The Paradoxical Effect of Military Spending on the Growth of GDP-PPP per capita

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Abstract

This paper examines the relationship between military spending and economic growth using GDP-PPP per capita data from 23 countries. We employ a multiple regression model incorporating both the raw military spending ratio and its Ghosh factor transformation to capture non-linear, context-dependent effects. Our findings reveal a paradoxical dual effect: while increases in military spending ratios are directly associated with lower GDP growth (coefficient -0.053), the Ghosh factor shows a positive relationship (coefficient $+0.127$). This paradox suggests that the impact of military spending on economic growth is fundamentally non-linear and depends critically on whether the economy is expanding or contracting. The model explains 51% of the variance in GDP growth rates, with significant residuals for high-growth emerging economies and stagnant developed nations.

The paper ends with "The End"

1 Introduction

The relationship between military expenditure and economic growth has long been a subject of debate in economics and political science. Traditional economic theory suggests that military spending, while necessary for national security, diverts resources from productive investment, potentially hindering economic growth. However, empirical evidence has been mixed, with some studies finding positive effects through technological spillovers and demand stimulation, while others document negative impacts through crowding out of private investment.

This paper contributes to this debate by analyzing recent data on military spending and GDP-PPP per capita growth across 23 major economies. Crucially, we employ the Ghosh factor—a novel statistical transformation that accounts for the non-linear relationship between military spending changes and economic performance, conditional on whether the economy is in expansion or contraction.

Our analysis reveals a striking paradox: military spending exhibits simultaneously negative direct effects and positive context-dependent effects on GDP growth. This finding has important implications for fiscal policy and defense strategy, suggesting that the economic impact of military expenditure cannot be understood through linear relationships alone.

2 Data Description

2.1 Sample and Variables

Our dataset comprises 23 countries spanning developed and emerging economies, including the United States, China, Russia, Germany, India, Japan, and others. For each country, we observe:

- **GDP-PPP per capita** (purchasing power parity adjusted) for two consecutive periods, measured in USD
- **Military spending** for the same two periods, measured in millions of USD
- **Rate of GDP-PPP per capita** (Y): The growth rate between periods
- **Ratio of Military spending** (R): The ratio of current to previous period military spending
- **Ghosh factor** (G_R): A transformed version of R based on the sign of Y

2.2 Summary Statistics

Table 1 presents key summary statistics for our sample.

Table 1: Summary Statistics

Variable	**Min**	**Max**	**Mean**	**Median**
GDP-PPP per capita (Last, USD)	9,817	132,570	48,469	49,995
Military spending (Last, USD mn)	2,836	997,309	96,328	—
GDP growth rate Y (%)	−2.80	5.54	1.23	—
Military spending ratio R	0.856	1.414	1.104	—
Ghosh factor G_R	−0.068	0.383	0.265	—

2.3 Key Observations

- **Wealth disparity**: Singapore leads with \$132,570 GDP-PPP per capita, while the minimum is \$9,817, indicating substantial variation in economic development.
- **Military dominance**: The United States accounts for approximately 45% of total military spending (\$997 billion out of \$2.2 trillion total).
- **Growth patterns**: Average GDP growth is 1.23%, with India (5.54%) and China (5.11%) at the top, while Saudi Arabia (−2.80%) and Argentina (−2.06%) experienced contractions.
- **Military spending trends**: 18 out of 23 countries (78%) increased military spending, with an average increase of 10.4%.
- **Largest increases**: Mexico (+41.4%), Netherlands (+39.4%), Russia (+36.4%), and Germany (+31.5%) showed the most dramatic military spending increases.

3 The Ghosh Factor

3.1 Definition

The Ghosh factor, introduced by Ghosh (unpublished), provides a context-dependent transformation of the military spending ratio. For a dependent variable y (GDP growth rate) and an independent variable $X > 0$ (military spending ratio), the Ghosh factor of X is defined as:

$$G_X = \begin{cases} \log(X) & \text{if } y < 0 \\ \log(1 + X) & \text{if } y \geq 0 \end{cases} \tag{1}$$

In our context:

$$G_R = \begin{cases} \log(R) & \text{if } Y < 0 \\ \log(1 + R) & \text{if } Y \geq 0 \end{cases} \tag{2}$$

3.2 Interpretation

The Ghosh factor serves several important purposes:

1. **Logarithmic dampening**: It compresses extreme values in the military spending ratio, making the distribution more suitable for linear regression.
2. **Differential treatment**: Economies experiencing contraction ($Y < 0$) are evaluated using $\log(R)$, which applies a harsher penalty to military spending increases during economic downturns.
3. **Growth-friendly transformation**: Expanding economies ($Y \geq 0$) use $\log(1 + R)$, a gentler transformation that acknowledges the potentially different role of military spending in growth contexts.
4. **Asymmetric effects**: This formulation allows military spending to have different impacts depending on the economic environment, capturing non-linearities that a simple linear model would miss.

3.3 Application to Sample

In our dataset:

- 6 countries experienced negative GDP growth and thus use $G_R = \log(R)$: Argentina, Australia, Canada, Saudi Arabia, South Africa, and Switzerland.
- 17 countries experienced positive GDP growth and thus use $G_R = \log(1 + R)$.

4 Regression Model

4.1 Model Specification

We estimate the following multiple linear regression model:

$$Y_i = a + b \cdot R_i + c \cdot G_{R,i} + \epsilon_i \tag{3}$$

where:

- Y_i is the rate of GDP-PPP per capita growth for country i
- R_i is the ratio of military spending (Last/Previous) for country i
- $G_{R,i}$ is the Ghosh factor of R_i for country i
- a, b, c are parameters to be estimated
- ϵ_i is the error term

4.2 Estimation Method

We employ Ordinary Least Squares (OLS) estimation. The parameters are obtained by solving the normal equations:

$$(\mathbf{X}'\mathbf{X})\beta = \mathbf{X}'\mathbf{Y} \tag{4}$$

where $\mathbf{X}$ is the design matrix containing columns for the intercept, R, and G_R, and $\beta = [a, b, c]'$ is the parameter vector.

5 Results

5.1 Regression Estimates

Table 2 presents the estimated regression coefficients.

Table 2: Regression Results: $Y = a + b \cdot R + c \cdot G_R$

Variable	**Coefficient**	**Interpretation**
Intercept (a)	0.0399	Baseline GDP growth
Military spending ratio (b)	-0.0531	Direct effect (negative)
Ghosh factor (c)	$+0.1273$	Context-dependent effect (positive)
Model Fit		
R^2	0.510	51.0% variance explained
Adjusted R^2	0.461	Adjusted for degrees of freedom
F-statistic	10.41	Model significance
Standard Error	0.0164	Average prediction error
Observations	23	Number of countries

The estimated regression equation is:

$$\hat{Y} = 0.0399 - 0.0531 \cdot R + 0.1273 \cdot G_R \tag{5}$$

5.2 Coefficient Interpretation

5.2.1 Intercept ($a = 0.0399$)

The intercept represents the baseline GDP growth rate when both R and G_R equal zero. While this is a theoretical construct (as $R = 0$ implies no military spending in either period, which is unrealistic), it provides a reference point for the model. The positive intercept of 3.99% suggests a baseline growth tendency in the absence of military spending effects.

5.2.2 Military Spending Ratio ($b = -0.0531$)

The coefficient on R is negative and economically significant. Holding the Ghosh factor constant, a one-unit increase in the military spending ratio is associated with a 5.31 percentage point *decrease* in GDP growth. This captures the **direct opportunity cost** of military spending:

- Resources allocated to defense cannot be used for productive investment
- Military expenditure may crowd out private sector activity
- Defense spending has lower multiplier effects than other forms of government expenditure

5.2.3 Ghosh Factor ($c = 0.1273$)

In contrast, the coefficient on G_R is positive and larger in absolute magnitude than the R coefficient. A one-unit increase in the Ghosh factor is associated with a 12.73 percentage point *increase* in GDP growth (holding R constant). This captures the **context-dependent, non-linear effect** of military spending:

- The logarithmic transformation emphasizes relative rather than absolute changes
- The differential formula based on GDP growth sign creates asymmetry
- Countries that increase military spending during economic expansion may benefit from defense-industrial spillovers
- The positive coefficient suggests that *how* military spending changes matters more than the raw change itself

5.3 Model Fit and Diagnostics

5.3.1 R^2 and Adjusted R^2

The model achieves an R^2 of 0.510, indicating that 51.0% of the variance in GDP growth rates is explained by the military spending ratio and its Ghosh factor. This is a moderate fit, suggesting that while military spending is an important determinant of growth, other factors (technological innovation, trade policy, institutional quality, demographic changes) play significant roles.

The adjusted R^2 of 0.461 accounts for the number of predictors relative to sample size, confirming that the model provides meaningful explanatory power even after penalizing for model complexity.

5.3.2 F-statistic

The F-statistic of 10.41 is highly significant, indicating that the model as a whole is statistically meaningful and that the coefficients are jointly different from zero.

5.3.3 Standard Error

The standard error of 0.0164 (1.64 percentage points) represents the typical deviation of actual GDP growth from predicted values. This indicates reasonably accurate predictions on average, though individual countries may deviate substantially.

5.4 Residual Analysis

Table 3 shows the countries with the largest prediction errors.

Table 3: Largest Residuals (Model Prediction Errors)

Country	**Actual (%)**	**Predicted (%)**	**Residual (%)**
Model Underestimates (Positive Residuals)			
India	5.54	2.39	+3.15
Russia	4.56	1.50	+3.05
China	5.11	2.36	+2.75
Model Overestimates (Negative Residuals)			
United Kingdom	0.03	2.29	−2.26
Italy	0.74	2.44	−1.70
France	0.83	2.29	−1.46

5.4.1 Interpretation of Residuals

Underestimated growth (positive residuals): The model significantly underestimates GDP growth for India, Russia, and China—all emerging economies with strong structural growth drivers beyond military spending. These countries benefit from:

- Demographic dividends (young, growing populations)
- Technological catch-up and productivity gains
- Integration into global value chains
- Urbanization and industrialization

Overestimated growth (negative residuals): The model overestimates growth for the United Kingdom, Italy, and France—mature European economies facing structural headwinds. These countries experience:

- Aging populations and declining labor force growth
- High debt burdens constraining fiscal space
- Slow productivity growth and innovation challenges
- Institutional rigidities

These systematic patterns in residuals suggest that country-specific structural factors, not captured by military spending alone, play crucial roles in determining GDP growth.

6 The Paradox Explained

6.1 The Dual Effect of Military Spending

Our regression results reveal a striking paradox: the coefficient on R is negative (-0.0531), while the coefficient on G_R (which is derived from R) is positive and larger in magnitude ($+0.1273$). How can the same underlying variable have opposite effects?

The resolution lies in understanding that R and G_R capture *different aspects* of military spending:

1. R **captures the direct, linear effect**: Higher military spending ratios directly reduce resources available for productive investment, creating an opportunity cost.

2. G_R **captures the non-linear, context-dependent effect**: The Ghosh factor transformation creates a variable that measures not just *how much* military spending changed, but *how that change relates to the economic environment.*

6.2 Mathematical Decomposition

Consider the total effect of a change in R on Y:

$$\frac{\partial Y}{\partial R} = b + c \cdot \frac{\partial G_R}{\partial R} \tag{6}$$

The derivative $\frac{\partial G_R}{\partial R}$ depends on the sign of Y:

$$\frac{\partial G_R}{\partial R} = \begin{cases} \frac{1}{R} & \text{if } Y < 0 \\ \frac{1}{1+R} & \text{if } Y \geq 0 \end{cases} \tag{7}$$

Thus, the total marginal effect is:

$$\frac{\partial Y}{\partial R} = \begin{cases} -0.0531 + 0.1273 \cdot \frac{1}{R} & \text{if } Y < 0 \\ -0.0531 + 0.1273 \cdot \frac{1}{1+R} & \text{if } Y \geq 0 \end{cases} \tag{8}$$

This reveals that:

- For *contracting economies* ($Y < 0$), the positive effect through G_R is larger (due to $1/R$ term), potentially offsetting or even reversing the direct negative effect.
- For *expanding economies* ($Y \geq 0$), the positive effect is dampened (due to $1/(1+R)$ term with $R > 0$), but still substantial.

6.3 Economic Interpretation

The paradox suggests several important insights:

1. **Context matters**: The impact of military spending on growth cannot be understood in isolation. The state of the economy fundamentally alters how defense expenditure affects output.

2. **Non-linearity is crucial**: Linear models that simply regress GDP growth on military spending miss the complex, conditional relationship. The Ghosh factor's differential formula captures this non-linearity.

3. **Marginal vs. average effects**: While high levels of military spending may be detrimental (captured by the negative b), *changes* in spending can have positive effects depending on economic context (captured by the positive c).

4. **Policy implications**: Governments should consider not just the level of military spending, but how changes in that spending interact with the broader economic cycle.

7 Discussion

7.1 Comparison with Existing Literature

Our findings contribute to a long-standing debate in the literature. Early studies (Benoit, 1973, 1978) found positive effects of military spending on growth, particularly in developing countries. However, later work (Deger and Smith, 1983; Dunne et al., 2005) documented negative effects through crowding out of investment.

Our analysis reconciles these conflicting findings by demonstrating that both effects exist simultaneously, with their relative strength depending on:

- The phase of the economic cycle (expansion vs. contraction)
- The magnitude of spending changes (captured by the logarithmic transformation)
- Country-specific factors that create residual variation

7.2 Limitations

Several limitations of our analysis should be acknowledged:

1. **Cross-sectional design**: Our data represents a snapshot comparison across countries at two time points. Panel data with multiple periods would provide more robust estimates and allow for country fixed effects.
2. **Omitted variables**: The model's R^2 of 0.51 indicates that nearly half of GDP growth variation remains unexplained. Important omitted factors include:
    - Trade openness and export competitiveness
    - Human capital and education levels
    - Institutional quality and governance
    - Technological innovation and R&D spending
    - Natural resource endowments
3. **Endogeneity concerns**: Military spending decisions are not exogenous—countries may increase defense budgets in response to economic conditions or security threats. This creates potential reverse causality that our cross-sectional analysis cannot fully address.
4. **Aggregation issues**: Military spending encompasses diverse activities (personnel, procurement, R&D, operations) with potentially different economic impacts. Our aggregate measure obscures this heterogeneity.
5. **Sample selection**: Our 23-country sample, while including major economies, may not be representative of all nations. Smaller countries, particularly those in conflict zones, are not represented.

7.3 Policy Implications

Despite these limitations, our findings offer several insights for policymakers:

1. **Timing matters**: Increases in military spending during economic downturns may have different (potentially less harmful or even beneficial) effects compared to increases during expansions.

2. **Non-linear thinking**: Simple linear projections of the economic impact of defense budgets are likely to be misleading. Policymakers should account for context-dependent effects.

3. **Complementary policies**: Countries seeking to increase military spending should consider complementary policies to mitigate the direct negative effect, such as:

   - Focusing on defense R&D with civilian spillovers
   - Ensuring efficient procurement processes
   - Maintaining overall fiscal discipline

4. **Strategic resource allocation**: The large residuals for emerging economies (China, India) and developed nations (UK, Italy) underscore that military spending is just one factor among many. Comprehensive growth strategies must address institutional, technological, and demographic factors.

8 Conclusion

This paper examined the relationship between military spending and GDP-PPP per capita growth across 23 countries using a novel approach that incorporates the Ghosh factor transformation. Our analysis reveals a fundamental paradox: military spending exhibits both direct negative effects (through the raw spending ratio) and context-dependent positive effects (through the Ghosh factor).

The estimated regression equation:

$$\hat{Y} = 0.0399 - 0.0531 \cdot R + 0.1273 \cdot G_R$$

explains 51% of the variance in GDP growth rates and is statistically significant. The paradox arises because the Ghosh factor captures non-linear, asymmetric relationships that depend on whether the economy is expanding or contracting.

Key findings include:

1. **Direct opportunity cost**: Each unit increase in the military spending ratio is associated with a 5.31 percentage point decrease in GDP growth, holding the Ghosh factor constant.

2. **Context-dependent benefit**: Each unit increase in the Ghosh factor is associated with a 12.73 percentage point increase in GDP growth, holding the spending ratio constant.

3. **Systematic residuals**: The model systematically underestimates growth for emerging economies with strong structural drivers (India, China, Russia) and overestimates growth for mature economies facing headwinds (UK, Italy, France).

4. **Global militarization**: The majority of countries (78%) increased military spending in the period studied, with an average increase of 10.4%, suggesting heightened global security concerns.

The paradox revealed in this analysis has important theoretical and practical implications. Theoretically, it demonstrates that the economic impact of military spending cannot be understood through simple linear relationships. The Ghosh factor provides a mathematical framework for capturing how the same policy lever (military spending) can have different effects depending on economic context.

Practically, the findings suggest that policymakers should move beyond simplistic debates about whether military spending is "good" or "bad" for growth. Instead, they should recognize that the economic impact is contingent on the state of the economy, the magnitude of spending changes, and country-specific structural factors.

Future research should extend this analysis in several directions:

- Panel data with multiple time periods to control for unobserved heterogeneity
- Instrumental variables approaches to address endogeneity concerns
- Decomposition of military spending into components with potentially different economic impacts
- Expansion to a broader set of countries, including smaller nations and those in conflict zones
- Integration of additional control variables capturing institutional quality, trade, and human capital

In conclusion, the paradoxical dual effect of military spending on economic growth—simultaneously negative through direct resource allocation and positive through context-dependent transformation—challenges conventional wisdom and calls for more nuanced policy approaches that account for economic conditions, non-linear relationships, and the complex interplay between defense and development.

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The End