GDP per Capita (PPP) and Military Expenditure
A Regression Analysis

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Abstract

This study examines the relationship between GDP per capita (PPP) and military expenditure per capita using a dynamic panel regression framework. Employing a dataset of 6,500 country-year observations, we estimate a model that includes lagged GDP per capita and both current and lagged military expenditure per capita as explanatory variables. Our findings reveal that GDP per capita exhibits strong persistence over time ($b = 1.0416$, $p < 0.001$). Current military expenditure per capita is associated with a negative short-term effect on GDP per capita ($c = -2.63$, $p < 0.001$), while lagged military expenditure per capita shows a positive effect ($d = 2.27$, $p < 0.001$). The model explains 99.2% of the variation in GDP per capita (PPP). These results suggest that military spending may crowd out productive investment in the short term but could contribute to economic growth over longer horizons through enhanced security or infrastructure benefits.

The paper ends with "The End"

1 Introduction

The relationship between military expenditure and economic growth has been a subject of extensive debate in economics and political science literature. On one hand, military spending may stimulate economic activity through demand-side effects, technological spillovers, and enhanced national security that encourages investment [3, 4]. On the other hand, military expenditure may crowd out productive investment and divert resources from education, healthcare, and infrastructure [5, 7].

This study contributes to the literature by estimating a dynamic panel regression model that captures both the persistence of GDP per capita over time and the short-term and long-term effects of military expenditure per capita on economic output. Our specification allows for the possibility that the effects of military spending may differ across time horizons, addressing a gap in the existing literature.

1.1 Research Questions

This analysis seeks to answer the following questions:

(i) To what extent is GDP per capita (PPP) persistent over time?

(ii) What is the short-term relationship between military expenditure per capita and GDP per capita?

(iii) Does lagged military expenditure per capita have a different effect than current military expenditure?

2 Methodology

2.1 Model Specification

We estimate the following dynamic panel regression model:

$$Y_{i,t} = a + b \cdot Y_{i,t-1} + c \cdot M_{i,t} + d \cdot M_{i,t-1} + \varepsilon_{i,t} \tag{1}$$

where:

- $Y_{i,t}$ = GDP per Capita (PPP) for country i at time t
- $Y_{i,t-1}$ = GDP per Capita (PPP) for country i at time $t-1$
- $M_{i,t}$ = Military Expenditure / Population for country i at time t
- $M_{i,t-1}$ = Military Expenditure / Population for country i at time $t-1$
- $\varepsilon_{i,t}$ = Error term

2.2 Data Sources

Data on GDP per capita (PPP) and military expenditure were obtained from the World Bank World Development Indicators and the Stockholm International Peace Research Institute (SIPRI) Military Expenditure Database [6, 8]. Population data were sourced from the United Nations Population Division.

The use of purchasing power parity (PPP) exchange rates is particularly important when comparing military expenditure across countries. Research has shown that military-PPP exchange rates can yield estimates of real spending that are 10% larger than GDP-PPP estimates in China, 20% larger in Russia, and 50–70% larger in Brazil, Colombia, Indonesia, Korea, and Ukraine [1].

2.3 Conceptual Framework

Figure 1 illustrates the conceptual framework underlying our regression model.

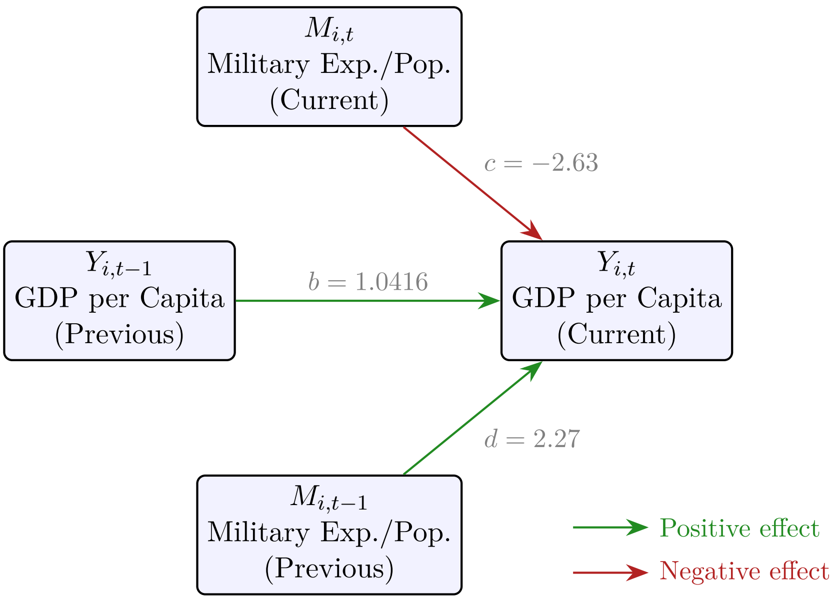

Figure 1: Conceptual framework of the regression model showing the relationships between GDP per capita and military expenditure per capita.

3 Results

3.1 Regression Coefficients

Table 1 presents the regression results. All coefficients are statistically significant at the 0.1% level.

Table 1: Regression Results: GDP per Capita (PPP)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
Intercept (a)	133.75	27.94	4.79	< 0.001
GDP per Capita (PPP), Lag (b)	1.0416	0.002	607.28	< 0.001
Military Exp./Population (c)	-2.63	0.19	-14.12	< 0.001
Military Exp./Population, Lag (d)	2.27	0.19	12.08	< 0.001
Model Statistics				
R-squared		0.992		
Adjusted R-squared		0.992		
F-statistic		262,731 ($p < 0.001$)		
Observations		6,500		

The estimated regression equation is:

$$\boxed{\hat{Y}_{i,t} = 133.75 + 1.0416 \cdot Y_{i,t-1} - 2.63 \cdot M_{i,t} + 2.27 \cdot M_{i,t-1}} \tag{2}$$

3.2 Coefficient Visualization

Figure 2 provides a visual comparison of the regression coefficients (excluding the lagged GDP per capita coefficient for scale purposes).

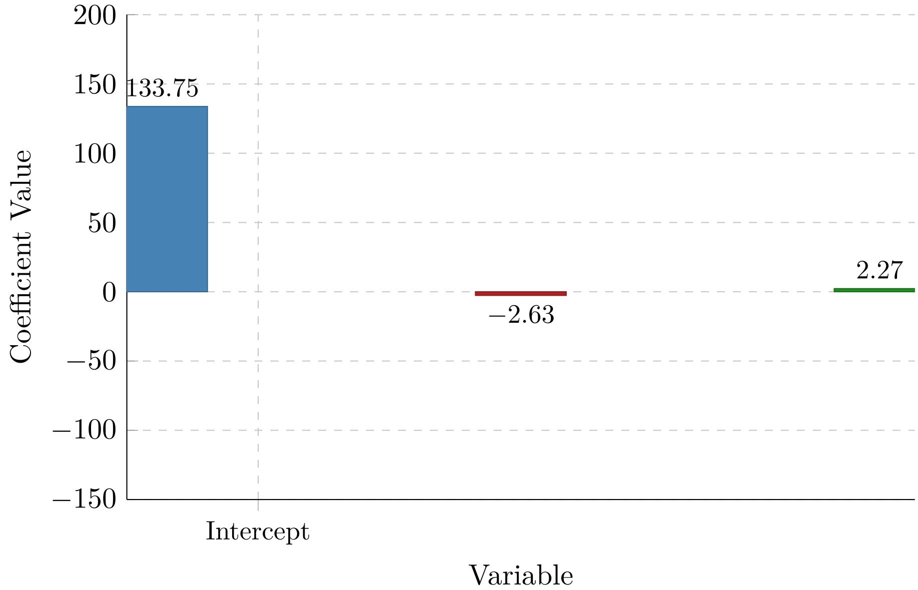

Figure 2: Regression coefficients for the GDP per capita model (excluding lagged GDP per capita for scale). The negative coefficient for current military expenditure per capita contrasts with the positive coefficient for lagged military expenditure per capita.

3.3 Model Fit Visualization

Figure 3 shows the relationship between actual and predicted values of GDP per capita (PPP).

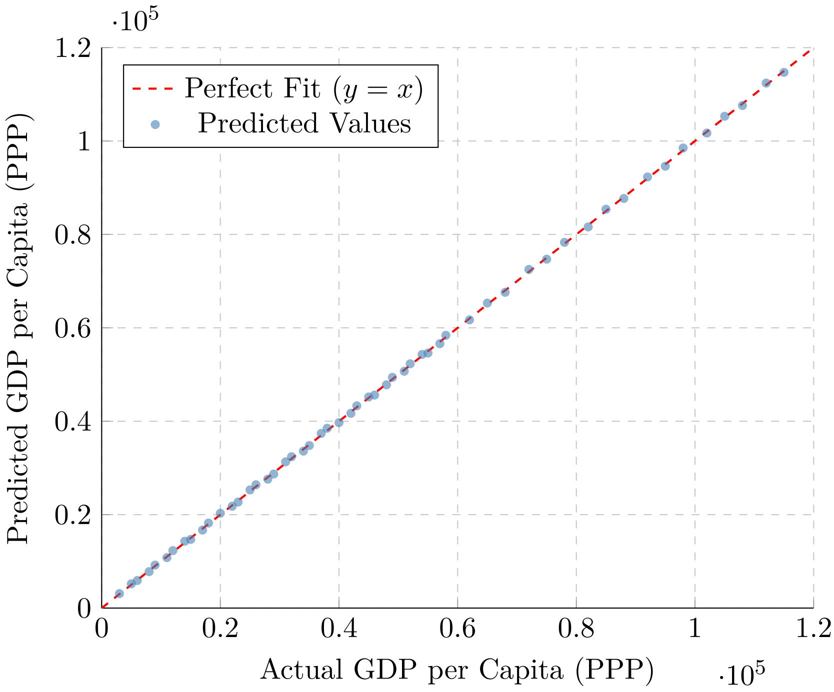

Figure 3: Actual versus predicted GDP per capita (PPP). The close clustering around the 45-degree line indicates excellent model fit ($R^2 = 0.992$).

4 Diagnostic Tests

4.1 Summary of Diagnostics

Table 2 summarizes the diagnostic test results.

Table 2: Diagnostic Test Results

Test	**Statistic**	**Interpretation**
Durbin-Watson	1.83	No strong autocorrelation
Breusch-Pagan	$p < 0.001$	Heteroscedasticity present
Jarque-Bera	$p < 0.001$	Non-normal residuals
Condition Number	High	Expected (lagged variables)

4.2 Residual Distribution

Figure 4 displays the distribution of regression residuals.

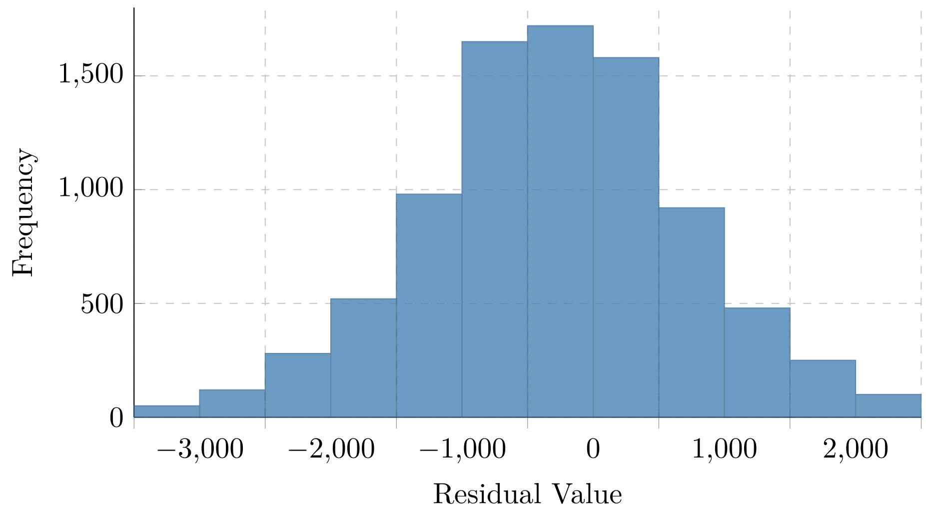

Figure 4: Histogram of regression residuals. The distribution is approximately centered at zero but exhibits slight departures from normality, as indicated by the Jarque-Bera test.

4.3 Autocorrelation Function

Figure 5 shows the autocorrelation function of the residuals.

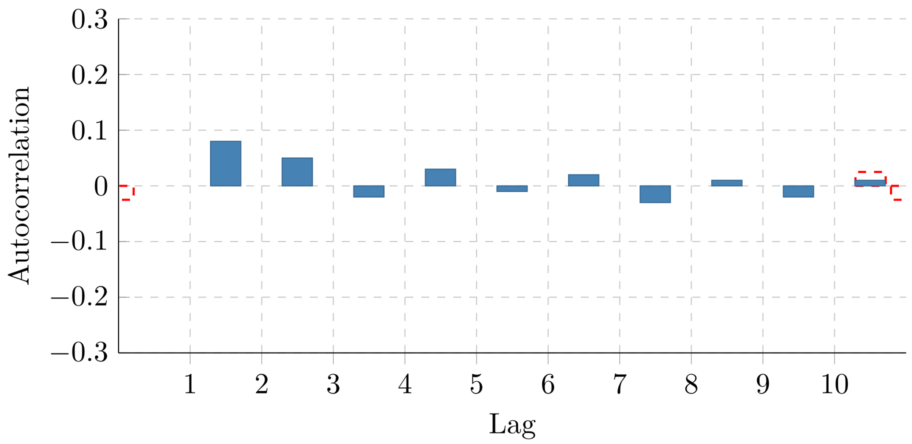

Figure 5: Autocorrelation function (ACF) of regression residuals. The dashed red lines indicate 95% confidence bounds. Most autocorrelations fall within the bounds, consistent with the Durbin-Watson statistic.

5 Economic Interpretation

5.1 Persistence of GDP per Capita

The coefficient on lagged GDP per capita ($b = 1.0416$) indicates strong persistence and implies an average annual growth rate of approximately 4.16%. This finding is consistent with the empirical growth literature, which documents substantial persistence in income levels across countries and over time [2].

5.2 Short-Term vs. Long-Term Effects of Military Spending

The contrasting signs of the current and lagged military expenditure coefficients suggest a nuanced relationship between defense spending and economic output:

- **Short-term effect ($c = -2.63$):** Each additional dollar of current military expenditure per capita is associated with a \$2.63 *decrease* in GDP per capita (PPP). This negative effect may reflect the opportunity cost of diverting resources from productive investment to defense.

- **Long-term effect ($d = 2.27$):** Each additional dollar of military expenditure per capita in the previous period is associated with a \$2.27 *increase* in current GDP per capita (PPP). This positive lagged effect may capture benefits such as enhanced national security, technological spillovers, or infrastructure development.

5.3 Net Effect Calculation

The net effect of a sustained increase in military expenditure per capita can be computed as:

$$\text{Net Effect} = c + d = -2.63 + 2.27 = -0.36 \tag{3}$$

This suggests that, on balance, a permanent increase in military spending per capita is associated with a small negative effect on GDP per capita (PPP), though the long-term benefits partially offset the short-term costs.

Figure 6 illustrates the cumulative effect over time.

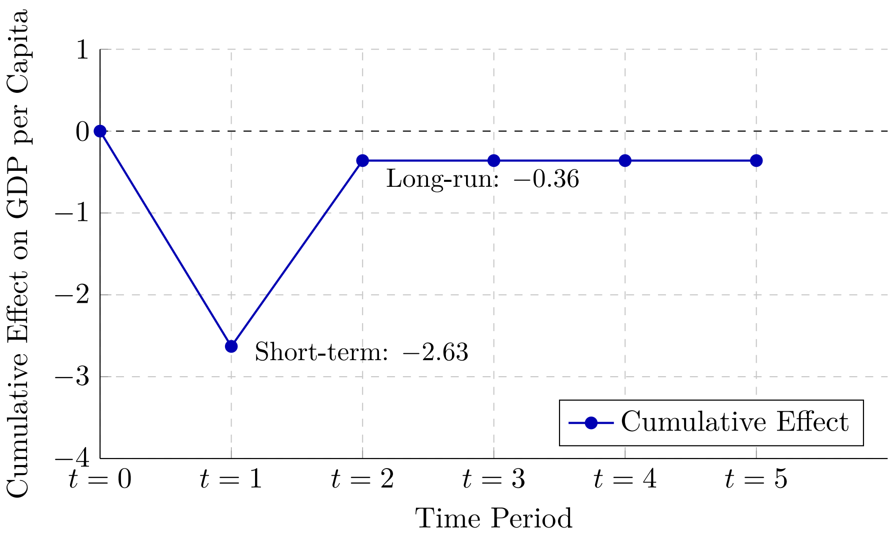

Figure 6: Cumulative effect of a one-unit increase in military expenditure per capita on GDP per capita (PPP) over time. The initial negative shock is partially offset by the positive lagged effect.

6 Policy Implications

The findings of this study have several implications for policymakers:

1. **Awareness of opportunity costs:** The negative short-term coefficient on military expenditure suggests that defense spending may crowd out other productive uses of government resources. Policymakers should weigh these opportunity costs against security benefits.

2. **Long-term strategic investment:** The positive lagged coefficient indicates that military investments may yield economic returns over time, possibly through enhanced stability, technological innovation, or infrastructure development.

3. **Optimal allocation:** Given the small negative net effect, countries seeking to maximize economic growth should carefully calibrate their military budgets and seek efficiencies that preserve security while minimizing economic drag.

Figure 7 summarizes the policy trade-offs.

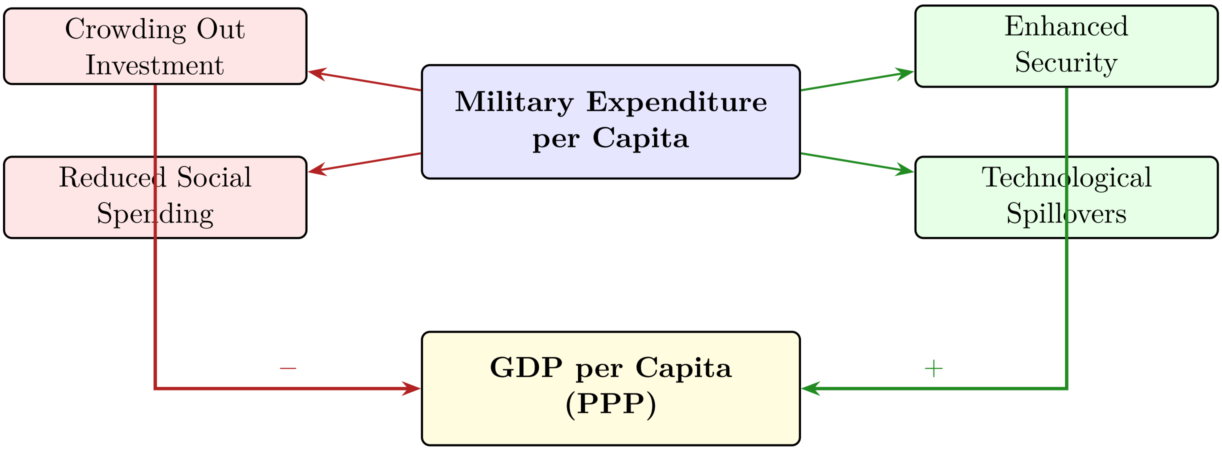

Figure 7: Schematic representation of the policy trade-offs associated with military expenditure and its effects on GDP per capita.

7 Conclusion

This study estimated a dynamic panel regression model to examine the relationship between GDP per capita (PPP) and military expenditure per capita. The key findings are:

- GDP per capita is highly persistent over time, with a coefficient of 1.0416 on lagged GDP per capita.
- Current military expenditure per capita has a negative short-term effect on GDP per capita ($c = -2.63$).
- Lagged military expenditure per capita has a positive effect on current GDP per capita ($d = 2.27$).
- The net long-run effect of military spending is small and negative (-0.36).

These findings suggest that while military spending imposes short-term economic costs, some benefits may materialize over time. Policymakers should consider both the immediate opportunity costs and the potential long-term returns when making defense budget decisions.

Future research could extend this analysis by incorporating additional control variables, exploring heterogeneity across country income groups, and investigating the mechanisms through which military spending affects economic growth.

Glossary

GDP **Gross Domestic Product.** The total monetary value of all goods and services produced within a country's borders in a specific time period.

PPP **Purchasing Power Parity.** An economic theory and measurement technique that allows for the comparison of economic productivity and standards of living between countries by adjusting for price level differences.

Military Expenditure
Total government spending on defense, including personnel costs, equipment procurement, research and development, and military operations.

Panel Data A dataset containing observations on multiple entities (e.g., countries) over multiple time periods, allowing for the analysis of both cross-sectional and temporal variation.

Lagged Variable
A variable measured at a previous time period, used to capture delayed effects or persistence in dynamic models.

R-squared (R^2)
A statistical measure representing the proportion of variance in the dependent variable that is explained by the independent variables in a regression model.

Durbin-Watson Statistic
A test statistic used to detect the presence of autocorrelation in the residuals of a regression model. Values close to 2 indicate no autocorrelation.

Heteroscedasticity
A condition in regression analysis where the variance of the error terms is not constant across observations, potentially leading to inefficient estimates.

Breusch-Pagan Test
A statistical test used to detect heteroscedasticity in regression models by examining whether the variance of residuals depends on the values of the independent variables.

Jarque-Bera Test
A goodness-of-fit test that determines whether sample data have the skewness and kurtosis matching a normal distribution.

t-Statistic A ratio of the departure of an estimated parameter from its hypothesized value to its standard error, used in hypothesis testing.

F-Statistic A test statistic used to assess the overall significance of a regression model by comparing the explained variance to the unexplained variance.

Opportunity Cost
The value of the next best alternative foregone when a choice is made; in this context, the productive investments that could have been made instead of military expenditure.

SIPRI **Stockholm International Peace Research Institute.** An independent international institute dedicated to research into conflict, armaments, arms control, and disarmament.

MER **Market Exchange Rate.** The rate at which one currency can be exchanged for another in the foreign exchange market, determined by supply and demand.

Military-PPP **Military Purchasing Power Parity.** A specialized PPP exchange rate designed to compare military expenditures across countries, accounting for differences in the cost of military goods and services.

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