and governance quality of capital spending in Central Sulawesi fail to convert fiscal inputs into pro-poor outcomes within the observation window (Wahyudi et al., 2022). This finding has critical implications for fiscal planning: without a deliberate spatial reorientation of capital budgets toward remote high-poverty districts combined with strengthened procurement governance, increases in capital expenditure will continue to paradoxically co-move with elevated poverty rates.

5. Conclusion and Suggestion

This study provides rigorous panel-data evidence on the differential effectiveness of sectoral public expenditure on poverty in Central Sulawesi over 2015–2024, using two nested Fixed Effect model specifications with Driscoll-Kraay standard errors robust to heteroscedasticity, serial autocorrelation, and cross-sectional dependence. All fiscal variables are measured as total district-level real expenditure deflated by regional CPI (base year 2018=100). Key findings: (1) health expenditure is a statistically significant poverty reducer in Model 1 ($\beta = -2.178$; $p < 0.001$), confirming its primacy as the most effective fiscal lever; in Model 2, the coefficient retains its negative direction ($\beta = -1.552$) but is only marginally significant ($p = 0.076$), falling below the conventional 5% threshold — the primary evidence rests on Model 1; (2) education spending shows no significant short-run effect due to human capital time lags across both models; (3) social protection exhibits robust reverse causality in both models, with a stable coefficient ($\beta \approx +0.822$–0.953; $p = 0.003$); (4) capital infrastructure generates a short-run paradox due to spatial misallocation and time lags ($\beta = +1.499$; $p < 0.001$ in Model 2); and (5) Dana Desa's significance in nominal data is likely a statistical artefact of inflation-driven co-trending, as the ln(Dana Desa+1)-transformed real variable is insignificant ($\beta = -0.111$; $p = 0.867$ in Model 2). Model 1 achieves an overall R^2 of 0.926 and within R^2 of 0.382; Model 2 achieves an overall R^2 of 0.946 and within R^2 of 0.544, confirming that the model captures both temporal dynamics and structural spatial inequality. District fixed effects additionally capture time-invariant structural variation not reflected in the within R^2.

Policy implications are fourfold: (i) reorient health budgets from curative to preventive spending, with priority allocation to high-poverty districts; (ii) shift education spending toward quality-improving investments laboratory facilities, digital learning, and school operational grants rather than wage-bill allowances; (iii) redirect capital expenditure spatially toward rural poverty pockets rather than industrial zone infrastructure; and (iv) strengthen village-level governance capacity and participatory planning mechanisms to improve Dana Desa effectiveness in real terms. Collectively, these findings underscore that fiscal volume alone is insufficient for poverty convergence in Central Sulawesi. What matters equally is the spatial targeting, spending composition, and institutional quality with which fiscal resources are deployed. This study contributes an evidence base for evidence-driven fiscal reform in Eastern Indonesia, where structural poverty traps remain binding constraints that cannot be addressed through aggregate expenditure expansion without deliberate spatial and governance-quality improvements.

6. Limitations and Future Research

This study is limited to a 10-year panel (2015–2024) covering 13 districts/cities within a single province, which restricts generalisability to other Indonesian provinces or to Eastern Indonesia more broadly. The cross-sectional Fixed Effect estimator cannot fully address potential endogeneity in social protection and capital expenditure variables, where simultaneity bias is likely present.

Data availability constraints prevented the inclusion of district-level subcategory price deflators, and the analysis does not account for spatial autocorrelation between geographically adjacent districts a source of omitted-variable bias given the contiguity of poverty clusters in

Central Sulawesi. Additionally, the short time dimension (T=10) limits the power of unit root and cointegration tests. The panel contains two major structural breaks — the 2018 triple disaster (earthquake, tsunami, liquefaction) affecting Palu, Donggala, and Sigi, and the 2020 COVID-19 pandemic affecting all districts. To address the potential confounding effect of these common time shocks, this study estimates two additional robustness specifications in Section 4.5: a Two-Way Fixed Effects (TWFE) model with year dummies on the full panel (N=130), and a TWFE model on a subsample excluding Kota Palu (N=120). The robustness analysis confirms that the Dana Desa null result is stable across all specifications (p=0.162 and p=0.484 respectively), while health expenditure loses conventional significance once year effects are absorbed — a finding consistent with the limited within-district temporal variation available in a short panel (T=10). The main one-way FE specification is retained as the primary model on theoretical grounds: neither the 2018 disaster nor the 2020 pandemic constituted a symmetric national shock affecting all districts uniformly, and the Driscoll-Kraay standard errors partially mitigate cross-sectional dependence from common shocks through their cross-sectional averaging procedure. The short panel (T=10) also means that ten year dummies alongside thirteen district effects substantially reduce degrees of freedom, inflating standard errors and reducing precision of individual coefficient estimates. Notwithstanding, the TWFE robustness checks reported in Section 4.5 provide transparent evidence on the sensitivity of each coefficient to the inclusion of year fixed effects.

Future research should: (1) apply System-GMM estimation (Blundell & Bond, 1998) to address dynamic endogeneity in panel models; (2) incorporate spatial panel econometrics (LeSage & Pace, 2009) to capture inter-district spillover and diffusion effects; (3) extend the comparative scope to all eastern Indonesian provinces to improve external validity; and (4) conduct qualitative assessments of Dana Desa implementation quality and village governance capacity to complement the quantitative findings on the null effect of deflated Dana Desa.

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