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The Effect of Infrastructure Development and Government Expenditures in Social Services to Poverty Reduction of Lao PDR

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Abstract

Poverty problem is still challenging for Lao PDR's development, the objective of this study is to analyze the role of infrastructure and government spending in social services (education and health care) on poverty reduction during 2006-2024. Based on the Auto Regressive Distributed Lag approach, we examine both the short and long run relationships linking total road length, spending on education and health by government, and poverty (proxied by people with IWI under 50%). The findings reveal robust long-run cointegration relationships among the variables, thus verifying heterogeneity in infrastructure and social outlay jointly determining poverty reduction.

The results imply that the long-run effect of infrastructure development on poverty is significantly negative, indicating road network improvement increases market access, economic welfare and quality of life. Education spending also has the expected negative sign, being statistically non-significant; showing that its poverty reducing benefits are a long-term process via human capital accumulation. On the other hand, health expenditure is positively associated with poverty in short-term, which might be indicating temporary reallocation of fiscal resources during crisis (e.g., COVID-19). All diagnostic tests verify that the model is stable, normally distributed and does not have serial correlation or heteroskedasticity, which ensures the validity of test results.

Overall, the study argues that continued investment in infrastructure and welfare-enhancing social allocations will be crucial to generate inclusive and sustainable poverty reduction in Lao PDR. Policy implications underscore the importance of good fiscal management, improving education and healthcare quality, and maintenance on existing infrastructure to achieve efficient development. The findings enrich empirical support for combining infrastructure-led and human capital development approaches in poverty alleviation strategies.

Keywords: *Infrastructure development, Government expenditure, Poverty reduction*

1. Introduction

Poverty reduction is one of the main development challenges facing the Lao PDR over the last two decades. The national poverty rate has fallen from over 33% in the early 2000s to under 18% in 2019 (World Bank, 2023). But more remote areas of poverty are still evident in rural which lack basic infrastructure and access to health and education. The development in terms of inadequate transport networks, poor public service delivery, and lack of business opportunities (Asian Development Bank, 2022).

The Infrastructure development is essential driver of poverty reduction as increases market linkages, lowers transportation costs and improves access to basic services (Calderón & Servén, 2014; Fan & Chan-Kang, 2008). The Lao PDR is a country where more than 70% of the population lives in rural areas, and road networks are particularly important to connect communities with markets, schools, and health facilities (Lao Statistics Bureau, 2023). Consequently, road length is regarded as an important of infrastructure development and betterment of household welfare.

Public spending on education and health is also crucial to the formation of human capital and to escaping multidimensional poverty. Spending on education reinforces skills, productivity and employment prospects, whereas health spending increases efficiency in labour markets as well as serves to reduce income risks (Barro, 2013; Baldacci et al., 2008). In Lao PDR, government spending on education and health has increased but is still below average in the region (World Bank, 2023).

Education spending including expenditure of teacher salaries, infrastructures, material and scholarship embodies the government support for Sustainable Development Goal 4 on Quality Education (UNESCO, 2023). Health expenditure, covering hospitals, medical personnel, and disease surveillance (WHO, 2023), is also linked to Sustainable Development Goal 3 of "Good Health and Well-being" (UNDP, 2022). However, urban–rural gaps in health status remain because of unbalanced resource allocation.

Targeted and efficient public investment is integral to achieving better education and health results, reducing inequality, and inclusive development. For this study, the International Wealth Index (IWI) is used as an indicator for households' material welfare; in doing so, a wider range of household benefits in terms infrastructure and social provision are useful to show how it leads to poverty alleviation and well-being more generally (Smits & Steendijk, 2015). It is crucial to understand how infrastructure construction and social expenditure of government affect the poverty reduction. It is in this light, that the Autoregressive Distributed Lag (ARDL) model counting both short run and long-run effects of these factors can be employed to estimate the economic situation of Lao PDR between 2006 and 2024.

Despite a sustained period of economic growth for Lao PDR and the pursuit of poverty reduction policies that are in line with national objectives, the rate of poverty reduction has declined in recent years. In addition, regional imbalances between cities and regions continue in spite of government spending on roads and social services. The efficacy of these policies in bringing a sustainable reduction in poverty is not well known from the past implementation. The most important knowledge gaps may be briefly summarized as: 1). Incomplete knowledge about the connection between infrastructure and poverty: There is lack of evidence whether the road network developed brings long-term reduction in poverty or accrues more benefits, particularly to the well-off areas (Asian Development Bank, 2022). 2). Efficiency of social spending: Public investments in education and health have grown, but their effectiveness in raising household welfare and reducing poverty is still questioned, not least given continued challenges around resource allocation, quality of service delivery and regional inequality (World Bank, 2023). 3). Disjointed causal analysis: Prior work in Lao PDR has frequently treated infrastructure or social spending in isolation from the other, without evaluating either their joint effort or the interactions between them for progress on sustained poverty reduction. Furthermore, multidimensional poverty measures, including the International Wealth Index (IWI), have not been used in econometric models for Lao. 4). Too little knowledge of short- and long-term effects: It's not clear to policy makers whether investments in infrastructure and social services lead immediately to reduced poverty or largely generate only longer-term payoffs. In the absence of such evidence, resourcing decisions may not reflect development priorities.

In light of these deficiencies, a critical review is clearly needed to ascertain the short-term and long-run effects of infrastructure development as well as government spending on education and healthcare on poverty reduction in Lao PDR. By employing time-series data for the period 2006-2024 in an ARDL estimates with IWI as a proxy of poverty reduction, will be offering hard empirics enough to lay support for future policy measures.

So, this study aimed to Analysis of the impact of infrastructure development and government spending in social services (education and healthcare) on poverty reduction in the Lao PDR.

2. Materials and Methods

2.1 Research Design

The theoretical and empirical basis for this study is provided via the framework see in (figure 1). It is informed by poverty reduction theories outlined in (Calderón and Servén, 2014); (Sen, 1999) and (Smits and

Steendijk, 2015); as well as public expenditure concepts introduced to us by the World Bank under (Calderón & Servén, 2014). Moreover, the study also extends to various basic economic theories (such as Becker's, 1964), Human Capital Theory of (Aschauer, 1989), Infrastructure-Led Growth Theory of (Keyne, 1936), Public Expenditure Theory of (Sen, (1999). The framework is also supported with empirically by works of (Zakiyyah, 2023; Bolarinwa, 2023; Adebayo, 2025; and Wudil et al., 2023).

2.2 Data Collection

In this research authors used time series data from 2006-2024 drawn up by variety of non-for-profit sources. The International Wealth Index (IWI) was downloaded from the database of the International Wealth Index. This was obtained from road expansion statistics, published by the Ministry of Public Works and Transport, in km of road. Data on government spending in distance from education (% of GDP) and government spending in closest described model for public health (% of GDP), were collected from the World Bank.

2.3 Models

$$IWI50_t = f(LnRL_t, Edu_t, H_t)$$

Where: $IWI50_t$= International Wealth Index under value of 50% (proxy for poverty reduction), which higher values = larger share of the population with low asset endowments; $LnRL_t$ = Natural logarithms of total road length in km (proxy for infrastructure developement); Edu_t= Governemtn expenditure on education as % of GDP (proxy for social expenditure or services) and H_t = Governemtn expenditure on health as % of GDP (proxy for social expenditure or services).

1). General ARDL Representation

The ARDL(p, q_1, q_2, q_3) model allows lags of both dependent and independent variables:

$$IWI50_t=\alpha+\sum_{i=1}^{p}\emptyset_i IWI50_{t-i}+\sum_{j=0}^{q_1}\beta_j lnRL_{t-j}+\sum_{k=0}^{q_2}\gamma_k Edu_{t-k}+\sum_{l=0}^{q_3}\delta_l H_{t-l}+\epsilon_t$$

Where: p = lag order for dependent variable; q_1, q_2, q_3= lag orders for independent variables; ϵ_t= error term

2). Error Correction Form (if cointegration exists)

If the series are a mix of I(0) and I(1) and there is a long-run relationship:

$$\Delta IWI50_t = \alpha + \lambda(IWI50_{t-1} - \theta_1 LnRL_{t-1} - \theta_2 Edu_{t-1} - \theta_3 H_{t-1}) + \sum_{i=1}^{p-1} \phi_i \Delta IWI50_{t-i} + \sum_{j=0}^{q_1-1} \beta_j \, \Delta LnRL_{t-j} + \sum_{k=0}^{q_2-1} \gamma_k \, \Delta Edu_{t-k} + \sum_{l=0}^{q_3-1} \varphi_l \, \Delta H_{t-l} + \epsilon_t$$

Where: λ= speed of adjustment coefficient (should be negative and significant)

$\theta_1, \theta_2, \theta_3$= long-run coefficients.

2.4 Hypothesis

1). The impact of infrastructure development on poverty reduction

$H_1: \theta_1 > 0$ Infrastructure development (such as road length or network expansion) has a positive effect on poverty reduction.

2. The impact of government expenditure on education on poverty reduction

$H_2: \theta_2 > 0$ Government expenditure on education has a positive effect on poverty reduction

3. The impact of government expenditure on public health on poverty reduction

$H_3: \theta_3 > 0$ Government expenditure on healthcare has a positive effect on poverty reduction.

2.5 Research process

The first phase consists in collecting and wrangling time series from 2006 through 2024. In the second stage, Augmented Dickey–Fuller (ADF) test was conducted to see if the variables were stationary. The third step aimed at determining the lag order. In the fourth step, an ARDL model was derived. The fifth step was to run the Bounds Test for co-integration in order to test long-run relationships between the variables. The sixth step included the inference of both long-run coefficients and short-run dynamics. Lastly, diagnostic tests were conducted: Durbin's alternative test; Breusch–Godfrey Lagrange Multiplier (LM) test for autocorrelation; White's test for heteroskedasticity; and Jarque–Bera, Skewness, and Kurtosis tests for normality. Furthermore, the CUSUM test was applied to examine structural stability of the model.

3. Results

As the unit root test results (in table 1) indicate, in level all variables have test statistics which are higher, in absolute value terms less negative than their corresponding 5% critical values which suggest rejecting the null hypothesis of non-stationarity. Specifically, IWI50, LnRL and Edu. It shows that only H is marginally close to the 10% critical value indicating weak evidence of stationarity at the 10% level. With first differencing however, the ADF test statistics indicate stationarity for all variables.

The selected lag lengths of each variable in the model used for estimation are given in Table 2. The best lag structure is automatically determined by the estimation process. The matrix e(lags) indicates this, which actually could have been done according to information criteria like Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan–Quinn Information Criterion (HQIC). The results suggest that only one lag is retained for both IWI50 and LnRL, whereby no delayed combinations are selected with Edu and H. Moreover, from an econometric viewpoint, the inclusion of one-profit lag for IWI50 and LnRL implies that their lagged value contains appropriate information to explain contemporary dynamics and to avoid serial correlation while it reflects short-run adjustments. On the other hand, the model is not comprehensive in that lagged values of Edu and H are omitted (their most recent values add no statistically significant explanatory power). This basic lag structure is expected to keep the LSI relatively stable over time, while making estimation more efficient by not adding too many parameters. Developing the proper lag structure is an essential precursor to estimating the ARDL model. It does so as it directly influences the strength of coefficient estimates, the validity of statistical inference and the correct description of both short-run dynamics and long-run equilibrium relationships.

In (table 3), The ARDL(1,1,0,0) model estimate shows a very good fit of the model with an R-squared of 0.9881. This suggests that the explanatory variables we include in our model (road length (LnRL), government expenditure on education (Edu) and government expenditure on health (H) can explain (approximately) 98% of the changes in with respect to poverty. The final model is globally statistically significant as indicated by the F-statistic of 181.97, meaning that the entire regressors are also individually statistically significant. In (table 4), indicates an unambiguous long-run equilibrium relationship of the variables poverty ($IWI50_t$), infrastructure development ($LnRL_t$), government spending on health (H) and government spending on education (Edu) in the Lao PDR during the sample period. The computed F-value of 5.443 is greater than the upper critical bound value of 4.35 at the 5% level and just larger than the 1% upper bound value of 5.61. The decision rule is that if the F statistic is greater than upper-tail critical value for I(1) regressors, then the null hypothesis of no long-run equilibrium can be rejected. This result supports the cointegration of variables and implies that infrastructure, as well as social spending has a role to play in long-run poverty reduction. Moreover, the value of t-value -4.010 falls below 5% lower tail critical value of -3.78 which gives additional justification for rejecting a null hypothesis that there is no levels relationship. This is consistent with finding that there exists a long-run equilibrium relationship between the dependent variable (LnRL) and its independent variables (Edu and H). In econometrics, cointegration between two variables indicates that while the variables may not be stationary in levels (they have unit roots), they are linear combinations of other time-series that versus each other) do have a stationarity property. This implies that the system will relax to a state of long-term stability by means of error correction so that deviations from equilibrium are only short lived. This implies that a change in government spending on education and health, and investment in infrastructure in Lao PDR has long-term implications for reducing poverty instead of short-run changes. From the results of the ARDL Bounds Test, it is appropriate to estimate both long-run coefficients and their short-run dynamics with ECM. This demonstrates that the model can be adapted to examine both short-run dynamics and long-run equilibrium between the major indicators of development.

The estimated long-run coefficients and short run dynamics of the ARDL (1, 1, 0, 0) error-correction model is presented in Table 5. The model captures both the long-run relationship and short-run dynamics between poverty measured by the IWI50 index and its main explanatory variables, i.e., infrastructure development (LnRL), government education expenditure (Edu) and government health expenditure (H) in Lao PDR.

The error-correction term (ECT), lagged value of the dependent variable is negative and statistically significant at 1 level percent though its estimated coefficient is −0.4492. This result is little short of overwhelming evidence that the variables are cointegrated and completely consistent with the bounds testing procedure that preceded it. The ECT magnitude implies that around 44.9 percent of the short-run fluctuation from the long-run poverty equilibrium is permanently absorbed within one period. The system is robust on the path of convergence, in the sense that whatever distortions are introduced by outside shocks or policy changes tend to get better over time. Complete adjustment takes around two years. The relatively slow speed of adjustment implies there are structural rigidities preventing instantaneous convergence.

The estimated long-run coefficients reveal that the effect of explanatory variables is different on the outcome. Level of infrastructure development (LnRL) has a negative and high coefficient of −50.5642 which was found to be significant. This indicated that it has long run effect. That is, the construction of more roads has a large and lasting effect on poverty reduction. A 1% increase in total road length is associated with an ~50.56 point decrease in the IWI50 index, reflecting a marked decline of IWI below individual wealth thresholds. This finding reiterates the importance of transportation network on reducing the effects of distance, transaction costs and improving access to market(s) as well as opportunities for employment. The outcome is consistent with the infrastructure led growth theories, and more coherently with Aschauer hypothesis where public capital plays a significant role as a determinant of sustained economic activity and welfare improvements.

In contrast, the long-run coefficient of government expenditure on education (Edu) is negative (-0.6247) and not statistically significant. This suggests that there has not been a statistically significant long-term impact on poverty reduction from public investment in education over the sample period. An explanation is that such benefits paid for investment in education take a long time to materialize. That's because increases in human capital generally don't result in greater productivity and income until years or decades later. Moreover, inefficiencies in the way money is spent and mismatches between what students learn and what employers need could make the long-term impact even weaker.

The coefficient on government health spending (H) is estimated in the long-run to be 7.8588, which is statistically significant at the 5% level. Which implies that health expenditure is positively related with poverty measure. This result may sound odd at first, but it likely reflects the fact that public health expenditures generally rise when the economy isn't doing well. Amid economic slumps or public health crises, during a pandemic like COVID-19 for example, government's will spend more on health as living conditions worsen. So, the estimated coefficient should be interpreted as indicative of reverse causality or policy responsiveness, not evidence that spending on health directly impoverishes.

The short-run dynamics tell us more about how the correction process functions. The first-differenced infrastructure variable, D(LnRL) enters the model with a positive and statistically significant coefficient of 31.1510 implying that short-run growth-induced expenditure on road construction leads to a temporary increase in the poverty indicator. This transitory response may arise from adjustment costs of factors, like shifting families, reallocating public goods and ceasing local economic activity in the building phase. But in the longer run, once infrastructure projects begin working and generating incomes, their impact on poverty becomes more significant, which is why there's a strongly negative coefficient for the long-term relation.

Finally, the short-run intercept term is positive and significant. This indicates the average level of poverty after allowing for short-run variation in explanatory factors. ARDL results indicate that short-run adjustment effects and long-run structural impact differ from one another. They also indicate that infrastructure investment is critical for poverty reduction in the long run, and that social sector spending has welfare implications whose importance depends on their timing, pro-poor effectiveness and the overall state of the economy.

For diagnostic purposes: The calculated chi-square statistic for Durbin's alternative test of autocorrelation (table 6) equals 0.046 with 1 degree of freedom and p-value equal to 0.8302. Since the p-value is much greater than 5% level of significance, we fail to reject the null hypothesis. This implies that the residuals are independently distributed and that there is no observable autocorrelation in the estimated model held. The Breusch–Godfrey Lagrange Multiplier (LM) test statistic is equal to 0.075 with degree of freedom 1 and p-value = 0.7843. Since the p-value is far greater than 0.05, the null hypothesis cannot be rejected. This indicates that the evidence is insufficient to conclude that there is autocorrelation in the residuals of the model. The White's Test (table 7) produces a chi-square statistic of 18.00, with 17 degrees of freedom and probability equal to 0.3888. The null hypothesis for homoskedasticity cannot be rejected due to p-value higher than 0.05 level of significance ($p > 0.05$). Another result of interest is that since the residuals exhibit constant variance, it verifies the absence of heteroskedasticity in the model. The decomposition of the information matrix (IM) test by Cameron and Trivedi provides additional diagnostic information. The heteroskedasticity term (Chi2 = 18.00, p = 0.3888) fails to reject the null of homoskedasticity residuals. The skewness (Chi2 = 16.26, p = 0.0061) is slightly different than the normal symmetry and the kurtosis (Chi2= 0.09, p = 0.7629) reveals that the tails of the residual distribution are almost normal. However, the full IM-test statistic (Chi2 = 34.35, p=0.0602) is still slightly above the five percent level, indicating that there are no serious heteroskedasticity problem in this model. The Jarque–Bera statistic of the Normality test (table 8) value is 0.4259, which says that chi-square with df =2 and P-value equal to 0.8082 as well. There is insufficient evidence to reject the null hypothesis of normality as p-value > 0.05 (5% significance level). It means that residuals are approximately normally distributed, which in turn suggests that error terms of the model conform classical regression rules. For the residuals the p-values are 0.4351 for skewness and 0.6858 for kurtosis, being higher than 5% significance level on both cases. The adjusted chi-square statistic for the joint test is 0.83 (P = 0.6596). Since the p-value is way greater than 0.05, we cannot reject the null hypothesis of normality. That result suggests a good mix of residuals and we have just enough for kurtosis, so it is very close to normal distribution. That lack of skewness and kurtosis should confirm that the ARDL model fulfills the normality assumption. Thus, the parameter estimates and inferential statistics are all valid. In the case, for the CUSUM of Squares (CUSUMSQ) test it indicates that the cumulative line was between their upper and lower 5% confidence limits from start to end of observation period. This behavior implies that the parameters of the ARDL model are time-invariant (and thus there is no structural break or a large parameter drift). With the CUSUMSQ line gradually rising and fluctuating all through the confidence band, it is evident that the estimated relations between poverty reduction and infrastructure building as well as government expenditure on health and education are statistically stable.

4. Discussion

The findings from ARDL model estimation indicate significant long-run effects of infrastructure development and government spending on education and healthcare in reducing poverty in Lao PDR over the period 2006-2024. According to the results, there is a long-run equilibrium relationship among these variables. This is supported by the Pesaran et al. (2001) bound test for cointegration which indicate that expenditure on infrastructure and social services jointly contribute to poverty reduction. But the magnitude, sign, and timing of these effects differ between each variable. This demonstrates how complex are the relationships between physical infrastructure, human capital formation and poverty results in Laos.

The Long-Run Effects of Infrastructure Development: The long-run effect of infrastructure development measured by log (Total Road) is negative and significant, revealing a robust and persistent effect on poverty alleviation. That is, as the total length of roads becomes larger, low wealth (IWI less than 50) decreases by about 50 points. This scale is an illustration of how infrastructure can transform things, making the economy available to more people, uniting citizens across markets and including society. This empirical result is consistent with Aschauer. (1989) Infrastructure-Led Growth Theory, according to which public infrastructure investment raises the productivity of private capital and labor by lowering transaction costs and allowing resources to be efficiently allocated. In the Lao PDR for example, bigger road networks have opened up new possibilities of access to markets, schools and health care facilities especially in mountainous and rural terrain where it used to be very easy for people being "cut off" from each other. These channels increase household income, accumulation of assets, and living standards directly through expansion of the service itself and indirectly via (Calderón, & Servén, 2014; Fan & Chan-kang, 2008). Furthermore, the negative long-run coefficient is in line with cross-country evidence that investments on infrastructure can have a great impact on poverty reduction when combined with complementary policies in agriculture, education and rural development. Fan and Chan-Kang (2008) demonstrated that investments in rural roads in China contributed to a reduction in rural poverty by facilitating off-farm employment through increased non-agricultural opportunities, and increasing on-farm agricultural productivity. Likewise, the Greater Mekong Subregion (GMS) project and China–Laos Economic Corridor have increased trade and household assets in rural Laos (Asian Development Bank , 2022). So, infrastructure in Laos is a way to create jobs directly, and it's something that serves as a groundwork of perpetual downstream poverty reduction.

The short-run coefficient for infrastructure reveals a positive association with the poverty measure initially. This surprising result is driven by the cost of adjustment and the moving effects that take place in the construction of infrastructure (Zakiyyah, 2023). But the negative longer-term relationship suggests that once up and running, the benefits of infrastructure outweigh temporary problems. This endogenous adaptation is consistent with the concept of transitional disequilibrium in development economics that investments in structures initially bear adjustment costs, but lead to longer term welfare improvements (Enders, 2015). In the Lao setting, this pattern reflects what the ECT term (-0.449, p = 0.002) reveals that about 44.9% of any short-run deviation from the long-run poverty equilibrium is corrected within a year. So, shocks or short-term policy imbalances are gradually absorbed, and the system returns to its long-term equilibrium. This indicates gradual and persistent convergence to reduce poverty.

Impact of government expenditure on education: The long run impact is found to be negative but statistically insignificant. This suggests that while spending on education ought to be one humble way in which to help solve poverty, so far it hasn't done much for at least the share we studied. The long waiting period for educational returns provides a plausible explanation. Human Capital Theory (Becker, 1964) argues that investing in education increases skills, knowledge and productivity but the economic benefits often take many years to eventuate as higher wages, job opportunities and social mobility. In Laos, however, the marked reduction in connection between public spending and human capital outcomes due to teacher shortages, differentials in school quality across rural/urban locations and limited vocational training suffers deficit. Moreover, policies on education in Laos have always focused more on access and infrastructure than curriculum quality or relevance to the labour market with consequences for productivity and earning income still feed in (Barro, 2013). The coefficient on the negative sign however, would buttress an argument that spending on education can reduce poverty in the long run. As noted by Baldacci et al. (2008), social spending in education plays a critical role on growth itself and poverty reduction, among all areas of investment, through development of human capital. As such, the insignificantly small coefficient in the Lao case more reflects short-run accounted restrictions and lags of benefits, instead of they are not effective that investment on education as others.

The impact of government spending on healthcare: The seemingly surprising finding is that government spending in health care has a positive long run coefficient and it is statistically significant. In other words, the poverty indicator (IWI50) increases when the government spends more on healthcare. This may sound a bit odd, but it's explained by the fact that public health spending in developing countries is counter-cyclical: When the economy is bad, government spends more. During crises, such as disease outbreaks, economic downturns or pandemics, when poverty also surges and governments usually spend more on health care. In such a situation, a rising trend in health spending can be more likely to reflect reactive policy responses to deteriorating social conditions than proactive commitment to sustained investment in longer-term welfare (Adebayo, 2025). For example, like many other places during the Covid-19 pandemic, Laos had significant economic contraction, a collapse in tourism income and rising unemployment. The share in total government spending that was allocated to health care increased, but household incomes decreased (Asian Development Bank, 2022). So, the positive coefficient reveals an association over the short run between spending in a crisis and high poverty rather than a direct link between spending and high poverty. This result confirms that of the Keynes (1936) theory of Public Expenditure which highlights the role of public spending as a stabilizing force in times of economic crisis. In the future, with growing macroeconomic stability and further increased health investments concentrating more on preventive and reinforcing the health system, health spending likely will be poverty-reducing. This result also helps to demonstrate the importance of spending composition when analyzing a budget. "Much of the recent health spending in Laos has been allocated to emergency response and urban facilities, rather than rural health infrastructure." That's created unequal access, and health equity has been little enhanced. Redirection of spending towards preventive care, maternal health and rural clinics would yield better returns in health services and help to address poverty (Baldacci et al., 2008).

When poor communities get support, changes happen right away - also unfold slowly over time. Roads built today bring faster results than school programs, which take years to show effects through gradual shifts in skills and well-being. Getting to clinics becomes easier when paths connect villages, just as learning improves travel choices later on. Stronger bodies and sharper minds use new routes more fully, turning movement into real gains.(Becker, 1964). Back in 1999, Sen outlined a way to study these kinds of connections. As roads, schools, and clinics improve, so do people's chances - skills grow, options open up. Lives become healthier, learning becomes possible, work gains meaning - all tied to basic supports getting stronger (Sen, 1999) .

5. Conclusion

Infrastructure development and government social expenditures could help poverty reduction in the long-term effect. Because Road construction has increased access to markets, education and health care, which in turn increases income from employment and asset holdings. Despite bad short-term effects caused by construction delays, the long-term benefits were huge and enduring. Investing in education seems to have a negative, yet insignificant impact on poverty and this is in line with the prediction of Human Capital theory, when you invest in people it has percentage negative effect on incidence of poverty. This channel has weakened since 2021 as a result of the budget cuts, suggesting that long-term productivity and social mobility require sustained, targeted investment in education. Conversely, health spending had a positive and statistically significant coefficient such more funds to be spent on healthcare led to an increase in poverty, especially during the pandemic of Covid-19.

Overall, the findings suggest that infrastructure is the most long-term effective for poverty reduction, and education/health have indirect lagged impacts. And they're mutually reinforcing: Well-funded physical infrastructure makes it easier to reach and do things, and social investments help people take advantage of those things. Over at least a 25-year period, infrastructure-led growth has brought on poverty reduction but for the long run inclusivity and sustainability of this indicator, there must be a balanced expenditure between what is to be spent in the education space and health. As a result, policy measures must combine infrastructural expansion with human development intervention to ensure fair and sustainable poverty reduction.

One way forward might be adding things like overseas investments, how open nations are to trade, and care for nature when studying ways to reduce poverty. Looking at differences between Southeast Asian countries may bring new clarity. Instead of basic models, using more complex tools - say, tracking data over time or mapping cause-effect chains - could sharpen results. Insights might then guide rules that actually fit real conditions. Each nation's path varies, yet patterns could still emerge.

6. Conflict of Interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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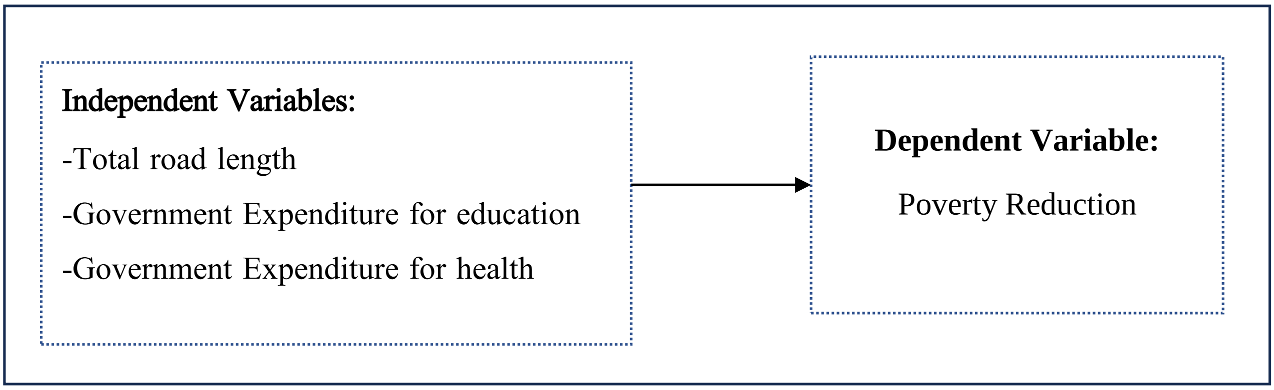

Figure 1: Conceptual framework

Table 1: Unit root test

H_0: Non-stationary		H_1: Stationary		
Interpolated Dickey-Fuller (Dickey & Fuller, 1979)				
Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	MacKinnon (Sig. Level)

		Before 1st Differences			
$IWI50_t$	-2.296	-3.750	-3.000	-2.630	0.1731
$LnRL_t$	-1.457	-3.750	-3.000	-2.630	0.5545
Edu_t	0.548	-3.750	-3.000	-2.630	0.9863
H_t	-2.860	-3.750	-3.000	-2.630	0.0502*
		After 1st Differences			
$D.IWI50_t$	-3.176	-3.750	-3.000	-2.630	0.0214**
$D.LnRL_t$	-1.716	-2.602	-1.753	-1.341	0.0534*
$D.Edu_t$	-3.249	-3.750	-3.000	-2.630	0.0173**
$D.H_t$	-6.575	-3.750	-3.000	-3.750	0.0000***

Note: ***,**,* Statistical significance levels of 0.01, 0.05 and 0.1 respectively

Table 2: Select lag length

E(lags) [1,4]				
	$IWI50_t$	$LnRL_t$	Edu_t	H_t
r_1	1	1	1	1

Table 3: ARDL(1,1,0,0) model

Variable	Coefficients	t	P>t
$IWI50_{t-1}$	0.5284***	4.49	0.001
$LnRL_t$	9.4621	0.76	0.462
$LnRL_{t-1}$	-33.0036**	-2.29	0.043
Edu_t	-0.2411	-0.54	0.600
H_t	3.4100**	2.68	0.021
_Cons	258.1537**	3.09	0.010
Number of Obs = 17, F(14, 1) = 21614.15, Prob > F= 0.0000			
R-squared = 0.9881, Adj R-squared = 0.9826, Root MSE = 1.5205			

Note: ***,**,* Statistical significance levels of 0.01, 0.05 and 0.1 respectively

-The value in brackets "[ ]" is a robust std. error

Table 4: Bounds Test for Cointegration

ARDL Bounds Test for Cointegration

H_0: no levels relationship, F = 5.443; t = -4.010

Critical Values (0.1-0.01), F-statistic

	I_0	I_1	I_0	I_1	I_0	I_1	I_0	I_1
	L_1	L_1	L_05	L_05	L_025	L_025	L_01	L_01
K_3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61

Critical Values (0.1-0.01), t-statistic

	I_0 L_1	I_1 L_1	I_0 L_05	I_1 L_05	I_0 L_025	I_1 L_025	I_0 L_01	I_1 L_01
K_3	-2.57	-3.46	-2.86	-3.78	-3.13	-4.05	-3.43	-4.37

Table 5: ARDL(1,1,0,0) model by Bound Test

Model	$D.IWI50_t$	Coefficient	T-test	P-value
ADJ	ECT_{t-1}	-0.4491***	-4.01	0.002
LR	$LnRL_t$	-50.5642***	-8.38	0.000
	Edu_t	-0.6246	-0.63	0.540
	H_t	7.8587**	2.98	0.011
SR	$D.LnRL_{t-1}$	31.1509**	2.23	0.046
	$Cons.$	248.5116**	3.06	0.010
	Obs	18		
	R-squared	0.6622		
	Adj R-squared	0.5214		
	Root MSE	1.4939		
	Log likelihood	-29.1161		

Note: ***,**,* Statistical significance levels of 0.01, 0.05 and 0.1 respectively

Table 6: Autocorrelation tests

Durbin's alternative test for autocorrelation			
lags(p)	chi2	df	Prob > chi2
1	0.046	1	0.8302
H_0: no serial correlation			
Breusch–Godfrey LM test for autocorrelation			
lags(p)	chi2	df	Prob > chi2
1	0.075	1	0.7843
H_0: no serial correlation			

Table 7: White's test

White's test			
H_0: Homoskedasticity			
H_1: Unrestricted heteroskedasticity			
chi2(17) = 18.00; Prob > chi2 = 0.3888			
Cameron & Trivedi's decomposition of IM-test			
Source	chi2	df	p
Heteroskedasticity	18	17	0.3888
Skewness	16.26	5	0.0061***
Kurtosis	0.09	1	0.7629
Total	34.35	23	0.0602*

Table 8: Normality Test

Jarque-Bera normality test	0.4259	Chi(2)	0.8082

Jarque-Bera test for H_0: normality					
Skewness and kurtosis tests for normality					
				Joint test	
Variabl e	Ob s	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi 2
resid	18	0.4351	0.6858	0.83	0.6596

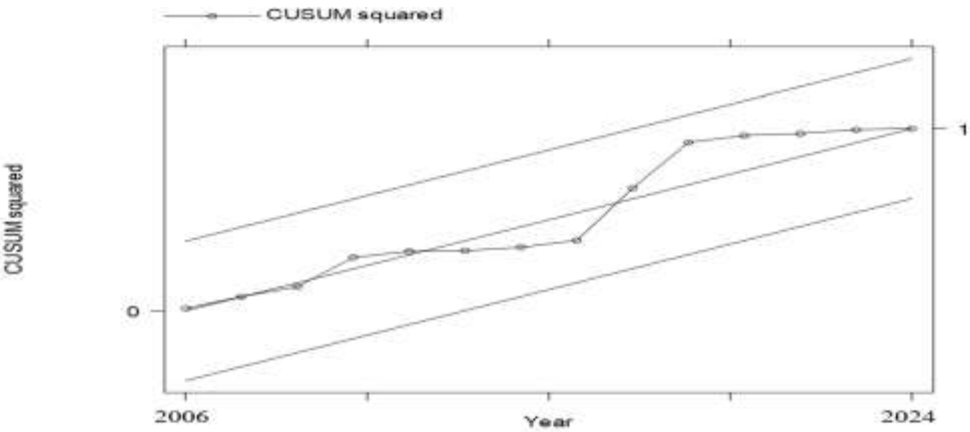

Figure 1: Stability test by CUSUM